WILDEARTH GUARDIANS
A FORCE FOR NATURE

September 16, 2015

Via Hand Delivery

Jenna Whitlock
Acting State Director
U.S. Bureau of Land Management
Utah State Office
440 West 200 South, Suite 500
Salt Lake City, UT 84101

Re: Protest of November 2015 Competitive Oil and Gas Lease Sale

Dear Ms. Whitlock:

Pursuant to 43 C.F.R. § 3120.1-3, WildEarth Guardians hereby protests the Bureau of Land Management's ("BLM's") proposal to offer 55 publicly owned oil and gas lease parcels covering 73,195.39 acres of land for competitive sale on November 17, 2015. Nine parcels are located in the West Desert District Office, 42 in the Green River District Office, and four parcels underlie the Fishlake National Forest. The lease parcels included for sale, as identified by the BLM's in its Final May 2015 Oil and Gas Sale List, include the following:[1]

Lease Serial Number	Acres	Field Office	County
UTU91266	162.98	Fillmore	Juab
UTU91267	840.00	Fillmore	Juab
UTU91268	1680.00	Fillmore	Juab
UTU91269	1616.74	Fillmore	Juab
UTU91270	2560.00	Fillmore	Juab
UTU91271	2520.00	Fillmore	Juab
UTU91272	1008.7	Fillmore	Juab
UTU91273	2195.08	Fillmore	Juab
UTU91274	360.00	Fillmore	Juab
UTU91302	440.34	Price	Carbon
UTU91303	702.68	Price	Carbon
UTU91304	2040.00	Price	Carbon
UTU91305	2285.98	Price	Carbon
UTU91306	2240.00	Price	Carbon

[1] This list of lease parcels is available on the BLM's website at http://www.blm.gov/ut/st/en/prog/energy/oil_and_gas/oil_and_gas_lease.html.

UTU91307	1288.50	Price	Carbon
UTU91308	1813.60	Price	Carbon
UTU91309	360.00	Vernal	Uintah
UTU91310	120.00	Vernal	Grand
UTU91311	220.82	Vernal	Grand
UTU91312	320.00	Vernal	Grand
UTU91313	440.64	Vernal	Grand
UTU91314	200.00	Price	Emery
UTU91315	2310.15	Price	Emery
UTU91316	925.17	Price	Emery
UTU91317	2382.50	Price	Emery
UTU91318	2520.00	Price	Emery
UTU91319	2008.79	Price	Emery
UTU91320	2560.00	Price	Emery
UTU91321	2560.00	Price	Emery
UTU91322	2560.00	Price	Emery
UTU91323	2010.24	Price	Emery
UTU91324	2506.92	Price	Emery
UTU91325	2540.63	Price	Emery
UTU91326	2560.00	Price	Emery
UTU91327	2557.84	Price	Emery
UTU91328	2558.28	Price	Emery
UTU91329	2558.96	Price	Emery
UTU91330	2319.64	Price	Emery
UTU91331	438.80	Price	Emery
UTU91332	400.00	Price	Emery
UTU91333	1305.00	Price	Emery
UTU91334	2316.22	Price	Emery
UTU91335	1125.54	Price	Emery
UTU91336	209.17	Price	Emery
UTU91337	961.23	Price	Emery
UTU91338	329.79	Vernal	Duchesne
UTU91339	760.00	Vernal	Duchesne
UTU91340	80.00	Price	Emery
UTU91341	531.89	Vernal	Duchesne
UTU91342	160.00	Vernal	Duchesne
UTU91343	70.00	Vernal	Duchesne
UTU91344	392.57	Richfield	Sevier
UTU91345	58.35	Richfield	Sevier
UTU91346	560.60	Richfield	Sevier
UTU91347	641.05	Richfield	Sevier

In support of its proposed leasing, the agency prepared three “Environmental Assessments” (“EAs”): One for leases in the Fillmore Field Office of Utah, DOI-BLM-UT-W020-2015-0004-EA (hereafter “Fillmore EA”); one for leases in the Vernal Field Office, DOI-

BLM-UT-G010-2015-089-EA (hereafter "Vernal EA"); and one for leases in the Price Field Office, DOI-BLM-UT-G021-2015-0031-EA (hereafter "Price EA"). For the lease parcels underlying the Fishlake National Forest, the agency relied upon a Final Environmental Impact Statement ("FEIS") prepared by the U.S. Forest Service ("USFS").

As will be explained, the BLM's proposal to lease falls short of ensuring compliance with applicable environmental protection laws and is not based on sufficient analysis and assessment of key environmental impacts under the National Environmental Policy Act ("NEPA"), 42 U.S.C. § 4331, *et seq*. The agency's EAs, as well as the adopted FEIS, are therefore deficient and fail to provide sufficient justification for its proposed action and its proposal to issue a FONSI. For the reasons below, we request the BLM refrain from offering the 55 proposed lease parcels for sale and issuance.[2]

STATEMENT OF INTEREST

WildEarth Guardians is a nonprofit environmental advocacy organization dedicated to protecting the wildlife, wild places, wild rivers, and health of the American West. On behalf of our members, Guardians has an interest in ensuring the BLM fully protects public lands and resources as it conveys the right for the oil and gas industry to develop publicly owned minerals. More specifically, Guardians has an interest in ensuring the BLM meaningfully and genuinely takes into account the climate implications of its oil and gas leasing decisions and objectively and robustly weighs the costs and benefits of authorizing the release of more greenhouse gas emissions that are known to contribute to global warming.

The mailing address for WildEarth Guardians to which correspondence regarding this protest should be directed is as follows:

WildEarth Guardians
1536 Wynkoop, Suite 310
Denver, CO 80202

STATEMENT OF REASONS

WildEarth Guardians protests the BLM's May 2015 oil and gas lease sale over the agency's failure to adequately analyze and assess the climate impacts of the reasonably foreseeable oil and gas development that will result in accordance with the National Environmental Policy Act ("NEPA"), 42 U.S.C. § 4331, *et seq*., and regulations promulgated thereunder by the White House Council on Environmental Quality ("CEQ"), 40 C.F.R. § 1500, *et seq*.

NEPA is our "basic national charter for protection of the environment." 40 C.F.R. § 1500.1(a). The law requires federal agencies to fully consider the environmental implications

[2] For purposes of this protest, we hereby incorporate by reference comments, objections, and attachments thereto submitted by WildEarth Guardians in response to the BLM's Draft EAs, as well as the USFS's Draft and Final EIS for leasing on the Fishlake National Forest. These documents should be a part of the BLM's record supporting its final decision(s).

of their actions, taking into account "high quality" information, "accurate scientific analysis," "expert agency comments," and "public scrutiny," prior to making decisions. *Id*. at 1500.1(b). This consideration is meant to "foster excellent action," meaning decisions that are well informed and that "protect, restore, and enhance the environment." *Id*. at 1500.1(c).

To fulfill the goals of NEPA, federal agencies are required to analyze the "effects," or impacts, of their actions to the human environment prior to undertaking their actions. 40 C.F.R. § 1502.16(d). To this end, the agency must analyze the "direct," "indirect," and "cumulative" effects of its actions, and assess their significance. 40 C.F.R. §§ 1502.16(a), (b), and (d). Direct effects include all impacts that are "caused by the action and occur at the same time and place." 40 C.F.R. § 1508.8(a). Indirect effects are "caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable." *Id*. at § 1508.8(b). Cumulative effects include the impacts of all past, present, and reasonably foreseeable actions, regardless of what entity or entities undertake the actions. 40 C.F.R. § 1508.7.

An agency may prepare an environmental assessment ("EA") to analyze the effects of its actions and assess the significance of impacts. *See* 40 C.F.R. § 1508.9; *see also* 43 C.F.R. § 46.300. Where effects are significant, an Environmental Impact Statement ("EIS") must be prepared. *See* 40 C.F.R. § 1502.3. Where significant impacts are not significant, an agency may issue a Finding of No Significant Impact ("FONSI") and implement its action. *See* 40 C.F.R. § 1508.13; *see also* 43 C.F.R. § 46.325(2).

Here, the BLM fell short of complying with NEPA with regards to analyzing and assessing the potentially significant climate impacts of oil and gas leasing. In support of its proposed leasing, the agency prepared three EAs and relied on an FEIS prepared by the USFS. In all EAs and the FEIS, however, the BLM failed to analyze the reasonably foreseeable greenhouse gas emissions that would result from selling the oil and gas lease parcels, as well as failed to assess the significance of any emissions, particularly in terms of carbon costs.

In the EAs, the BLM seemingly acknowledged that climate change is a very serious issue and that it is being fueled by the release of human-produced greenhouse gas emissions. Unfortunately, in spite of recognizing serious climate consequences resulting from the release of greenhouse gas emissions, the BLM made no effort in the EAs or the FEIS to analyze and assess the potential greenhouse gas emissions that would result from oil and gas development and the likely climate consequences.

The EA fails to analyze the reasonably foreseeable greenhouse gas emissions that would result from development of the proposed leases. Instead of using readily available information and methods, including analyses that other BLM offices have been perfectly capable of preparing, the agency instead asserts that it is simply impossible to estimate such emissions. *See* EA at 69. The issue, however, is not that it is impossible to estimate emissions, but that BLM believes it cannot estimate emissions as precisely as it prefers to. This is not allowed under NEPA. Although the agency may believe that without definitive development proposals, it cannot project impacts, the whole point of leasing oil and gas is to facilitate development. The BLM cannot claim that the act of leasing carries with it no intention to foster future development. Regardless, because leasing conveys a right to develop, absent any stipulations that provide the agency with authority to constrain or even prevent future development to limit greenhouse gas or climate impacts, the BLM has basis to assert that it is appropriate to wait to conduct its legally required analysis under NEPA, or worse, assert that there would be no reasonably foreseeable emissions associated with its proposed action.

In any case, the BLM has completely failed to provide information and analysis, even brief information and analysis, supporting a FONSI and any decision to sell and issue the aforementioned lease parcels. Either the BLM must prepare an EIS or it cannot proceed with the lease sale as proposed. Below, we detail how BLM's proposal fails to comply with NEPA.

1. **The BLM Failed to Fully Analyze and Assess the Direct, Indirect, and Cumulative Impacts of Greenhouse Gas Emissions that Would Result from Issuing the Proposed Lease Parcels**

In the Vernal EA, the BLM completely rejected analyzing and assessing the potential direct and indirect greenhouse gas emissions, including carbon dioxide and methane, that would result from the reasonably foreseeable development of the proposed leases. Although acknowledging that development of the lease parcels would occur and that greenhouse gas emissions would be produced, no analysis of these emissions was actually prepared. The BLM asserted, "The assessment of greenhouse gas emissions and climate change remains in its earliest stages of formulation...Drilling and development activities as a result of the proposed leasing are anticipated to release a negligible amount of greenhouse gases into the local air-shed." Vernal EA at 32-33.

While the BLM has no basis for asserting that greenhouse gas emissions associated with development of leases in the Vernal Field Office would be negligible as no estimate of reasonably foreseeable greenhouse gas emissions was actually prepared, the agency's claim nevertheless stands in direct contrast to the analyses in the Fillmore EA, the Price EA, and the USFS's FEIS. Indeed, in all three NEPA analysis, the BLM actually did estimate the likely greenhouse gas emissions that would result from development of the proposed leases. In the Fillmore EA, the BLM disclosed development of leases would release 7,074.54 metric tons of carbon dioxide equivalent ("CO_2e"). Fillmore EA at 55. In the Price EA, the BLM disclosed development of the proposed leases would release 66,527.34 metric tons of CO_2e at the high end. Price EA at 52.[3] In the FEIS, the USFS disclosed that development of leases on the Fishlake National Forest would release 365,336 metric tons of CO_2e. FEIS at 39. Although we disagree that these estimates are accurate (we believe the BLM significantly underestimated CO_2e emissions), it is nevertheless unclear how, in the face of these disclosures, the Vernal Field Office was prevented from analyzing and disclosing similar information.

Although the BLM may assert that disclosure of greenhouse gas emissions would be of no value because of the claim that they would be negligible, there is no basis for this argument In the Price EA, the BLM appears to claim that emissions would be negligible because they represent a fraction of statewide greenhouse gas emissions. *See* Price EA at 52. However, if the scope of the BLM's analysis of greenhouse gas emissions is going to be statewide, or even

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[3] Interestingly, this comes even as the Price Field Office asserts that it would be "unreasonable" to quantify potenital greenhouse gas emissions. Price EA, Appendix C at 8.

larger, then the agency is obligated to also analyze and assess greenhouse gas emissions from similar and cumulative actions. As NEPA requires, an agency must analyze the impacts of "similar" and "cumulative" actions in the same NEPA document in order to adequately disclose impacts in an Environmental Impact Statement ("EIS") or provide sufficient justification for a FONSI in an EA. *See* 40 C.F.R. §§ 1508.25(a)(2) and (3). Here, it appears that given the scope of the agency's analysis of greenhouse gas emissions, the BLM was required to at least take into account the greenhouse gas emissions resulting from other proposed oil and gas leasing in Utah, as well as related oil and gas development, and to analyze the impacts of these actions in terms of their direct, indirect, and cumulative impacts. At a minimum, it would appear the BLM was required to analyze the impacts of leasing in the Vernal, Price, and Fillmore Field Offices, as well as on the Fishlake National Forest, in a single NEPA document. The failure to conduct such an analysis consistent with the BLM's own stated scope of analysis of greenhouse gas emissions means there is no basis for the claim that emissions would be "negligible" or that FONSIs are warranted.

Adding to the shortcomings, all three EAs, as well as the FEIS, fail to fully analyze and assess all reasonably foreseeable greenhouse gas emissions associated with development of the proposed leases. Notably, while the BLM recognizes that development and production will lead to truck traffic and related activity (*see e.g.* Vernal EA at 11), there is no estimate of the greenhouse gas emissions that would result from this activity. Further, neither EA fully discloses the greenhouse gas emissions that would result from all reasonably foreseeable development. The Price EA, for example, discloses a number of activities that are likely to release greenhouse gas emissions, including produced water handling and plugging and abandonment. *See* Price EA at 38. The Fillmore EA discloses that similar activities will occur, as well as maintenance. *See* Fillmore EA at 10. Even though the Fillmore and Price EAs disclose potential CO_2e emissions, there is no indication that these estimates account for all reasonably foreseeable actions that would result from leasing the proposed parcels.

Most significantly, there is no estimate of the likely emissions that would result from the consumption, namely combustion, of produced oil and gas. There are readily available methods for analyzing and assessing such emissions, including estimates by the U.S. Environmental Protection Agency ("EPA") as to much CO_2e is produced per barrel of oil consumed and per therm of natural gas consumed. *See* EPA, "Calculations and References," website available at http://www.epa.gov/cleanenergy/energy-resources/refs.html (last accessed Sept. 15, 2015). According to the EPA, 0.43 metric tons of CO_2 is released per barrel of oil consumed and 0.005302 metric tons of CO_2 is released per therm of natural gas consumed.[4]

The failure to fully analyze and assess reasonably foreseeable greenhouse gas emissions is made worse by the fact that the underlying Final EISs prepared for these Field Offices' Resource Management Plans nowhere analyze or assess greenhouse gas emissions associated with oil and gas development. In light of this, the BLM clearly has no basis to conclude that greenhouse gas emissions resulting from the reasonably foreseeable impacts of oil and gas development associated with the proposed leasing would not be significant. Without any

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[4] According to the U.S. Energy Information Administration ("EIA"), a one Mcf of natural gas generally equals 10.28 therms. *See* EIA, "Frequently Asked Questions," website available at http://www.eia.gov/tools/faqs/faq.cfm?id=45&t=8 (last accessed Sept. 15, 2015).

analysis of cumulative greenhouse emissions whatsoever, the agency's proposed FONSIs are unsupported under NEPA and the agency's reliance upon the USFS's FEIS does not seve to support its proposed action of leasing under the Fishlake National Forest.

2. The BLM Failed to Analyze the Costs of Reasonably Foreseeable Carbon Emissions Using Well-Accepted, Valid, Credible, GAO-Endorsed, Interagency Methods for Assessing Carbon Costs that are Supported by the White House

Compounding the failure of the BLM to make any effort to estimate the greenhouse gas emissions that would result from reasonably foreseeable oil and gas development is that the agency also rejected analyzing and assessing these emissions in the context of their costs to society. It is particularly disconcerting that the agency refused to analyze and assess costs using the social cost of carbon protocol, a valid, well-accepted, credible, and interagency endorsed method of calculating the costs of greenhouse gas emissions and understanding the potential significance of such emissions.

The social cost of carbon protocol for assessing climate impacts is a method for "estimat[ing] the economic damages associated with a small increase in carbon dioxide (CO2) emissions, conventionally one metric ton, in a given year [and] represents the value of damages avoided for a small emission reduction (i.e. the benefit of a CO2 reduction)." Exhibit 1, U.S. Environmental Protection Agency ("EPA"), "Fact Sheet: Social Cost of Carbon" (Nov. 2013) at 1, available online at http://www.epa.gov/climatechange/Downloads/EPAactivities/scc-fact-sheet.pdf (last accessed Sept., 2015). The protocol was developed by a working group consisting of several federal agencies, including the U.S. Department of Agriculture, EPA, CEQ, and others, with the primary aim of implementing Executive Order 12866, which requires that the costs of proposed regulations be taken into account.

In 2009, an Interagency Working Group was formed to develop the protocol and issued final estimates of carbon costs in 2010. *See* Exhibit 2, Interagency Working Group on Social Cost of Carbon, "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866" (Feb. 2010), available online at https://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf (last accessed Sept., 2015). These estimates were then revised in 2013 by the Interagency Working Group, which at the time consisted of 13 agencies. *See* Exhibit 3, Interagency Working Group on Social Cost of Carbon, "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866" (May 2013), available online at https://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf (last accessed Sept., 2015). This report and the social cost of carbon estimates were again revised in 2015. *See* Exhibit 4, Interagency Working Group on Social Cost of Carbon, "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866" (July 2015), available online at https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf (last accessed Sept. 15, 2015).

Depending on the discount rate and the year during which the carbon emissions are produced, the Interagency Working Group estimates the cost of carbon emissions, and therefore the benefits of reducing carbon emissions, to range from $11 to $220 per metric ton of carbon dioxide. *See* Chart Below. In its most recent update to the Social Cost of Carbon Technical Support Document, the White House's central estimate was reported to be $36 per metric ton. *See* Exhibit 5, White House, "Estimating the Benefits from Carbon Dioxide Emissions Reductions," website available at https://www.whitehouse.gov/blog/2015/07/02/estimating-benefits-carbon-dioxide-emissions-reductions (last accessed Sept. 15, 2015). In July 2014, the U.S. Government Accountability Office ("GAO") confirmed that the Interagency Working Group's estimates were based on
sound procedures and methodology. *See* Exhibit 6, GAO, "Regulatory Impact Analysis, Development of Social Cost of Carbon Estimates," GAO-14-663 (July 2014), available online at http://www.gao.gov/assets/670/665016.pdf (last accessed Sept. 15, 2015).

Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

Most recent social cost of carbon estimates presented by Interagency Working Group on Social Cost of Carbon. The 95th percentile value is meant to represent "higher-than-expected" impacts from climate change. *See* Exhibit 4 at 3.

Although often utilized in the context of agency rulemakings, the protocol has been recommended for use and has been used in project-level decisions. For instance, the EPA recommended that an EIS prepared by the U.S. Department of State for the proposed Keystone XL oil pipeline include "an estimate of the 'social cost of carbon' associated with potential increases of GHG emissions." Exhibit 7, EPA, Comments on Supplemental Draft EIS for the Keystone XL Oil Pipeline (June 6, 2011).

More importantly, the BLM has also utilized the social cost of carbon protocol in the context of oil and gas leasing. In recent Environmental Assessments for oil and gas leasing in Montana, the agency estimated "the annual SCC [social cost of carbon] associated with potential development on lease sale parcels." Exhibit 8, BLM, "Environmental Assessment for October 21, 2014 Oil and Gas lease Sale," DOI-BLM-MT-0010-2014-0011-EA (May 19, 2014) at 76, available online at
http://www.blm.gov/style/medialib/blm/mt/blm_programs/energy/oil_and_gas/leasing/lease_sales/2014/oct__21_2014/july23posting.Par.25990.File.dat/MCFO%20EA%20October%202014%20Sale_Post%20with%20Sale%20(1).pdf (Sept. 15, 2015). In conducting its analysis, the BLM used a "3 percent average discount rate and year 2020 values," presuming social costs of carbon

to be \$46 per metric ton. *Id*. Based on its estimate of greenhouse gas emissions, the agency estimated total carbon costs to be "\$38,499 (in 2011 dollars)." *Id*. In Idaho, the BLM also utilized the social cost of carbon protocol to analyze and assess the costs of oil and gas leasing. Using a 3% average discount rate and year 2020 values, the agency estimated the cost of carbon to be \$51 per ton of annual CO_2e increase. *See* Exhibit 9, BLM, "Little Willow Creek Protective Oil and Gas Leasing," EA No. DOI-BLM-ID-B010-2014-0036-EA (February 10, 2015) at 81, available online at https://www.blm.gov/epl-front-office/projects/nepa/39064/55133/59825/DOI-BLM-ID-B010-2014-0036-EA_UPDATED_02272015.pdf (last accessed Sept. 15, 2015). Based on this estimate, the agency estimated that the total carbon cost of developing 25 wells on five lease parcels to be \$3,689,442 annually. *Id*. at 83.

To be certain, the social cost of carbon protocol presents a conservative estimate of economic damages associated with the environmental impacts climate change. As the EPA has noted, the protocol "does not currently include all important [climate change] damages." Exhibit 1. As explained:

> The models used to develop [social cost of carbon] estimates do not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models naturally lags behind the most recent research.

Id. In fact, more recent studies have reported significantly higher carbon costs. For instance, a report published this month found that current estimates for the social cost of carbon should be increased six times for a mid-range value of \$220 per ton. *See* Exhibit 10, Moore, C.F. and B.D. Delvane, "Temperature impacts on economic growth warrant stringent mitigation policy," *Nature Climate Change* (January 12, 2015) at 2. In spite of uncertainty and likely underestimation of carbon costs, nevertheless, "the SCC is a useful measure to assess the benefits of CO2 reductions," and thus a useful measure to assess the costs of CO2 increases. Exhibit 1.

That the economic impacts of climate change, as reflected by an assessment of social cost of carbon, should be a significant consideration in agency decisionmaking, is emphasized by a recent White House report, which warned that delaying carbon reductions would yield significant economic costs. *See* Exhibit 11, Executive Office of the President of the United States, "The Cost of Delaying Action to Stem Climate Change" (July 2014), available online at https://www.whitehouse.gov/sites/default/files/docs/the_cost_of_delaying_action_to_stem_climate_change.pdf (last accessed Sept. 15, 2015). As the report states:

> [D]elaying action to limit the effects of climate change is costly. Because CO_2 accumulates in the atmosphere, delaying action increases CO_2 concentrations. Thus, if a policy delay leads to higher ultimate CO_2 concentrations, that delay produces persistent economic damages that arise from higher temperatures and higher CO_2 concentrations. Alternatively, if a delayed policy still aims to hit a given climate target, such as limiting CO_2 concentration to given level, then that delay means that the policy, when implemented, must be more stringent and thus more costly in subsequent years. In either case, delay is costly.

Exhibit 11 at 1.

The requirement to analyze the social cost of carbon is supported by the general requirements of NEPA, specifically supported in federal case law, and by Executive Order 13,514. As explained, NEPA requires agencies to analyze the consequences of proposed agency actions and consider include direct, indirect, and cumulative consequences. In terms of oil and gas leasing, an analysis of site-specific impacts must take place at the lease stage and cannot be deferred until after receiving applications to drill. *See New Mexico ex rel. Richardson v. Bureau of Land Management*, 565 F.3d 683, 717-18 (10th Cir. 2009); *Conner v. Burford,* 848 F.2d 1441 (9th Cir.1988); *Bob Marshall Alliance v. Hodel,* 852 F.2d 1223, 1227 (9th Cir.1988).

To this end, courts have ordered agencies to assess the social cost of carbon pollution, even before a federal protocol for such analysis was adopted. In 2008, the U.S. Court of Appeals for the Ninth Circuit ordered the National Highway Traffic Safety Administration to include a monetized benefit for carbon emissions reductions in an Environmental Assessment prepared under NEPA. *Center for Biological Diversity v. National Highway Traffic Safety Administration*, 538 F.3d 1172, 1203 (9th Cir. 2008). The Highway Traffic Safety Administration had proposed a rule setting corporate average fuel economy standards for light trucks. A number of states and public interest groups challenged the rule for, among other things, failing to monetize the benefits that would accrue from a decision that led to lower carbon dioxide emissions. The Administration had monetized the employment and sales impacts of the proposed action. *Id*. at 1199. The agency argued, however, that valuing the costs of carbon emissions was too uncertain. *Id*. at 1200. The court found this argument to be arbitrary and capricious. *Id*. The court noted that while estimates of the value of carbon emissions reductions occupied a wide range of values, the correct value was certainly not zero. *Id.* It further noted that other benefits, while also uncertain, were monetized by the agency. *Id*. at 1202.

More recently, a federal court has done likewise for a federally approved coal lease. That court began its analysis by recognizing that a monetary cost-benefit analysis is not universally required by NEPA. *See* High *Country Conservation Advocates v. U.S. Forest Service*, ---F. Supp.2d---, 2014 WL 2922751 (D. Colo. 2014), citing 40 C.F.R. § 1502.23. However, when an agency prepares a cost-benefit analysis, “it cannot be misleading.” *Id*. at 3 (citations omitted). In that case, the NEPA analysis included a quantification of benefits of the project. However, the quantification of the social cost of carbon, although included in earlier analyses, was omitted in the final NEPA analysis. *Id*. at p. 19. The agencies then relied on the stated benefits of the project to justify project approval. This, the court explained, was arbitrary and capricious. *Id*. Such approval was based on a NEPA analysis with misleading economic assumptions, an approach long disallowed by courts throughout the country. *Id*. at pp. 19-20.

In light of all this, it appears more than reasonable to have expected the BLM to take into account carbon costs as part of its NEPA analyses. The agency did not. Instead, the BLM rejected the notion that a social cost of carbon analysis was appropriate, implicitly concluding that there would be no cost associated with the proposed oil and gas leasing.

The BLM provides varied responses for not addressing the social cost of carbon. In the Vernal EA, the agency asserts that calculating social cost of carbon is "neither possible not required." Vernal EA at 101. However, calculating social cost of carbon is not only possible using basic multiplication skills, it is required to demonstrate the BLM took a hard look at the reasonably foreseeable impacts of the proposed leasing and provided sufficient justification for a FONSI.

In the Price EA, the agency asserts that calculating social cost of carbon is only appropriate during rulemaking. *See* Price EA at 60-61. However, there is nothing to suggest that calculating social cost of carbon is not an appropriate means of analyzing and assessing greenhouse gas emissions at the project level. Not only has the EPA endorsed its use at the project-level, but the federal court in *High Country Conservation Advocates* expressly found there was no support for the assertion that the social cost of carbon protocol was inaccurate or otherwise not useful at the project level. *See High Country Conservation Advocates* at p. 19.

In all three EAs, the BLM either states or strongly implies that it does not believe a social cost of carbon analysis would be "useful" or "appropriate." *See e.g.* Fillmore EA at 67. This is specious. The BLM has, in the context of other oil and gas lease sale environmental analyses, clearly acknowledged that social cost of carbon analyses are appropriate and useful. Furthermore, it is unclear how disclosing information that conveys the potential significance of the climate impacts of greenhouse gas emissions associated with oil and gas development would not be useful or appropriate. The EPA itself calls the social cost of carbon a "useful" tool and has supported it as an appropriate methodology for assessing climate impacts. The BLM cannot reject disclosing impacts because of make believe concerns over the methods available to assessment impacts. Here, unless the BLM has a better methodology for analyzing and assessing the climate impacts of greenhouse gas emissions from oil and gas development, the agency cannot summarily dismiss the social cost of carbon protocol as a means to disclose such information.

Finally, it is important to point out that in the USFS's FEIS, there is no mention of social cost of carbon. Thus, the BLM has no basis for concluding it has adequately analyzed and assessed the climate impacts of leasing beneath the Fishlake National Forest.

Sincerely,

Jeremy Nichols
Climate and Energy Program Director
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Exhibit 1

Fact Sheet: Social Cost of Carbon

Background

EPA and other federal agencies use the social cost of carbon (SCC) to estimate the climate benefits of rulemakings. The SCC is an estimate of the economic damages associated with a small increase in carbon dioxide (CO_2) emissions, conventionally one metric ton, in a given year. This dollar figure also represents the value of damages avoided for a small emission reduction (i.e. the benefit of a CO_2 reduction).

The SCC is meant to be a comprehensive estimate of climate change damages and includes, among other things, changes in net agricultural productivity, human health, and property damages from increased flood risk. However, it does not currently include all important damages. As noted by the IPCC Fourth Assessment Report, it is "very likely that [the SCC] underestimates" the damages. The models used to develop SCC estimates do not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models naturally lags behind the most recent research. Nonetheless, the SCC is a useful measure to assess the benefits of CO_2 reductions.

The timing of the emission release (or reduction) is key to estimation of the SCC, which is based on a present value calculation. The integrated assessment models first estimate damages occurring after the emission release and into the future, often as far out as the year 2300. The models then discount the value of those damages over the entire time span back to present value to arrive at the SCC. For example, the SCC for the year 2020 represents the present value of climate change damages that occur between the years 2020 and 2300 (assuming 2300 is the final year of the model run); these damages are associated with the release of one ton of carbon dioxide in the year 2020. The SCC will vary based on the year of emissions for multiple reasons. In model runs where the last year is fixed (e.g., 2300), the time span covered in the present value calculation will be smaller for later emission years—the SCC in 2050 will include 40 fewer years of damages than the 2010 SCC estimates. This modeling choice—selection of a fixed end year—will place downward pressure on the SCC estimates for later emission years. Alternatively, the SCC should increase over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater levels of climatic change.

One of the most important factors influencing SCC estimates is the discount rate. A large portion of climate change damages are expected to occur many decades into the future and the present value of those damages (the value at present of damages that occur in the future) is highly dependent on the discount rate. To understand the effect that the discount rate has on present value calculations, consider the following example. Let's say that you have been promised that in 50 years you will receive $1 billion. In "present value" terms, that sum of money is worth $291 million today with a 2.5 percent discount rate. In other words, if you invested $291 million today at 2.5 percent and let it compound, it would be worth $1 billion in 50 years. A higher discount rate of 3 percent would decrease the value today to $228 million, and the value would be even lower—$87 million-- with a 5 percent rate. This effect is even more pronounced when looking at the present value of damages further out in time. The value of $1 billion in 100 years is $85 million, $52 million, and $8 million, for discount rates of 2.5 percent, 3 percent, and 5 percent, respectively. Similarly, the selection of a 2.5 percent discount rate would result in higher SCC estimates than would the selection of 3 and 5 percent rates, all else equal.

Process Used to Develop the SCC

An interagency working group was convened by the Council of Economic Advisers and the Office of Management and Budget in 2009-2010 to design an SCC modeling exercise and develop estimates for use in rulemakings. The interagency group was comprised of scientific and economic experts from the White House and federal agencies, including: Council on Environmental Quality, National Economic Council, Office of Energy and Climate Change, and Office of Science and Technology Policy, EPA, and the Departments of Agriculture, Commerce, Energy, Transportation, and Treasury. The interagency group identified a variety of assumptions, which EPA then used to estimate the SCC using three integrated assessment models, which each combine climate processes, economic growth, and interactions between the two in a single modeling framework.

SCC Values

The 2009-2010 interagency group developed a set of four SCC estimates for use in regulatory analyses. The first three values are based on the average SCC from three integrated assessment models, at discount rates of 5, 3, and 2.5 percent. SCC estimates based on several discount rates are included because the literature shows that the SCC is highly sensitive to the discount rate and because no consensus exists on the appropriate rate to use for analyses spanning multiple generations. The fourth value is the 95th percentile of the SCC from all three models at a 3 percent discount rate, and is intended to represent the potential for higher-than-average damages. See the SCC Technical Support Document (PDF, 51pp, 848K) for a complete discussion about the methodology and resulting estimates.

The interagency group recently updated these estimates, using new versions of each integrated assessment model and published them in May 2013. The 2013 interagency process did not revisit the 2009-2010 interagency modeling decisions (e.g., with regard to the discount rate, reference case socioeconomic and emission scenarios or equilibrium climate sensitivity). Rather, improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves and as used in the peer-reviewed literature.

The SCC estimates using the updated versions of the models are higher than those developed in the 2009-2010 modeling exercise. The four 2020 SCC estimates reported in the 2010 interagency group were $7, $28, $44 and $86 per metric ton (2011$). The corresponding four updated SCC estimates for 2020 are $13, $46, $68, and $137 per metric ton (2011$). The May 2013 SCC Technical Support Document (PDF, 22pp, 780K) provides a detailed discussion of the model updates relevant to these estimates.

The table below summarizes the four SCC estimates in certain years.

Social Cost of CO_2, 2015-2050 [a] (in 2011 Dollars)

Year	Discount Rate and Statistic			
	5% Average	3% Average	2.5% Average	3% 95th percentile
2015	$12	$39	$61	$116
2020	$13	$46	$68	$137
2025	$15	$50	$74	$153
2030	$17	$55	$80	$170
2035	$20	$60	$85	$187
2040	$22	$65	$92	$204
2045	$26	$70	$98	$220
2050	$28	$76	$104	$235

[a] The SCC values are dollar-year and emissions-year specific.

Examples of SCC Applications to Rulemakings

EPA has used the SCC to analyze the carbon dioxide impacts of various rulemakings since the interagency group first published estimates in 2010. Examples of these rulemakings include:

- The Joint EPA/Department of Transportation Rulemaking to establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards (2012-2016)
- Amendments to the National Emission Standards for Hazardous Air Pollutants and New Source Performance Standards (NSPS) for the Portland Cement Manufacturing Industry
- Regulatory Impact Results for the Reconsideration Proposal for National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters at Major Sources
- Proposed National Emission Standards for Hazardous Air Pollutants (NESHAP) for Mercury Emissions from Mercury Cell Chlor Alkali Plants
- Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units Standards
- Final Mercury and Air Toxics Standards
- Joint EPA/Department of Transportation Rulemaking to establish Medium- and Heavy - Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards
- Proposed Carbon Pollution Standard for Future Power Plants
- Joint EPA/Department of Transportation Rulemaking to establish 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards

Limitations of SCC

The interagency group noted a number of limitations to the SCC analysis, including the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. Additional details are discussed in the 2010[1] and 2013[2] SCC Technical Support Documents.

Next Steps

The U.S. government committed to updating the current estimates as the science and economic understanding of climate change and its impacts on society improves over time. For example, EPA and Department of Energy also hosted a series of workshops to inform SCC development. The first workshop focused on conceptual and methodological issues related to integrated assessment modeling and valuing climate change impacts, along with methods of incorporating these estimates into policy analysis. The second workshop reviewed research on estimating impacts and valuing damages on a sectoral basis. Papers based on the presentations from both workshops were published in a special issue of Climatic Change (April 2013). In addition, EPA funded a workshop on discounting in September 2011 that invited world-recognized experts to discuss how the benefits and costs of regulations should be discounted for projects with long horizons. In particular, it explored what principles should be used to determine the rates at which to discount the costs and benefits of regulatory programs when costs and benefits extend over very long horizons.

EPA and other agencies continue to engage in research on modeling and valuation of climate impacts to improve these estimates.

[1] See http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf
[2] See http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf

Exhibit 2

Technical Support Document: -
Social Cost of Carbon for Regulatory Impact Analysis -
Under Executive Order 12866 -

Interagency Working Group on Social Cost of Carbon, United States Government

With participation by

Council of Economic Advisers
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Energy
Department of Transportation
Environmental Protection Agency
National Economic Council
Office of Energy and Climate Change
Office of Management and Budget
Office of Science and Technology Policy
Department of the Treasury

February 2010

Executive Summary

Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the "social cost of carbon" (SCC) estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that have small, or "marginal," impacts on cumulative global emissions. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.

This document presents a summary of the interagency process that developed these SCC estimates. Technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

The interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC from three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth value, which represents the 95th percentile SCC estimate across all three models at a 3 percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

Social Cost of CO_2, 2010 – 2050 (in 2007 dollars)

Discount Rate Year	5% Avg	3% Avg	2.5% Avg	3% 95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

I. Monetizing Carbon Dioxide Emissions

The "social cost of carbon" (SCC) is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. We report estimates of the social cost of carbon in dollars per metric ton of carbon dioxide throughout this document.[1]

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of serious challenges. A recent report from the National Academies of Science (NRC 2009) points out that any assessment will suffer from uncertainty, speculation, and lack of information about (1) future emissions of greenhouse gases, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

Despite the serious limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing carbon dioxide emissions. Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the SCC estimates presented here is to make it possible for agencies to incorporate the social benefits from reducing carbon dioxide emissions into cost-benefit analyses of regulatory actions that have small, or "marginal," impacts on cumulative global emissions. Most federal regulatory actions can be expected to have marginal impacts on global emissions.

For such policies, the benefits from reduced (or costs from increased) emissions in any future year can be estimated by multiplying the change in emissions in that year by the SCC value appropriate for that year. The net present value of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across all affected years. This approach assumes that the marginal damages from increased emissions are constant for small departures from the baseline emissions path, an approximation that is reasonable for policies that have effects on emissions that are small relative to cumulative global carbon dioxide emissions. For policies that have a large (non-marginal) impact on global cumulative emissions, there is a separate question of whether the SCC is an appropriate tool for calculating the benefits of reduced emissions; we do not attempt to answer that question here.

An interagency group convened on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key inputs and assumptions in order to generate SCC estimates. Agencies that actively participated in the interagency process include the Environmental Protection

[1] In this document, we present all values of the SCC as the cost per metric ton of CO_2 emissions. Alternatively, one could report the SCC as the cost per metric ton of carbon emissions. The multiplier for translating between mass of CO_2 and the mass of carbon is 3.67 (the molecular weight of CO_2 divided by the molecular weight of carbon = 44/12 = 3.67).

Agency, and the Departments of Agriculture, Commerce, Energy, Transportation, and Treasury. This process was convened by the Council of Economic Advisers and the Office of Management and Budget, with active participation and regular input from the Council on Environmental Quality, National Economic Council, Office of Energy and Climate Change, and Office of Science and Technology Policy. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions that are grounded in the existing literature. In this way, key uncertainties and model differences can more transparently and consistently inform the range of SCC estimates used in the rulemaking process.

The interagency group selected four SCC estimates for use in regulatory analyses. For 2010, these estimates are $5, $21, $35, and $65 (in 2007 dollars). The first three estimates are based on the average SCC across models and socio-economic and emissions scenarios at the 5, 3, and 2.5 percent discount rates, respectively. The fourth value is included to represent the higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95^{th} percentile at a 3 percent discount rate. The central value is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range. These SCC estimates also grow over time. For instance, the central value increases to $24 per ton of CO_2 in 2015 and $26 per ton of CO_2 in 2020. See Appendix A for the full range of annual SCC estimates from 2010 to 2050.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. Specifically, we have set a preliminary goal of revisiting the SCC values within two years or at such time as substantially updated models become available, and to continue to support research in this area. In the meantime, we will continue to explore the issues raised in this document and consider public comments as part of the ongoing interagency process.

II. Social Cost of Carbon Values Used in Past Regulatory Analyses

To date, economic analyses for Federal regulations have used a wide range of values to estimate the benefits associated with reducing carbon dioxide emissions. In the final model year 2011 CAFE rule, the Department of Transportation (DOT) used both a "domestic" SCC value of $2 per ton of CO_2 and a "global" SCC value of $33 per ton of CO_2 for 2007 emission reductions (in 2007 dollars), increasing both values at 2.4 percent per year. It also included a sensitivity analysis at $80 per ton of CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in carbon dioxide emissions, while a global SCC value is meant to reflect the value of damages worldwide.

A 2008 regulation proposed by DOT assumed a domestic SCC value of $7 per ton CO_2 (in 2006 dollars) for 2011 emission reductions (with a range of $0-$14 for sensitivity analysis), also increasing at 2.4 percent per year. A regulation finalized by DOE in October of 2008 used a domestic SCC range of $0 to $20 per ton CO_2 for 2007 emission reductions (in 2007 dollars). In addition, EPA's 2008 Advance Notice of Proposed Rulemaking for Greenhouse Gases identified what it described as "very preliminary" SCC estimates subject to revision. EPA's global mean values were $68 and $40 per ton CO_2 for discount rates of approximately 2 percent and 3 percent, respectively (in 2006 dollars for 2007 emissions).

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted.

The outcome of the preliminary assessment by the interagency group was a set of five interim values: global SCC estimates for 2007 (in 2006 dollars) of $55, $33, $19, $10, and $5 per ton of CO_2. The $33 and $5 values represented model-weighted means of the published estimates produced from the most recently available versions of three integrated assessment models—DICE, PAGE, and FUND—at approximately 3 and 5 percent discount rates. The $55 and $10 values were derived by adjusting the published estimates for uncertainty in the discount rate (using factors developed by Newell and Pizer (2003)) at 3 and 5 percent discount rates, respectively. The $19 value was chosen as a central value between the $5 and $33 per ton estimates. All of these values were assumed to increase at 3 percent annually to represent growth in incremental damages over time as the magnitude of climate change increases.

These interim values represent the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules and were offered for public comment in connection with proposed rules, including the joint EPA-DOT fuel economy and CO_2 tailpipe emission proposed rules.

III. Approach and Key Assumptions

Since the release of the interim values, interagency group has reconvened on a regular basis to generate improved SCC estimates. Specifically, the group has considered public comments and further explored the technical literature in relevant fields. This section details the several choices and assumptions that underlie the resulting estimates of the SCC.

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable since they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Academy of Science (2009) points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. Throughout this document, we highlight a number of concerns and problems that should be addressed by the research community, including research programs housed in many of the agencies participating in the interagency process to estimate the SCC.

The U.S. Government will periodically review and reconsider estimates of the SCC used for cost-benefit analyses to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling. In this context, statements recognizing the limitations of the analysis and calling for further research take on exceptional significance. The interagency group offers the new SCC values with all due humility about the uncertainties embedded in them and with a sincere promise to continue work to improve them.

A. Integrated Assessment Models

We rely on three integrated assessment models (IAMs) commonly used to estimate the SCC: the FUND, DICE, and PAGE models.[2] These models are frequently cited in the peer-reviewed literature and used in the IPCC assessment. Each model is given equal weight in the SCC values developed through this process, bearing in mind their different limitations (discussed below).

These models are useful because they combine climate processes, economic growth, and feedbacks between the climate and the global economy into a single modeling framework. At the same time, they gain this advantage at the expense of a more detailed representation of the underlying climatic and economic systems. DICE, PAGE, and FUND all take stylized, reduced-form approaches (see NRC 2009 for a more detailed discussion; see Nordhaus 2008 on the possible advantages of this approach). Other IAMs may better reflect the complexity of the science in their modeling frameworks but do not link physical impacts to economic damages. There is currently a limited amount of research linking climate impacts to economic damages, which makes this exercise even more difficult. Underlying the three IAMs selected for this exercise are a number of simplifying assumptions and judgments reflecting the various modelers' best attempts to synthesize the available scientific and economic research characterizing these relationships.

The three IAMs translate emissions into changes in atmospheric greenhouse concentrations, atmospheric concentrations into changes in temperature, and changes in temperature into economic damages. The emissions projections used in the models are based on specified socio-economic (GDP and population) pathways. These emissions are translated into concentrations using the carbon cycle built into each model, and concentrations are translated into warming based on each model's simplified representation of the climate and a key parameter, climate sensitivity. Each model uses a different approach to translate warming into damages. Finally, transforming the stream of economic damages over time into a single value requires judgments about how to discount them.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. In PAGE, for example, the consumption-equivalent damages in each period are calculated as a fraction of GDP, depending on the temperature in that period relative to the pre-industrial average temperature in each region. In FUND, damages in each period also depend on the rate of temperature change from the prior period. In DICE, temperature affects both consumption and investment. We describe each model in greater detail here. In a later section, we discuss key gaps in how the models account for various scientific and economic processes (e.g. the probability of catastrophe, and the ability to adapt to climate change and the physical changes it causes).

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[2] The DICE (Dynamic Integrated Climate and Economy) model by William Nordhaus evolved from a series of energy models and was first presented in 1990 (Nordhaus and Boyer 2000, Nordhaus 2008). The PAGE (Policy Analysis of the Greenhouse Effect) model was developed by Chris Hope in 1991 for use by European decision-makers in assessing the marginal impact of carbon emissions (Hope 2006, Hope 2008). The FUND (Climate Framework for Uncertainty, Negotiation, and Distribution) model, developed by Richard Tol in the early 1990s, originally to study international capital transfers in climate policy. is now widely used to study climate impacts (e.g., Tol 2002a, Tol 2002b, Anthoff et al. 2009, Tol 2009).

The parameters and assumptions embedded in the three models vary widely. A key objective of the interagency process was to enable a consistent exploration of the three models while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers' best estimates and judgments. In DICE, these parameters are handled deterministically and represented by fixed constants; in PAGE, most parameters are represented by probability distributions. FUND was also run in a mode in which parameters were treated probabilistically.

The sensitivity of the results to other aspects of the models (e.g. the carbon cycle or damage function) is also important to explore in the context of future revisions to the SCC but has not been incorporated into these estimates. Areas for future research are highlighted at the end of this document.

The DICE Model

The DICE model is an optimal growth model based on a global production function with an extra stock variable (atmospheric carbon dioxide concentrations). Emission reductions are treated as analogous to investment in "natural capital." By investing in natural capital today through reductions in emissions—implying reduced consumption—harmful effects of climate change can be avoided and future consumption thereby increased.

For purposes of estimating the SCC, carbon dioxide emissions are a function of global GDP and the carbon intensity of economic output, with the latter declining over time due to technological progress. The DICE damage function links global average temperature to the overall impact on the world economy. It varies quadratically with temperature change to capture the more rapid increase in damages expected to occur under more extreme climate change, and is calibrated to include the effects of warming on the production of market and nonmarket goods and services. It incorporates impacts on agriculture, coastal areas (due to sea level rise), "other vulnerable market sectors" (based primarily on changes in energy use), human health (based on climate-related diseases, such as malaria and dengue fever, and pollution), non-market amenities (based on outdoor recreation), and human settlements and ecosystems. The DICE damage function also includes the expected value of damages associated with low probability, high impact "catastrophic" climate change. This last component is calibrated based on a survey of experts (Nordhaus 1994). The expected value of these impacts is then added to the other market and non-market impacts mentioned above.

No structural components of the DICE model represent adaptation explicitly, though it is included implicitly through the choice of studies used to calibrate the aggregate damage function. For example, its agricultural impact estimates assume that farmers can adjust land use decisions in response to changing climate conditions, and its health impact estimates assume improvements in healthcare over time. In addition, the small impacts on forestry, water systems, construction, fisheries, and outdoor recreation imply optimistic and costless adaptation in these sectors (Nordhaus and Boyer, 2000; Warren et al., 2006). Costs of resettlement due to sea level rise are incorporated into damage estimates, but their magnitude is not clearly reported. Mastrandrea's (2009) review concludes that "in general, DICE assumes very effective adaptation, and largely ignores adaptation costs."

Note that the damage function in DICE has a somewhat different meaning from the damage functions in FUND and PAGE. Because GDP is endogenous in DICE and because damages in a given year reduce investment in that year, damages propagate forward in time and reduce GDP in future years. In contrast, GDP is exogenous in FUND and PAGE, so damages in any given year do not propagate forward.[3]

The PAGE Model

PAGE2002 (version 1.4epm) treats GDP growth as exogenous. It divides impacts into economic, non-economic, and catastrophic categories and calculates these impacts separately for eight geographic regions. Damages in each region are expressed as a fraction of output, where the fraction lost depends on the temperature change in each region. Damages are expressed as power functions of temperature change. The exponents of the damage function are the same in all regions but are treated as uncertain, with values ranging from 1 to 3 (instead of being fixed at 2 as in DICE).

PAGE2002 includes the consequences of catastrophic events in a separate damage sub-function. Unlike DICE, PAGE2002 models these events probabilistically. The probability of a "discontinuity" (i.e., a catastrophic event) is assumed to increase with temperature above a specified threshold. The threshold temperature, the rate at which the probability of experiencing a discontinuity increases above the threshold, and the magnitude of the resulting catastrophe are all modeled probabilistically.

Adaptation is explicitly included in PAGE. Impacts are assumed to occur for temperature increases above some tolerable level (2°C for developed countries and 0°C for developing countries for economic impacts, and 0°C for all regions for non-economic impacts), but adaptation is assumed to reduce these impacts. Default values in PAGE2002 assume that the developed countries can ultimately eliminate up to 90 percent of all economic impacts beyond the tolerable 2°C increase and that developing countries can eventually eliminate 50 percent of their economic impacts. All regions are assumed to be able to mitigate 25 percent of the non-economic impacts through adaptation (Hope 2006).

The FUND Model

Like PAGE, the FUND model treats GDP growth as exogenous. It includes separately calibrated damage functions for eight market and nonmarket sectors: agriculture, forestry, water, energy (based on heating and cooling demand), sea level rise (based on the value of land lost and the cost of protection),

[3] Using the default assumptions in DICE 2007, this effect generates an approximately 25 percent increase in the SCC relative to damages calculated by fixing GDP. In DICE2007, the time path of GDP is endogenous. Specifically, the path of GDP depends on the rate of saving and level of abatement in each period chosen by the optimizing representative agent in the model. We made two modifications to DICE to make it consistent with EMF GDP trajectories (see next section): we assumed a fixed rate of savings of 20%, and we re-calibrated the exogenous path of total factor productivity so that DICE would produce GDP projections in the absence of warming that exactly matched the EMF scenarios.

ecosystems, human health (diarrhea, vector-borne diseases, and cardiovascular and respiratory mortality), and extreme weather. Each impact sector has a different functional form, and is calculated separately for sixteen geographic regions. In some impact sectors, the fraction of output lost or gained due to climate change depends not only on the absolute temperature change but also on the rate of temperature change and level of regional income.[4] In the forestry and agricultural sectors, economic damages also depend on CO_2 concentrations.

Tol (2009) discusses impacts not included in FUND, noting that many are likely to have a relatively small effect on damage estimates (both positive and negative). However, he characterizes several omitted impacts as "big unknowns": for instance, extreme climate scenarios, biodiversity loss, and effects on economic development and political violence. With regard to potentially catastrophic events, he notes, "Exactly what would cause these sorts of changes or what effects they would have are not well-understood, although the chance of any one of them happening seems low. But they do have the potential to happen relatively quickly, and if they did, the costs could be substantial. Only a few studies of climate change have examined these issues."

Adaptation is included both implicitly and explicitly in FUND. Explicit adaptation is seen in the agriculture and sea level rise sectors. Implicit adaptation is included in sectors such as energy and human health, where wealthier populations are assumed to be less vulnerable to climate impacts. For example, the damages to agriculture are the sum of three effects: (1) those due to the rate of temperature change (damages are always positive); (2) those due to the level of temperature change (damages can be positive or negative depending on region and temperature); and (3) those from CO_2 fertilization (damages are generally negative but diminishing to zero).

Adaptation is incorporated into FUND by allowing damages to be smaller if climate change happens more slowly. The combined effect of CO_2 fertilization in the agricultural sector, positive impacts to some regions from higher temperatures, and sufficiently slow increases in temperature across these sectors can result in negative economic damages from climate change.

Damage Functions

To generate revised SCC values, we rely on the IAM modelers' current best judgments of how to represent the effects of climate change (represented by the increase in global-average surface temperature) on the consumption-equivalent value of both market and non-market goods (represented as a fraction of global GDP). We recognize that these representations are incomplete and highly uncertain. But given the paucity of data linking the physical impacts to economic damages, we were not able to identify a better way to translate changes in climate into net economic damages, short of launching our own research program.

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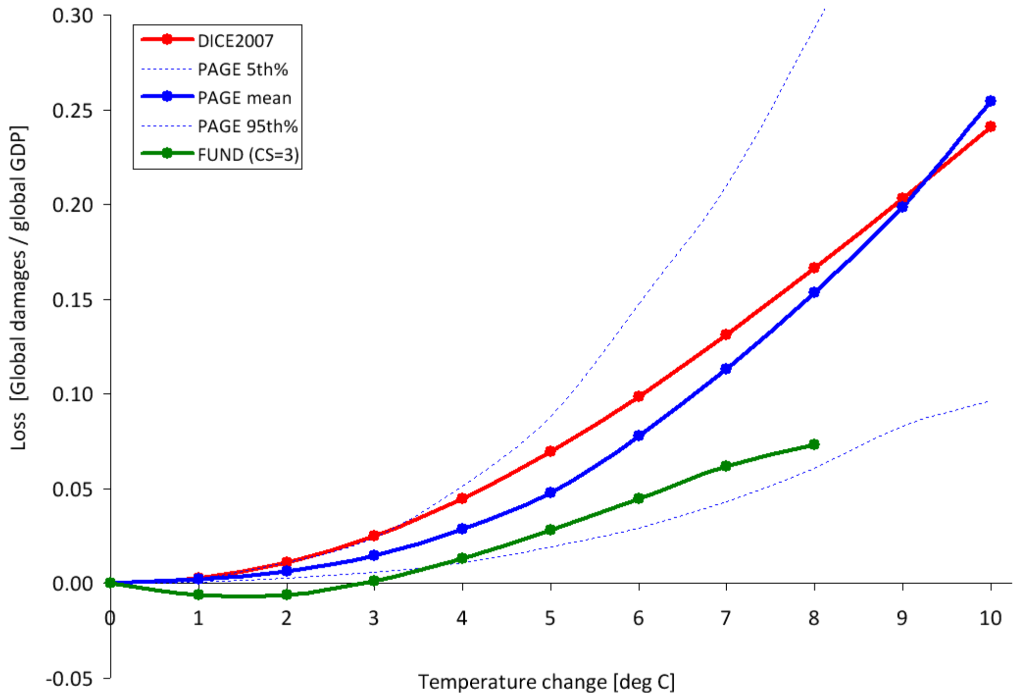
[4] In the deterministic version of FUND, the majority of damages are attributable to increased air conditioning demand, while reduced cold stress in Europe, North America, and Central and East Asia results in health benefits in those regions at low to moderate levels of warming (Warren et al., 2006).

Figure 1A: Annual Consumption Loss as a Fraction of Global GDP in 2100 Due to an Increase in Annual - Global Temperature in the DICE, FUND, and PAGE models[5]



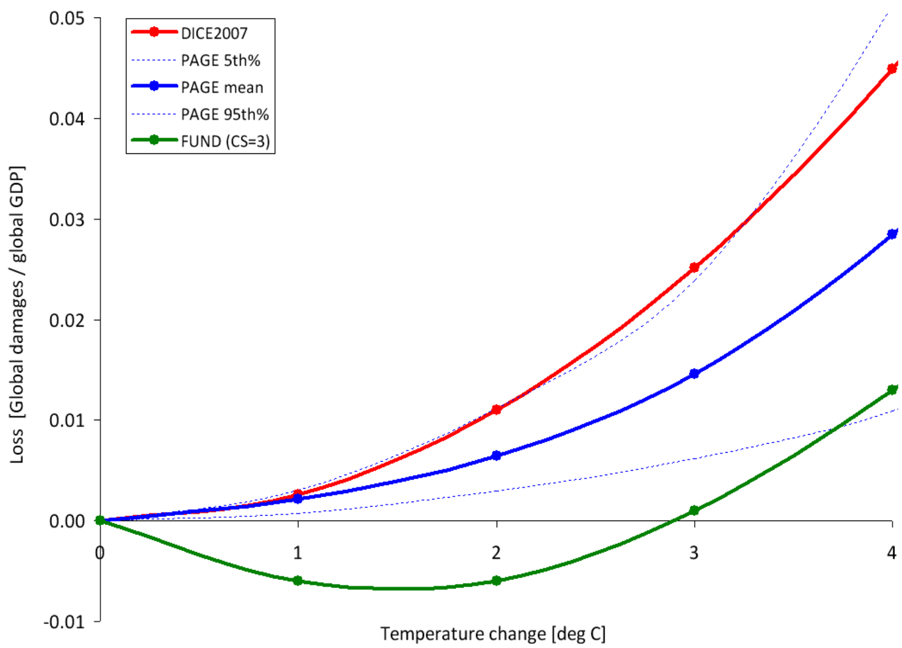
The damage functions for the three IAMs are presented in Figures 1A and 1B, using the modeler's default scenarios and mean input assumptions. There are significant differences between the three models both at lower (figure 1B) and higher (figure 1A) increases in global-average temperature.

The lack of agreement among the models at lower temperature increases is underscored by the fact that the damages from FUND are well below the 5th percentile estimated by PAGE, while the damages estimated by DICE are roughly equal to the 95th percentile estimated by PAGE. This is significant because at higher discount rates we expect that a greater proportion of the SCC value is due to damages in years with lower temperature increases. For example, when the discount rate is 2.5 percent, about 45 percent of the 2010 SCC value in DICE is due to damages that occur in years when the temperature is less than or equal to 3 °C. This increases to approximately 55 percent and 80 percent at discount rates of 3 and 5 percent, respectively.

These differences underscore the need for a thorough review of damage functions—in particular, how the models incorporate adaptation, technological change, and catastrophic damages. Gaps in the literature make modifying these aspects of the models challenging, which highlights the need for additional research. As knowledge improves, the Federal government is committed to exploring how these (and other) models can be modified to incorporate more accurate estimates of damages.

[5] The x-axis represents increases in annual, rather than equilibrium, temperature, while the y-axis represents the annual stream of benefits as a share of global GDP. Each specific combination of climate sensitivity, socio-economic, and emissions parameters will produce a different realization of damages for each IAM. The damage functions represented in Figures 1A and 1B are the outcome of default assumptions. For instance, under alternate assumptions, the damages from FUND may cross from negative to positive at less than or greater than 3 °C.

Figure 1B: Annual Consumption Loss for Lower Temperature Changes in DICE, FUND, and PAGE -



B. Global versus Domestic Measures of SCC

Because of the distinctive nature of the climate change problem, we center our current attention on a global measure of SCC. This approach is the same as that taken for the interim values, but it otherwise represents a departure from past practices, which tended to put greater emphasis on a domestic measure of SCC (limited to impacts of climate change experienced within U.S. borders). As a matter of law, consideration of both global and domestic values is generally permissible; the relevant statutory provisions are usually ambiguous and allow selection of either measure.[6]

Global SCC

Under current OMB guidance contained in Circular A-4, analysis of economically significant proposed and final regulations from the domestic perspective is required, while analysis from the international perspective is optional. However, the climate change problem is highly unusual in at least two respects. First, it involves a global externality: emissions of most greenhouse gases contribute to damages around the world even when they are emitted in the United States. Consequently, to address the global nature of the problem, the SCC must incorporate the full (global) damages caused by GHG emissions. Second, climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change. Other countries would also need to take action to reduce emissions if

[6] It is true that federal statutes are presumed not to have extraterritorial effect, in part to ensure that the laws of the United States respect the interests of foreign sovereigns. But use of a global measure for the SCC does not give extraterritorial effect to federal law and hence does not intrude on such interests.

significant changes in the global climate are to be avoided. Emphasizing the need for a global solution to a global problem, the United States has been actively involved in seeking international agreements to reduce emissions and in encouraging other nations, including emerging major economies, to take significant steps to reduce emissions. When these considerations are taken as a whole, the interagency group concluded that a global measure of the benefits from reducing U.S. emissions is preferable.

When quantifying the damages associated with a change in emissions, a number of analysts (e.g., Anthoff, et al. 2009a) employ "equity weighting" to aggregate changes in consumption across regions. This weighting takes into account the relative reductions in wealth in different regions of the world. A per-capita loss of $500 in GDP, for instance, is weighted more heavily in a country with a per-capita GDP of $2,000 than in one with a per-capita GDP of $40,000. The main argument for this approach is that a loss of $500 in a poor country causes a greater reduction in utility or welfare than does the same loss in a wealthy nation. Notwithstanding the theoretical claims on behalf of equity weighting, the interagency group concluded that this approach would not be appropriate for estimating a SCC value used in domestic regulatory analysis.[7] For this reason, the group concluded that using the global (rather than domestic) value, without equity weighting, is the appropriate approach.

Domestic SCC

As an empirical matter, the development of a domestic SCC is greatly complicated by the relatively few region- or country-specific estimates of the SCC in the literature. One potential source of estimates comes from the FUND model. The resulting estimates suggest that the ratio of domestic to global benefits of emission reductions varies with key parameter assumptions. For example, with a 2.5 or 3 percent discount rate, the U.S. benefit is about 7-10 percent of the global benefit, on average, across the scenarios analyzed. Alternatively, if the fraction of GDP lost due to climate change is assumed to be similar across countries, the domestic benefit would be proportional to the U.S. share of global GDP, which is currently about 23 percent.[8]

On the basis of this evidence, the interagency workgroup determined that a range of values from 7 to 23 percent should be used to adjust the global SCC to calculate domestic effects. Reported domestic values should use this range. It is recognized that these values are approximate, provisional, and highly speculative. There is no a priori reason why domestic benefits should be a constant fraction of net global damages over time. Further, FUND does not account for how damages in other regions could affect the United States (e.g., global migration, economic and political destabilization). If more accurate methods for calculating the domestic SCC become available, the Federal government will examine these to determine whether to update its approach.

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[7] It is plausible that a loss of $X inflicts more serious harm on a poor nation than on a wealthy one, but development of the appropriate "equity weight" is challenging. Emissions reductions also impose costs, and hence a full account would have to consider that a given cost of emissions reductions imposes a greater utility or welfare loss on a poor nation than on a wealthy one. Even if equity weighting—for both the costs and benefits of emissions reductions—is appropriate when considering the utility or welfare effects of international action, the interagency group concluded that it should not be used in developing an SCC for use in regulatory policy at this time.

[8] Based on 2008 GDP (in current US dollars) from the *World Bank Development Indicators Report*.

C. Valuing Non-CO_2 Emissions

While CO_2 is the most prevalent greenhouse gas emitted into the atmosphere, the U.S. included five other greenhouse gases in its recent endangerment finding: methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The climate impact of these gases is commonly discussed in terms of their 100-year global warming potential (GWP). GWP measures the ability of different gases to trap heat in the atmosphere (i.e., radiative forcing per unit of mass) over a particular timeframe relative to CO_2. However, because these gases differ in both radiative forcing and atmospheric lifetimes, their relative damages are not constant over time. For example, because methane has a short lifetime, its impacts occur primarily in the near term and thus are not discounted as heavily as those caused by longer-lived gases. Impacts other than temperature change also vary across gases in ways that are not captured by GWP. For instance, CO_2 emissions, unlike methane and other greenhouse gases, contribute to ocean acidification. Likewise, damages from methane emissions are not offset by the positive effect of CO_2 fertilization. Thus, transforming gases into CO_2-equivalents using GWP, and then multiplying the carbon-equivalents by the SCC, would not result in accurate estimates of the social costs of non-CO_2 gases.

In light of these limitations, and the significant contributions of non-CO_2 emissions to climate change, further research is required to link non-CO_2 emissions to economic impacts. Such work would feed into efforts to develop a monetized value of reductions in non-CO_2 greenhouse gas emissions. As part of ongoing work to further improve the SCC estimates, the interagency group hopes to develop methods to value these other greenhouse gases. The goal is to develop these estimates by the time we issue revised SCC estimates for carbon dioxide emissions.

D. Equilibrium Climate Sensitivity

Equilibrium climate sensitivity (ECS) is a key input parameter for the DICE, PAGE, and FUND models.[9] It is defined as the long-term increase in the annual global-average surface temperature from a doubling of atmospheric CO_2 concentration relative to pre-industrial levels (or stabilization at a concentration of approximately 550 parts per million (ppm)). Uncertainties in this important parameter have received substantial attention in the peer-reviewed literature.

The most authoritative statement about equilibrium climate sensitivity appears in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC):

> *Basing our assessment on a combination of several independent lines of evidence…including observed climate change and the strength of known feedbacks simulated in [global climate models], we conclude that the global mean equilibrium warming for doubling CO_2, or 'equilibrium climate*

[9] The equilibrium climate sensitivity includes the response of the climate system to increased greenhouse gas concentrations over the short to medium term (up to 100-200 years), but it does not include long-term feedback effects due to possible large-scale changes in ice sheets or the biosphere, which occur on a time scale of many hundreds to thousands of years (e.g. Hansen et al. 2007).

sensitivity', is likely to lie in the range 2 °C to 4.5 °C, with a most likely value of about 3 °C. Equilibrium climate sensitivity is very likely larger than 1.5 °C.[10]

For fundamental physical reasons as well as data limitations, values substantially higher than 4.5 °C still cannot be excluded, but agreement with observations and proxy data is generally worse for those high values than for values in the 2 °C to 4.5 °C range. (Meehl et al., 2007, p 799)

After consulting with several lead authors of this chapter of the IPCC report, the interagency workgroup selected four candidate probability distributions and calibrated them to be consistent with the above statement: Roe and Baker (2007), log-normal, gamma, and Weibull. Table 1 included below gives summary statistics for the four calibrated distributions.

Table 1: Summary Statistics for Four Calibrated Climate Sensitivity Distributions

	Roe & Baker	Log-normal	Gamma	Weibull
Pr(ECS < 1.5°C)	0.013	0.050	0.070	0.102
Pr(2°C < ECS < 4.5°C)	0.667	0.667	0.667	0.667
5th percentile	1.72	1.49	1.37	1.13
10th percentile	1.91	1.74	1.65	1.48
Mode	2.34	2.52	2.65	2.90
Median (50th percentile)	3.00	3.00	3.00	3.00
Mean	3.50	3.28	3.19	3.07
90th percentile	5.86	5.14	4.93	4.69
95th percentile	7.14	5.97	5.59	5.17

Each distribution was calibrated by applying three constraints from the IPCC:

(1) a median equal to 3°C, to reflect the judgment of "a most likely value of about 3 °C";[11]
(2) two-thirds probability that the equilibrium climate sensitivity lies between 2 and 4.5 °C; and
(3) zero probability that it is less than 0°C or greater than 10°C (see Hegerl et al. 2006, p. 721).

We selected the calibrated Roe and Baker distribution from the four candidates for two reasons. First, the Roe and Baker distribution is the only one of the four that is based on a theoretical understanding of the response of the climate system to increased greenhouse gas concentrations (Roe and Baker 2007,

[10] This is in accord with the judgment that it "is likely to lie in the range 2 °C to 4.5 °C" and the IPCC definition of "likely" as greater than 66 percent probability (Le Treut et al.2007). "Very likely" indicates a greater than 90 percent probability.

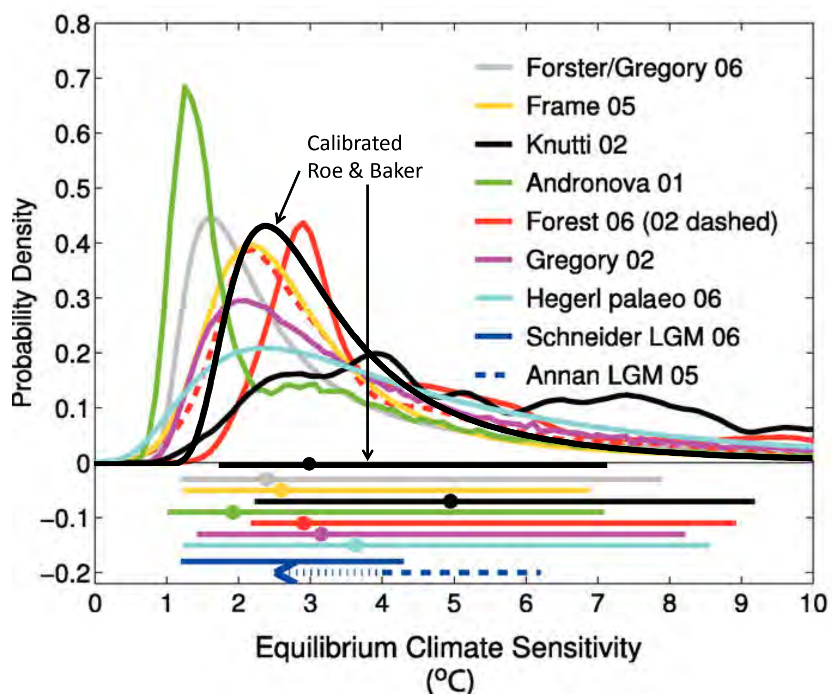
[11] Strictly speaking, "most likely" refers to the mode of a distribution rather than the median, but common usage would allow the mode, median, or mean to serve as candidates for the central or "most likely" value and the IPCC report is not specific on this point. For the distributions we considered, the median was between the mode and the mean. For the Roe and Baker distribution, setting the median equal to 3°C, rather than the mode or mean, gave a 95th percentile that is more consistent with IPCC judgments and the literature. For example, setting the mean and mode equal to 3°C produced 95th percentiles of 5.6 and 8.6 °C, respectively, which are in the lower and upper end of the range in the literature. Finally, the median is closer to 3°C than is the mode for the truncated distributions selected by the IPCC (Hegerl, et al., 2006); the average median is 3.1 °C and the average mode is 2.3 °C, which is most consistent with a Roe and Baker distribution with the median set equal to 3 °C.

Roe 2008). In contrast, the other three distributions are mathematical functions that are arbitrarily chosen based on simplicity, convenience, and general shape. The Roe and Baker distribution results from three assumptions about climate response: (1) absent feedback effects, the equilibrium climate sensitivity is equal to 1.2 °C; (2) feedback factors are proportional to the change in surface temperature; and (3) uncertainties in feedback factors are normally distributed. There is widespread agreement on the first point and the second and third points are common assumptions.

Second, the calibrated Roe and Baker distribution better reflects the IPCC judgment that "values substantially higher than 4.5°C still cannot be excluded." Although the IPCC made no quantitative judgment, the 95th percentile of the calibrated Roe & Baker distribution (7.1 °C) is much closer to the mean and the median (7.2 °C) of the 95th percentiles of 21 previous studies summarized by Newbold and Daigneault (2009). It is also closer to the mean (7.5 °C) and median (7.9 °C) of the nine truncated distributions examined by the IPCC (Hegerl, et al., 2006) than are the 95th percentiles of the three other calibrated distributions (5.2-6.0 °C).

Finally, we note the IPCC judgment that the equilibrium climate sensitivity "is very likely larger than 1.5°C." Although the calibrated Roe & Baker distribution, for which the probability of equilibrium climate sensitivity being greater than 1.5°C is almost 99 percent, is not inconsistent with the IPCC definition of "very likely" as "greater than 90 percent probability," it reflects a greater degree of certainty about very low values of ECS than was expressed by the IPCC.

Figure 2: Estimates of the Probability Density Function for Equilibrium Climate Sensitivity (°C)



To show how the calibrated Roe and Baker distribution compares to different estimates of the probability distribution function of equilibrium climate sensitivity in the empirical literature, Figure 2 (below) overlays it on Figure 9.20 from the IPCC Fourth Assessment Report. These functions are scaled to integrate to unity between 0 °C and 10 °C. The horizontal bars show the respective 5 percent to 95 percent ranges; dots indicate the median estimate.[12]

E. Socio-Economic and Emissions Trajectories

Another key issue considered by the interagency group is how to select the set of socio-economic and emissions parameters for use in PAGE, DICE, and FUND. Socio-economic pathways are closely tied to climate damages because, all else equal, more and wealthier people tend to emit more greenhouse gases and also have a higher (absolute) willingness to pay to avoid climate disruptions. For this reason, we consider how to model several input parameters in tandem: GDP, population, CO_2 emissions, and non-CO_2 radiative forcing. A wide variety of scenarios have been developed and used for climate change policy simulations (e.g., SRES 2000, CCSP 2007, EMF 2009). In determining which scenarios are appropriate for inclusion, we aimed to select scenarios that span most of the plausible ranges of outcomes for these variables.

To accomplish this task in a transparent way, we decided to rely on the recent Stanford Energy Modeling Forum exercise, EMF-22. EMF-22 uses ten well-recognized models to evaluate substantial, coordinated global action to meet specific stabilization targets. A key advantage of relying on these data is that GDP, population, and emission trajectories are internally consistent for each model and scenario evaluated. The EMF-22 modeling effort also is preferable to the IPCC SRES due to their age (SRES were developed in 1997) and the fact that 3 of 4 of the SRES scenarios are now extreme outliers in one or more variables. Although the EMF-22 scenarios have not undergone the same level of scrutiny as the SRES scenarios, they are recent, peer-reviewed, published, and publicly available.

To estimate the SCC for use in evaluating domestic policies that will have a small effect on global cumulative emissions, we use socio-economic and emission trajectories that span a range of plausible scenarios. Five trajectories were selected from EMF-22 (see Table 2 below). Four of these represent potential business-as-usual (BAU) growth in population, wealth, and emissions and are associated with CO_2 (only) concentrations ranging from 612 to 889 ppm in 2100. One represents an emissions pathway that achieves stabilization at 550 ppm CO_2e (i.e., CO_2-only concentrations of 425 – 484 ppm or a radiative forcing of 3.7 W/m^2) in 2100, a lower-than-BAU trajectory.[13] Out of the 10 models included in the EMF-22 exercise, we selected the trajectories used by MiniCAM, MESSAGE, IMAGE, and the optimistic scenario from MERGE. For the BAU pathways, we used the GDP, population, and emission trajectories from each of these four models. For the 550 ppm CO_2e scenario, we averaged the GDP, population, and emission trajectories implied by these same four models.

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[12] The estimates based on instrumental data are from Andronova and Schlesinger (2001), Forest et al. (2002; dashed line, anthropogenic forcings only), Forest et al. (2006; solid line, anthropogenic and natural forcings), Gregory et al. (2002a), Knutti et al. (2002), Frame et al. (2005), and Forster and Gregory (2006). Hegerl et al. (2006) are based on multiple palaeoclimatic reconstructions of north hemisphere mean temperatures over the last 700 years. Also shown are the 5-95 percent approximate ranges for two estimates from the last glacial maximum (dashed, Annan et al. 2005; solid, Schneider von Deimling et al. 2006), which are based on models with different structural properties.

[13] Such an emissions path would be consistent with widespread action by countries to mitigate GHG emissions, though it could also result from technological advances. It was chosen because it represents the most stringent case analyzed by the EMF-22 where all the models converge: a 550 ppm, not to exceed, full participation scenario.

Table 2: Socioeconomic and Emissions Projections from Select EMF-22 Reference Scenarios -

Reference Fossil and Industrial CO_2 Emissions ($GtCO_2$/yr) -

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	26.6	31.9	36.9	40.0	45.3	60.1
MERGE Optimistic	24.6	31.5	37.6	45.1	66.5	117.9
MESSAGE	26.8	29.2	37.6	42.1	43.5	42.7
MiniCAM	26.5	31.8	38.0	45.1	57.8	80.5
550 ppm average	26.2	31.1	33.2	32.4	20.0	12.8

Reference GDP (using market exchange rates in trillion 2005$)[14]

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	38.6	53.0	73.5	97.2	156.3	396.6
MERGE Optimistic	36.3	45.9	59.7	76.8	122.7	268.0
MESSAGE	38.1	52.3	69.4	91.4	153.7	334.9
MiniCAM	36.1	47.4	60.8	78.9	125.7	369.5
550 ppm average	37.1	49.6	65.6	85.5	137.4	337.9

Global Population (billions)

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	6.1	6.9	7.6	8.2	9.0	9.1
MERGE Optimistic	6.0	6.8	7.5	8.2	9.0	9.7
MESSAGE	6.1	6.9	7.7	8.4	9.4	10.4
MiniCAM	6.0	6.8	7.5	8.1	8.8	8.7
550 ppm average	6.1	6.8	7.6	8.2	8.7	9.1

We explore how sensitive the SCC is to various assumptions about how the future will evolve without prejudging what is likely to occur. The interagency group considered formally assigning probability weights to different states of the world, but this proved challenging to do in an analytically rigorous way given the dearth of information on the likelihood of a full range of future socio-economic pathways.

There are a number of caveats. First, EMF BAU scenarios represent the modelers' judgment of the most likely pathway absent mitigation policies to reduce greenhouse gas emissions, rather than the wider range of possible outcomes. Nevertheless, these views of the most likely outcome span a wide range,

[14] While the EMF-22 models used market exchange rates (MER) to calculate global GDP, it is also possible to use purchasing power parity (PPP). PPP takes into account the different price levels across countries, so it more accurately describes relative standards of living across countries. MERs tend to make low-income countries appear poorer than they actually are. Because many models assume convergence in per capita income over time, use of MER-adjusted GDP gives rise to projections of higher economic growth in low income countries. There is an ongoing debate about how much this will affect estimated climate impacts. Critics of the use of MER argue that it leads to overstated economic growth and hence a significant upward bias in projections of greenhouse gas emissions, and unrealistically high future temperatures (e.g., Castles and Henderson 2003). Others argue that convergence of the emissions-intensity gap across countries at least partially offset the overstated income gap so that differences in exchange rates have less of an effect on emissions (Holtsmark and Alfsen, 2005; Tol, 2006). Nordhaus (2007b) argues that the ideal approach is to use superlative PPP accounts (i.e., using cross-sectional PPP measures for relative incomes and outputs and national accounts price and quantity indexes for time-series extrapolations). However, he notes that it important to keep this debate in perspective; it is by no means clear that exchange-rate-conversion issues are as important as uncertainties about population, technological change, or the many geophysical uncertainties.

from the more optimistic (e.g. abundant low-cost, low-carbon energy) to more pessimistic (e.g. constraints on the availability of nuclear and renewables).[15] Second, the socio-economic trajectories associated with a 550 ppm CO_2e concentration scenario are not derived from an assessment of what policy is optimal from a benefit-cost standpoint. Rather, it is indicative of one possible future outcome. The emission trajectories underlying some BAU scenarios (e.g. MESSAGE's 612 ppm) also are consistent with some modest policy action to address climate change.[16] We chose not to include socio-economic trajectories that achieve even lower GHG concentrations at this time, given the difficulty many models had in converging to meet these targets.

For comparison purposes, the Energy Information Agency in its 2009 Annual Energy Outlook projected that global carbon dioxide emissions will grow to 30.8, 35.6, and 40.4 gigatons in 2010, 2020, and 2030, respectively, while world GDP is projected to be $51.8, $71.0 and $93.9 trillion (in 2005 dollars using market exchange rates) in 2010, 2020, and 2030, respectively. These projections are consistent with one or more EMF-22 scenarios. Likewise, the United Nations' 2008 Population Prospect projects population will grow from 6.1 billion people in 2000 to 9.1 billion people in 2050, which is close to the population trajectories for the IMAGE, MiniCAM, and MERGE models.

In addition to fossil and industrial CO_2 emissions, each EMF scenario provides projections of methane, nitrous oxide, fluorinated greenhouse gases, and net land use CO_2 emissions out to 2100. These assumptions also are used in the three models while retaining the default radiative forcings due to other factors (e.g. aerosols and other gases). See the Appendix for greater detail.

F. Discount Rate

The choice of a discount rate, especially over long periods of time, raises highly contested and exceedingly difficult questions of science, economics, philosophy, and law. Although it is well understood that the discount rate has a large influence on the current value of future damages, there is no consensus about what rates to use in this context. Because carbon dioxide emissions are long-lived, subsequent damages occur over many years. In calculating the SCC, we first estimate the future damages to agriculture, human health, and other market and non-market sectors from an additional unit of carbon dioxide emitted in a particular year in terms of reduced consumption (or consumption equivalents) due to the impacts of elevated temperatures, as represented in each of the three IAMs. Then we discount the stream of future damages to its present value in the year when the additional unit of emissions was released using the selected discount rate, which is intended to reflect society's marginal rate of substitution between consumption in different time periods.

For rules with both intra- and intergenerational effects, agencies traditionally employ constant discount rates of both 3 percent and 7 percent in accordance with OMB Circular A-4. As Circular A-4 acknowledges, however, the choice of discount rate for intergenerational problems raises distinctive

[15] For instance, in the MESSAGE model's reference case total primary energy production from nuclear, biomass, and non-biomass renewables is projected to increase from about 15 percent of total primary energy in 2000 to 54 percent in 2100. In comparison, the MiniCAM reference case shows 10 percent in 2000 and 21 percent in 2100.

[16] For example, MiniCAM projects if all non-US OECD countries reduce CO_2 emissions to 83 percent below 2005 levels by 2050 (per the G-8 agreement) but all other countries continue along a BAU path CO_2 concentrations in 2100 would drop from 794 ppmv in its reference case to 762 ppmv.

problems and presents considerable challenges. After reviewing those challenges, Circular A-4 states, “If your rule will have important intergenerational benefits or costs you might consider a further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefits using discount rates of 3 and 7 percent.” For the specific purpose of developing the SCC, we adapt and revise that approach here.

Arrow et al. (1996) outlined two main approaches to determine the discount rate for climate change analysis, which they labeled “descriptive” and “prescriptive.” The descriptive approach reflects a positive (non-normative) perspective based on observations of people’s actual choices—e.g., savings versus consumption decisions over time, and allocations of savings among more and less risky investments. Advocates of this approach generally call for inferring the discount rate from market rates of return “because of a lack of justification for choosing a social welfare function that is any different than what decision makers [individuals] actually use” (Arrow et al. 1996).

One theoretical foundation for the cost-benefit analyses in which the social cost of carbon will be used—the Kaldor-Hicks potential-compensation test—also suggests that market rates should be used to discount future benefits and costs, because it is the market interest rate that would govern the returns potentially set aside today to compensate future individuals for climate damages that they bear (e.g., Just et al. 2004). As some have noted, the word “potentially” is an important qualification; there is no assurance that such returns will actually be set aside to provide compensation, and the very idea of compensation is difficult to define in the intergenerational context. On the other hand, societies provide compensation to future generations through investments in human capital and the resulting increase in knowledge, as well as infrastructure and other physical capital.

The prescriptive approach specifies a social welfare function that formalizes the normative judgments that the decision-maker wants explicitly to incorporate into the policy evaluation—e.g., how inter-personal comparisons of utility should be made, and how the welfare of future generations should be weighed against that of the present generation. Ramsey (1928), for example, has argued that it is “ethically indefensible” to apply a positive pure rate of time preference to discount values across generations, and many agree with this view.

Other concerns also motivate making adjustments to descriptive discount rates. In particular, it has been noted that the preferences of future generations with regard to consumption versus environmental amenities may not be the same as those today, making the current market rate on consumption an inappropriate metric by which to discount future climate-related damages. Others argue that the discount rate should be below market rates to correct for market distortions and uncertainties or inefficiencies in intergenerational transfers of wealth, which in the Kaldor-Hicks logic are presumed to compensate future generations for damage (a potentially controversial assumption, as noted above) (Arrow et al. 1996, Weitzman 1999).

Further, a legitimate concern about both descriptive and prescriptive approaches is that they tend to obscure important heterogeneity in the population. The utility function that underlies the prescriptive approach assumes a representative agent with perfect foresight and no credit constraints. This is an artificial rendering of the real world that misses many of the frictions that characterize individuals’ lives and indeed the available descriptive evidence supports this. For instance, many individuals smooth consumption by borrowing with credit cards that have relatively high rates. Some are unable to access traditional credit markets and rely on payday lending operations or other high cost forms of smoothing consumption. Whether one puts greater weight on the prescriptive or descriptive approach, the high interest rates that credit-constrained individuals accept suggest that some account should be given to the discount rates revealed by their behavior.

We draw on both approaches but rely primarily on the descriptive approach to inform the choice of discount rate. With recognition of its limitations, we find this approach to be the most defensible and transparent given its consistency with the standard contemporary theoretical foundations of benefit-cost analysis and with the approach required by OMB's existing guidance. The logic of this framework also suggests that market rates should be used for discounting future consumption-equivalent damages. Regardless of the theoretical approach used to derive the appropriate discount rate(s), we note the inherent conceptual and practical difficulties of adequately capturing consumption trade-offs over many decades or even centuries. While relying primarily on the descriptive approach in selecting specific discount rates, the interagency group has been keenly aware of the deeply normative dimensions of both the debate over discounting in the intergenerational context and the consequences of selecting one discount rate over another.

Historically Observed Interest Rates

In a market with no distortions, the return to savings would equal the private return on investment, and the market rate of interest would be the appropriate choice for the social discount rate. In the real world risk, taxes, and other market imperfections drive a wedge between the risk-free rate of return on capital and the consumption rate of interest. Thus, the literature recognizes two conceptual discount concepts—the consumption rate of interest and the opportunity cost of capital.

According to OMB's Circular A-4, it is appropriate to use the rate of return on capital when a regulation is expected to displace or alter the use of capital in the private sector. In this case, OMB recommends Agencies use a discount rate of 7 percent. When regulation is expected to primarily affect private consumption—for instance, via higher prices for goods and services—a lower discount rate of 3 percent is appropriate to reflect how private individuals trade-off current and future consumption.

The interagency group examined the economics literature and concluded that the consumption rate of interest is the correct concept to use in evaluating the benefits and costs of a marginal change in carbon emissions (see Lind 1990, Arrow et al 1996, and Arrow 2000). The consumption rate of interest also is appropriate when the impacts of a regulation are measured in consumption (-equivalent) units, as is done in the three integrated assessment models used for estimating the SCC.

Individuals use a variety of savings instruments that vary with risk level, time horizon, and tax characteristics. The standard analytic framework used to develop intuition about the discount rate typically assumes a representative agent with perfect foresight and no credit constraints. The risk-free rate is appropriate for discounting certain future benefits or costs, but the benefits calculated by IAMs are uncertain. To use the risk-free rate to discount uncertain benefits, these benefits first must be transformed into "certainty equivalents," that is the maximum certain amount that we would exchange for the uncertain amount. However, the calculation of the certainty-equivalent requires first estimating the correlation between the benefits of the policy and baseline consumption.

If the IAM projections of future impacts represent expected values (not certainty-equivalent values), then the appropriate discount rate generally does not equal the risk-free rate. If the benefits of the policy tend to be high in those states of the world in which consumption is low, then the certainty-equivalent benefits will be higher than the expected benefits (and vice versa). Since many (though not necessarily all) of the important impacts of climate change will flow through market sectors such as agriculture and energy, and since willingness to pay for environmental protections typically increases with income, we might expect a positive (though not necessarily perfect) correlation between the net benefits from climate policies and market returns. This line of reasoning suggests that the proper discount rate would exceed the riskless rate. Alternatively, a negative correlation between the returns to climate policies and market returns would imply that a discount rate below the riskless rate is appropriate.

This discussion suggests that both the post-tax riskless and risky rates can be used to capture individuals' consumption-equivalent interest rate. As a measure of the post-tax riskless rate, we calculate the average real return from Treasury notes over the longest time period available (those from Newell and Pizer 2003) and adjust for Federal taxes (the average marginal rate from tax years 2003 through 2006 is around 27 percent).[17] This calculation produces a real interest rate of about 2.7 percent, which is roughly consistent with Circular A-4's recommendation to use 3 percent to represent the consumption rate of interest.[18] A measure of the post-tax risky rate for investments whose returns are positively correlated with overall equity market returns can be obtained by adjusting pre-tax rates of household returns to risky investments (approximately 7 percent) for taxes yields a real rate of roughly 5 percent.[19]

The Ramsey Equation

Ramsey discounting also provides a useful framework to inform the choice of a discount rate. Under this approach, the analyst applies either positive or normative judgments in selecting values for the key parameters of the Ramsey equation: η (coefficient of relative risk aversion or elasticity of the marginal utility of consumption) and ρ (pure rate of time preference).[20] These are then combined with g (growth

[17] The literature argues for a risk-free rate on government bonds as an appropriate measure of the consumption rate of interest. Arrow (2000) suggests that it is roughly 3-4 percent. OMB cites evidence of a 3.1 percent pre-tax rate for 10-year Treasury notes in the A-4 guidance. Newell and Pizer (2003) find real interest rates between 3.5 and 4 percent for 30-year Treasury securities.

[18] The positive approach reflects how individuals make allocation choices across time, but it is important to keep in mind that we wish to reflect preferences for society as a whole, which generally has a longer planning horizon.

[19] Cambell et al (2001) estimates that the annual real return from stocks for 1900-1995 was about 7 percent. The annual real rate of return for the S&P 500 from 1950 – 2008 was about 6.8 percent. In the absence of a better way to population-weight the tax rates, we use the middle of the 20 – 40 percent range to derive a post-tax interest rate (Kotlikoff and Rapson 2006).

[20] The parameter ρ measures the *pure rate of time preference*: people's behavior reveals a preference for an increase in utility today versus the future. Consequently, it is standard to place a lower weight on utility in the future. The parameter η captures *diminishing marginal utility*: consumption in the future is likely to be higher than consumption today, so diminishing marginal utility of consumption implies that the same monetary damage will

rate of per-capita consumption) to equal the interest rate at which future monetized damages are discounted: $\rho + \eta \cdot g$.[21] In the simplest version of the Ramsey model, with an optimizing representative agent with perfect foresight, what we are calling the "Ramsey discount rate," $\rho + \eta \cdot g$, will be equal to the rate of return to capital, i.e., the market interest rate.

A review of the literature provides some guidance on reasonable parameter values for the Ramsey discounting equation, based on both prescriptive and descriptive approaches.

- η. Most papers in the climate change literature adopt values for η in the range of 0.5 to 3 (Weitzman cites plausible values as those ranging from 1 to 4), although not all authors articulate whether their choice is based on prescriptive or descriptive reasoning.[22] Dasgupta (2008) argues that η should be greater than 1 and may be as high as 3, since η equal to 1 suggests savings rates that do not conform to observed behavior.

- ρ. With respect to the pure rate of time preference, most papers in the climate change literature adopt values for ρ in the range of 0 to 3 percent per year. The very low rates tend to follow from moral judgments involving intergenerational neutrality. Some have argued that to use any value other than $\rho = 0$ would unjustly discriminate against future generations (e.g., Arrow et al. 1996, Stern et al. 2006). However, even in an inter-generational setting, it may make sense to use a small positive pure rate of time preference because of the small probability of unforeseen cataclysmic events (Stern et al. 2006).

- g. A commonly accepted approximation is around 2 percent per year. For the socio-economic scenarios used for this exercise, the EMF models assume that g is about 1.5-2 percent to 2100.

Some economists and non-economists have argued for constant discount rates below 2 percent based on the prescriptive approach. When grounded in the Ramsey framework, proponents of this approach have argued that a ρ of zero avoids giving preferential treatment to one generation over another. The choice of η has also been posed as an ethical choice linked to the value of an additional dollar in poorer

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cause a smaller reduction of utility for wealthier individuals, either in the future or in current generations. If $\eta = 0$, then a one dollar increase in income is equally valuable regardless of level of income; if $\eta = 1$, then a one percent increase in income is equally valuable no matter the level of income; and if $\eta > 1$, then a one percent increase in income is less valuable to wealthier individuals.

[21] In this case, g could be taken from the selected EMF socioeconomic scenarios or alternative assumptions about the rate of consumption growth.

[22] Empirical estimates of η span a wide range of values. A benchmark value of 2 is near the middle of the range of values estimated or used by Szpiro (1986), Hall and Jones (2007), Arrow (2007), Dasgupta (2006, 2008), Weitzman (2007, 2009), and Nordhaus (2008). However, Chetty (2006) developed a method of estimating η using data on labor supply behavior. He shows that existing evidence of the effects of wage changes on labor supply imposes a tight upper bound on the curvature of utility over wealth (CRRA < 2) with the mean implied value of 0.71 and concludes that the standard expected utility model cannot generate high levels of risk aversion without contradicting established facts about labor supply. Recent work has jointly estimated the components of the Ramsey equation. Evans and Sezer (2005) estimate $\eta = 1.49$ for 22 OECD countries. They also estimate $\rho = 1.08$ percent per year using data on mortality rates. Anthoff, et al. (2009b) estimate $\eta = 1.18$, and $\rho = 1.4$ percent. When they multiply the bivariate probability distributions from their work and Evans and Sezer (2005) together, they find $\eta = 1.47$, and $\rho = 1.07$.

countries compared to wealthier ones. Stern et al. (2006) applies this perspective through his choice of ρ = 0.1 percent per year, η = 1 and g = 1.3 percent per year, which yields an annual discount rate of 1.4 percent. In the context of permanent income savings behavior, however, Stern's assumptions suggest that individuals would save 93 percent of their income.[23]

Recently, Stern (2008) revisited the values used in Stern et al. (2006), stating that there is a case to be made for raising η due to the amount of weight lower values place on damages far in the future (over 90 percent of expected damages occur after 2200 with η = 1). Using Stern's assumption that ρ = 0.1 percent, combined with a η of 1.5 to 2 and his original growth rate, yields a discount rate greater 2 percent.

We conclude that arguments made under the prescriptive approach can be used to justify discount rates between roughly 1.4 and 3.1 percent. In light of concerns about the most appropriate value for η, we find it difficult to justify rates at the lower end of this range under the Ramsey framework.

Accounting for Uncertainty in the Discount Rate

While the consumption rate of interest is an important driver of the benefits estimate, it is uncertain over time. Ideally, we would formally model this uncertainty, just as we do for climate sensitivity. Weitzman (1998, 2001) showed theoretically and Newell and Pizer (2003) and Groom et al. (2006) confirm empirically that discount rate uncertainty can have a large effect on net present values. A main result from these studies is that if there is a persistent element to the uncertainty in the discount rate (e.g., the rate follows a random walk), then it will result in an effective (or certainty-equivalent) discount rate that declines over time. Consequently, lower discount rates tend to dominate over the very long term (see Weitzman 1998, 1999, 2001; Newell and Pizer 2003; Groom et al. 2006; Gollier 2008; Summers and Zeckhauser 2008; and Gollier and Weitzman 2009).

The proper way to model discount rate uncertainty remains an active area of research. Newell and Pizer (2003) employ a model of how long-term interest rates change over time to forecast future discount rates. Their model incorporates some of the basic features of how interest rates move over time, and its parameters are estimated based on historical observations of long-term rates. Subsequent work on this topic, most notably Groom et al. (2006), uses more general models of interest rate dynamics to allow for better forecasts. Specifically, the volatility of interest rates depends on whether rates are currently low or high and variation in the level of persistence over time.

While Newell and Pizer (2003) and Groom et al (2006) attempt formally to model uncertainty in the discount rate, others argue for a declining scale of discount rates applied over time (e.g., Weitzman 2001, and the UK's "Green Book" for regulatory analysis). This approach uses a higher discount rate

[23] Stern (2008) argues that building in a positive rate of exogenous technical change over time reduces the implied savings rate and that η at or above 2 are inconsistent with observed behavior with regard to equity. (At the same time, adding exogenous technical change—all else equal—would increase g as well.)

initially, but applies a graduated scale of lower discount rates further out in time.[24] A key question that has emerged with regard to both of these approaches is the trade-off between potential time inconsistency and giving greater weight to far future outcomes (see the EPA Science Advisory Board's recent comments on this topic as part of its review of their *Guidelines for Economic Analysis*).[25]

The Discount Rates Selected for Estimating SCC

In light of disagreement in the literature on the appropriate market interest rate to use in this context and uncertainty about how interest rates may change over time, we use three discount rates to span a plausible range of certainty-equivalent constant discount rates: 2.5, 3, and 5 percent per year. Based on the review in the previous sections, the interagency workgroup determined that these three rates reflect reasonable judgments under both descriptive and prescriptive approaches.

The central value, 3 percent, is consistent with estimates provided in the economics literature and OMB's Circular A-4 guidance for the consumption rate of interest. As previously mentioned, the consumption rate of interest is the correct discounting concept to use when future damages from elevated temperatures are estimated in consumption-equivalent units. Further, 3 percent roughly corresponds to the after-tax riskless interest rate. The upper value of 5 percent is included to represent the possibility that climate damages are positively correlated with market returns. Additionally, this discount rate may be justified by the high interest rates that many consumers use to smooth consumption across periods.

The low value, 2.5 percent, is included to incorporate the concern that interest rates are highly uncertain over time. It represents the average certainty-equivalent rate using the mean-reverting and random walk approaches from Newell and Pizer (2003) starting at a discount rate of 3 percent. Using this approach, the certainty equivalent is about 2.2 percent using the random walk model and 2.8 percent using the mean reverting approach.[26] Without giving preference to a particular model, the average of the two rates is 2.5 percent. Further, a rate below the riskless rate would be justified if climate investments are negatively correlated with the overall market rate of return. Use of this lower value also responds to certain judgments using the prescriptive or normative approach and to ethical objections that have been raised about rates of 3 percent or higher.

[24] For instance, the UK applies a discount rate of 3.5 percent to the first 30 years; 3 percent for years 31 - 75; 2.5 percent for years 76 - 125; 2 percent for years 126 - 200; 1.5 percent for years 201 - 300; and 1 percent after 300 years. As a sensitivity, it recommends a discount rate of 3 percent for the first 30 years, also decreasing over time.

[25] Uncertainty in future damages is distinct from uncertainty in the discount rate. Weitzman (2008) argues that Stern's choice of a low discount rate was "right for the wrong reasons." He demonstrates how the damages from a low probability, catastrophic event far in the future dominate the effect of the discount rate in a present value calculation and result in an infinite willingness-to-pay for mitigation today. Newbold and Daigneault, (2009) and Nordhaus (2009) find that Weitzman's result is sensitive to the functional forms chosen for climate sensitivity, utility, and consumption. Summers and Zeckhauser (2008) argue that uncertainty in future damages can also work in the other direction by increasing the benefits of waiting to learn the appropriate level of mitigation required.

[26] Calculations done by Pizer et al. using the original simulation program from Newell and Pizer (2003).

IV. Revised SCC Estimates

Our general approach to estimating SCC values is to run the three integrated assessment models (FUND, DICE, and PAGE) using the following inputs agreed upon by the interagency group:

- A Roe and Baker distribution for the climate sensitivity parameter bounded between 0 and 10 with a median of 3 °C and a cumulative probability between 2 and 4.5 °C of two-thirds.
- Five sets of GDP, population and carbon emissions trajectories based on EMF-22.
- Constant annual discount rates of 2.5, 3, and 5 percent.

Because the climate sensitivity parameter is modeled probabilistically, and because PAGE and FUND incorporate uncertainty in other model parameters, the final output from each model run is a distribution over the SCC in year *t*.

For each of the IAMS, the basic computational steps for calculating the SCC in a particular year *t* are:

1. Input the path of emissions, GDP, and population from the selected EMF-22 scenarios, and the extrapolations based on these scenarios for post-2100 years.

2. Calculate the temperature effects and (consumption-equivalent) damages in each year resulting from the baseline path of emissions.

    a. In PAGE, the consumption-equivalent damages in each period are calculated as a fraction of the EMF GDP forecast, depending on the temperature in that period relative to the pre-industrial average temperature in each region.
    b. In FUND, damages in each period depend on both the level and the rate of temperature change in that period.
    c. In DICE, temperature affects both consumption and investment, so we first adjust the EMF GDP paths as follows: Using the Cobb-Douglas production function with the DICE2007 parameters, we extract the path of exogenous technical change implied by the EMF GDP and population paths, then we recalculate the baseline GDP path taking into account climate damages resulting from the baseline emissions path.

3. Add an additional unit of carbon emissions in year *t.* (The exact unit varies by model.)

4. Recalculate the temperature effects and damages expected in all years beyond *t* resulting from this adjusted path of emissions, as in step 2.

5. Subtract the damages computed in step 2 from those in step 4 in each year. (DICE is run in 10 year time steps, FUND in annual time steps, while the time steps in PAGE vary.)

6. Discount the resulting path of marginal damages back to the year of emissions using the agreed upon fixed discount rates.

7. Calculate the SCC as the net present value of the discounted path of damages computed in step 6, divided by the unit of carbon emissions used to shock the models in step 3.

8. Multiply by 12/44 to convert from dollars per ton of carbon to dollars per ton of CO_2 (2007 dollars) in DICE and FUND. (All calculations are done in tons of CO_2 in PAGE).

The steps above were repeated in each model for multiple future years to cover the time horizons anticipated for upcoming rulemaking analysis. To maintain consistency across the three IAMs, climate damages are calculated as lost consumption in each future year.

It is important to note that each of the three models has a different default end year. The default time horizon is 2200 for PAGE, 2595 for DICE, and 3000 for the latest version of FUND. This is an issue for the multi-model approach because differences in SCC estimates may arise simply due to the model time horizon. Many consider 2200 too short a time horizon because it could miss a significant fraction of damages under certain assumptions about the growth of marginal damages and discounting, so each model is run here through 2300. This step required a small adjustment in the PAGE model only. This step also required assumptions about GDP, population, and greenhouse gas emission trajectories after 2100, the last year for which these data are available from the EMF-22 models. (A more detailed discussion of these assumptions is included in the Appendix.)

This exercise produces 45 separate distributions of the SCC for a given year, the product of 3 models, 3 discount rates, and 5 socioeconomic scenarios. This is clearly too many separate distributions for consideration in a regulatory impact analysis.

To produce a range of plausible estimates that still reflects the uncertainty in the estimation exercise, the distributions from each of the models and scenarios are equally weighed and combined to produce three separate probability distributions for SCC in a given year, one for each assumed discount rate. These distributions are then used to define a range of point estimates for the global SCC. In this way, no integrated assessment model or socioeconomic scenario is given greater weight than another. Because the literature shows that the SCC is quite sensitive to assumptions about the discount rate, and because no consensus exists on the appropriate rate to use in an intergenerational context, we present SCCs based on the average values across models and socioeconomic scenarios for each discount rate.

The interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC across models and socio-economic and emissions scenarios at the 2.5, 3, and 5 percent discount rates. The fourth value is included to represent the higher-than-expected economic impacts from climate change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. (The full set of distributions by model and scenario combination is included in the Appendix.) As noted above, the 3 percent discount rate is the central value, and so the central value that emerges is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range.

As previously discussed, low probability, high impact events are incorporated into the SCC values through explicit consideration of their effects in two of the three models as well as the use of a probability density function for equilibrium climate sensitivity. Treating climate sensitivity probabilistically results in more high temperature outcomes, which in turn lead to higher projections of damages. Although FUND does not include catastrophic damages (in contrast to the other two models), its probabilistic treatment of the equilibrium climate sensitivity parameter will directly affect the non-catastrophic damages that are a function of the rate of temperature change.

In Table 3, we begin by presenting SCC estimates for 2010 by model, scenario, and discount rate to illustrate the variability in the SCC across each of these input parameters. As expected, higher discount rates consistently result in lower SCC values, while lower discount rates result in higher SCC values for each socioeconomic trajectory. It is also evident that there are differences in the SCC estimated across the three main models. For these estimates, FUND produces the lowest estimates, while PAGE generally produces the highest estimates.

Table 3: Disaggregated Social Cost of CO_2 Values by Model, Socio-Economic Trajectory, and Discount Rate for 2010 (in 2007 dollars)

	Discount rate:	**5%**	**3%**	**2.5%**	**3%**
Model	*Scenario*	Avg	Avg	Avg	95th
DICE	IMAGE	10.8	35.8	54.2	70.8
	MERGE	7.5	22.0	31.6	42.1
	Message	9.8	29.8	43.5	58.6
	MiniCAM	8.6	28.8	44.4	57.9
	550 Average	8.2	24.9	37.4	50.8
PAGE	IMAGE	8.3	39.5	65.5	142.4
	MERGE	5.2	22.3	34.6	82.4
	Message	7.2	30.3	49.2	115.6
	MiniCAM	6.4	31.8	54.7	115.4
	550 Average	5.5	25.4	42.9	104.7
FUND	IMAGE	-1.3	8.2	19.3	39.7
	MERGE	-0.3	8.0	14.8	41.3
	Message	-1.9	3.6	8.8	32.1
	MiniCAM	-0.6	10.2	22.2	42.6
	550 Average	-2.7	-0.2	3.0	19.4

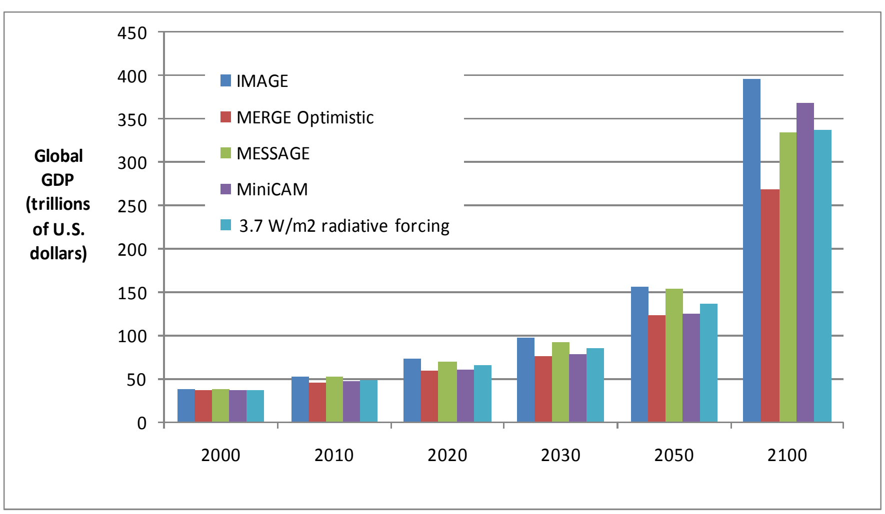
These results are not surprising when compared to the estimates in the literature for the latest versions of each model. For example, adjusting the values from the literature that were used to develop interim

SCC values to 2007 dollars for the year 2010 (assuming, as we did for the interim process, that SCC grows at 3 percent per year), FUND yields SCC estimates at or near zero for a 5 percent discount rate and around $9 per ton for a 3 percent discount rate. There are far fewer estimates using the latest versions of DICE and PAGE in the literature: Using similar adjustments to generate 2010 estimates, we calculate a SCC from DICE (based on Nordhaus 2008) of around $9 per ton for a 5 percent discount rate, and a SCC from PAGE (based on Hope 2006, 2008) close to $8 per ton for a 4 percent discount rate. Note that these comparisons are only approximate since the literature generally relies on Ramsey discounting, while we have assumed constant discount rates.[27]

The SCC estimates from FUND are sensitive to differences in emissions paths but relatively insensitive to differences in GDP paths across scenarios, while the reverse is true for DICE and PAGE. This likely occurs because of several structural differences among the models. Specifically in DICE and PAGE, the fraction of economic output lost due to climate damages increases with the level of temperature alone, whereas in FUND the fractional loss also increases with the rate of temperature change. Furthermore, in FUND increases in income over time decrease vulnerability to climate change (a form of adaptation), whereas this does not occur in DICE and PAGE. These structural differences among the models make FUND more sensitive to the path of emissions and less sensitive to GDP compared to DICE and PAGE.

Figure 3 shows that IMAGE has the highest GDP in 2100 while MERGE Optimistic has the lowest. The ordering of global GDP levels in 2100 directly corresponds to the rank ordering of SCC for PAGE and DICE. For FUND, the correspondence is less clear, a result that is to be expected given its less direct relationship between its damage function and GDP.

Figure 3: Level of Global GDP across EMF Scenarios



[27] Nordhaus (2008) runs DICE2007 with ρ = 1.5 and η = 2. The default approach in PAGE2002 (version 1.4epm) treats ρ and η as random parameters, specified using a triangular distribution such that the min, mode, and max = 0.1, 1, and 2 for ρ, and 0.5, 1, and 2 for η, respectively. The FUND default value for η is 1, and Tol generates SCC estimates for values of ρ = 0, 1, and 3 in many recent papers (e.g. Anthoff et al. 2009). The path of per-capita consumption growth, g, varies over time but is treated deterministically in two of the three models. In DICE, g is endogenous. Under Ramsey discounting, as economic growth slows in the future, the large damages from climate change that occur far out in the future are discounted at a lower rate than impacts that occur in the nearer term.

Table 4 shows the four selected SCC values in five year increments from 2010 to 2050. Values for 2010, 2020, 2040, and 2050 are calculated by first combining all outputs (10,000 estimates per model run) from all scenarios and models for a given discount rate. Values for the years in between are calculated using a simple linear interpolation.

Table 4: Social Cost of CO_2, 2010 – 2050 (in 2007 dollars)

Discount Rate Year	5% Avg	3% Avg	2.5% Avg	3% 95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

The SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. Note that this approach allows us to estimate the growth rate of the SCC directly using DICE, PAGE, and FUND rather than assuming a constant annual growth rate as was done for the interim estimates (using 3 percent). This helps to ensure that the estimates are internally consistent with other modeling assumptions. Table 5 illustrates how the growth rate for these four SCC estimates varies over time. The full set of annual SCC estimates between 2010 and 2050 is reported in the Appendix.

Table 5: Changes in the Average Annual Growth Rates of SCC Estimates between 2010 and 2050

Average Annual Growth Rate (%)	**5%** Avg	**3%** Avg	**2.5%** Avg	**3.0%** 95th
2010-2020	3.6%	2.1%	1.7%	2.2%
2020-2030	3.7%	2.2%	1.8%	2.2%
2030-2040	2.7%	1.8%	1.6%	1.8%
2040-2050	2.1%	1.4%	1.1%	1.3%

While the SCC estimate grows over time, the future monetized value of emissions reductions in each year (the SCC in year *t* multiplied by the change in emissions in year *t*) must be discounted to the present to determine its total net present value for use in regulatory analysis. Damages from future emissions should be discounted at the same rate as that used to calculate the SCC estimates themselves to ensure internal consistency—i.e., future damages from climate change, whether they result from emissions today or emissions in a later year, should be discounted using the same rate. For example, climate damages in the year 2020 that are calculated using a SCC based on a 5 percent discount rate also should be discounted back to the analysis year using a 5 percent discount rate.[28]

V. Limitations of the Analysis

As noted, any estimate of the SCC must be taken as provisional and subject to further refinement (and possibly significant change) in accordance with evolving scientific, economic, and ethical understandings. During the course of our modeling, it became apparent that there are several areas in particular need of additional exploration and research. These caveats, and additional observations in the following section, are necessary to consider when interpreting and applying the SCC estimates.

Incomplete treatment of non-catastrophic damages. The impacts of climate change are expected to be widespread, diverse, and heterogeneous. In addition, the exact magnitude of these impacts is uncertain because of the inherent complexity of climate processes, the economic behavior of current and future populations, and our inability to accurately forecast technological change and adaptation. Current IAMs do not assign value to all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature (some of which are discussed above) because of lack of precise information on the nature of damages and because the science incorporated into these models understandably lags behind the most recent research. Our ability to quantify and monetize impacts will undoubtedly improve with time. But it is also likely that even in future applications, a number of potentially significant damage categories will remain non-monetized. (Ocean acidification is one example of a potentially large damage from CO_2 emissions not quantified by any of the three models. Species and wildlife loss is another example that is exceedingly difficult to monetize.)

Incomplete treatment of potential catastrophic damages. There has been considerable recent discussion of the risk of catastrophic impacts and how best to account for extreme scenarios, such as the collapse of the Atlantic Meridional Overturning Circulation or the West Antarctic Ice Sheet, or large releases of methane from melting permafrost and warming oceans. Weitzman (2009) suggests that catastrophic damages are extremely large—so large, in fact, that the damages from a low probability, catastrophic event far in the future dominate the effect of the discount rate in a present value calculation and result in an infinite willingness-to-pay for mitigation today. However, Nordhaus (2009) concluded that the conditions under which Weitzman's results hold "are limited and do not apply to a wide range of potential uncertain scenarios."

Using a simplified IAM, Newbold and Daigneault (2009) confirmed the potential for large catastrophe risk premiums but also showed that the aggregate benefit estimates can be highly sensitive to the shapes of both the climate sensitivity distribution and the damage function at high temperature changes. Pindyck (2009) also used a simplified IAM to examine high-impact low-probability risks, using a right-skewed gamma distribution for climate sensitivity as well as an uncertain damage coefficient, but in most cases found only a modest risk premium. Given this difference in opinion, further research in this area is needed before its practical significance can be fully understood and a reasonable approach developed to account for such risks in regulatory analysis. (The next section discusses the scientific evidence on catastrophic impacts in greater detail.)

[28] However, it is possible that other benefits or costs of proposed regulations unrelated to CO_2 emissions will be discounted at rates that differ from those used to develop the SCC estimates.

Uncertainty in extrapolation of damages to high temperatures: The damage functions in these IAMs are typically calibrated by estimating damages at moderate temperature increases (e.g., DICE was calibrated at 2.5 °C) and extrapolated to far higher temperatures by assuming that damages increase as some power of the temperature change. Hence, estimated damages are far more uncertain under more extreme climate change scenarios.

Incomplete treatment of adaptation and technological change: Each of the three integrated assessment models used here assumes a certain degree of low- or no-cost adaptation. For instance, Tol assumes a great deal of adaptation in FUND, including widespread reliance on air conditioning ; so much so, that the largest single benefit category in FUND is the reduced electricity costs from not having to run air conditioning as intensively (NRC 2009).

Climate change also will increase returns on investment to develop technologies that allow individuals to cope with adverse climate conditions, and IAMs to do not adequately account for this directed technological change.[29] For example, scientists may develop crops that are better able to withstand higher and more variable temperatures. Although DICE and FUND have both calibrated their agricultural sectors under the assumption that farmers will change land use practices in response to climate change (Mastrandrea, 2009), they do not take into account technological changes that lower the cost of this adaptation over time. On the other hand, the calibrations do not account for increases in climate variability, pests, or diseases, which could make adaptation more difficult than assumed by the IAMs for a given temperature change. Hence, models do not adequately account for potential adaptation or technical change that might alter the emissions pathway and resulting damages. In this respect, it is difficult to determine whether the incomplete treatment of adaptation and technological change in these IAMs under or overstate the likely damages.

Risk aversion: A key question unanswered during this interagency process is what to assume about relative risk aversion with regard to high-impact outcomes. These calculations do not take into account the possibility that individuals may have a higher willingness to pay to reduce the likelihood of low-probability, high-impact damages than they do to reduce the likelihood of higher-probability but lower-impact damages with the same expected cost. (The inclusion of the 95th percentile estimate in the final set of SCC values was largely motivated by this concern.) If individuals do show such a higher willingness to pay, a further question is whether that fact should be taken into account for regulatory policy. Even if individuals are not risk-averse for such scenarios, it is possible that regulatory policy should include a degree of risk-aversion.

Assuming a risk-neutral representative agent is consistent with OMB's Circular A-4, which advises that the estimates of benefits and costs used in regulatory analysis are usually based on the average or the expected value and that "emphasis on these expected values is appropriate as long as society is 'risk neutral' with respect to the regulatory alternatives. While this may not always be the case, [analysts] should in general assume 'risk neutrality' in [their] analysis."

Nordhaus (2008) points to the need to explore the relationship between risk and income in the context of climate change across models and to explore the role of uncertainty regarding various parameters in

[29] However these research dollars will be diverted from whatever their next best use would have been in the absence of climate change (so productivity/GDP would have been still higher).

the results. Using FUND, Anthoff et al (2009) explored the sensitivity of the SCC to Ramsey equation parameter assumptions based on observed behavior. They conclude that "the assumed rate of risk aversion is at least as important as the assumed rate of time preference in determining the social cost of carbon." Since Circular A-4 allows for a different assumption on risk preference in regulatory analysis if it is adequately justified, we plan to continue investigating this issue.

V. A Further Discussion of Catastrophic Impacts and Damage Functions

As noted above, the damage functions underlying the three IAMs used to estimate the SCC may not capture the economic effects of all possible adverse consequences of climate change and may therefore lead to underestimates of the SCC (Mastrandrea 2009). In particular, the models' functional forms may not adequately capture: (1) potentially discontinuous "tipping point" behavior in Earth systems, (2) inter-sectoral and inter-regional interactions, including global security impacts of high-end warming, and (3) limited near-term substitutability between damage to natural systems and increased consumption.

It is the hope of the interagency group that over time researchers and modelers will work to fill these gaps and that the SCC estimates used for regulatory analysis by the Federal government will continue to evolve with improvements in modeling. In the meantime, we discuss some of the available evidence.

Extrapolation of climate damages to high levels of warming

The damage functions in the models are calibrated at moderate levels of warming and should therefore be viewed cautiously when extrapolated to the high temperatures found in the upper end of the distribution. Recent science suggests that there are a number of potential climatic "tipping points" at which the Earth system may exhibit discontinuous behavior with potentially severe social and economic consequences (e.g., Lenton et al, 2008, Kriegler et al., 2009). These tipping points include the disruption of the Indian Summer Monsoon, dieback of the Amazon Rainforest and boreal forests, collapse of the Greenland Ice Sheet and the West Antarctic Ice Sheet, reorganization of the Atlantic Meridional Overturning Circulation, strengthening of El Niño-Southern Oscillation, and the release of methane from melting permafrost. Many of these tipping points are estimated to have thresholds between about 3 °C and 5 °C (Lenton et al., 2008). Probabilities of several of these tipping points were assessed through expert elicitation in 2005–2006 by Kriegler et al. (2009); results from this study are highlighted in Table 6. Ranges of probability are averaged across core experts on each topic.

As previously mentioned, FUND does not include potentially catastrophic effects. DICE assumes a small probability of catastrophic damages that increases with increased warming, but the damages from these risks are incorporated as expected values (i.e., ignoring potential risk aversion). PAGE models catastrophic impacts in a probabilistic framework (see Figure 1), so the high-end output from PAGE potentially offers the best insight into the SCC if the world were to experience catastrophic climate change. For instance, at the 95th percentile and a 3 percent discount rate, the SCC estimated by PAGE across the five socio-economic and emission trajectories of $113 per ton of CO_2 is almost double the value estimated by DICE, $58 per ton in 2010. We cannot evaluate how well the three models account for catastrophic or non-catastrophic impacts, but this estimate highlights the sensitivity of SCC values in the tails of the distribution to the assumptions made about catastrophic impacts.

Table 6: Probabilities of Various Tipping Points from Expert Elicitation -

Possible Tipping Points	Duration before effect is fully realized (in years)	Additional Warming by 2100		
		0.5-1.5 C	1.5-3.0 C	3-5 C
Reorganization of Atlantic Meridional Overturning Circulation	about 100	0-18%	6-39%	18-67%
Greenland Ice Sheet collapse	at least 300	8-39%	33-73%	67-96%
West Antarctic Ice Sheet collapse	at least 300	5-41%	10-63%	33-88%
Dieback of Amazon rainforest	about 50	2-46%	14-84%	41-94%
Strengthening of El Niño-Southern Oscillation	about 100	1-13%	6-32%	19-49%
Dieback of boreal forests	about 50	13-43%	20-81%	34-91%
Shift in Indian Summer Monsoon	about 1	Not formally assessed		
Release of methane from melting permafrost	Less than 100	Not formally assessed.		

PAGE treats the possibility of a catastrophic event probabilistically, while DICE treats it deterministically (that is, by adding the expected value of the damage from a catastrophe to the aggregate damage function). In part, this results in different probabilities being assigned to a catastrophic event across the two models. For instance, PAGE places a probability near zero on a catastrophe at 2.5 °C warming, while DICE assumes a 4 percent probability of a catastrophe at 2.5 °C. By comparison, Kriegler et al. (2009) estimate a probability of at least 16-36 percent of crossing at least one of their primary climatic tipping points in a scenario with temperatures about 2-4 °C warmer than pre-Industrial levels in 2100.

It is important to note that crossing a climatic tipping point will not necessarily lead to an economic catastrophe in the sense used in the IAMs. A tipping point is a critical threshold across which some aspect of the Earth system starts to shifts into a qualitatively different state (for instance, one with dramatically reduced ice sheet volumes and higher sea levels). In the IAMs, a catastrophe is a low-probability environmental change with high economic impact.

Failure to incorporate inter-sectoral and inter-regional interactions

The damage functions do not fully incorporate either inter-sectoral or inter-regional interactions. For instance, while damages to the agricultural sector are incorporated, the effects of changes in food supply on human health are not fully captured and depend on the modeler's choice of studies used to calibrate the IAM. Likewise, the effects of climate damages in one region of the world on another region are not included in some of the models (FUND includes the effects of migration from sea level rise). These inter-regional interactions, though difficult to quantify, are the basis for climate-induced national and economic security concerns (e.g., Campbell et al., 2007; U.S. Department of Defense 2010) and are particularly worrisome at higher levels of warming. High-end warming scenarios, for instance, project water scarcity affecting 4.3-6.9 billion people by 2050, food scarcity affecting about 120 million additional people by 2080, and the creation of millions of climate refugees (Easterling et al., 2007; Campbell et al., 2007).

Imperfect substitutability of environmental amenities

Data from the geological record of past climate changes suggests that 6 °C of warming may have severe consequences for natural systems. For instance, during the Paleocene-Eocene Thermal Maximum about 55.5 million years ago, when the Earth experienced a geologically rapid release of carbon associated with an approximately 5 °C increase in global mean temperatures, the effects included shifts of about 400-900 miles in the range of plants (Wing et al., 2005), and dwarfing of both land mammals (Gingerich, 2006) and soil fauna (Smith et al., 2009).

The three IAMs used here assume that it is possible to compensate for the economic consequences of damages to natural systems through increased consumption of non-climate goods, a common assumption in many economic models. In the context of climate change, however, it is possible that the damages to natural systems could become so great that no increase in consumption of non-climate goods would provide complete compensation (Levy et al., 2005). For instance, as water supplies become scarcer or ecosystems become more fragile and less bio-diverse, the services they provide may become increasingly more costly to replace. Uncalibrated attempts to incorporate the imperfect substitutability of such amenities into IAMs (Sterner and Persson, 2008) indicate that the optimal degree of emissions abatement can be considerably greater than is commonly recognized.

VI. Conclusion

The interagency group selected four SCC estimates for use in regulatory analyses. For 2010, these estimates are $5, $21, $35, and $65 (in 2007 dollars). The first three estimates are based on the average SCC across models and socio-economic and emissions scenarios at the 5, 3, and 2.5 percent discount rates, respectively. The fourth value is included to represent the higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. The central value is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range. These SCC estimates also grow over time. For instance, the central value increases to $24 per ton of CO_2 in 2015 and $26 per ton of CO_2 in 2020.

We noted a number of limitations to this analysis, including the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. The limited amount of research linking climate impacts to economic damages makes this modeling exercise even more difficult. It is the hope of the interagency group that over time researchers and modelers will work to fill these gaps and that the SCC estimates used for regulatory analysis by the Federal government will continue to evolve with improvements in modeling.

References

Andronova, N., and M. Schlesinger. 2001. "Objective estimation of the probability density function for climate sensitivity." *J. Geophys. Res.*, 106(D19), 22605–22611.

Annan, J., et al., 2005. "Efficiently constraining climate sensitivity with paleoclimate simulations." *Scientific Online Letters on the Atmosphere*, 1, 181–184.

Anthoff D, C. Hepburn, and R. Tol. 2009a. "Equity Weighting and the Marginal Damage Costs of Climate Change." *Ecological Economics* 68:836-849.

Anthoff, D., R. Tol, and G. Yohe. 2009b. "Risk aversion, time preference, and the social cost of carbon." *Environmental Research Letters* 4: 024002 (7pp).

Arrow, K. 2007. "Global climate change: a challenge to policy." *Economist's Voice* 4(3):Article 2.

Arrow, K. 2000. "A Comment on Cooper." *The World Bank Research Observer*. vol 15, no. 2.

Arrow, K., et al. 1996. *Benefit-Cost Analysis in Environmental, Health, and Safety Regulation: A Statement of Principles*. Washington, D.C., AEI Press. pp. 13-14.

Arrow, K.J., et al. 1996. "Intertemporal equity, discounting and economic efficiency," in Climate Change 1995: Economic and Social Dimensions of Climate Change, Contribution of Working Group III to the *Second Assessment Report of the Intergovernmental Panel on Climate Change*.

Campbell, J., P. Diamond, and J. Shoven. 2001. "Estimating the Real Rate of Return on Stocks Over the Long Term." Presented to the Social Security Advisory Board. August.

Campbell, K. et al. 2007. *The age of consequences: The foreign policy and national security implications of global climate change*. Center for Strategic & International Studies, 119 pp.

Castles, I. and D. Henderson. 2003. "The IPCC Emission Scenarios: An Economic-Statistical Critique." *Energy and Environment* 14(2-3): 159-185.

Chetty, R. 2006. "A New Method of Estimating Risk Aversion." *American Economic Review* 96(5): 1821–1834.

Dasgupta P. 2006. "Comments on the Stern Review's economics of climate change." University of Cambridge working paper.

Dasgupta P. 2008. "Discounting climate change." *Journal of Risk and Uncertainty* 37:141-169.

Easterling, W., et al. 2007. *Climate Change 2007: Impacts, Adaptation, and Vulnerability*. Intergovernmental Panel on Climate Change, 976 pp. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm, last accessed March 25, 2010.

Evans D., and H. Sezer. 2005. "Social discount rates for member countries of the European Union." *J. Econ. Stud*. 32 47–59.

Forest, C., et al. 2002. “Quantifying uncertainties in climate system properties with the use of recent observations.” *Science* 295, 113.

Forest, D., P. Stone, and A. Sokolov. 2006. “Estimated PDFs of climate system properties including natural and anthropogenic forcings.” *Geophys. Res. Lett*., 33, L01705.

Forster, P., and J. Gregory. 2006. “The climate sensitivity and its components diagnosed from Earth radiation budget data.” *J. Clim*., 19, 39–52.

Frame, D., et al. 2005. “Constraining climate forecasts: The role of prior assumptions.” *Geophys. Res. Lett*., 32, L09702.

Gingerich, P. 2006. “Environment and evolution through the Paleocene-Eocene thermal maximum.” *Trends Ecol. Evol.* 21: 246-253.

Gollier, C. 2008. “Discounting with fat-tailed economic growth.” *Journal of Risk and Uncertainty* 37:171-186.

Gollier, C. and M. Weitzman (2009). "How Should the Distant Future be Discounted When Discount Rates are Uncertain?" Harvard University, mimeo, Nov 2009.

Gregory, J., et al. 2002a. “An observationally based estimate of the climate sensitivity.” *J. Clim*., 15(22), 3117–3121.

Groom, B., Koundouri, P., Panipoulou, E., Pantelidis, T. 2006. “An econometric approach to estimating long-run discount rates.” *Journal of Applied Econometrics.*

Hall R, and C. Jones . 2007. “The value of life and the rise in health spending.” Quarterly *Journal of Economics* 122(1):39-72.

Hansen, J.,M. Sato, P. Kharecha, G. Russell, D. W. Lea and M. Siddall. 2007. “Climate change and trace gases.” *Phil. Trans. Roy. Soc. A* 365: 1925-1954.

Hegerl G, et al. 2007. “Understanding and attributing climate change.” in Solomon S, et al. (eds) *Climate Change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html

Hegerl, G., T. Crowley, W. Hyde, and D. Frame. 2006. “Constraints on climate sensitivity from temperature reconstructions of the past seven centuries.” *Nature* 440.

Holtsmark, B., and K. Alfsen. 2005. “PPP Correction of the IPCC Emission Scenarios – Does it Matter?” *Climatic Change* 68(1-2): 11-19.

Hope C. 2006. “The marginal impact of CO2 from PAGE2002: an integrated assessment model incorporating the IPCC’s five reasons for concern.” *The Integrated Assessment Journal* 6(1):19-56.

Hope C. 2008. “Optimal carbon emissions and the social cost of carbon under uncertainty.” *The Integrated Assessment Journal* 8(1):107-122.

Intergovernmental Panel on Climate Change (2007). “Summary for Policymakers.” In *Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Just, R., D. Hueth, and A. Schmitz. 2004. *The Welfare Economics of Public Policy*. Glos UK: Edward Elgar Publishing Limited.

Knutti, R., T. Stocker, F. Joos, and G. Plattner. 2002. “Constraints on radiative forcing and future climate change from observations and climate model ensembles.” *Nature*, 416, 719–723.

Kriegler, E. et al. 2009. “Imprecise probability assessment of tipping points in the climate system.” *Proc. Natl. Acad. Sci.* 106: 5041-5046.

Kotlikoff, L. and D. Rapson. 2006. “Does It Pay, at the Margin, to Work and Save? – Measuring Effective Marginal Taxes on Americans’ Labor Supply and Saving.” National Bureau of Economic Research, Working Paper, No. 12533.

Le Treut H., et al. 2007. “Historical Overview of Climate Change.” in Solomon et al., *Climate Change 2007*.

Lenton, T., et al. 2008. “Tipping elements in the Earth’s climate system.” *Proc. Natl. Acad. Sci.* 105: 1786-1793.

Levy, M., et al. 2005. “Ecosystem conditions and human well-being.” In: *Ecosystems and Human Well-being: Current State and Trends, Volume 1.* [R. Hassan, R. Scholes, and N. Ash, eds.] Washington: Island Press. pp. 123-164.

Lind, R. 1990. “Reassessing the Government’s Discount Rate Policy in Light of New Theory and Data in a World Economy with a High Degree of Capital Mobility.” *Journal of Environmental Economics and Management* 18, S-8-S-28.

Mastrandre, M. 2009. “Calculating the benefits of climate policy: Examining the assumptions of Integrated Assessment Models.” Pew Center on Global Climate Change Working Paper, 60 pp.

Meehl, G, et al. 2007. “Global Climate Projections.” in Solomon et al., *Climate Change 2007*.

National Research Council (2009). *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*. National Academies Press.

Newbold S, Daigneault A. 2009. “Climate response uncertainty and the benefits of greenhouse gas emissions reductions.” *Environmental and Resource Economics* 44:351-377.

Newell, R., and W. Pizer. 2003. Discounting the distant future: how much do uncertain rates increase valuations? *Journal of Environmental Economics and Management* 46: 52-71.

Nordhaus, W. 1994. “Expert Opinion on Climate Change.” *American Scientist* 82: 45-51.

Nordhaus, W. 2007a. *Accompanying notes and documentation on development of DICE-2007 model: notes on DICE-2007.delta.v8 as of September 21, 2007.*

Nordhaus, W. 2007b. “Alternative measures of output in global economic-environmental models: Purchasing power parity or market exchange rates?” *Energy Economics* 29: 349-372.

Nordhaus W. 2008. *A Question of Balance: Weighing the Options on Global Warming Policies*. New Haven, CT: Yale University Press.

Nordhaus, W. 2009. “An Analysis of the Dismal Theorem. Cowles Foundation Discussion Paper. No. 1686. January.

Nordhaus W., and Boyer J. 2000. *Warming the World: Economic Models of Global Warming*. Cambridge, MA: MIT Press.

Pindyck, R. 2009. “Uncertain Outcomes and Climate Change Policy.” NBER Working Paper, No. 15259. August.

Ramsey, F. 1928. “A Mathematical Theory of Saving.” *The Economic Journal* 38(152): 543-559.

Roe, G. 2008. “Feedbacks, timescales, and seeing red.” *Annual Review of Earth and Planetary Sciences* 37:5.1-5.23.

Roe, G., and M. Baker. 2007. “Why is climate sensitivity so unpredictable?” *Science* 318:629-632.

Schneider von Deimling, T., H. Held, A. Ganopolski, and S. Rahmstorf. 2006. “Climate sensitivity estimated from ensemble simulations of glacial climate.” *Clim. Dyn.*, 27, 149–163.

Smith, J. et al. 2009. “Transient dwarfism of soil fauna during the Paleocene-Eocene Thermal Maximum.” *Proc. Natl. Acad. Sci.* 106: 17665-17660.

Stern, N., et al. (2006), *Stern Review: The Economics of Climate Change*, HM Treasury, London. See http://www.hm-treasury.gov.uk/stern_review_report.htm, last accessed March 25, 2010.

Stern N. 2008. “The economics of climate change.” *American Economic Review* 98(2):1-37.

Sterner, T., and U. Persson. 2008. An even Sterner review: Introducing relative prices into the discounting debate. *Rev. Env. Econ. Pol.* 2: 61-76.

Summers, L., and R. Zeckhauser. 2008. “Policymaking for Posterity.” Journal of Risk and Uncertainty 37: 115-140.

Szpiro, G. 1986. “Measuring Risk Aversion: An Alternative Approach.” *The Review of Economics and Statistics* 68(1): 156-9.

Tol, R. 2002a. “Estimates of the damage costs of climate change. Part I: benchmark estimates.” *Environmental and Resource Economics* 21:47-73.

Tol, R. 2002b. “Estimates of the damage costs of climate change. Part II: dynamic estimates.” *Environmental and Resource Economics* 21:135-160.

Tol, R. 2006. “Exchange Rates and Climate Change: An Application of FUND.” *Climatic Change* 75(1-2): 59-80.

Tol, R. 2009. "An analysis of mitigation as a response to climate change." Copenhagen Consensus on Climate. Discussion Paper.

U.S. Department of Defense. 2010. Quadrennial Defense Review Report. February.

Warren, R., et al. 2006. "Spotlight Impact Functions in Integrated Assessment." Tyndall Center for Climate Change Research, Working Paper 91.

Weitzman, M. 2009. "On modeling and interpreting the economics of catastrophic climate change." *Review of Economics and Statistics* 91:1-19.

Weitzman, M. 2007. "A review of The Stern Review of the Economics of Climate Change*." Journal of Economic Literature* 45:703-724.

Weitzman, M. 1999. In Portney P.R. and Weyant J.P. (eds.), *Discounting and Intergenerational Equity*, Resources for the Future, Washington, D.C.

Weitzman, M. 1998. "Why the Far-Distant Future Should Be Discounted at Its Lowest Possible Rate." *Journal of Environmental Economics and Management* 36 (3): 201-208.

Wing, S. et al. 2005. "Transient floral change and rapid global warming at the Paleocene-Eocene boundary." *Science* 310: 993-996.

Appendix

Table A1: Annual SCC Values: 2010–2050 (in 2007 dollars)

Discount Rate Year	5% Avg	3% Avg	2.5% Avg	3% 95th
2010	4.7	21.4	35.1	64.9
2011	4.9	21.9	35.7	66.5
2012	5.1	22.4	36.4	68.1
2013	5.3	22.8	37.0	69.6
2014	5.5	23.3	37.7	71.2
2015	5.7	23.8	38.4	72.8
2016	5.9	24.3	39.0	74.4
2017	6.1	24.8	39.7	76.0
2018	6.3	25.3	40.4	77.5
2019	6.5	25.8	41.0	79.1
2020	6.8	26.3	41.7	80.7
2021	7.1	27.0	42.5	82.6
2022	7.4	27.6	43.4	84.6
2023	7.7	28.3	44.2	86.5
2024	7.9	28.9	45.0	88.4
2025	8.2	29.6	45.9	90.4
2026	8.5	30.2	46.7	92.3
2027	8.8	30.9	47.5	94.2
2028	9.1	31.5	48.4	96.2
2029	9.4	32.1	49.2	98.1
2030	9.7	32.8	50.0	100.0
2031	10.0	33.4	50.9	102.0
2032	10.3	34.1	51.7	103.9
2033	10.6	34.7	52.5	105.8
2034	10.9	35.4	53.4	107.8
2035	11.2	36.0	54.2	109.7
2036	11.5	36.7	55.0	111.6
2037	11.8	37.3	55.9	113.6
2038	12.1	37.9	56.7	115.5
2039	12.4	38.6	57.5	117.4
2040	12.7	39.2	58.4	119.3
2041	13.0	39.8	59.0	121.0
2042	13.3	40.4	59.7	122.7
2043	13.6	40.9	60.4	124.4
2044	13.9	41.5	61.0	126.1
2045	14.2	42.1	61.7	127.8
2046	14.5	42.6	62.4	129.4
2047	14.8	43.2	63.0	131.1
2048	15.1	43.8	63.7	132.8
2049	15.4	44.4	64.4	134.5
2050	15.7	44.9	65.0	136.2

This Appendix also provides additional technical information about the non-CO_2 emission projections used in the modeling and the method for extrapolating emissions forecasts through 2300, and shows the full distribution of 2010 SCC estimates by model and scenario combination.

1. Other (non-CO_2) gases

In addition to fossil and industrial CO_2 emissions, each EMF scenario provides projections of methane (CH_4), nitrous oxide (N_2O), fluorinated gases, and net land use CO_2 emissions to 2100. These assumptions are used in all three IAMs while retaining each model's default radiative forcings (RF) due to other factors (e.g., aerosols and other gases). Specifically, to obtain the RF associated with the non-CO_2 EMF emissions only, we calculated the RF associated with the EMF atmospheric CO_2 concentrations and subtracted them from the EMF total RF.[30] This approach respects the EMF scenarios as much as possible and at the same time takes account of those components not included in the EMF projections. Since each model treats non-CO_2 gases differently (e.g., DICE lumps all other gases into one composite exogenous input), this approach was applied slightly differently in each of the models.

FUND: Rather than relying on RF for these gases, the actual emissions from each scenario were used in FUND. The model default trajectories for CH_4, N_20, SF_6, and the CO_2 emissions from land were replaced with the EMF values.

PAGE: PAGE models CO_2, CH_4, sulfur hexafluoride (SF_6), and aerosols and contains an "excess forcing" vector that includes the RF for everything else. To include the EMF values, we removed the default CH_4 and SF_6 factors[31], decomposed the excess forcing vector, and constructed a new excess forcing vector that includes the EMF RF for CH_4, N_20, and fluorinated gases, as well as the model default values for aerosols and other factors. Net land use CO_2 emissions were added to the fossil and industrial CO_2 emissions pathway.

DICE: DICE presents the greatest challenge because all forcing due to factors other than industrial CO_2 emissions is embedded in an exogenous non-CO_2 RF vector. To decompose this exogenous forcing path into EMF non-CO_2 gases and other gases, we relied on the references in DICE2007 to the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4) and the discussion of aerosol forecasts in the IPCC's Third Assessment Report (TAR) and in AR4, as explained below. In DICE2007, Nordhaus assumes that exogenous forcing from all non-CO_2 sources is -0.06 W/m^2 in 2005, as reported in AR4, and increases linearly to 0.3 W/m^2 in 2105, based on GISS projections, and then stays constant after that time.

[30] Note EMF did not provide CO_2 concentrations for the IMAGE reference scenario. Thus, for this scenario, we fed the fossil, industrial and land CO_2 emissions into MAGICC (considered a "neutral arbiter" model, which is tuned to emulate the major global climate models) and the resulting CO_2 concentrations were used. Note also that MERGE assumes a neutral biosphere so net land CO_2 emissions are set to zero for all years for the MERGE Optimistic reference scenario, and for the MERGE component of the average 550 scenario (i.e., we add up the land use emissions from the other three models and divide by 4).

[31] Both the model default CH_4 emissions and the initial atmospheric CH_4 is set to zero to avoid double counting the effect of past CH_4 emissions.

According to AR4, the RF in 2005 from CH_4, N_20, and halocarbons (approximately similar to the F-gases in the EMF-22 scenarios) was 0.48 + 0.16 + 0.34 = 0.98 W/m^2 and RF from total aerosols was -1.2 W/m^2. Thus, the -.06 W/m^2 non-CO_2 forcing in DICE can be decomposed into: 0.98 W/m^2 due to the EMF non-CO_2 gases, -1.2 W/m^2 due to aerosols, and the remainder, 0.16 W/m^2, due to other residual forcing.

For subsequent years, we calculated the DICE default RF from aerosols and other non-CO_2 gases based on the following two assumptions:

(1) RF from aerosols declines linearly from 2005 to 2100 at the rate projected by the TAR and then stays constant thereafter, and
(2) With respect to RF from non-CO_2 gases not included in the EMF-22 scenarios, the share of non-aerosol RF matches the share implicit in the AR4 summary statistics cited above and remains constant over time.

Assumption (1) means that the RF from aerosols in 2100 equals 66 percent of that in 2000, which is the fraction of the TAR projection of total RF from aerosols (including sulfates, black carbon, and organic carbon) in 2100 vs. 2000 under the A1B SRES emissions scenario. Since the SRES marker scenarios were not updated for the AR4, the TAR provides the most recent IPCC projection of aerosol forcing. We rely on the A1B projection from the TAR because it provides one of the lower aerosol forecasts among the SRES marker scenarios and is more consistent with the AR4 discussion of the post-SRES literature on aerosols:

Aerosols have a net cooling effect and the representation of aerosol and aerosol precursor emissions, including sulphur dioxide, black carbon and organic carbon, has improved in the post-SRES scenarios. Generally, these emissions are projected to be lower than reported in SRES. {WGIII 3.2, TS.3, SPM}.[32]

Assuming a simple linear decline in aerosols from 2000 to 2100 also is more consistent with the recent literature on these emissions. For example, Figure A1 shows that the sulfur dioxide emissions peak over the short-term of some SRES scenarios above the upper bound estimates of the more recent scenarios.[33] Recent scenarios project sulfur emissions to peak earlier and at lower levels compared to the SRES in part because of new information about present and planned sulfur legislation in some developing countries, such as India and China.[34] The lower bound projections of the recent literature have also shifted downward slightly compared to the SRES scenario (IPCC 2007).

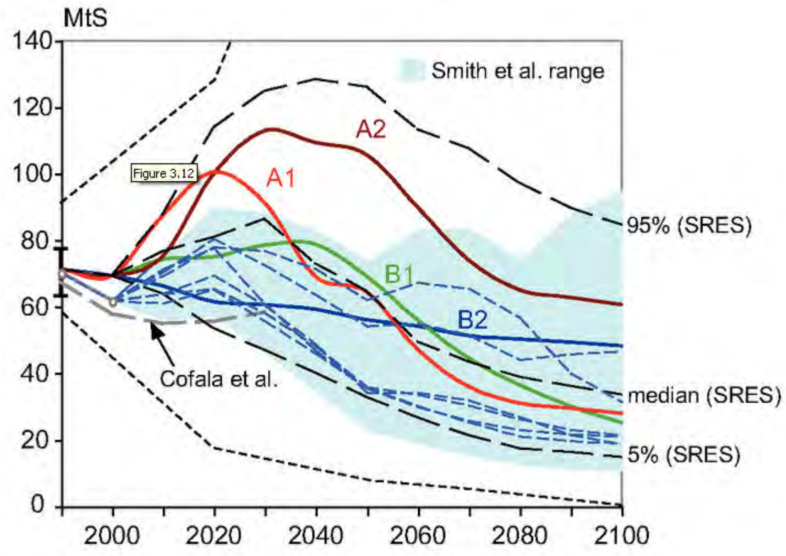
[32] AR4 Synthesis Report, p. 44, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

[33] See Smith, S.J., R. Andres, E. Conception, and J. Lurz, 2004: Historical sulfur dioxide emissions, 1850-2000: methods and results. Joint Global Research Institute, College Park, 14 pp.

[34] See Carmichael, G., D. Streets, G. Calori, M. Amann, M. Jacobson, J. Hansen, and H. Ueda, 2002: Changing trends in sulphur emissions in Asia: implications for acid deposition, air pollution, and climate. Environmental Science and Technology, 36(22):4707- 4713; Streets, D., K. Jiang, X. Hu, J. Sinton, X.-Q. Zhang, D. Xu, M. Jacobson, and J. Hansen, 2001: Recent reductions in China's greenhouse gas emissions. Science, 294(5548): 1835-1837.

With these assumptions, the DICE aerosol forcing changes from -1.2 in 2005 to -0.792 in 2105 W/m^2; forcing due to other non-CO_2 gases not included in the EMF scenarios declines from 0.160 to 0.153 W/m^2.

Figure A1: Sulphur Dioxide Emission Scenarios -



Notes: Thick colored lines depict the four SRES marker scenarios and black dashed lines show the median, 5th and 95th percentile of the frequency distribution for the full ensemble of 40 SRES scenarios. The blue area (and the thin dashed lines in blue) illustrates individual scenarios and the range of Smith et al. (2004). Dotted lines indicate the minimum and maximum of SO_2 emissions scenarios developed pre-SRES.
Source: IPCC (2007), AR4 WGIII 3.2, http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch3-ens3-2-2-4.html.

Although other approaches to decomposing the DICE exogenous forcing vector are possible, initial sensitivity analysis suggests that the differences among reasonable alternative approaches are likely to be minor. For example, adjusting the TAR aerosol projection above to assume that aerosols will be maintained at 2000 levels through 2100 reduces average SCC values (for 2010) by approximately 3 percent (or less than $2); assuming all aerosols are phased out by 2100 increases average 2010 SCC values by 6-7 percent (or $0.50-$3)–depending on the discount rate. These differences increase slightly for SCC values in later years but are still well within 10 percent of each other as far out as 2050.

Finally, as in PAGE, the EMF net land use CO_2 emissions are added to the fossil and industrial CO_2 emissions pathway.

2. - Extrapolating Emissions Projections to 2300

To run each model through 2300 requires assumptions about GDP, population, greenhouse gas emissions, and radiative forcing trajectories after 2100, the last year for which these projections are available from the EMF-22 models. These inputs were extrapolated from 2100 to 2300 as follows:

1. Population growth rate declines linearly, reaching zero in the year 2200.
2. GDP/ per capita growth rate declines linearly, reaching zero in the year 2300.
3. The decline in the fossil and industrial carbon intensity (CO_2/GDP) growth rate over 2090-2100 is maintained from 2100 through 2300.
4. Net land use CO_2 emissions decline linearly, reaching zero in the year 2200.
5. Non-CO_2 radiative forcing remains constant after 2100.

Long run stabilization of GDP per capita was viewed as a more realistic simplifying assumption than a linear or exponential extrapolation of the pre-2100 economic growth rate of each EMF scenario. This is based on the idea that increasing scarcity of natural resources and the degradation of environmental sinks available for assimilating pollution from economic production activities may eventually overtake the rate of technological progress. Thus, the overall rate of economic growth may slow over the very long run. The interagency group also considered allowing an exponential decline in the growth rate of GDP per capita. However, since this would require an additional assumption about how close to zero the growth rate would get by 2300, the group opted for the simpler and more transparent linear extrapolation to zero by 2300.

The population growth rate is also assumed to decline linearly, reaching zero by 2200. This assumption is reasonably consistent with the United Nations long run population forecast, which estimates global population to be fairly stable after 2150 in the medium scenario (UN 2004).[35] The resulting range of EMF population trajectories (Figure A2) also encompass the UN medium scenario forecasts through 2300 – global population of 8.5 billion by 2200, and 9 billion by 2300.

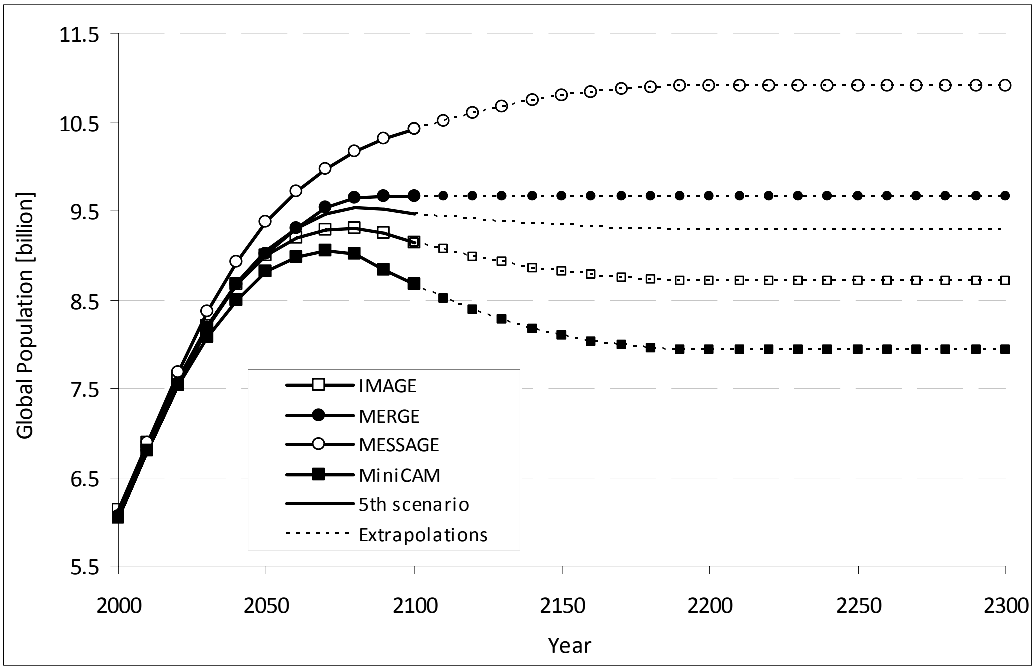
Maintaining the decline in the 2090-2100 carbon intensity growth rate (i.e., CO_2 per dollar of GDP) through 2300 assumes that technological improvements and innovations in the areas of energy efficiency and other carbon reducing technologies (possibly including currently unavailable methods) will continue to proceed at roughly the same pace that is projected to occur towards the end of the forecast period for each EMF scenario. This assumption implies that total cumulative emissions in 2300 will be between 5,000 and 12,000 GtC, which is within the range of the total potential global carbon stock estimated in the literature.

Net land use CO_2 emissions are expected to stabilize in the long run, so in the absence of any post 2100 projections, the group assumed a linear decline to zero by 2200. Given no a priori reasons for assuming a long run increase or decline in non-CO_2 radiative forcing, it is assumed to remain at the 2100 levels for each EMF scenario through 2300.

Figures A2-A7 show the paths of global population, GDP, fossil and industrial CO_2 emissions, net land CO_2 emissions, non-CO_2 radiative forcing, and CO_2 intensity (fossil and industrial CO_2 emissions/GDP) resulting from these assumptions.

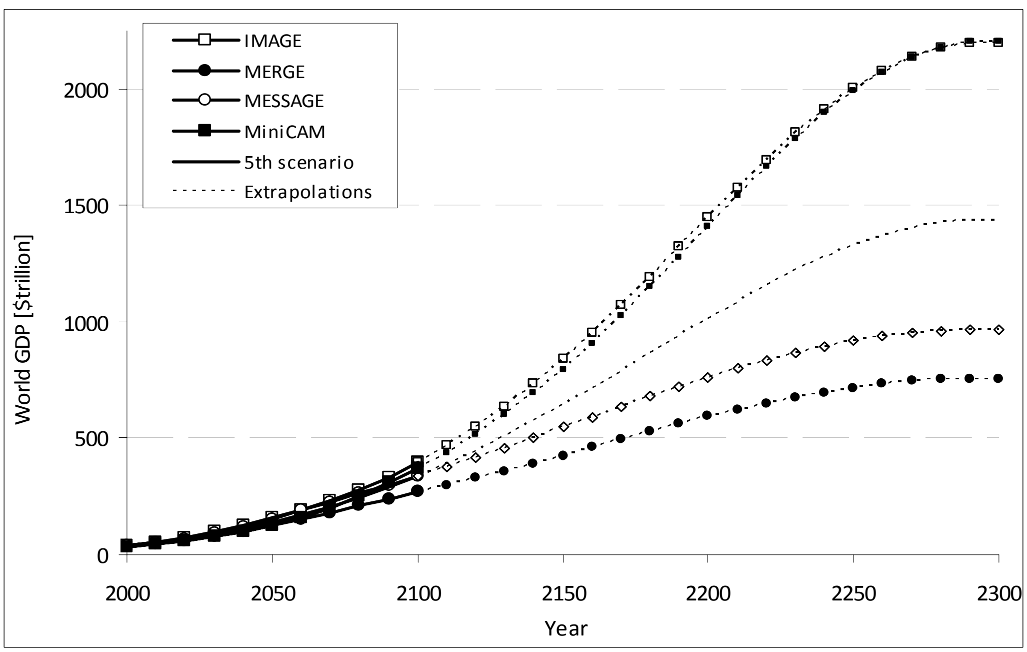
[35] United Nations. 2004. *World Population to 2300*.
http://www.un.org/esa/population/publications/longrange2/worldpop2300final.pdf

Figure A2. Global Population, 2000-2300 (Post-2100 extrapolations assume the population growth - rate changes linearly to reach a zero growth rate by 2200.) -



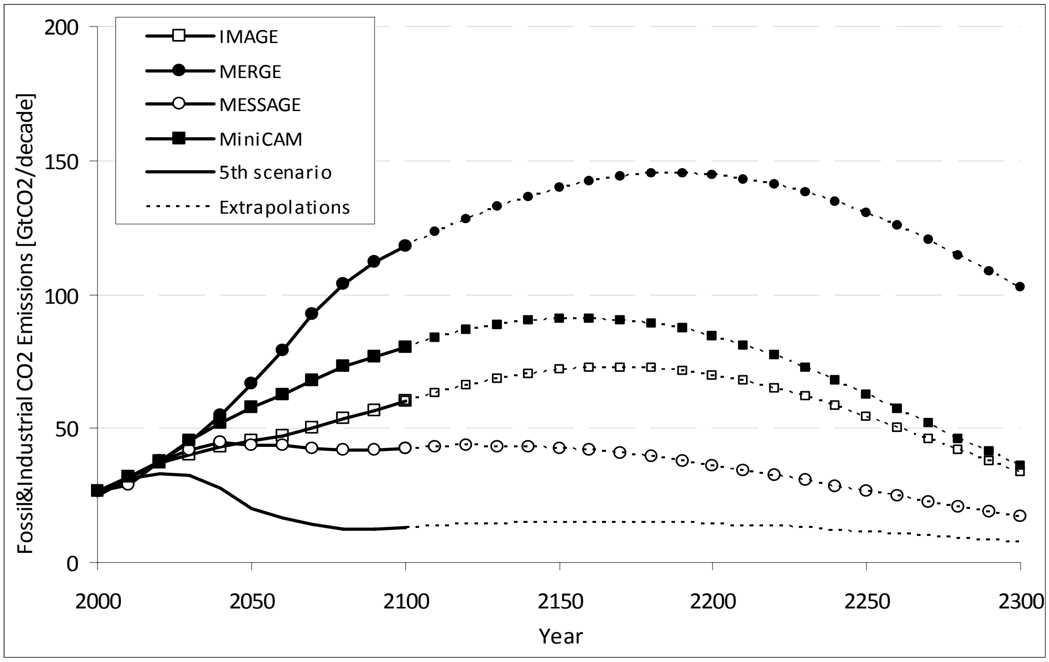
Note: In the fifth scenario, 2000-2100 population is equal to the average of the population under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A3. World GDP, 2000-2300 (Post-2100 extrapolations assume GDP per capita growth declines linearly, reaching zero in the year 2300)



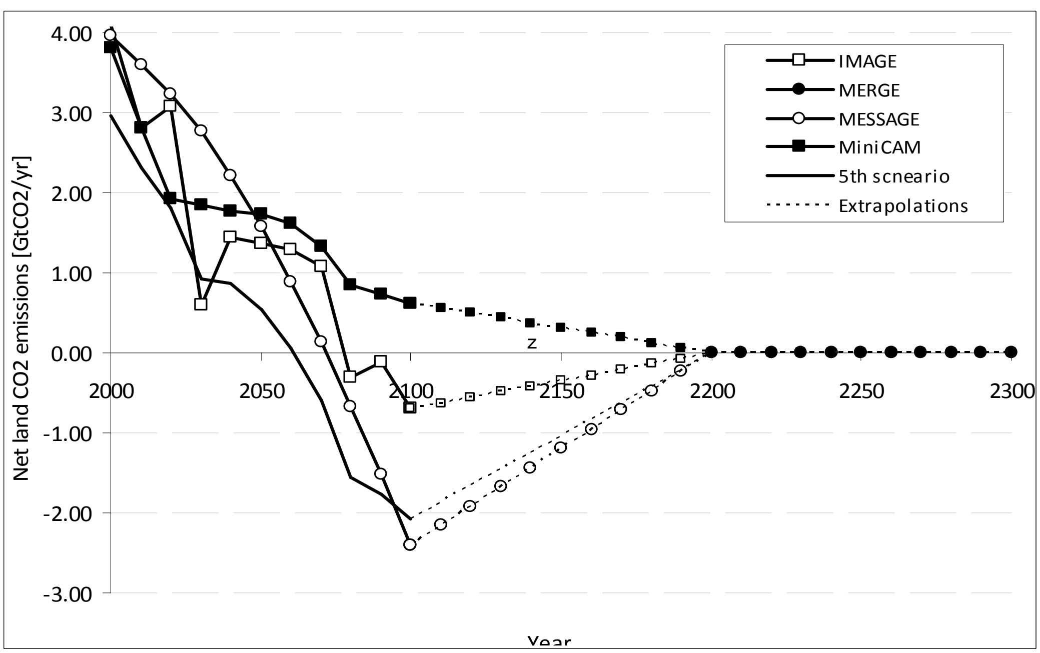
Note: In the fifth scenario, 2000-2100 GDP is equal to the average of the GDP under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A4. Global Fossil and Industrial CO_2 Emissions, 2000-2300 (Post-2100 extrapolations assume growth rate of CO_2 intensity (CO_2/GDP) over 2090-2100 is maintained through 2300.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A5. Global Net Land Use CO_2 Emissions, 2000-2300 (Post-2100 extrapolations assume emissions decline linearly, reaching zero in the year 2200)[36]



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

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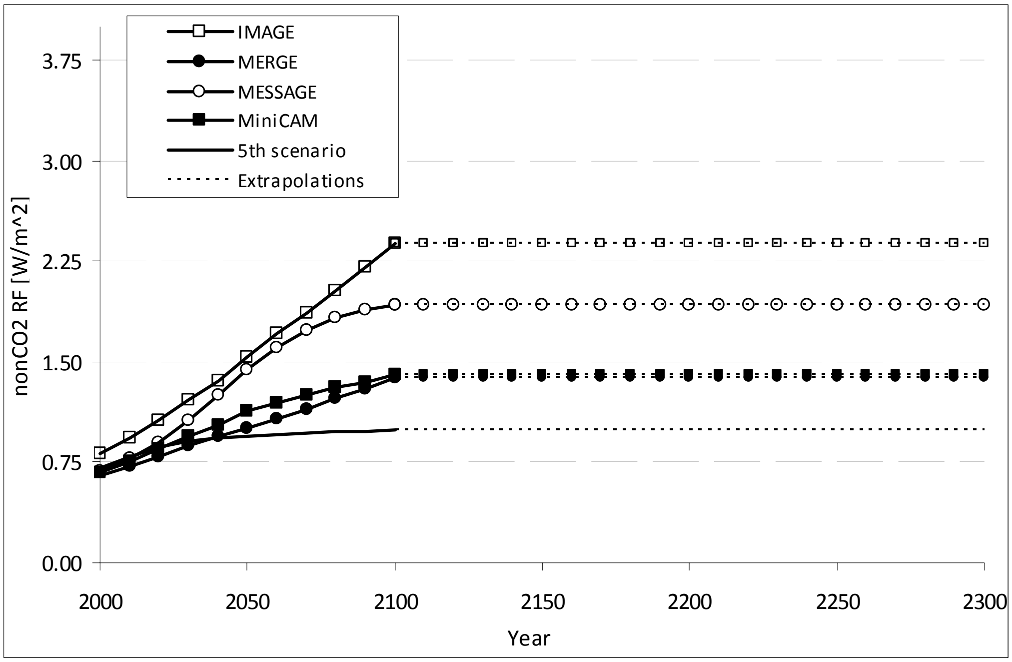
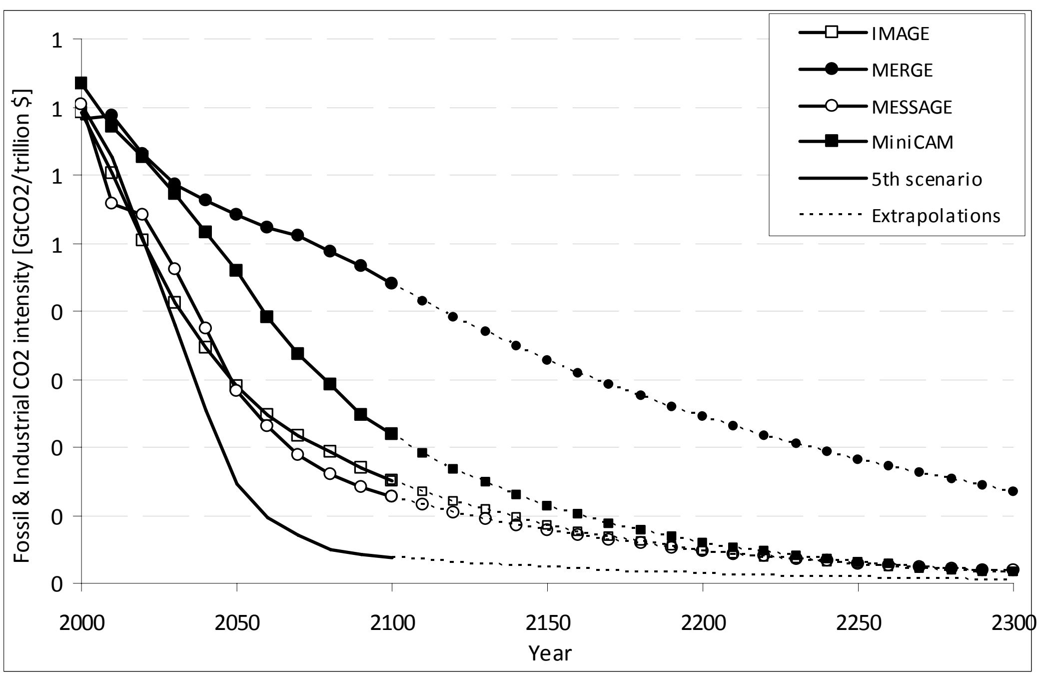
[36] MERGE assumes a neutral biosphere so net land CO_2 emissions are set to zero for all years for the MERGE Optimistic reference scenario, and for the MERGE component of the average 550 scenario (i.e., we add up the land use emissions from the other three models and divide by 4).

Figure A6. Global Non-CO_2 Radiative Forcing, 2000-2300 (Post-2100 extrapolations assume constant non-CO_2 radiative forcing after 2100.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A7. Global CO_2 Intensity (fossil & industrial CO_2 emissions/GDP), 2000-2300 (Post-2100 extrapolations assume decline in CO_2/GDP growth rate over 2090-2100 is maintained through 2300.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Table A2. 2010 Global SCC Estimates at 2.5 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario					**PAGE**					
IMAGE	3.3	5.9	8.1	13.9	28.8	65.5	68.2	147.9	239.6	563.8
MERGE optimistic	1.9	3.2	4.3	7.2	14.6	34.6	36.2	79.8	124.8	288.3
Message	2.4	4.3	5.8	9.8	20.3	49.2	50.7	114.9	181.7	428.4
MiniCAM base	2.7	4.6	6.4	11.2	22.8	54.7	55.7	120.5	195.3	482.3
5th scenario	2.0	3.5	4.7	8.1	16.3	42.9	41.5	103.9	176.3	371.9
Scenario					**DICE**					
IMAGE	16.4	21.4	25	33.3	46.8	54.2	69.7	96.3	111.1	130.0
MERGE optimistic	9.7	12.6	14.9	19.7	27.9	31.6	40.7	54.5	63.5	73.3
Message	13.5	17.2	20.1	27	38.5	43.5	55.1	75.8	87.9	103.0
MiniCAM base	13.1	16.7	19.8	26.7	38.6	44.4	56.8	79.5	92.8	109.3
5th scenario	10.8	14	16.7	22.2	32	37.4	47.7	67.8	80.2	96.8
Scenario					**FUND**					
IMAGE	-33.1	-18.9	-13.3	-5.5	4.1	19.3	18.7	43.5	67.1	150.7
MERGE optimistic	-33.1	-14.8	-10	-3	5.9	14.8	20.4	43.9	65.4	132.9
Message	-32.5	-19.8	-14.6	-7.2	1.5	8.8	13.8	33.7	52.3	119.2
MiniCAM base	-31.0	-15.9	-10.7	-3.4	6	22.2	21	46.4	70.4	152.9
5th scenario	-32.2	-21.6	-16.7	-9.7	-2.3	3	6.7	20.5	34.2	96.8

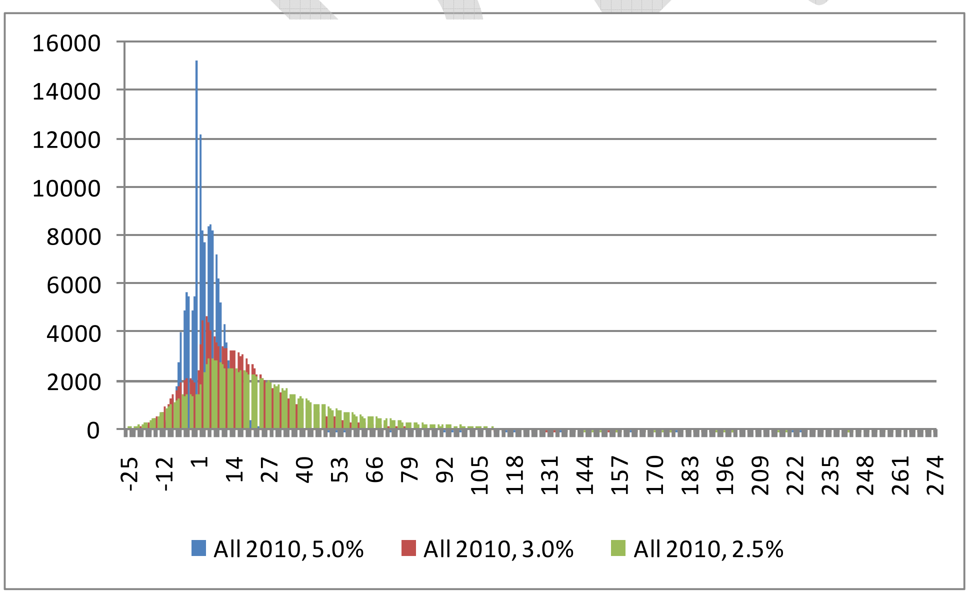
Table A3. 2010 Global SCC Estimates at 3 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario					**PAGE**					
IMAGE	2.0	3.5	4.8	8.1	16.5	39.5	41.6	90.3	142.4	327.4
MERGE optimistic	1.2	2.1	2.8	4.6	9.3	22.3	22.8	51.3	82.4	190.0
Message	1.6	2.7	3.6	6.2	12.5	30.3	31	71.4	115.6	263.0
MiniCAM base	1.7	2.8	3.8	6.5	13.2	31.8	32.4	72.6	115.4	287.0
5th scenario	1.3	2.3	3.1	5	9.6	25.4	23.6	62.1	104.7	222.5
Scenario					**DICE**					
IMAGE	11.0	14.5	17.2	22.8	31.6	35.8	45.4	61.9	70.8	82.1
MERGE optimistic	7.1	9.2	10.8	14.3	19.9	22	27.9	36.9	42.1	48.8
Message	9.7	12.5	14.7	19	26.6	29.8	37.8	51.1	58.6	67.4
MiniCAM base	8.8	11.5	13.6	18	25.2	28.8	36.9	50.4	57.9	67.8
5th scenario	7.9	10.1	11.8	15.6	21.6	24.9	31.8	43.7	50.8	60.6
Scenario					**FUND**					
IMAGE	-25.2	-15.3	-11.2	-5.6	0.9	8.2	10.4	25.4	39.7	90.3
MERGE optimistic	-24.0	-12.4	-8.7	-3.6	2.6	8	12.2	27	41.3	85.3
Message	-25.3	-16.2	-12.2	-6.8	-0.5	3.6	7.7	20.1	32.1	72.5
MiniCAM base	-23.1	-12.9	-9.3	-4	2.4	10.2	12.2	27.7	42.6	93.0
5th scenario	-24.1	-16.6	-13.2	-8.3	-3	-0.2	2.9	11.2	19.4	53.6

Table A4. 2010 Global SCC Estimates at 5 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario					PAGE					
IMAGE	0.5	0.8	1.1	1.8	3.5	8.3	8.5	19.5	31.4	67.2
MERGE optimistic	0.3	0.5	0.7	1.2	2.3	5.2	5.4	12.3	19.5	42.4
Message	0.4	0.7	0.9	1.6	3	7.2	7.2	17	28.2	60.8
MiniCAM base	0.3	0.6	0.8	1.4	2.7	6.4	6.6	15.9	24.9	52.6
5th scenario	0.3	0.6	0.8	1.3	2.3	5.5	5	12.9	22	48.7
Scenario					DICE					
IMAGE	4.2	5.4	6.2	7.6	10	10.8	13.4	16.8	18.7	21.1
MERGE optimistic	2.9	3.7	4.2	5.3	7	7.5	9.3	11.7	12.9	14.4
Message	3.9	4.9	5.5	7	9.2	9.8	12.2	15.4	17.1	18.8
MiniCAM base	3.4	4.2	4.7	6	7.9	8.6	10.7	13.5	15.1	16.9
5th scenario	3.2	4	4.6	5.7	7.6	8.2	10.2	12.8	14.3	16.0
Scenario					FUND					
IMAGE	-11.7	-8.4	-6.9	-4.6	-2.2	-1.3	0.7	4.1	7.4	17.4
MERGE optimistic	-10.6	-7.1	-5.6	-3.6	-1.3	-0.3	1.6	5.4	9.1	19.0
Message	-12.2	-8.9	-7.3	-4.9	-2.5	-1.9	0.3	3.5	6.5	15.6
MiniCAM base	-10.4	-7.2	-5.8	-3.8	-1.5	-0.6	1.3	4.8	8.2	18.0
5th scenario	-10.9	-8.3	-7	-5	-2.9	-2.7	-0.8	1.4	3.2	9.2

Figure A8. Histogram of Global SCC Estimates in 2010 (2007$/ton CO_2), by discount rate



* The distribution of SCC values ranges from -$5,192 to $66,116 but the X-axis has been truncated at approximately the 1st and 99th percentiles to better show the data.

Table A5. Additional Summary Statistics of 2010 Global SCC Estimates -

Discount rate:	5%				3%				2.5%			
Scenario	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
DICE	9.0	13.1	0.8	0.2	28.3	209.8	1.1	0.9	42.2	534.9	1.2	1.1
PAGE	6.5	136.0	6.3	72.4	29.8	3,383.7	8.6	151.0	49.3	9,546.0	8.7	143.8
FUND	-1.3	70.1	28.2	1,479.0	6.0	16,382.5	128.0	18,976.5	13.6	150,732.6	149.0	23,558.3

Exhibit 3

Technical Support Document: -
Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis -
Under Executive Order 12866 -

Interagency Working Group on Social Cost of Carbon, United States Government

With participation by

Council of Economic Advisers
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Energy
Department of Transportation
Domestic Policy Council
Environmental Protection Agency
National Economic Council
Office of Management and Budget
Office of Science and Technology Policy
Department of the Treasury

May 2013

Revised November 2013
See Appendix B for Details on Revision

Executive Summary

Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the "social cost of carbon" (SCC) estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that impact cumulative global emissions. The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.

The interagency process that developed the original U.S. government's SCC estimates is described in the 2010 interagency technical support document (TSD) (Interagency Working Group on Social Cost of Carbon 2010). Through that process the interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC from three integrated assessment models (IAMs), at discount rates of 2.5, 3, and 5 percent. The fourth value, which represents the 95th percentile SCC estimate across all three models at a 3 percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

While acknowledging the continued limitations of the approach taken by the interagency group in 2010, this document provides an update of the SCC estimates based on new versions of each IAM (DICE, PAGE, and FUND). It does not revisit other interagency modeling decisions (e.g., with regard to the discount rate, reference case socioeconomic and emission scenarios, or equilibrium climate sensitivity). Improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves in the peer-reviewed literature.

The SCC estimates using the updated versions of the models are higher than those reported in the 2010 TSD. By way of comparison, the four 2020 SCC estimates reported in the 2010 TSD were $7, $26, $42 and $81 (2007$). The corresponding four updated SCC estimates for 2020 are $12, $43, $64, and $128 (2007$). The model updates that are relevant to the SCC estimates include: an explicit representation of sea level rise damages in the DICE and PAGE models; updated adaptation assumptions, revisions to ensure damages are constrained by GDP, updated regional scaling of damages, and a revised treatment of potentially abrupt shifts in climate damages in the PAGE model; an updated carbon cycle in the DICE model; and updated damage functions for sea level rise impacts, the agricultural sector, and reduced space heating requirements, as well as changes to the transient response of temperature to the buildup of GHG concentrations and the inclusion of indirect effects of methane emissions in the FUND model. The SCC estimates vary by year, and the following table summarizes the revised SCC estimates from 2010 through 2050.

Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	11	32	51	89
2015	11	37	57	109
2020	12	43	64	128
2025	14	47	69	143
2030	16	52	75	159
2035	19	56	80	175
2040	21	61	86	191
2045	24	66	92	206
2050	26	71	97	220

I. Purpose

The purpose of this document is to update the schedule of social cost of carbon (SCC) estimates from the 2010 interagency technical support document (TSD) (Interagency Working Group on Social Cost of Carbon 2010).[1] E.O. 13563 commits the Administration to regulatory decision making "based on the best available science."[2] Additionally, the interagency group recommended in 2010 that the SCC estimates be revisited on a regular basis or as model updates that reflect the growing body of scientific and economic knowledge become available.[3] New versions of the three integrated assessment models used by the U.S. government to estimate the SCC (DICE, FUND, and PAGE), are now available and have been published in the peer reviewed literature. While acknowledging the continued limitations of the approach taken by the interagency group in 2010 (documented in the original 2010 TSD), this document provides an update of the SCC estimates based on the latest peer-reviewed version of the models, replacing model versions that were developed up to ten years ago in a rapidly evolving field. It does not revisit other assumptions with regard to the discount rate, reference case socioeconomic and emission scenarios, or equilibrium climate sensitivity. Improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves in the peer-reviewed literature. The agencies participating in the interagency working group continue to investigate potential improvements to the way in which economic damages associated with changes in CO_2 emissions are quantified.

Section II summarizes the major updates relevant to SCC estimation that are contained in the new versions of the integrated assessment models released since the 2010 interagency report. Section III presents the updated schedule of SCC estimates for 2010 – 2050 based on these versions of the models. Section IV provides a discussion of other model limitations and research gaps.

II. Summary of Model Updates

This section briefly summarizes changes to the most recent versions of the three integrated assessment models (IAMs) used by the interagency group in 2010. We focus on describing those model updates that are relevant to estimating the social cost of carbon, as summarized in Table 1. For example, both the DICE and PAGE models now include an explicit representation of sea level rise damages. Other revisions to PAGE include: updated adaptation assumptions, revisions to ensure damages are constrained by GDP, updated regional scaling of damages, and a revised treatment of potentially abrupt shifts in climate damages. The DICE model's simple carbon cycle has been updated to be more consistent with a more complex climate model. The FUND model includes updated damage functions for sea level rise impacts, the agricultural sector, and reduced space heating requirements, as well as changes to the transient response of temperature to the buildup of GHG concentrations and the inclusion of indirect effects of

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[1] In this document, we present all values of the SCC as the cost per metric ton of CO_2 emissions. Alternatively, one could report the SCC as the cost per metric ton of carbon emissions. The multiplier for translating between mass of CO_2 and the mass of carbon is 3.67 (the molecular weight of CO_2 divided by the molecular weight of carbon = 44/12 = 3.67).

[2] http://www.whitehouse.gov/sites/default/files/omb/inforeg/eo12866/eo13563_01182011.pdf

[3] See p. 1, 3, 4, 29, and 33 (Interagency Working Group on Social Cost of Carbon 2010).

methane emissions. Changes made to parts of the models that are superseded by the interagency working group's modeling assumptions – regarding equilibrium climate sensitivity, discounting, and socioeconomic variables – are not discussed here but can be found in the references provided in each section below.

Table 1: Summary of Key Model Revisions Relevant to the Interagency SCC

IAM	**Version used in 2010 Interagency Analysis**	**New Version**	**Key changes relevant to interagency SCC**
DICE	2007	2010	Updated calibration of the carbon cycle model and explicit representation of sea level rise (SLR) and associated damages.
FUND	3.5 (2009)	3.8 (2012)	Updated damage functions for space heating, SLR, agricultural impacts, changes to transient response of temperature to buildup of GHG concentrations, and inclusion of indirect climate effects of methane.
PAGE	2002	2009	Explicit representation of SLR damages, revisions to damage function to ensure damages do not exceed 100% of GDP, change in regional scaling of damages, revised treatment of potential abrupt damages, and updated adaptation assumptions.

A. DICE

DICE 2010 includes a number of changes over the previous 2007 version used in the 2010 interagency report. The model changes that are relevant for the SCC estimates developed by the interagency working group include: 1) updated parameter values for the carbon cycle model, 2) an explicit representation of sea level dynamics, and 3) a re-calibrated damage function that includes an explicit representation of economic damages from sea level rise. Changes were also made to other parts of the DICE model—including the equilibrium climate sensitivity parameter, the rate of change of total factor productivity, and the elasticity of the marginal utility of consumption—but these components of DICE are superseded by the interagency working group's assumptions and so will not be discussed here. More details on DICE2007 can be found in Nordhaus (2008) and on DICE2010 in Nordhaus (2010). The DICE2010 model and documentation is also available for download from the homepage of William Nordhaus.

Carbon Cycle Parameters

DICE uses a three-box model of carbon stocks and flows to represent the accumulation and transfer of carbon among the atmosphere, the shallow ocean and terrestrial biosphere, and the deep ocean. These parameters are "calibrated to match the carbon cycle in the Model for the Assessment of Greenhouse

Gas Induced Climate Change (MAGICC)" (Nordhaus 2008 p 44).[4] Carbon cycle transfer coefficient values in DICE2010 are based on re-calibration of the model to match the newer 2009 version of MAGICC (Nordhaus 2010 p 2). For example, in DICE2010, in each decade, 12 percent of the carbon in the atmosphere is transferred to the shallow ocean, 4.7 percent of the carbon in the shallow ocean is transferred to the atmosphere, 94.8 percent remains in the shallow ocean, and 0.5 percent is transferred to the deep ocean. For comparison, in DICE 2007, 18.9 percent of the carbon in the atmosphere is transferred to the shallow ocean each decade, 9.7 percent of the carbon in the shallow ocean is transferred to the atmosphere, 85.3 percent remains in the shallow ocean, and 5 percent is transferred to the deep ocean.

The implication of these changes for DICE2010 is in general a weakening of the ocean as a carbon sink and therefore a higher concentration of carbon in the atmosphere than in DICE2007, for a given path of emissions. All else equal, these changes will generally increase the level of warming and therefore the SCC estimates in DICE2010 relative to those from DICE2007.

Sea Level Dynamics

A new feature of DICE2010 is an explicit representation of the dynamics of the global average sea level anomaly to be used in the updated damage function (discussed below). This section contains a brief description of the sea level rise (SLR) module; a more detailed description can be found on the model developer's website.[5] The average global sea level anomaly is modeled as the sum of four terms that represent contributions from: 1) thermal expansion of the oceans, 2) melting of glaciers and small ice caps, 3) melting of the Greenland ice sheet, and 4) melting of the Antarctic ice sheet.

The parameters of the four components of the SLR module are calibrated to match consensus results from the IPCC's Fourth Assessment Report (AR4).[6] The rise in sea level from thermal expansion in each time period (decade) is 2 percent of the difference between the sea level in the previous period and the long run equilibrium sea level, which is 0.5 meters per degree Celsius (°C) above the average global temperature in 1900. The rise in sea level from the melting of glaciers and small ice caps occurs at a rate of 0.008 meters per decade per °C above the average global temperature in 1900.

The contribution to sea level rise from melting of the Greenland ice sheet is more complex. The equilibrium contribution to SLR is 0 meters for temperature anomalies less than 1 °C and increases linearly from 0 meters to a maximum of 7.3 meters for temperature anomalies between 1 °C and 3.5 °C. The contribution to SLR in each period is proportional to the difference between the previous period's sea level anomaly and the equilibrium sea level anomaly, where the constant of proportionality increases with the temperature anomaly in the current period.

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[4] MAGICC is a simple climate model initially developed by the U.S. National Center for Atmospheric Research that has been used heavily by the Intergovernmental Panel on Climate Change (IPCC) to emulate projections from more sophisticated state of the art earth system simulation models (Randall et al. 2007).
[5] Documentation on the new sea level rise module of DICE is available on William Nordhaus' website at: http://nordhaus.econ.yale.edu/documents/SLR_021910.pdf.
[6] For a review of post-IPCC AR4 research on sea level rise, see Nicholls et al. (2011) and NAS (2011).

The contribution to SLR from the melting of the Antarctic ice sheet is -0.001 meters per decade when the temperature anomaly is below 3 °C and increases linearly between 3 °C and 6 °C to a maximum rate of 0.025 meters per decade at a temperature anomaly of 6 °C.

Re-calibrated Damage Function

Economic damages from climate change in the DICE model are represented by a fractional loss of gross economic output in each period. A portion of the remaining economic output in each period (net of climate change damages) is consumed and the remainder is invested in the physical capital stock to support future economic production, so each period's climate damages will reduce consumption in that period and in all future periods due to the lost investment. The fraction of output in each period that is lost due to climate change impacts is represented as one minus a fraction, which is one divided by a quadratic function of the temperature anomaly, producing a sigmoid ("S"-shaped) function.[7] The loss function in DICE2010 has been expanded by adding a quadratic function of SLR to the quadratic function of temperature. In DICE2010 the temperature anomaly coefficients have been recalibrated to avoid double-counting damages from sea level rise that were implicitly included in these parameters in DICE2007.

The aggregate damages in DICE2010 are illustrated by Nordhaus (2010 p 3), who notes that "…damages in the uncontrolled (baseline) [i.e., reference] case … in 2095 are $12 trillion, or 2.8 percent of global output, for a global temperature increase of 3.4 °C above 1900 levels." This compares to a loss of 3.2 percent of global output at 3.4 °C in DICE2007. However, in DICE2010, annual damages are lower in most of the early periods of the modeling horizon but higher in later periods than would be calculated using the DICE2007 damage function. Specifically, the percent difference between damages in the base run of DICE2010 and those that would be calculated using the DICE2007 damage function starts at +7 percent in 2005, decreases to a low of -14 percent in 2065, then continuously increases to +20 percent by 2300 (the end of the interagency analysis time horizon), and to +160 percent by the end of the model time horizon in 2595. The large increases in the far future years of the time horizon are due to the permanence associated with damages from sea level rise, along with the assumption that the sea level is projected to continue to rise long after the global average temperature begins to decrease. The changes to the loss function generally decrease the interagency working group SCC estimates slightly given that relative increases in damages in later periods are discounted more heavily, all else equal.

B. FUND

FUND version 3.8 includes a number of changes over the previous version 3.5 (Narita et al. 2010) used in the 2010 interagency report. Documentation supporting FUND and the model's source code for all versions of the model is available from the model authors.[8] Notable changes, due to their impact on the

[7] The model and documentation, including formulas, are available on the author's webpage at http://www.econ.yale.edu/~nordhaus/homepage/RICEmodels.htm.

[8] http://www.fund-model.org/. This report uses version 3.8 of the FUND model, which represents a modest update to the most recent version of the model to appear in the literature (version 3.7) (Anthoff and Tol, 2013a). For the purpose of computing the SCC, the relevant changes (between 3.7 to 3.8) are associated with improving

SCC estimates, are adjustments to the space heating, agriculture, and sea level rise damage functions in addition to changes to the temperature response function and the inclusion of indirect effects from methane emissions.[9] We discuss each of these in turn.

Space Heating

In FUND, the damages associated with the change in energy needs for space heating are based on the estimated impact due to one degree of warming. These baseline damages are scaled based on the forecasted temperature anomaly's deviation from the one degree benchmark and adjusted for changes in vulnerability due to economic and energy efficiency growth. In FUND 3.5, the function that scales the base year damages adjusted for vulnerability allows for the possibility that in some simulations the benefits associated with reduced heating needs may be an unbounded convex function of the temperature anomaly. In FUND 3.8, the form of the scaling has been modified to ensure that the function is everywhere concave and that there will exist an upper bound on the benefits a region may receive from reduced space heating needs. The new formulation approaches a value of two in the limit of large temperature anomalies, or in other words, assuming no decrease in vulnerability, the reduced expenditures on space heating at any level of warming will not exceed two times the reductions experienced at one degree of warming. Since the reduced need for space heating represents a benefit of climate change in the model, or a negative damage, this change will increase the estimated SCC. This update accounts for a significant portion of the difference in the expected SCC estimates reported by the two versions of the model when run probabilistically.

Sea Level Rise and Land Loss

The FUND model explicitly includes damages associated with the inundation of dry land due to sea level rise. The amount of land lost within a region is dependent upon the proportion of the coastline being protected by adequate sea walls and the amount of sea level rise. In FUND 3.5 the function defining the potential land lost in a given year due to sea level rise is linear in the rate of sea level rise for that year. This assumption implicitly assumes that all regions are well represented by a homogeneous coastline in length and a constant uniform slope moving inland. In FUND 3.8 the function defining the potential land lost has been changed to be a convex function of sea level rise, thereby assuming that the slope of the shore line increases moving inland. The effect of this change is to typically reduce the vulnerability of some regions to sea level rise based land loss, thereby lowering the expected SCC estimate. [10]

Agriculture

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consistency with IPCC AR4 by adjusting the atmospheric lifetimes of CH4 and N2O and incorporating the indirect forcing effects of CH4, along with making minor stability improvements in the sea wall construction algorithm.

[9] The other damage sectors (water resources, space cooling, land loss, migration, ecosystems, human health, and extreme weather) were not significantly updated.

[10] For stability purposes this report also uses an update to the model which assumes that regional coastal protection measures will be built to protect the most valuable land first, such that the marginal benefits of coastal protection is decreasing in the level of protection following Fankhauser (1995).

In FUND, the damages associated with the agricultural sector are measured as proportional to the sector's value. The fraction is bounded from above by one and is made up of three additive components that represent the effects from carbon fertilization, the rate of temperature change, and the level of the temperature anomaly. In both FUND 3.5 and FUND 3.8, the fraction of the sector's value lost due to the level of the temperature anomaly is modeled as a quadratic function with an intercept of zero. In FUND 3.5, the coefficients of this loss function are modeled as the ratio of two random normal variables. This specification had the potential for unintended extreme behavior as draws from the parameter in the denominator approached zero or went negative. In FUND 3.8, the coefficients are drawn directly from truncated normal distributions so that they remain in the range $[0,\infty)$ and $(-\infty,0]$, respectively, ensuring the correct sign and eliminating the potential for divide by zero errors. The means for the new distributions are set equal to the ratio of the means from the normal distributions used in the previous version. In general the impact of this change has been to decrease the range of the distribution while spreading out the distributions' mass over the remaining range relative to the previous version. The net effect of this change on the SCC estimates is difficult to predict.

Transient Temperature Response

The temperature response model translates changes in global levels of radiative forcing into the current expected temperature anomaly. In FUND, a given year's increase in the temperature anomaly is based on a mean reverting function where the mean equals the equilibrium temperature anomaly that would eventually be reached if that year's level of radiative forcing were sustained. The rate of mean reversion defines the rate at which the transient temperature approaches the equilibrium. In FUND 3.5, the rate of temperature response is defined as a decreasing linear function of equilibrium climate sensitivity to capture the fact that the progressive heat uptake of the deep ocean causes the rate to slow at higher values of the equilibrium climate sensitivity. In FUND 3.8, the rate of temperature response has been updated to a quadratic function of the equilibrium climate sensitivity. This change reduces the sensitivity of the rate of temperature response to the level of the equilibrium climate sensitivity, a relationship first noted by Hansen et al. (1985) based on the heat uptake of the deep ocean. Therefore in FUND 3.8, the temperature response will typically be faster than in the previous version. The overall effect of this change is likely to increase estimates of the SCC as higher temperatures are reached during the timeframe analyzed and as the same damages experienced in the previous version of the model are now experienced earlier and therefore discounted less.

Methane

The IPCC AR4 notes a series of indirect effects of methane emissions, and has developed methods for proxying such effects when computing the global warming potential of methane (Forster et al. 2007). FUND 3.8 now includes the same methods for incorporating the indirect effects of methane emissions. Specifically, the average atmospheric lifetime of methane has been set to 12 years to account for the feedback of methane emissions on its own lifetime. The radiative forcing associated with atmospheric methane has also been increased by 40% to account for its net impact on ozone production and stratospheric water vapor. All else equal, the effect of this increased radiative forcing will be to increase the estimated SCC values, due to greater projected temperature anomaly.

C. PAGE

PAGE09 (Hope 2013) includes a number of changes from PAGE2002, the version used in the 2010 SCC interagency report. The changes that most directly affect the SCC estimates include: explicitly modeling the impacts from sea level rise, revisions to the damage function to ensure damages are constrained by GDP, a change in the regional scaling of damages, a revised treatment for the probability of a discontinuity within the damage function, and revised assumptions on adaptation. The model also includes revisions to the carbon cycle feedback and the calculation of regional temperatures.[11] More details on PAGE09 can be found in Hope (2011a, 2011b, 2011c). A description of PAGE2002 can be found in Hope (2006).

Sea Level Rise

While PAGE2002 aggregates all damages into two categories – economic and non-economic impacts -, PAGE09 adds a third explicit category: damages from sea level rise. In the previous version of the model, damages from sea level rise were subsumed by the other damage categories. In PAGE09 sea level damages increase less than linearly with sea level under the assumption that land, people, and GDP are more concentrated in low-lying shoreline areas. Damages from the economic and non-economic sector were adjusted to account for the introduction of this new category.

Revised Damage Function to Account for Saturation

In PAGE09, small initial economic and non-economic benefits (negative damages) are modeled for small temperature increases, but all regions eventually experience economic damages from climate change, where damages are the sum of additively separable polynomial functions of temperature and sea level rise. Damages transition from this polynomial function to a logistic path once they exceed a certain proportion of remaining Gross Domestic Product (GDP) to ensure that damages do not exceed 100 percent of GDP. This differs from PAGE2002, which allowed Eastern Europe to potentially experience large benefits from temperature increases, and which also did not bound the possible damages that could be experienced.

Regional Scaling Factors

As in the previous version of PAGE, the PAGE09 model calculates the damages for the European Union (EU) and then, assumes that damages for other regions are proportional based on a given scaling factor. The scaling factor in PAGE09 is based on the length of a region's coastline relative to the EU (Hope 2011b). Because of the long coastline in the EU, other regions are, on average, less vulnerable than the EU for the same sea level and temperature increase, but all regions have a positive scaling factor. PAGE2002 based its scaling factors on four studies reported in the IPCC's third assessment report, and allowed for benefits from temperature increase in Eastern Europe, smaller impacts in developed countries, and higher damages in developing countries.

[11] Because several changes in the PAGE model are structural (e.g., the addition of sea level rise and treatment of discontinuity), it is not possible to assess the direct impact of each change on the SCC in isolation as done for the other two models above.

Probability of a Discontinuity

In PAGE2002, the damages associated with a "discontinuity" (nonlinear extreme event) were modeled as an expected value. Specifically, a stochastic probability of a discontinuity was multiplied by the damages associated with a discontinuity to obtain an expected value, and this was added to the economic and non-economic impacts. That is, additional damages from an extreme event, such as extreme melting of the Greenland ice sheet, were multiplied by the probability of the event occurring and added to the damage estimate. In PAGE09, the probability of discontinuity is treated as a discrete event for each year in the model. The damages for each model run are estimated either with or without a discontinuity occurring, rather than as an expected value. A large-scale discontinuity becomes possible when the temperature rises beyond some threshold value between 2 and 4°C. The probability that a discontinuity will occur beyond this threshold then increases by between 10 and 30 percent for every 1°C rise in temperature beyond the threshold. If a discontinuity occurs, the EU loses an additional 5 to 25 percent of its GDP (drawn from a triangular distribution with a mean of 15 percent) in addition to other damages, and other regions lose an amount determined by the regional scaling factor. The threshold value for a possible discontinuity is lower than in PAGE2002, while the rate at which the probability of a discontinuity increases with the temperature anomaly and the damages that result from a discontinuity are both higher than in PAGE2002. The model assumes that only one discontinuity can occur and that the impact is phased in over a period of time, but once it occurs, its effect is permanent.

Adaptation

As in PAGE2002, adaptation is available to help mitigate any climate change impacts that occur. In PAGE this adaptation is the same regardless of the temperature change or sea level rise and is therefore akin to what is more commonly considered a reduction in vulnerability. It is modeled by reducing the damages by some percentage. PAGE09 assumes a smaller decrease in vulnerability than the previous version of the model and assumes that it will take longer for this change in vulnerability to be realized. In the aggregated economic sector, at the time of full implementation, this adaptation will mitigate all damages up to a temperature increase of 1°C, and for temperature anomalies between 1°C and 2°C, it will reduce damages by 15-30 percent (depending on the region). However, it takes 20 years to fully implement this adaptation. In PAGE2002, adaptation was assumed to reduce economic sector damages up to 2°C by 50-90 percent after 20 years. Beyond 2°C, no adaptation is assumed to be available to mitigate the impacts of climate change. For the non-economic sector, in PAGE09 adaptation is available to reduce 15 percent of the damages due to a temperature increase between 0°C and 2°C and is assumed to take 40 years to fully implement, instead of 25 percent of the damages over 20 years assumed in PAGE2002. Similarly, adaptation is assumed to alleviate 25-50 percent of the damages from the first 0.20 to 0.25 meters of sea level rise but is assumed to be ineffective thereafter. Hope (2011c) estimates that the less optimistic assumptions regarding the ability to offset impacts of temperature and sea level rise via adaptation increase the SCC by approximately 30 percent.

Other Noteworthy Changes

Two other changes in the model are worth noting. There is a change in the way the model accounts for decreased CO_2 absorption on land and in the ocean as temperature rises. PAGE09 introduces a linear feedback from global mean temperature to the percentage gain in the excess concentration of CO_2, capped at a maximum level. In PAGE2002, an additional amount was added to the CO_2 emissions each period to account for a decrease in ocean absorption and a loss of soil carbon. Also updated is the method by which the average global and annual temperature anomaly is downscaled to determine annual average regional temperature anomalies to be used in the regional damage functions. In PAGE2002, the scaling was determined solely based on regional difference in emissions of sulfate aerosols. In PAGE09, this regional temperature anomaly is further adjusted using an additive factor that is based on the average absolute latitude of a region relative to the area weighted average absolute latitude of the Earth's landmass, to capture relatively greater changes in temperature forecast to be experienced at higher latitudes.

III. Revised SCC Estimates

The updated versions of the three integrated assessment models were run using the same methodology detailed in the 2010 TSD (Interagency Working Group on Social Cost of Carbon 2010). The approach along with the inputs for the socioeconomic emissions scenarios, equilibrium climate sensitivity distribution, and discount rate remains the same. This includes the five reference scenarios based on the EMF-22 modeling exercise, the Roe and Baker equilibrium climate sensitivity distribution calibrated to the IPCC AR4, and three constant discount rates of 2.5, 3, and 5 percent.

As was previously the case, the use of three models, three discount rates, and five scenarios produces 45 separate distributions for the global SCC. The approach laid out in the 2010 TSD applied equal weight to each model and socioeconomic scenario in order to reduce the dimensionality down to three separate distributions representative of the three discount rates. The interagency group selected four values from these distributions for use in regulatory analysis. Three values are based on the average SCC across models and socio-economic-emissions scenarios at the 2.5, 3, and 5 percent discount rates, respectively. The fourth value was chosen to represent the higher-than-expected economic impacts from climate change further out in the tails of the SCC distribution. For this purpose, the 95th percentile of the SCC estimates at a 3 percent discount rate was chosen. (A detailed set of percentiles by model and scenario combination and additional summary statistics for the 2020 values is available in the Appendix.) As noted in the 2010 TSD, "the 3 percent discount rate is the central value, and so the central value that emerges is the average SCC across models at the 3 percent discount rate" (Interagency Working Group on Social Cost of Carbon 2010, p. 25). However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance and value of including all four SCC values.

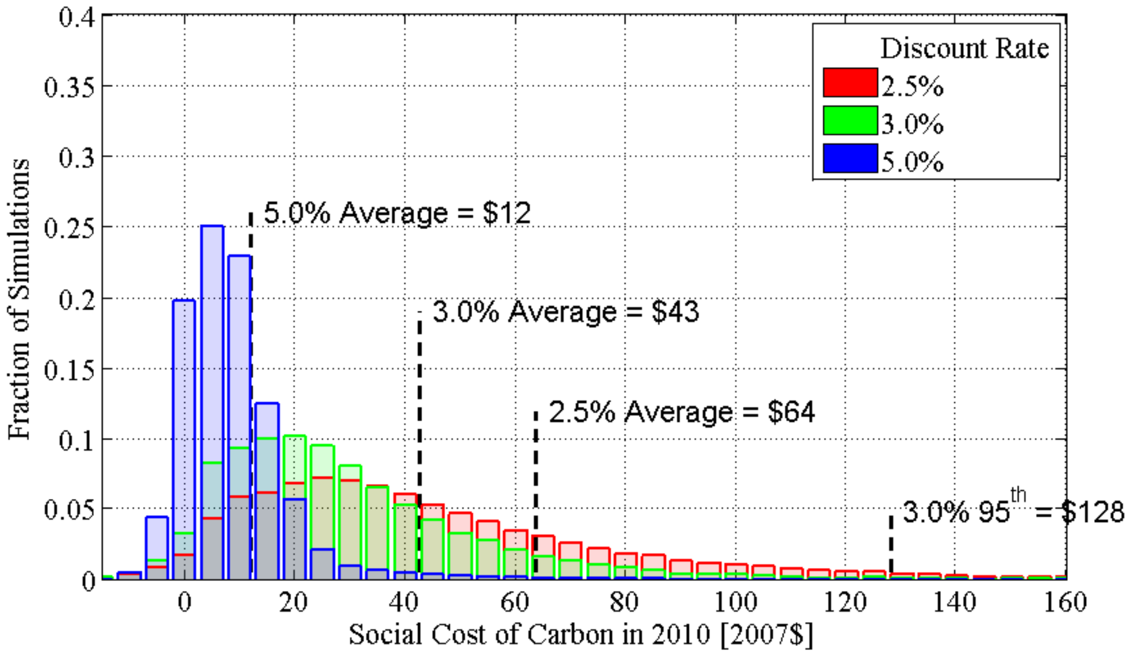
Table 2 shows the four selected SCC estimates in five year increments from 2010 to 2050. Values for 2010, 2020, 2030, 2040, and 2050 are calculated by first combining all outputs (10,000 estimates per model run) from all scenarios and models for a given discount rate. Values for the years in between are calculated using linear interpolation. The full set of revised annual SCC estimates between 2010 and 2050 is reported in the Appendix.

Table 2: Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	11	32	51	89
2015	11	37	57	109
2020	12	43	64	128
2025	14	47	69	143
2030	16	52	75	159
2035	19	56	80	175
2040	21	61	86	191
2045	24	66	92	206
2050	26	71	97	220

The SCC estimates using the updated versions of the models are higher than those reported in the 2010 TSD due to the changes to the models outlined in the previous section. By way of comparison, the 2020 SCC estimates reported in the original TSD were \$7, \$26, \$42 and \$81 (2007\$) (Interagency Working Group on Social Cost of Carbon 2010). Figure 1 illustrates where the four SCC values for 2020 fall within the full distribution for each discount rate based on the combined set of runs for each model and scenario (150,000 estimates in total for each discount rate). In general, the distributions are skewed to the right and have long tails. The Figure also shows that the lower the discount rate, the longer the right tail of the distribution.

Figure 1: Distribution of SCC Estimates for 2020 (in 2007\$ per metric ton CO_2)



As was the case in the 2010 TSD, the SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. The approach taken by the interagency group is to compute the cost of a marginal ton emitted in the future by running the models for a set of perturbation years out to 2050. Table 3 illustrates how the growth rate for these four SCC estimates varies over time.

Table 3: Average Annual Growth Rates of SCC Estimates between 2010 and 2050

Average Annual Growth Rate (%)	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010-2020	1.2%	3.3%	2.4%	4.4%
2020-2030	3.4%	2.1%	1.7%	2.4%
2030-2040	3.0%	1.9%	1.5%	2.1%
2040-2050	2.6%	1.6%	1.3%	1.5%

The future monetized value of emission reductions in each year (the SCC in year *t* multiplied by the change in emissions in year *t*) must be discounted to the present to determine its total net present value for use in regulatory analysis. As previously discussed in the 2010 TSD, damages from future emissions should be discounted at the same rate as that used to calculate the SCC estimates themselves to ensure internal consistency – i.e., future damages from climate change, whether they result from emissions today or emissions in a later year, should be discounted using the same rate.

Under current OMB guidance contained in Circular A-4, analysis of economically significant proposed and final regulations from the domestic perspective is required, while analysis from the international perspective is optional. However, the climate change problem is highly unusual in at least two respects. First, it involves a global externality: emissions of most greenhouse gases contribute to damages around the world even when they are emitted in the United States. Consequently, to address the global nature of the problem, the SCC must incorporate the full (global) damages caused by GHG emissions. Second, climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change. Other countries would also need to take action to reduce emissions if significant changes in the global climate are to be avoided. Emphasizing the need for a global solution to a global problem, the United States has been actively involved in seeking international agreements to reduce emissions and in encouraging other nations, including emerging major economies, to take significant steps to reduce emissions. When these considerations are taken as a whole, the interagency group concluded that a global measure of the benefits from reducing U.S. emissions is preferable. For additional discussion, see the 2010 TSD.

IV. Other Model Limitations and Research Gaps

The 2010 interagency SCC TSD discusses a number of important limitations for which additional research is needed. In particular, the document highlights the need to improve the quantification of both non-catastrophic and catastrophic damages, the treatment of adaptation and technological change, and the way in which inter-regional and inter-sectoral linkages are modeled. While the new version of the models discussed above offer some improvements in these areas, further work remains warranted. The 2010 TSD also discusses the need to more carefully assess the implications of risk aversion for SCC estimation as well as the inability to perfectly substitute between climate and non-climate goods at higher temperature increases, both of which have implications for the discount rate used. EPA, DOE, and other agencies continue to engage in research on modeling and valuation of climate impacts that can potentially improve SCC estimation in the future.

References

Anthoff, D. and Tol, R.S.J. 2013a. The uncertainty about the social cost of carbon: a decomposition analysis using FUND. *Climatic Change* 117: 515–530.

Anthoff, D. and Tol, R.S.J. 2013b. Erratum to: The uncertainty about the social cost of carbon: A decomposition analysis using FUND. *Climatic Change*. Advance online publication. doi: 10.1007/s10584-013-0959-1.

Fankhauser, S. 1995. Valuing climate change: The economics of the greenhouse. London, England: Earthscan.

Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland. 2007. Changes in Atmospheric Constituents and in Radiative Forcing. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Hope, Chris. 2006. "The Marginal Impact of CO_2 from PAGE2002: An Integrated Assessment Model Incorporating the IPCC's Five Reasons for Concern." *The Integrated Assessment Journal*. 6(1): 19–56.

Hope, Chris. 2011a "The PAGE09 Integrated Assessment Model: A Technical Description" Cambridge Judge Business School Working Paper No. 4/2011 (April). Accessed November 23, 2011: http://www.jbs.cam.ac.uk/research/working_papers/2011/wp1104.pdf.

Hope, Chris. 2011b "The Social Cost of CO_2 from the PAGE09 Model" Cambridge Judge Business School Working Paper No. 5/2011 (June). Accessed November 23, 2011: http://www.jbs.cam.ac.uk/research/working_papers/2011/wp1105.pdf.

Hope, Chris. 2011c "New Insights from the PAGE09 Model: The Social Cost of CO_2" Cambridge Judge Business School Working Paper No. 8/2011 (July). Accessed November 23, 2011: http://www.jbs.cam.ac.uk/research/working_papers/2011/wp1108.pdf.

Hope, C. 2013. Critical issues for the calculation of the social cost of CO_2: why the estimates from PAGE09 are higher than those from PAGE2002. *Climatic Change* 117: 531–543.

Interagency Working Group on Social Cost of Carbon. 2010. Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866. February. United States Government. http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver and Z.-C. Zhao. 2007. Global Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Narita, D., R. S. J. Tol and D. Anthoff. 2010. Economic costs of extratropical storms under climate change: an application of FUND. *Journal of Environmental Planning and Management* 53(3): 371-384.

National Academy of Sciences. 2011. *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia*. Washington, DC: National Academies Press, Inc.

Nicholls, R.J., N. Marinova, J.A. Lowe, S. Brown, P. Vellinga, D. de Gusmão, J. Hinkel and R.S.J. Tol. 2011. Sea-level rise and its possible impacts given a 'beyond 4°C world' in the twenty-first century. *Phil. Trans. R. Soc. A* 369(1934): 161-181.

Nordhaus, W. 2010. Economic aspects of global warming in a post-Copenhagen environment. *Proceedings of the National Academy of Sciences* 107(26): 11721-11726.

Nordhaus, W. 2008. A Question of Balance: Weighing the Options on Global Warming Policies. New Haven, CT: Yale University Press.

Randall, D.A., R.A. Wood, S. Bony, R. Colman, T. Fichefet, J. Fyfe, V. Kattsov, A. Pitman, J. Shukla, J. Srinivasan, R.J. Stouffer, A. Sumi and K.E. Taylor. 2007. Climate Models and Their Evaluation. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Appendix A

Table A1: Annual SCC Values: 2010-2050 (2007$/metric ton CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	11	32	51	89
2011	11	33	52	93
2012	11	34	54	97
2013	11	35	55	101
2014	11	36	56	105
2015	11	37	57	109
2016	12	38	59	112
2017	12	39	60	116
2018	12	40	61	120
2019	12	42	62	124
2020	12	43	64	128
2021	12	43	65	131
2022	13	44	66	134
2023	13	45	67	137
2024	14	46	68	140
2025	14	47	69	143
2026	15	48	70	146
2027	15	49	71	149
2028	15	50	72	152
2029	16	51	73	155
2030	16	52	75	159
2031	17	52	76	162
2032	17	53	77	165
2033	18	54	78	168
2034	18	55	79	172
2035	19	56	80	175
2036	19	57	81	178
2037	20	58	83	181
2038	20	59	84	185
2039	21	60	85	188
2040	21	61	86	191
2041	22	62	87	194
2042	22	63	88	197
2043	23	64	89	200
2044	23	65	90	203
2045	24	66	92	206
2046	24	67	93	209
2047	25	68	94	211
2048	25	69	95	214
2049	26	70	96	217
2050	26	71	97	220

Table A2: 2020 Global SCC Estimates at 2.5 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario[12]	PAGE									
IMAGE	6	11	15	27	58	129	139	327	515	991
MERGE	4	6	9	16	34	78	82	196	317	649
MESSAGE	4	8	11	20	42	108	107	278	483	918
MiniCAM Base	5	9	12	22	47	107	113	266	431	872
5th Scenario	2	4	6	11	25	85	68	200	387	955
Scenario	DICE									
IMAGE	25	31	37	47	64	72	92	123	139	161
MERGE	14	18	20	26	36	40	50	65	74	85
MESSAGE	20	24	28	37	51	58	71	95	109	221
MiniCAM Base	20	25	29	38	53	61	76	102	117	135
5th Scenario	17	22	25	33	45	52	65	91	106	126
Scenario	FUND									
IMAGE	-14	-2	4	15	31	39	55	86	107	157
MERGE	-6	1	6	14	27	35	46	70	87	141
MESSAGE	-16	-5	1	11	24	31	43	67	83	126
MiniCAM Base	-7	2	7	16	32	39	55	83	103	158
5th Scenario	-29	-13	-6	4	16	21	32	53	69	103

Table A3: 2020 Global SCC Estimates at 3 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario	PAGE									
IMAGE	4	7	10	18	38	91	95	238	385	727
MERGE	2	4	6	11	23	56	58	142	232	481
MESSAGE	3	5	7	13	29	75	74	197	330	641
MiniCAM Base	3	5	8	14	30	73	75	184	300	623
5th Scenario	1	3	4	7	17	58	48	136	264	660
Scenario	DICE									
IMAGE	16	21	24	32	43	48	60	79	90	102
MERGE	10	13	15	19	25	28	35	44	50	58
MESSAGE	14	18	20	26	35	40	49	64	73	83
MiniCAM Base	13	17	20	26	35	39	49	65	73	85
5th Scenario	12	15	17	22	30	34	43	58	67	79
Scenario	FUND									
IMAGE	-13	-4	0	8	18	23	33	51	65	99
MERGE	-7	-1	2	8	17	21	29	45	57	95
MESSAGE	-14	-6	-2	5	14	18	26	41	52	82
MiniCAM Base	-7	-1	3	9	19	23	33	50	63	101
5th Scenario	-22	-11	-6	1	8	11	18	31	40	62

[12] See 2010 TSD for a description of these scenarios.

Table A4: 2020 Global SCC Estimates at 5 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario	PAGE									
IMAGE	1	2	2	5	10	28	27	71	123	244
MERGE	1	1	2	3	7	17	17	45	75	153
MESSAGE	1	1	2	4	9	24	22	60	106	216
MiniCAM Base	1	1	2	3	8	21	21	54	94	190
5th Scenario	0	1	1	2	5	18	14	41	78	208
Scenario	DICE									
IMAGE	6	8	9	11	14	15	18	22	25	27
MERGE	4	5	6	7	9	10	12	15	16	18
MESSAGE	6	7	8	10	12	13	16	20	22	25
MiniCAM Base	5	6	7	8	11	12	14	18	20	22
5th Scenario	5	6	6	8	10	11	14	17	19	21
Scenario	FUND									
IMAGE	-9	-5	-4	-1	2	3	6	10	14	24
MERGE	-6	-4	-2	0	3	4	6	11	15	26
MESSAGE	-10	-6	-4	-1	1	2	5	9	12	21
MiniCAM Base	-7	-4	-2	0	3	4	6	11	14	25
5th Scenario	-11	-7	-5	-3	0	0	3	5	7	13

Table A5: Additional Summary Statistics of 2020 Global SCC Estimates

Discount rate:	5.0%				3.0%				2.5%			
Statistic:	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
DICE	12	26	2	15	38	409	3	24	57	1097	3	30
PAGE	22	1616	5	32	71	14953	4	22	101	29312	4	23
FUND	3	41	5	179	19	1452	-42	8727	33	6154	-73	14931

Appendix B

The November 2013 revision of this technical support document is based on two corrections to the runs based on the FUND model. First, the potential dry land loss in the algorithm that estimates regional coastal protections was misspecified in the model's computer code. This correction is covered in an erratum to Anthoff and Tol (2013a) published in the same journal (Climatic Change) in October 2013 (Anthoff and Tol (2013b)). Second, the equilibrium climate sensitivity distribution was inadvertently specified as a truncated Gamma distribution (the default in FUND) as opposed to the truncated Roe and Baker distribution as was intended. The truncated Gamma distribution used in the FUND runs had approximately the same mean and upper truncation point, but lower variance and faster decay of the upper tail, as compared to the intended specification based on the Roe and Baker distribution. The difference between the original estimates reported in the May 2013 version of this technical support document and this revision are generally one dollar or less.

Exhibit 4

Technical Support Document: -
Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis -
Under Executive Order 12866 -

Interagency Working Group on Social Cost of Carbon, United States Government

With participation by

Council of Economic Advisers
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Energy
Department of Transportation
Environmental Protection Agency
National Economic Council
Office of Management and Budget
Office of Science and Technology Policy
Department of the Treasury

May 2013

Revised July 2015
See Appendix B for Details on Revision

Executive Summary

Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the "social cost of carbon" (SCC) estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that impact cumulative global emissions. The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.

The interagency process that developed the original U.S. government's SCC estimates is described in the 2010 interagency technical support document (TSD) (Interagency Working Group on Social Cost of Carbon 2010). Through that process the interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC from three integrated assessment models (IAMs), at discount rates of 2.5, 3, and 5 percent. The fourth value, which represents the 95th percentile SCC estimate across all three models at a 3 percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

While acknowledging the continued limitations of the approach taken by the interagency group in 2010, this document provides an update of the SCC estimates based on new versions of each IAM (DICE, PAGE, and FUND). It does not revisit other interagency modeling decisions (e.g., with regard to the discount rate, reference case socioeconomic and emission scenarios, or equilibrium climate sensitivity). Improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves in the peer-reviewed literature.

The SCC estimates using the updated versions of the models are higher than those reported in the 2010 TSD. By way of comparison, the four 2020 SCC estimates reported in the 2010 TSD were $7, $26, $42 and $81 (2007$). The corresponding four updated SCC estimates for 2020 are $12, $43, $64, and $128 (2007$). The model updates that are relevant to the SCC estimates include: an explicit representation of sea level rise damages in the DICE and PAGE models; updated adaptation assumptions, revisions to ensure damages are constrained by GDP, updated regional scaling of damages, and a revised treatment of potentially abrupt shifts in climate damages in the PAGE model; an updated carbon cycle in the DICE model; and updated damage functions for sea level rise impacts, the agricultural sector, and reduced space heating requirements, as well as changes to the transient response of temperature to the buildup of GHG concentrations and the inclusion of indirect effects of methane emissions in the FUND model. The SCC estimates vary by year, and the following table summarizes the revised SCC estimates from 2010 through 2050.

Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

I. Purpose

The purpose of this document is to update the schedule of social cost of carbon (SCC) estimates from the 2010 interagency technical support document (TSD) (Interagency Working Group on Social Cost of Carbon 2010).[1] E.O. 13563 commits the Administration to regulatory decision making "based on the best available science."[2] Additionally, the interagency group recommended in 2010 that the SCC estimates be revisited on a regular basis or as model updates that reflect the growing body of scientific and economic knowledge become available.[3] New versions of the three integrated assessment models used by the U.S. government to estimate the SCC (DICE, FUND, and PAGE), are now available and have been published in the peer reviewed literature. While acknowledging the continued limitations of the approach taken by the interagency group in 2010 (documented in the original 2010 TSD), this document provides an update of the SCC estimates based on the latest peer-reviewed version of the models, replacing model versions that were developed up to ten years ago in a rapidly evolving field. It does not revisit other assumptions with regard to the discount rate, reference case socioeconomic and emission scenarios, or equilibrium climate sensitivity. Improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves in the peer-reviewed literature. The agencies participating in the interagency working group continue to investigate potential improvements to the way in which economic damages associated with changes in CO_2 emissions are quantified.

Section II summarizes the major updates relevant to SCC estimation that are contained in the new versions of the integrated assessment models released since the 2010 interagency report. Section III presents the updated schedule of SCC estimates for 2010 – 2050 based on these versions of the models. Section IV provides a discussion of other model limitations and research gaps.

II. **Summary of Model Updates**

This section briefly summarizes changes to the most recent versions of the three integrated assessment models (IAMs) used by the interagency group in 2010. We focus on describing those model updates that are relevant to estimating the social cost of carbon, as summarized in Table 1. For example, both the DICE and PAGE models now include an explicit representation of sea level rise damages. Other revisions to PAGE include: updated adaptation assumptions, revisions to ensure damages are constrained by GDP, updated regional scaling of damages, and a revised treatment of potentially abrupt shifts in climate damages. The DICE model's simple carbon cycle has been updated to be more consistent with a more complex climate model. The FUND model includes updated damage functions for sea level rise impacts, the agricultural sector, and reduced space heating requirements, as well as changes to the transient response of temperature to the buildup of GHG concentrations and the inclusion of indirect effects of

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[1] In this document, we present all values of the SCC as the cost per metric ton of CO_2 emissions. Alternatively, one could report the SCC as the cost per metric ton of carbon emissions. The multiplier for translating between mass of CO_2 and the mass of carbon is 3.67 (the molecular weight of CO_2 divided by the molecular weight of carbon = 44/12 = 3.67).

[2] http://www.whitehouse.gov/sites/default/files/omb/inforeg/eo12866/eo13563_01182011.pdf

[3] See p. 1, 3, 4, 29, and 33 (Interagency Working Group on Social Cost of Carbon 2010).

methane emissions. Changes made to parts of the models that are superseded by the interagency working group's modeling assumptions – regarding equilibrium climate sensitivity, discounting, and socioeconomic variables – are not discussed here but can be found in the references provided in each section below.

Table 1: Summary of Key Model Revisions Relevant to the Interagency SCC

IAM	Version used in 2010 Interagency Analysis	New Version	Key changes relevant to interagency SCC
DICE	2007	2010	Updated calibration of the carbon cycle model and explicit representation of sea level rise (SLR) and associated damages.
FUND	3.5 (2009)	3.8 (2012)	Updated damage functions for space heating, SLR, agricultural impacts, changes to transient response of temperature to buildup of GHG concentrations, and inclusion of indirect climate effects of methane.
PAGE	2002	2009	Explicit representation of SLR damages, revisions to damage function to ensure damages do not exceed 100% of GDP, change in regional scaling of damages, revised treatment of potential abrupt damages, and updated adaptation assumptions.

A. DICE

DICE 2010 includes a number of changes over the previous 2007 version used in the 2010 interagency report. The model changes that are relevant for the SCC estimates developed by the interagency working group include: 1) updated parameter values for the carbon cycle model, 2) an explicit representation of sea level dynamics, and 3) a re-calibrated damage function that includes an explicit representation of economic damages from sea level rise. Changes were also made to other parts of the DICE model—including the equilibrium climate sensitivity parameter, the rate of change of total factor productivity, and the elasticity of the marginal utility of consumption—but these components of DICE are superseded by the interagency working group's assumptions and so will not be discussed here. More details on DICE2007 can be found in Nordhaus (2008) and on DICE2010 in Nordhaus (2010). The DICE2010 model and documentation is also available for download from the homepage of William Nordhaus.

Carbon Cycle Parameters

DICE uses a three-box model of carbon stocks and flows to represent the accumulation and transfer of carbon among the atmosphere, the shallow ocean and terrestrial biosphere, and the deep ocean. These parameters are "calibrated to match the carbon cycle in the Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC)" (Nordhaus 2008 p 44).[4] Carbon cycle transfer coefficient values

[4] MAGICC is a simple climate model initially developed by the U.S. National Center for Atmospheric Research that has been used heavily by the Intergovernmental Panel on Climate Change (IPCC) to emulate projections from more sophisticated state of the art earth system simulation models (Randall et al. 2007).

in DICE2010 are based on re-calibration of the model to match the newer 2009 version of MAGICC (Nordhaus 2010 p 2). For example, in DICE2010, in each decade, 12 percent of the carbon in the atmosphere is transferred to the shallow ocean, 4.7 percent of the carbon in the shallow ocean is transferred to the atmosphere, 94.8 percent remains in the shallow ocean, and 0.5 percent is transferred to the deep ocean. For comparison, in DICE 2007, 18.9 percent of the carbon in the atmosphere is transferred to the shallow ocean each decade, 9.7 percent of the carbon in the shallow ocean is transferred to the atmosphere, 85.3 percent remains in the shallow ocean, and 5 percent is transferred to the deep ocean.

The implication of these changes for DICE2010 is in general a weakening of the ocean as a carbon sink and therefore a higher concentration of carbon in the atmosphere than in DICE2007, for a given path of emissions. All else equal, these changes will generally increase the level of warming and therefore the SCC estimates in DICE2010 relative to those from DICE2007.

Sea Level Dynamics

A new feature of DICE2010 is an explicit representation of the dynamics of the global average sea level anomaly to be used in the updated damage function (discussed below). This section contains a brief description of the sea level rise (SLR) module; a more detailed description can be found on the model developer's website.[5] The average global sea level anomaly is modeled as the sum of four terms that represent contributions from: 1) thermal expansion of the oceans, 2) melting of glaciers and small ice caps, 3) melting of the Greenland ice sheet, and 4) melting of the Antarctic ice sheet.

The parameters of the four components of the SLR module are calibrated to match consensus results from the IPCC's Fourth Assessment Report (AR4).[6] The rise in sea level from thermal expansion in each time period (decade) is 2 percent of the difference between the sea level in the previous period and the long run equilibrium sea level, which is 0.5 meters per degree Celsius (°C) above the average global temperature in 1900. The rise in sea level from the melting of glaciers and small ice caps occurs at a rate of 0.008 meters per decade per °C above the average global temperature in 1900.

The contribution to sea level rise from melting of the Greenland ice sheet is more complex. The equilibrium contribution to SLR is 0 meters for temperature anomalies less than 1 °C and increases linearly from 0 meters to a maximum of 7.3 meters for temperature anomalies between 1 °C and 3.5 °C. The contribution to SLR in each period is proportional to the difference between the previous period's sea level anomaly and the equilibrium sea level anomaly, where the constant of proportionality increases with the temperature anomaly in the current period.

[5] Documentation on the new sea level rise module of DICE is available on William Nordhaus' website at: http://nordhaus.econ.yale.edu/documents/SLR_021910.pdf.
[6] For a review of post-IPCC AR4 research on sea level rise, see Nicholls et al. (2011) and NAS (2011).

The contribution to SLR from the melting of the Antarctic ice sheet is -0.001 meters per decade when the temperature anomaly is below 3 °C and increases linearly between 3 °C and 6 °C to a maximum rate of 0.025 meters per decade at a temperature anomaly of 6 °C.

Re-calibrated Damage Function

Economic damages from climate change in the DICE model are represented by a fractional loss of gross economic output in each period. A portion of the remaining economic output in each period (net of climate change damages) is consumed and the remainder is invested in the physical capital stock to support future economic production, so each period's climate damages will reduce consumption in that period and in all future periods due to the lost investment. The fraction of output in each period that is lost due to climate change impacts is represented as one minus a fraction, which is one divided by a quadratic function of the temperature anomaly, producing a sigmoid ("S"-shaped) function.[7] The loss function in DICE2010 has been expanded by adding a quadratic function of SLR to the quadratic function of temperature. In DICE2010 the temperature anomaly coefficients have been recalibrated to avoid double-counting damages from sea level rise that were implicitly included in these parameters in DICE2007.

The aggregate damages in DICE2010 are illustrated by Nordhaus (2010 p 3), who notes that "…damages in the uncontrolled (baseline) [i.e., reference] case … in 2095 are $12 trillion, or 2.8 percent of global output, for a global temperature increase of 3.4 °C above 1900 levels." This compares to a loss of 3.2 percent of global output at 3.4 °C in DICE2007. However, in DICE2010, annual damages are lower in most of the early periods of the modeling horizon but higher in later periods than would be calculated using the DICE2007 damage function. Specifically, the percent difference between damages in the base run of DICE2010 and those that would be calculated using the DICE2007 damage function starts at +7 percent in 2005, decreases to a low of -14 percent in 2065, then continuously increases to +20 percent by 2300 (the end of the interagency analysis time horizon), and to +160 percent by the end of the model time horizon in 2595. The large increases in the far future years of the time horizon are due to the permanence associated with damages from sea level rise, along with the assumption that the sea level is projected to continue to rise long after the global average temperature begins to decrease. The changes to the loss function generally decrease the interagency working group SCC estimates slightly given that relative increases in damages in later periods are discounted more heavily, all else equal.

B. FUND

FUND version 3.8 includes a number of changes over the previous version 3.5 (Narita et al. 2010) used in the 2010 interagency report. Documentation supporting FUND and the model's source code for all versions of the model is available from the model authors.[8] Notable changes, due to their impact on the

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[7] The model and documentation, including formulas, are available on the author's webpage at http://www.econ.yale.edu/~nordhaus/homepage/RICEmodels.htm.

[8] http://www.fund-model.org/. This report uses version 3.8 of the FUND model, which represents a modest update to the most recent version of the model to appear in the literature (version 3.7) (Anthoff and Tol, 2013). For the purpose of computing the SCC, the relevant changes (between 3.7 to 3.8) are associated with improving

SCC estimates, are adjustments to the space heating, agriculture, and sea level rise damage functions in addition to changes to the temperature response function and the inclusion of indirect effects from methane emissions.[9] We discuss each of these in turn.

Space Heating

In FUND, the damages associated with the change in energy needs for space heating are based on the estimated impact due to one degree of warming. These baseline damages are scaled based on the forecasted temperature anomaly's deviation from the one degree benchmark and adjusted for changes in vulnerability due to economic and energy efficiency growth. In FUND 3.5, the function that scales the base year damages adjusted for vulnerability allows for the possibility that in some simulations the benefits associated with reduced heating needs may be an unbounded convex function of the temperature anomaly. In FUND 3.8, the form of the scaling has been modified to ensure that the function is everywhere concave and that there will exist an upper bound on the benefits a region may receive from reduced space heating needs. The new formulation approaches a value of two in the limit of large temperature anomalies, or in other words, assuming no decrease in vulnerability, the reduced expenditures on space heating at any level of warming will not exceed two times the reductions experienced at one degree of warming. Since the reduced need for space heating represents a benefit of climate change in the model, or a negative damage, this change will increase the estimated SCC. This update accounts for a significant portion of the difference in the expected SCC estimates reported by the two versions of the model when run probabilistically.

Sea Level Rise and Land Loss

The FUND model explicitly includes damages associated with the inundation of dry land due to sea level rise. The amount of land lost within a region is dependent upon the proportion of the coastline being protected by adequate sea walls and the amount of sea level rise. In FUND 3.5 the function defining the potential land lost in a given year due to sea level rise is linear in the rate of sea level rise for that year. This assumption implicitly assumes that all regions are well represented by a homogeneous coastline in length and a constant uniform slope moving inland. In FUND 3.8 the function defining the potential land lost has been changed to be a convex function of sea level rise, thereby assuming that the slope of the shore line increases moving inland. The effect of this change is to typically reduce the vulnerability of some regions to sea level rise based land loss, thereby lowering the expected SCC estimate. [10]

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consistency with IPCC AR4 by adjusting the atmospheric lifetimes of CH4 and N2O and incorporating the indirect forcing effects of CH4, along with making minor stability improvements in the sea wall construction algorithm.

[9] The other damage sectors (water resources, space cooling, land loss, migration, ecosystems, human health, and extreme weather) were not significantly updated.

[10] For stability purposes this report also uses an update to the model which assumes that regional coastal protection measures will be built to protect the most valuable land first, such that the marginal benefits of coastal protection is decreasing in the level of protection following Fankhauser (1995).

Agriculture

In FUND, the damages associated with the agricultural sector are measured as proportional to the sector's value. The fraction is bounded from above by one and is made up of three additive components that represent the effects from carbon fertilization, the rate of temperature change, and the level of the temperature anomaly. In both FUND 3.5 and FUND 3.8, the fraction of the sector's value lost due to the level of the temperature anomaly is modeled as a quadratic function with an intercept of zero. In FUND 3.5, the coefficients of this loss function are modeled as the ratio of two random normal variables. This specification had the potential for unintended extreme behavior as draws from the parameter in the denominator approached zero or went negative. In FUND 3.8, the coefficients are drawn directly from truncated normal distributions so that they remain in the range $[0,\infty)$ and $(-\infty,0]$, respectively, ensuring the correct sign and eliminating the potential for divide by zero errors. The means for the new distributions are set equal to the ratio of the means from the normal distributions used in the previous version. In general the impact of this change has been to decrease the range of the distribution while spreading out the distributions' mass over the remaining range relative to the previous version. The net effect of this change on the SCC estimates is difficult to predict.

Transient Temperature Response

The temperature response model translates changes in global levels of radiative forcing into the current expected temperature anomaly. In FUND, a given year's increase in the temperature anomaly is based on a mean reverting function where the mean equals the equilibrium temperature anomaly that would eventually be reached if that year's level of radiative forcing were sustained. The rate of mean reversion defines the rate at which the transient temperature approaches the equilibrium. In FUND 3.5, the rate of temperature response is defined as a decreasing linear function of equilibrium climate sensitivity to capture the fact that the progressive heat uptake of the deep ocean causes the rate to slow at higher values of the equilibrium climate sensitivity. In FUND 3.8, the rate of temperature response has been updated to a quadratic function of the equilibrium climate sensitivity. This change reduces the sensitivity of the rate of temperature response to the level of the equilibrium climate sensitivity, a relationship first noted by Hansen et al. (1985) based on the heat uptake of the deep ocean. Therefore in FUND 3.8, the temperature response will typically be faster than in the previous version. The overall effect of this change is likely to increase estimates of the SCC as higher temperatures are reached during the timeframe analyzed and as the same damages experienced in the previous version of the model are now experienced earlier and therefore discounted less.

Methane

The IPCC AR4 notes a series of indirect effects of methane emissions, and has developed methods for proxying such effects when computing the global warming potential of methane (Forster et al. 2007). FUND 3.8 now includes the same methods for incorporating the indirect effects of methane emissions. Specifically, the average atmospheric lifetime of methane has been set to 12 years to account for the feedback of methane emissions on its own lifetime. The radiative forcing associated with atmospheric methane has also been increased by 40% to account for its net impact on ozone production and stratospheric water vapor. All else equal, the effect of this increased radiative forcing will be to increase the estimated SCC values, due to greater projected temperature anomaly.

C. PAGE

PAGE09 (Hope 2013) includes a number of changes from PAGE2002, the version used in the 2010 SCC interagency report. The changes that most directly affect the SCC estimates include: explicitly modeling the impacts from sea level rise, revisions to the damage function to ensure damages are constrained by GDP, a change in the regional scaling of damages, a revised treatment for the probability of a discontinuity within the damage function, and revised assumptions on adaptation. The model also includes revisions to the carbon cycle feedback and the calculation of regional temperatures.[11] More details on PAGE09 can be found in Hope (2011a, 2011b, 2011c). A description of PAGE2002 can be found in Hope (2006).

Sea Level Rise

While PAGE2002 aggregates all damages into two categories – economic and non-economic impacts -, PAGE09 adds a third explicit category: damages from sea level rise. In the previous version of the model, damages from sea level rise were subsumed by the other damage categories. In PAGE09 sea level damages increase less than linearly with sea level under the assumption that land, people, and GDP are more concentrated in low-lying shoreline areas. Damages from the economic and non-economic sector were adjusted to account for the introduction of this new category.

Revised Damage Function to Account for Saturation

In PAGE09, small initial economic and non-economic benefits (negative damages) are modeled for small temperature increases, but all regions eventually experience economic damages from climate change, where damages are the sum of additively separable polynomial functions of temperature and sea level rise. Damages transition from this polynomial function to a logistic path once they exceed a certain proportion of remaining Gross Domestic Product (GDP) to ensure that damages do not exceed 100 percent of GDP. This differs from PAGE2002, which allowed Eastern Europe to potentially experience large benefits from temperature increases, and which also did not bound the possible damages that could be experienced.

Regional Scaling Factors

As in the previous version of PAGE, the PAGE09 model calculates the damages for the European Union (EU) and then, assumes that damages for other regions are proportional based on a given scaling factor. The scaling factor in PAGE09 is based on the length of a region’s coastline relative to the EU (Hope 2011b). Because of the long coastline in the EU, other regions are, on average, less vulnerable than the EU for the same sea level and temperature increase, but all regions have a positive scaling factor. PAGE2002 based its scaling factors on four studies reported in the IPCC’s third assessment report, and allowed for benefits

[11] Because several changes in the PAGE model are structural (e.g., the addition of sea level rise and treatment of discontinuity), it is not possible to assess the direct impact of each change on the SCC in isolation as done for the other two models above.

from temperature increase in Eastern Europe, smaller impacts in developed countries, and higher damages in developing countries.

Probability of a Discontinuity

In PAGE2002, the damages associated with a “discontinuity” (nonlinear extreme event) were modeled as an expected value. Specifically, a stochastic probability of a discontinuity was multiplied by the damages associated with a discontinuity to obtain an expected value, and this was added to the economic and non-economic impacts. That is, additional damages from an extreme event, such as extreme melting of the Greenland ice sheet, were multiplied by the probability of the event occurring and added to the damage estimate. In PAGE09, the probability of discontinuity is treated as a discrete event for each year in the model. The damages for each model run are estimated either with or without a discontinuity occurring, rather than as an expected value. A large-scale discontinuity becomes possible when the temperature rises beyond some threshold value between 2 and 4°C. The probability that a discontinuity will occur beyond this threshold then increases by between 10 and 30 percent for every 1°C rise in temperature beyond the threshold. If a discontinuity occurs, the EU loses an additional 5 to 25 percent of its GDP (drawn from a triangular distribution with a mean of 15 percent) in addition to other damages, and other regions lose an amount determined by the regional scaling factor. The threshold value for a possible discontinuity is lower than in PAGE2002, while the rate at which the probability of a discontinuity increases with the temperature anomaly and the damages that result from a discontinuity are both higher than in PAGE2002. The model assumes that only one discontinuity can occur and that the impact is phased in over a period of time, but once it occurs, its effect is permanent.

Adaptation

As in PAGE2002, adaptation is available to help mitigate any climate change impacts that occur. In PAGE this adaptation is the same regardless of the temperature change or sea level rise and is therefore akin to what is more commonly considered a reduction in vulnerability. It is modeled by reducing the damages by some percentage. PAGE09 assumes a smaller decrease in vulnerability than the previous version of the model and assumes that it will take longer for this change in vulnerability to be realized. In the aggregated economic sector, at the time of full implementation, this adaptation will mitigate all damages up to a temperature increase of 1°C, and for temperature anomalies between 1°C and 2°C, it will reduce damages by 15-30 percent (depending on the region). However, it takes 20 years to fully implement this adaptation. In PAGE2002, adaptation was assumed to reduce economic sector damages up to 2°C by 50-90 percent after 20 years. Beyond 2°C, no adaptation is assumed to be available to mitigate the impacts of climate change. For the non-economic sector, in PAGE09 adaptation is available to reduce 15 percent of the damages due to a temperature increase between 0°C and 2°C and is assumed to take 40 years to fully implement, instead of 25 percent of the damages over 20 years assumed in PAGE2002. Similarly, adaptation is assumed to alleviate 25-50 percent of the damages from the first 0.20 to 0.25 meters of sea level rise but is assumed to be ineffective thereafter. Hope (2011c) estimates that the less optimistic assumptions regarding the ability to offset impacts of temperature and sea level rise via adaptation increase the SCC by approximately 30 percent.

Other Noteworthy Changes

Two other changes in the model are worth noting. There is a change in the way the model accounts for decreased CO_2 absorption on land and in the ocean as temperature rises. PAGE09 introduces a linear feedback from global mean temperature to the percentage gain in the excess concentration of CO_2, capped at a maximum level. In PAGE2002, an additional amount was added to the CO_2 emissions each period to account for a decrease in ocean absorption and a loss of soil carbon. Also updated is the method by which the average global and annual temperature anomaly is downscaled to determine annual average regional temperature anomalies to be used in the regional damage functions. In PAGE2002, the scaling was determined solely based on regional difference in emissions of sulfate aerosols. In PAGE09, this regional temperature anomaly is further adjusted using an additive factor that is based on the average absolute latitude of a region relative to the area weighted average absolute latitude of the Earth's landmass, to capture relatively greater changes in temperature forecast to be experienced at higher latitudes.

III. Revised SCC Estimates

The updated versions of the three integrated assessment models were run using the same methodology detailed in the 2010 TSD (Interagency Working Group on Social Cost of Carbon 2010). The approach along with the inputs for the socioeconomic emissions scenarios, equilibrium climate sensitivity distribution, and discount rate remains the same. This includes the five reference scenarios based on the EMF-22 modeling exercise, the Roe and Baker equilibrium climate sensitivity distribution calibrated to the IPCC AR4, and three constant discount rates of 2.5, 3, and 5 percent.

As was previously the case, the use of three models, three discount rates, and five scenarios produces 45 separate distributions for the global SCC. The approach laid out in the 2010 TSD applied equal weight to each model and socioeconomic scenario in order to reduce the dimensionality down to three separate distributions representative of the three discount rates. The interagency group selected four values from these distributions for use in regulatory analysis. Three values are based on the average SCC across models and socio-economic-emissions scenarios at the 2.5, 3, and 5 percent discount rates, respectively. The fourth value was chosen to represent the higher-than-expected economic impacts from climate change further out in the tails of the SCC distribution. For this purpose, the 95th percentile of the SCC estimates at a 3 percent discount rate was chosen. (A detailed set of percentiles by model and scenario combination and additional summary statistics for the 2020 values is available in the Appendix.) As noted in the 2010 TSD, "the 3 percent discount rate is the central value, and so the central value that emerges is the average SCC across models at the 3 percent discount rate" (Interagency Working Group on Social Cost of Carbon 2010, p. 25). However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance and value of including all four SCC values.

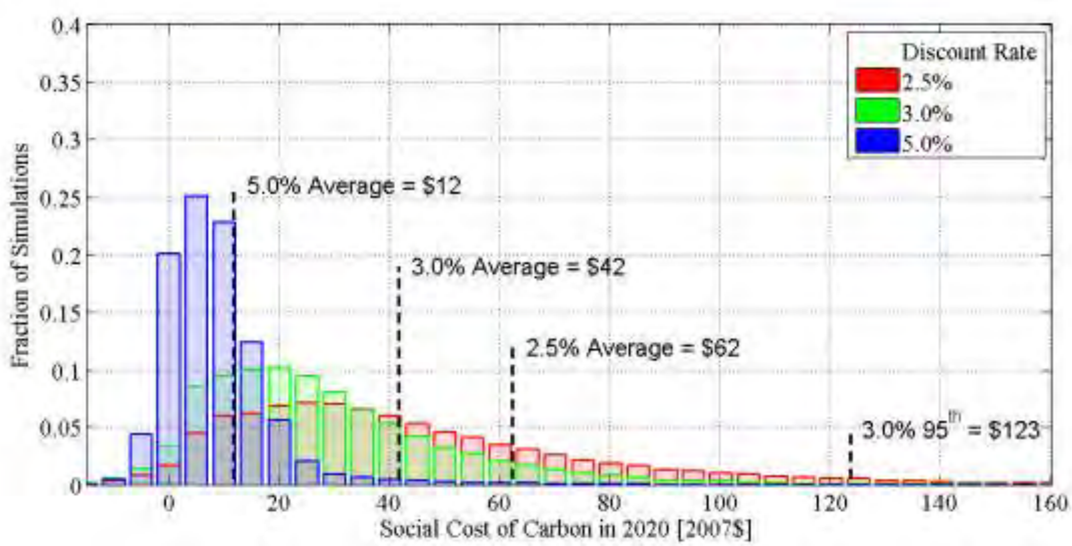
Table 2 shows the four selected SCC estimates in five year increments from 2010 to 2050. Values for 2010, 2020, 2030, 2040, and 2050 are calculated by first combining all outputs (10,000 estimates per model run) from all scenarios and models for a given discount rate. Values for the years in between are calculated using linear interpolation. The full set of revised annual SCC estimates between 2010 and 2050 is reported in the Appendix.

Table 2: Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

The SCC estimates using the updated versions of the models are higher than those reported in the 2010 TSD due to the changes to the models outlined in the previous section. By way of comparison, the 2020 SCC estimates reported in the original TSD were $7, $26, $42 and $81 (2007$) (Interagency Working Group on Social Cost of Carbon 2010). Figure 1 illustrates where the four SCC values for 2020 fall within the full distribution for each discount rate based on the combined set of runs for each model and scenario (150,000 estimates in total for each discount rate). In general, the distributions are skewed to the right and have long tails. The Figure also shows that the lower the discount rate, the longer the right tail of the distribution.

Figure 1: Distribution of SCC Estimates for 2020 (in 2007$ per metric ton CO_2)



As was the case in the 2010 TSD, the SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. The approach taken by the interagency group is to compute the cost of a marginal ton emitted in the future by running the models for a set of perturbation years out to 2050. Table 3 illustrates how the growth rate for these four SCC estimates varies over time.

Table 3: Average Annual Growth Rates of SCC Estimates between 2010 and 2050

Average Annual Growth Rate (%)	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010-2020	1.2%	3.2%	2.4%	4.4%
2020-2030	3.4%	2.1%	1.7%	2.3%
2030-2040	3.0%	1.9%	1.5%	2.0%
2040-2050	2.6%	1.6%	1.3%	1.6%

The future monetized value of emission reductions in each year (the SCC in year *t* multiplied by the change in emissions in year *t*) must be discounted to the present to determine its total net present value for use in regulatory analysis. As previously discussed in the 2010 TSD, damages from future emissions should be discounted at the same rate as that used to calculate the SCC estimates themselves to ensure internal consistency – i.e., future damages from climate change, whether they result from emissions today or emissions in a later year, should be discounted using the same rate.

Under current OMB guidance contained in Circular A-4, analysis of economically significant proposed and final regulations from the domestic perspective is required, while analysis from the international perspective is optional. However, the climate change problem is highly unusual in at least two respects. First, it involves a global externality: emissions of most greenhouse gases contribute to damages around the world even when they are emitted in the United States. Consequently, to address the global nature of the problem, the SCC must incorporate the full (global) damages caused by GHG emissions. Second, climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change. Other countries would also need to take action to reduce emissions if significant changes in the global climate are to be avoided. Emphasizing the need for a global solution to a global problem, the United States has been actively involved in seeking international agreements to reduce emissions and in encouraging other nations, including emerging major economies, to take significant steps to reduce emissions. When these considerations are taken as a whole, the interagency group concluded that a global measure of the benefits from reducing U.S. emissions is preferable. For additional discussion, see the 2010 TSD.

IV. Other Model Limitations and Research Gaps

The 2010 interagency SCC TSD discusses a number of important limitations for which additional research is needed. In particular, the document highlights the need to improve the quantification of both non-catastrophic and catastrophic damages, the treatment of adaptation and technological change, and the way in which inter-regional and inter-sectoral linkages are modeled. While the new version of the models discussed above offer some improvements in these areas, further work remains warranted. The 2010 TSD also discusses the need to more carefully assess the implications of risk aversion for SCC estimation as well as the inability to perfectly substitute between climate and non-climate goods at higher temperature increases, both of which have implications for the discount rate used. EPA, DOE, and other agencies continue to engage in research on modeling and valuation of climate impacts that can potentially improve SCC estimation in the future.

References

Anthoff, D. and Tol, R.S.J. 2013. The uncertainty about the social cost of carbon: a decomposition analysis using FUND. *Climatic Change* 117: 515–530.

Anthoff, D. and Tol, R.S.J. 2013. Erratum to: The uncertainty about the social cost of carbon: A decomposition analysis using FUND. *Climatic Change*. Advance online publication. doi: 10.1007/s10584-013-0959-1.

Fankhauser, S. 1995. Valuing climate change: The economics of the greenhouse. London, England: Earthscan.

Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland. 2007. Changes in Atmospheric Constituents and in Radiative Forcing. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Hope, Chris. 2006. "The Marginal Impact of CO_2 from PAGE2002: An Integrated Assessment Model Incorporating the IPCC's Five Reasons for Concern." *The Integrated Assessment Journal*. 6(1): 19–56.

Hope, Chris. 2011a "The PAGE09 Integrated Assessment Model: A Technical Description" Cambridge Judge Business School Working Paper No. 4/2011 (April). Accessed November 23, 2011: http://www.jbs.cam.ac.uk/research/working_papers/2011/wp1104.pdf.

Hope, Chris. 2011b "The Social Cost of CO_2 from the PAGE09 Model" Cambridge Judge Business School Working Paper No. 5/2011 (June). Accessed November 23, 2011: http://www.jbs.cam.ac.uk/research/working_papers/2011/wp1105.pdf.

Hope, Chris. 2011c "New Insights from the PAGE09 Model: The Social Cost of CO_2" Cambridge Judge Business School Working Paper No. 8/2011 (July). Accessed November 23, 2011: http://www.jbs.cam.ac.uk/research/working_papers/2011/wp1108.pdf.

Hope, C. 2013. Critical issues for the calculation of the social cost of CO_2: why the estimates from PAGE09 are higher than those from PAGE2002. *Climatic Change* 117: 531–543.

Interagency Working Group on Social Cost of Carbon. 2010. Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866. February. United States Government. http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver and Z.-C. Zhao. 2007. Global Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Narita, D., R. S. J. Tol and D. Anthoff. 2010. Economic costs of extratropical storms under climate change: an application of FUND. *Journal of Environmental Planning and Management* 53(3): 371-384.

National Academy of Sciences. 2011. *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia*. Washington, DC: National Academies Press, Inc.

Nicholls, R.J., N. Marinova, J.A. Lowe, S. Brown, P. Vellinga, D. de Gusmão, J. Hinkel and R.S.J. Tol. 2011. Sea-level rise and its possible impacts given a 'beyond 4°C world' in the twenty-first century. *Phil. Trans. R. Soc. A* 369(1934): 161-181.

Nordhaus, W. 2010. Economic aspects of global warming in a post-Copenhagen environment. *Proceedings of the National Academy of Sciences* 107(26): 11721-11726.

Nordhaus, W. 2008. A Question of Balance: Weighing the Options on Global Warming Policies. New Haven, CT: Yale University Press.

Randall, D.A., R.A. Wood, S. Bony, R. Colman, T. Fichefet, J. Fyfe, V. Kattsov, A. Pitman, J. Shukla, J. Srinivasan, R.J. Stouffer, A. Sumi and K.E. Taylor. 2007. Climate Models and Their Evaluation. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Appendix A

Table A1: Annual SCC Values: 2010-2050 (2007$/metric ton CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	10	31	50	86
2011	11	32	51	90
2012	11	33	53	93
2013	11	34	54	97
2014	11	35	55	101
2015	11	36	56	105
2016	11	38	57	108
2017	11	39	59	112
2018	12	40	60	116
2019	12	41	61	120
2020	12	42	62	123
2021	12	42	63	126
2022	13	43	64	129
2023	13	44	65	132
2024	13	45	66	135
2025	14	46	68	138
2026	14	47	69	141
2027	15	48	70	143
2028	15	49	71	146
2029	15	49	72	149
2030	16	50	73	152
2031	16	51	74	155
2032	17	52	75	158
2033	17	53	76	161
2034	18	54	77	164
2035	18	55	78	168
2036	19	56	79	171
2037	19	57	81	174
2038	20	58	82	177
2039	20	59	83	180
2040	21	60	84	183
2041	21	61	85	186
2042	22	61	86	189
2043	22	62	87	192
2044	23	63	88	194
2045	23	64	89	197
2046	24	65	90	200
2047	24	66	92	203
2048	25	67	93	206
2049	25	68	94	209
2050	26	69	95	212

Table A2: 2020 Global SCC Estimates at 2.5 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario[12]					PAGE					
IMAGE	6	10	15	26	55	123	133	313	493	949
MERGE Optimistic	4	6	8	15	32	75	79	188	304	621
MESSAGE	4	7	10	19	41	104	103	266	463	879
MiniCAM Base	5	8	12	21	45	102	108	255	412	835
5th Scenario	2	4	6	11	24	81	66	192	371	915
Scenario					DICE					
IMAGE	25	31	37	47	64	72	92	123	139	161
MERGE Optimistic	14	18	20	26	36	40	50	65	74	85
MESSAGE	20	24	28	37	51	58	71	95	109	221
MiniCAM Base	20	25	29	38	53	61	76	102	117	135
5th Scenario	17	22	25	33	45	52	65	91	106	126
Scenario					FUND					
IMAGE	-14	-2	4	15	31	39	55	86	107	157
MERGE Optimistic	-6	1	6	14	27	35	46	70	87	141
MESSAGE	-16	-5	1	11	24	31	43	67	83	126
MiniCAM Base	-7	2	7	16	32	39	55	83	103	158
5th Scenario	-29	-13	-6	4	16	21	32	53	69	103

Table A3: 2020 Global SCC Estimates at 3 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario					PAGE					
IMAGE	4	7	9	17	36	87	91	228	369	696
MERGE Optimistic	2	4	6	10	22	54	55	136	222	461
MESSAGE	3	5	7	13	28	72	71	188	316	614
MiniCAM Base	3	5	7	13	29	70	72	177	288	597
5th Scenario	1	3	4	7	16	55	46	130	252	632
Scenario					DICE					
IMAGE	16	21	24	32	43	48	60	79	90	102
MERGE Optimistic	10	13	15	19	25	28	35	44	50	58
MESSAGE	14	18	20	26	35	40	49	64	73	83
MiniCAM Base	13	17	20	26	35	39	49	65	73	85
5th Scenario	12	15	17	22	30	34	43	58	67	79
Scenario					FUND					
IMAGE	-13	-4	0	8	18	23	33	51	65	99
MERGE Optimistic	-7	-1	2	8	17	21	29	45	57	95
MESSAGE	-14	-6	-2	5	14	18	26	41	52	82
MiniCAM Base	-7	-1	3	9	19	23	33	50	63	101
5th Scenario	-22	-11	-6	1	8	11	18	31	40	62

[12] See 2010 TSD for a description of these scenarios.

Table A4: 2020 Global SCC Estimates at 5 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario					PAGE					
IMAGE	1	2	2	4	10	27	26	68	118	234
MERGE Optimistic	1	1	2	3	6	17	17	43	72	146
MESSAGE	1	1	2	4	8	23	22	58	102	207
MiniCAM Base	1	1	2	3	8	20	20	52	90	182
5th Scenario	0	1	1	2	5	17	14	39	75	199
Scenario					DICE					
IMAGE	6	8	9	11	14	15	18	22	25	27
MERGE Optimistic	4	5	6	7	9	10	12	15	16	18
MESSAGE	6	7	8	10	12	13	16	20	22	25
MiniCAM Base	5	6	7	8	11	12	14	18	20	22
5th Scenario	5	6	6	8	10	11	14	17	19	21
Scenario					FUND					
IMAGE	-9	-5	-4	-1	2	3	6	10	14	24
MERGE Optimistic	-6	-4	-2	0	3	4	6	11	15	26
MESSAGE	-10	-6	-4	-1	1	2	5	9	12	21
MiniCAM Base	-7	-4	-2	0	3	4	6	11	14	25
5th Scenario	-11	-7	-5	-3	0	0	3	5	7	13

Table A5: Additional Summary Statistics of 2020 Global SCC Estimates

Discount rate:	5.0%				3.0%				2.5%			
Statistic:	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
DICE	12	26	2	15	38	409	3	24	57	1097	3	30
PAGE	21	1481	5	32	68	13712	4	22	97	26878	4	23
FUND	3	41	5	179	19	1452	-42	8727	33	6154	-73	14931

Appendix B

The November 2013 revision of this technical support document is based on two corrections to the runs based on the FUND model. First, the potential dry land loss in the algorithm that estimates regional coastal protections was misspecified in the model's computer code. This correction is covered in an erratum to Anthoff and Tol (2013) published in the same journal (Climatic Change) in October 2013 (Anthoff and Tol (2013b)). Second, the equilibrium climate sensitivity distribution was inadvertently specified as a truncated Gamma distribution (the default in FUND) as opposed to the truncated Roe and Baker distribution as was intended. The truncated Gamma distribution used in the FUND runs had approximately the same mean and upper truncation point, but lower variance and faster decay of the upper tail, as compared to the intended specification based on the Roe and Baker distribution. The difference between the original estimates reported in the May 2013 version of this technical support document and this revision are generally one dollar or less.

The July 2015 revision of this technical support document is based on two corrections. First, the DICE model had been run up to 2300 rather than through 2300, as was intended, thereby leaving out the marginal damages in the last year of the time horizon. Second, due to an indexing error, the results from the PAGE model were in 2008 U.S. dollars rather than 2007 U.S. dollars, as was intended. In the current revision, all models have been run through 2300, and all estimates are in 2007 U.S. dollars. On average the revised SCC estimates are one dollar less than the mean SCC estimates reported in the November 2013 version of this technical support document. The difference between the 95th percentile estimates with a 3% discount rate is slightly larger, as those estimates are heavily influenced by results from the PAGE model.

Exhibit 5

Estimating the Benefits from Carbon Dioxide Emissions Reductions

JULY 2, 2015 AT 2:00 PM ET BY HOWARD SHELANSKI AND MAURICE OBSTFELD

Summary: The social cost of carbon (SCC) is a tool that helps Federal agencies decide which carbon-reducing regulatory approaches make the most sense

By now, just about everyone accepts that carbon dioxide emissions from burning fossil fuels are warming our planet and changing our climate in harmful ways. With growing frequency we see headlines about extreme weather events such as heat waves, polar melting, severe drought, and violent storms—a dangerous mix whose costs for our economy and environment will only grow over time. Transitioning to a lower carbon economy is an essential step toward reducing these costs. The social cost of carbon (SCC) is a tool that helps Federal agencies decide which carbon-reducing regulatory approaches make the most sense—to know which come at too great a cost and which are a good deal for society. The SCC is a range of estimates, in dollars, of the long-term damage done by one ton of carbon emissions.

The effort to incorporate the SCC into regulatory impact analysis started during the Bush Administration. At that time, each Federal agency developed its own estimate of the SCC using a variety of methodologies. In 2009, the Obama Administration established a working group of technical experts from across the government to develop a single set of estimates, based on the best available science and economics, to be used by all agencies in their emissions reducing regulations. In February 2010, after considering public comments on interim values that agencies had been using, the working group released harmonized and improved SCC estimates, along with a Technical Support Document (TSD) that explained how the SCC estimates were derived. Recognizing that the underlying models would evolve and improve over time as scientific and economic understanding increased, the Administration committed to periodic updates of the 2010 estimates.

In November 2013, OMB published a request for comment on a set of updated SCC estimates and the methodology used to develop them, to supplement the comments already routinely received when agencies use the SCC in particular rulemakings. In response, we received about 150 substantive comments, some quite lengthy and technical, as well as about 39,000 form letters that expressed support for our efforts to establish a harmonized SCC.

Today, we are following up on that public comment process and announcing next steps for further refining the social cost of carbon:

- First, we are publishing a detailed summary and formal response to the many thoughtful comments we received.

- Second, we are issuing some minor technical revisions to the SCC, and publishing a revised TSD that explains those changes. The resulting central SCC estimate for a ton of CO_2 emitted in 2015 is $36.

- Third, to ensure that the next SCC update keeps up with the latest available science and economics, we will seek independent expert advice on opportunities to improve the estimates, including many of the approaches suggested by commenters and summarized in the Response to Comments document. Specifically, we are asking the National Academies of Sciences, Engineering, and Medicine to provide advice on the pros and cons of potential approaches to future updates. Input from the Academies, informed by on-going public comment and the peer-reviewed literature, will help to ensure that the SCC estimates used by the federal government continue to reflect the best available science and economics. Federal agencies will continue to use the current SCC estimates in regulatory impact analysis until further updates can be made to reflect the forthcoming guidance from the Academies.

The SCC will become increasingly important if we are to protect our economy, environment, and quality of life for current and future generations from the mounting costs of climate change. The Administration is committed to ensuring consistency across Federal agencies in how they value the carbon emission reductions that will result from their rules. We will continue to keep these estimates informed by the most up-to-date science and economics so that agencies can appropriately account for the social cost of carbon emissions in evaluating the costs and benefits of their regulations.

Howard Shelanski is the Administrator of the Office of Information and Regulatory Affairs. Maurice Obstfeld is a Member of the Council of Economic Advisers.

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Exhibit 6

United States Government Accountability Office

Report to Congressional Requesters

July 2014

REGULATORY IMPACT ANALYSIS

Development of Social Cost of Carbon Estimates

GAO-14-663

July 2014

REGULATORY IMPACT ANALYSIS

Development of Social Cost of Carbon Estimates

GAO Highlights

Highlights of GAO-14-663, a report to congressional requesters

Why GAO Did This Study

Executive Order 12866 directs federal agencies to assess the economic effects of their proposed significant regulatory actions, including a determination that a regulation's benefits justify the costs. In 2008, a federal appeals court directed DOT to update a regulatory impact analysis with an estimate of the social cost of carbon—the dollar value of the net effects (damages and benefits) of an increase in emissions of carbon dioxide, a greenhouse gas.

In 2009, the Interagency Working Group on Social Cost of Carbon was convened to develop estimates for use governmentwide, and it issued final estimates in its 2010 Technical Support Document. In 2013, the group issued revised estimates that were about 50 percent higher than the 2010 estimates, which raised public interest.

GAO was asked to review the working group's development of social cost of carbon estimates. This report describes the participating entities and processes and methods they used to develop the 2010 and 2013 estimates. GAO reviewed executive orders, OMB guidance, the Technical Support Document, its 2013 update, and other key documents. GAO interviewed officials who participated in the working group on behalf of the EOP offices and agencies involved. GAO did not evaluate the quality of the working group's approach.

GAO is making no recommendations in this report. Of seven agencies, OMB and Treasury provided written or oral comments and generally agreed with the findings in this report. Other agencies provided technical comments only or had no comments.

View GAO-14-663. For more information, contact J. Alfredo Gómez at (202) 512-3841 or gomezj@gao.gov.

What GAO Found

To develop the 2010 and 2013 social cost of carbon estimates, the Office of Management and Budget (OMB) and Council of Economic Advisers convened and led an informal interagency working group in which four other offices from the Executive Office of the President (EOP) and six federal agencies participated. Participating agencies were the Environmental Protection Agency (EPA) and the Departments of Agriculture, Commerce, Energy, Transportation (DOT), and the Treasury. According to several working group participants, the working group included relevant subject-matter experts and the agencies likely to use the estimates in future rulemakings. According to OMB staff, there is no single approach for convening informal interagency working groups and no requirement that this type of working group should document its activities or proceedings. However, OMB and EPA participants stated that the working group documented all major issues discussed in the Technical Support Document, which is consistent with federal standards for internal control. According to the Technical Support Document and participants GAO interviewed, the working group's processes and methods reflected the following three principles:

- ***Used consensus-based decision making.*** The working group used a consensus-based approach for making key decisions in developing the 2010 and 2013 estimates. Participants generally stated that they were satisfied that the Technical Support Document addressed individual comments on draft versions and reflected the overall consensus of the working group.
- ***Relied on existing academic literature and models.*** The working group relied largely on existing academic literature and models to develop its estimates. Specifically, the working group used three prevalent academic models that integrate climate and economic data to estimate future economic effects from climate change. The group agreed on three modeling inputs reflecting the wide uncertainty in the academic literature, including discount rates. Once the group reached agreement, EPA officials—sometimes with the assistance of the model developers—calculated the estimates. All other model assumptions and features were unchanged by the working group, which weighted each model equally to calculate estimates. After the academic models were updated to reflect new scientific information, such as in sea level rise and associated damages, the working group used the updated models to revise its estimates in 2013, resulting in higher estimates.
- ***Took steps to disclose limitations and incorporate new information.*** The Technical Support Document discloses several limitations of the estimates and areas that the working group identified as being in need of additional research. It also sets a goal of revisiting the estimates when substantially updated models become available. Since 2008, agencies have published dozens of regulatory actions for public comment that use various social cost of carbon estimates in regulatory analyses and, according to working group participants, agencies received many comments on the estimates throughout this process. Several participants told GAO that the working group decided to revise the estimates in 2013 after a number of public comments encouraged revisions because the models used to develop the 2010 estimates had been updated and used in peer-reviewed academic literature.

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Abbreviations

ADS-B	Automatic Dependent Surveillance-Broadcast
ATC	Air Traffic Control
DICE	Dynamic Integrated Climate and Economy
DOT	Department of Transportation
EOP	Executive Office of the President
EPA	Environmental Protection Agency
FUND	Climate Framework for Uncertainty, Negotiation, and Distribution
NHTSA	National Highway Traffic Safety Administration
OMB	Office of Management and Budget
PAGE	Policy Analysis of the Greenhouse Effect

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July 24, 2014

The Honorable David Vitter
Ranking Member
Committee on Environment and Public Works
United States Senate

The Honorable Tim Murphy
Chairman
Subcommittee on Oversight and Investigations
Committee on Energy and Commerce
House of Representatives

The Honorable John Culberson
House of Representatives

The Honorable Duncan Hunter
House of Representatives

To encourage a regulatory system that protects and improves health, safety, the environment, and the economy, without imposing unreasonable costs on society, federal agencies are required to assess the economic effects of proposed significant regulatory actions. Agencies can use regulatory impact analysis to assess whether a proposed regulation's benefits justify the costs. For example, regulations aimed at benefiting society by decreasing health risks associated with air pollution may require regulated entities, such as power plants, to incur costs for installing pollution control technologies. According to Environmental Protection Agency (EPA) officials, beginning in 2008, some agencies' regulatory impact analyses incorporated estimates of the social cost of carbon,[1] which agencies use to value the net effects of reducing or

[1]The social cost of carbon (measured in dollars per metric ton of carbon dioxide) is the monetized net effects (damages and benefits) associated with an incremental increase in carbon emissions in a given year. Estimates of the social cost of carbon depend on the data and the models used to calculate them and can include a wide range of damage categories, such as projected changes in net agricultural productivity, human health, and property damages from increased flood risk due to increased carbon emissions. Monetization is the process of estimating the dollar value of benefits and costs.

increasing carbon dioxide emissions.[2] In 2009, in part because agencies used varying estimates of the social cost of carbon, the Executive Office of the President's (EOP) Office of Management and Budget (OMB) and Council of Economic Advisers convened an interagency working group to develop social cost of carbon estimates for federal agencies to use in their regulatory impact analyses. The working group finalized its estimates in 2010 and included them in a document—called the Technical Support Document—that also provides guidance for agencies on using the estimates.[3] In May 2013, the working group issued an update to the Technical Support Document that included revised estimates of the social cost of carbon.[4] These 2013 estimates of the social cost of carbon were approximately 50 percent higher than the 2010 estimates, which raised public interest.

You asked us to review the interagency working group's development of social cost of carbon estimates. This report describes the approach used, including participating entities and processes and methods, to develop the 2010 and 2013 social cost of carbon estimates for regulatory impact analysis.

To address this objective, we reviewed pertinent requirements and guidance, including executive orders and OMB guidance; the Technical Support Document and its 2013 update; published materials and presentations by working group participants on the development of the social cost of carbon estimates; and related GAO reports. We interviewed current and former federal officials or staff who participated in the working group on behalf of the EOP offices and agencies named in the Technical

[2]Carbon dioxide is a greenhouse gas recognized as a major contributor to climate change. Concentrations of greenhouse gases—including carbon dioxide, methane, nitrous oxide, and synthetic chemicals such as fluorinated gases—trap heat in the atmosphere and prevent it from returning to space.

[3]Interagency Working Group on Social Cost of Carbon, United States Government, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866* (Washington, D.C.: February 2010).

[4]Interagency Working Group on Social Cost of Carbon, United States Government, *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866* (Washington, D.C.: May 2013). This document was reissued with minor technical corrections in November 2013.

Support Document.[5] We identified these participants by contacting all of the agencies and OMB and then following up with additional individuals identified during our discussions with them. Through this process, we interviewed over 20 individuals who participated in the working group to develop the estimates in the Technical Support Document or its 2013 update, or both. We also corresponded with researchers who developed key academic materials the working group used. Our review describes the approach the working group used to develop estimates of the social cost of carbon; evaluating the quality of the approach is outside the scope of this review.

We conducted this performance audit from November 2013 to July 2014 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Executive Order 12866 directs federal agencies to assess the potential costs and benefits of their significant regulatory actions, consisting of several categories of regulatory actions, including those likely to result in a rule that may have an annual effect on the economy of $100 million or more or that have a material adverse effect on the economy; a sector of the economy; productivity; competition; jobs; the environment; public health or safety; or state, local, or tribal governments or communities.[6] Under the executive order, for regulatory actions expected to meet this

[5]According to the Technical Support Document, the working group consisted of participants from the Council of Economic Advisers, Council on Environmental Quality, EPA, National Economic Council, Office of Energy and Climate Change, OMB, Office of Science and Technology Policy, and the Departments of Agriculture, Commerce, Energy, Transportation, and the Treasury. In March 2011, the Office of Energy and Climate Change joined the Domestic Policy Council.

[6]Exec. Order No. 12866, 58 Fed. Reg. 51,735 (Sept. 30, 1993). Other significant regulatory actions include those that are likely to result in a rule that may create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or raise novel legal or policy issues arising out of legal mandates, the President’s priorities, or the principles set forth in Executive Order 12866.

threshold, or economically significant regulatory actions, agencies must also assess costs and benefits of reasonably feasible alternatives and explain why the planned regulatory action is preferable to the identified alternatives. For each significant regulatory action, the agency is to develop the proposed regulation and associated regulatory impact analysis and submit them to OMB for formal review. After OMB concludes its review, the agency is to publish the proposed rule in the *Federal Register* for public comment. The agency is to issue a document summarizing its consideration of the public comments and, if appropriate, modify the proposed rule in response to the comments. This phase of regulatory development may also include further internal and external review. For significant regulatory actions, the agency is to submit the final regulatory impact analysis and regulation to OMB for review before it publishes the final rule.

In 2003, OMB issued Circular A-4 to provide guidance to federal agencies on the development of regulatory analysis as directed by Executive Order 12866.[7] Circular A-4 states that it is designed to assist agencies by defining good regulatory analysis and standardizing the way benefits and costs of federal regulatory actions are measured and reported. In particular, the guidance provides for systematic evaluation of qualitative and quantitative benefits and costs, including their monetization. Circular A-4 also provides guidance on the selection of discount rates to adjust the estimated benefits and costs for differences in timing.[8] According to Circular A-4, a regulatory impact analysis should include an evaluation of the benefits and costs of the proposed action and any reasonable alternatives, as well as a description of assumptions and uncertainty.[9] It acknowledges that agencies cannot analyze all regulations according to a

[7]OMB, Circular A-4: Regulatory Analysis (Sept. 17, 2003).

[8]When the benefits and costs of a regulatory action will occur in the future, agencies must determine the present value of future benefits and costs by applying an appropriate discount rate—the interest rate used to convert benefits and costs occurring in different time periods to a common present value.

[9]Circular A-4 states that agencies should discount future benefits and costs using rates of 3 and 7 percent but notes that agencies may, in addition, consider a lower discount rate if a rule will have important intergenerational benefits or costs. In July 2014, we reported on the application of the guidance in Circular A-4 and the Technical Support Document and made recommendations to OMB to help clarify the relationship between those two documents. See GAO, *Environmental Regulation: EPA Should Improve Adherence to Guidance for Selected Elements of Regulatory Impact Analyses*, GAO-14-519 (Washington, D.C.: July 18, 2014).

formula, and that different regulations may call for different emphases in the analysis. Executive Order 13563, which reaffirmed and supplemented Executive Order 12866 in 2011, generally directs federal agencies to conduct regulatory actions based on the best available science.[10] It also directs agencies to use the best available techniques to quantify benefits and costs accurately.

Federal agencies began including estimates of the social cost of carbon in regulatory impact analyses following a decision by the U.S. Court of Appeals for the Ninth Circuit. Specifically, in 2006, the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) issued a final rule on fuel economy standards for certain vehicles which, like other regulations at the time, did not include estimates of the social cost of carbon.[11] The final rule stated that the agency had identified a benefit from a significant reduction in carbon dioxide emissions but stated that the dollar value of the benefit could not be determined because of the wide variation in published estimates of the social cost of carbon. In 2008, in response to a challenge from 11 states and several other organizations, the Ninth Circuit held that NHTSA had acted arbitrarily and capriciously by failing to monetize the value of carbon emissions reduction and directed NHTSA to include such a monetized value in an updated regulatory impact analysis for the regulation.[12] The court stated that, "[w]hile the record shows that there is a range of values, the value of carbon emissions reduction is certainly not zero."[13] Following the court's decision, the Department of Energy, the Department of Transportation, and EPA incorporated a variety of individually developed estimates of the social cost of carbon into their regulatory analyses. These estimates were derived from academic literature and ranged, in general, from $0 to $159 (in 2006, 2007, or 2008 dollars) per metric ton of carbon dioxide emitted

[10]Exec. Order No. 13563, 76 Fed. Reg. 3821 (Jan. 18, 2011).

[11]Average Fuel Economy Standards for Light Trucks Model Years 2008-2011, 71 Fed. Reg. 17,566 (Apr. 6, 2006). According to EPA officials, other regulations at the time did not typically quantify changes in carbon emissions.

[12]*Ctr. For Biological Diversity v. Nat'l Highway Traffic Safety Admin.*, 538 F.3d 1172, 1203 (9th Cir. 2008). The Ninth Circuit issued the 2008 opinion after vacating and withdrawing its prior opinion, 508 F.3d 508, issued on Nov. 15, 2007.

[13]*Id.* at 1200.

in 2007. They also varied in whether they reflected domestic or global measures of the social cost of carbon.[14]

In early 2009, in part to improve consistency in agencies' use of social cost of carbon estimates for regulatory impact analysis, OMB's Office of Information and Regulatory Affairs and the Council of Economic Advisers convened the Interagency Working Group on Social Cost of Carbon. The working group developed interim governmentwide social cost of carbon estimates based on an average of selected estimates published in academic literature. The interim estimates first appeared—and, thus, were first available for public review—in August 2009 in the Department of Energy's final rule on energy standards for vending machines.[15] Agencies subsequently incorporated the interim estimates into several published regulatory actions that sought public comments to inform the development of final estimates for future use. The middle or "central" value for the range of interim estimates was $19 (in 2006 dollars) per metric ton of carbon dioxide emitted in 2007.[16]

In October 2009, after developing the interim estimates, the working group reassembled to begin developing the final social cost of carbon estimates issued in the Technical Support Document. While the Technical Support Document is dated February 2010, it was first released publicly in March 2010 as an appendix to the Department of Energy's final rule on energy standards for small electric motors.[17] Subsequently, dozens of published regulatory actions incorporated the estimates. The Technical

[14]The benefits and costs of reducing most greenhouse gas emissions, including carbon dioxide, differ from most other benefits and costs in at least two respects: (1) greenhouse gas emissions can contribute to global damages even when emitted in the United States because these emissions can disperse widely throughout the atmosphere, and (2) these emissions generally remain in the atmosphere for years, causing subsequent long-term damages. While Circular A-4 states that agencies should generally estimate domestic benefits and costs of regulations, it also provides latitude to include global economic effects resulting from regulations when relevant and states that such effects should be reported separately and in addition to domestic effects.

[15]Energy Conservation Program: Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines, 74 Fed. Reg. 44,914 (Aug. 31, 2009).

[16]The working group calculated five interim estimates of the social cost of carbon using different discount rate scenarios and referred to $19—the middle of the five estimates—as the "central value."

[17]Energy Conservation Program: Energy Conservation Standards for Small Electric Motors, 75 Fed. Reg. 10,874 (Mar. 9, 2010).

Support Document states that the working group agreed to regularly update the social cost of carbon estimates as the research underlying the estimates evolves. In June 2013, after using the 2010 estimates in an earlier proposal of the rule, the Department of Energy's final rule on energy standards for microwaves was the first regulatory action to incorporate the revised estimates developed by the working group in the 2013 update to the Technical Support Document.[18] Table 1 shows the central values for the range of 2010 and 2013 social cost of carbon estimates for carbon emissions occurring in selected years.

Table 1: Central Values for the Social Cost of Carbon Estimates Issued by the Interagency Working Group on Social Cost of Carbon in 2010 and 2013

Dollars are 2007 dollars per metric ton of carbon dioxide

Year	2010 central values	2013 central values
2010	$21	$32
2020	26	43
2030	33	52
2040	39	61
2050	$45	$71

Source: Interagency Working Group on Social Cost of Carbon's Technical Support Document and 2013 update. | GAO-14-663

Note: The Technical Support Document states that the working group calculated the social cost of carbon for emissions occurring in multiple future years to cover the time horizons anticipated for upcoming regulatory analysis. When the benefits and costs of a regulatory action will occur in the future, agencies must determine the present value of future benefits and costs by applying an appropriate discount rate—the interest rate used to convert benefits and costs occurring in different periods to a common present value. According to the Technical Support Document, the social cost of carbon estimates increase over time because future emissions are expected to produce larger incremental damages as the environment and the economy become more stressed in response to greater climate change. The working group selected four values of the social cost of carbon for regulatory analysis. The first three values are based on the average of estimates calculated at discount rates of 2.5 percent, 3 percent, and 5 percent, and the fourth value was included to represent higher-than-expected economic impacts at the 3 percent discount rate. The Technical Support Document refers to the average of estimates calculated at the 3 percent discount rate as the "central value" of the social cost of carbon and states that agencies should consider all four values when conducting regulatory analyses.

Appendix I lists regulatory actions from 2008 to 2014 and the type of social cost of carbon estimates (i.e., individually developed, interim, 2010, or 2013) incorporated in the actions' regulatory analyses.

[18]Energy Conservation Program: Energy Conservation Standards for Standby Mode and Off Mode for Microwave Ovens, 78 Fed. Reg. 36,316 (June 17, 2013).

Approach Used to Develop Estimates of the Social Cost of Carbon

According to the Technical Support Document and participants we interviewed, the working group consisted of participants representing six EOP offices and six federal agencies and was convened under Executive Order 12866. The working group's processes and methods for developing the estimates reflected three key principles. Specifically, according to participants, the working group (1) used consensus-based decision making; (2) relied largely on existing academic literature and models, including technical assistance from outside resources; and (3) took steps to disclose limitations and incorporate new information by considering public comments and revising the estimates as updated research became available.

Participating Entities

According to the Technical Support Document and participants we spoke with, OMB and the Council of Economic Advisers convened and led the working group, and four other EOP offices and six federal agencies actively participated in the group. According to several participants, the participating EOP offices included the relevant subject-matter experts to best contribute on behalf of the EOP,[19] and the other participating agencies were those likely to conduct rulemakings affecting carbon emissions and, therefore, use the social cost of carbon estimates in the future. For example, EPA and the Department of Energy have issued numerous rules using the social cost of carbon estimates (see app. I).

OMB staff and EPA officials told us that OMB and the Council of Economic Advisers decided which EOP offices and federal agencies to invite to participate in the working group and, according to participants we interviewed from several agencies, each agency that chose to participate decided which of its internal offices would send representatives. OMB staff stated that any federal agency was welcome to participate in the working group, and EPA officials told us that at least two invited agencies declined to participate. OMB staff recalled that the working group generally included up to several participants from each participating office and agency and numbered approximately two dozen participants in total.

[19]We previously reported that four of these EOP offices—the Council on Environmental Quality, Office of Energy and Climate Change, OMB, and Office of Science and Technology Policy—provide high-level policy direction for federal climate change programs and activities and commonly lead formal and informal interagency initiatives on related issues. See GAO, *Climate Change: Improvements Needed to Clarify National Priorities and Better Align Them with Federal Funding Decisions*, GAO-11-317 (Washington, D.C.: May 20, 2011).

Table 2 lists the 12 participating offices and agencies, along with the internal offices they sent to represent them on the working group.

Table 2: Offices and Agencies Participating in the Interagency Working Group on Social Cost of Carbon to Develop the 2010 and 2013 Social Cost of Carbon Estimates

	Participating office or agency	2010 estimates	2013 estimates
Executive Office of the President			
	Council of Economic Advisers[a]	X	X
	Council on Environmental Quality	X	X
	National Economic Council	X	X
	Office of Energy and Climate Change[b]	X	X
	Office of Management and Budget[a] Office of Information and Regulatory Affairs	X	X
	Office of Science and Technology Policy	X	X
Federal agencies			
	Department of Agriculture		
	• Office of the Chief Economist	X	X
	Department of Commerce[c]		
	• International Trade Administration, Office of Competition and Economic Analysis[d]	X	
	• National Oceanic and Atmospheric Administration, National Marine Fisheries Service[e]		X
	Department of Energy[f]		
	• Office of Climate Change Policy and Technology[g]	X	X
	Department of Transportation		
	• Office of the Secretary	X	X
	• Volpe, The National Transportation Systems Center	X	
	Department of the Treasury		
	• Office of Economic Policy	X	
	• Office of International Affairs, Office of Environment and Energy	X	X
	Environmental Protection Agency		
	• Office of Air and Radiation, Office of Atmospheric Programs	X	X
	• Office of Policy, National Center for Environmental Economics	X	X

Source: GAO analysis of information provided by the Office of Management and Budget, Environmental Protection Agency, and Departments of Agriculture, Commerce, Energy, Transportation, and the Treasury. | GAO-14-663

[a]The Council of Economic Advisers and the Office of Management and Budget convened and led the working group to develop the 2010 and 2013 estimates.

[b]In March 2011, the Office of Energy and Climate Change joined the Domestic Policy Council.

[c]An official from the Department of Commerce's Economics and Statistics Administration told us that he attended two working group meetings as an observer during the development of the 2013 estimates, but that he did not review any materials produced by the group or otherwise contribute to the development of the estimates.

[d]The International Trade Administration's Office of Competition and Economic Analysis is now known as the Office of Trade and Economic Analysis.

[e]An official from the Department of Commerce's National Oceanic and Atmospheric Administration told us that she participated in the working group to develop the 2010 estimates while serving on detail to the Office of Science and Technology Policy.

[f]A former Administrator of the Energy Information Administration told us that he participated as a technical advisor to the working group to develop the 2010 estimates and not as a representative of the Department of Energy. Participants told us that the Energy Information Administration also sent a representative to some working group meetings as an observer during the development of the 2013 estimates.

[g]The Office of Climate Change Policy and Technology is now known as the Office of Climate, Environment, and Efficiency.

In establishing the working group, several participants told us that OMB and the Council of Economic Advisers made efforts to ensure that the group's members, collectively, brought the necessary technical expertise for developing social cost of carbon estimates. For example, according to these participants and EPA documentation, participants from the EOP offices included individuals with expertise in pertinent topics, such as economics and climate science. The former Deputy Assistant Secretary for Environment and Energy at the Department of the Treasury stated that he was invited to participate in the working group because of his prior experience researching ways to discount costs and benefits across generations. In addition, the former Administrator of the Energy Information Administration told us that he was asked to participate, in part, based on his previous experience evaluating climate models while conducting research with the National Academy of Sciences. According to an OMB staff member, the six participating federal agencies were also responsible for ensuring that they provided adequate technical expertise to the working group. Agency representatives included environmental economists and climate scientists, among other key professionals. According to EPA documentation, participants from EPA also provided technical expertise in climate science, economics, and academic modeling to the broader group, as needed.

When the working group reconvened in 2013 to update the estimates, the same EOP offices and agencies generally participated, although some of the individuals participating on behalf of offices or agencies changed, in part due to individuals changing positions or leaving the government altogether. Also, some participants who previously had been serving details at other participating agencies had returned to their home agencies. For example, certain participants who were on detail to the

Council of Economic Advisers during the development of the 2010 Technical Support Document instead represented EPA on the working group during the development of the 2013 update.

According to the Technical Support Document, the working group was convened under the broad direction of Executive Order 12866 for agencies to assess the costs and benefits of intended regulations.[20] In addition, participants from several agencies told us that the executive order was the key requirement driving the working group's effort to develop social cost of carbon estimates. OMB staff stated that, while there is no single requirement or other approach for convening interagency working groups, it is appropriate for OMB to form interagency working groups to collaborate on policy or analytic needs identified under Executive Order 12866. These OMB staff members said that, instead of being organized under a written agreement or other requirements, the working group was an informal interagency working group with no charter or other convening document. According to OMB staff, there was no requirement that the informal working group should document its activities or proceedings, including the meetings held or specific discussions that occurred at each. However, OMB staff and EPA officials stated that all major issues discussed during working group meetings are documented in the Technical Support Document and its 2013 update, which is consistent with the control activities standard in the federal standards for internal control.[21] We have also reported that interagency working groups use a variety of mechanisms to implement interagency collaborative efforts, including temporary working groups,[22] and that not all collaborative arrangements, particularly those that are informal, need to be documented through written guidance and agreements.[23]

[20]The 2013 update to the Technical Support Document adds that Executive Order 13563, issued after the working group developed the 2010 social cost of carbon estimates, commits the administration to regulatory decision making based on the best available science.

[21]GAO, *Standards for Internal Control in the Federal Government*, GAO/AIMD-00-21.3.1 (Washington, D.C.: November 1999).

[22]GAO, GAO-11-317; *Managing for Results: Key Considerations for Implementing Interagency Collaborative Mechanisms*, GAO-12-1022 (Washington, D.C.: Sept. 27, 2012); and *Managing for Results: Implementation Approaches Used to Enhance Collaboration in Interagency Groups*, GAO-14-220 (Washington, D.C.: Feb. 14, 2014).

[23]GAO-12-1022.

Processes and Methods

Participants told us that the working group's processes and methods reflected three key principles. First, the group used consensus-based decision making. Second, the group relied largely on existing academic literature and models, including technical assistance from outside resources. Third, the group took steps to disclose limitations and incorporate new information by considering public comments and revising the estimates as updated research became available.

Used Consensus-Based Decision Making

All of the participants we spoke with said that the working group used a consensus-based approach for making key decisions on developing the social cost of carbon estimates. Most participants said that the working group's overall approach was open and collegial, and that participants had many opportunities to make contributions and raise issues for discussion that were important to them.

OMB staff stated that the working group did not assign roles or responsibilities, and many participants told us that different working group participants and agencies volunteered to take responsibility for various aspects of the development of the estimates that fell within their particular areas of expertise. For example, OMB staff stated that, while OMB and the Council of Economic Advisers were the official leaders of the working group meetings, all EOP offices that participated played a large role during the meetings, and discussions were informal. According to these staff and other officials we spoke with, participants could generally choose the extent of their involvement, and all participants' contributions were considered equally.

According to many participants, the Council of Economic Advisers coordinated drafting the Technical Support Document, including gathering feedback from working group members. Specifically, they told us that, following the meetings, officials from the Council of Economic Advisers summarized the group discussions to include in the latest draft of the Technical Support Document and circulated draft sections of the Technical Support Document for the working group to review. For example, a participant told us that he raised concerns about whether the Technical Support Document provided adequate information on domestic measures of the social cost of carbon. The participant said that, in response to this feedback, the working group decided to include a separate discussion in the Technical Support Document on estimating domestic benefits and costs. The Technical Support Document states that reported domestic effects should be calculated using a range of values from 7 to 23 percent of the global measure of the social cost of carbon, although it cautions that these values are approximate, provisional, and highly speculative due to limited evidence. None of the participants we spoke with expressed concerns about how their contributions were incorporated into the final Technical Support Document. The participants generally stated that they were satisfied that the final Technical Support Document successfully addressed individual comments on the draft version and the overall consensus of the working group and its participating offices and agencies.

Relied on Existing Academic Literature and Models

The Technical Support Document states that the main objective of the working group was to develop a range of estimates of the social cost of carbon using a defensible set of modeling inputs based on existing academic literature. Many participants confirmed that the working group relied largely on existing academic literature and models to develop its estimates. According to the Technical Support Document and many participants we spoke with, the working group calculated its estimates using three models that integrate climate and economic data into a single modeling framework for estimating future economic effects resulting from climate change.[24] In general, each model translates carbon dioxide emissions scenarios into changes in greenhouse gas concentrations in the atmosphere, greenhouse gas concentrations in the atmosphere into temperature changes, and temperature changes into net economic effects (i.e., damages and benefits). However, each model uses its own methods to estimate these effects. The Technical Support Document states that the three models are frequently cited in peer-reviewed literature. They have also been used in climate assessments by the Intergovernmental Panel on Climate Change—an organization within the United Nations that assesses scientific, technical, and economic information on the effects of climate change. In addition, the National Research Council of the National Academies recognized these three models as three of the most widely used models of their kind.[25]

Many participants told us that the working group spent most of its meeting time reviewing and discussing academic literature to help decide on

[24]The three models are Dynamic Integrated Climate and Economy (DICE), Climate Framework for Uncertainty, Negotiation, and Distribution (FUND), and Policy Analysis of the Greenhouse Effect (PAGE). They were first developed in the early 1990s by researchers acknowledged as leaders in their field and are updated regularly based on new developments in climate and economic research.

[25]National Research Council, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use* (Washington, D.C.: National Academies Press, 2010).

values for three key modeling inputs to run in each model. The key modeling inputs the working group selected were based on data from prevalent research organizations, such as the Stanford Energy Modeling Forum, and reflected the wide uncertainty in the academic literature, according to the Technical Support Document.[26] These inputs were as follows:

- scenarios for future population and economic growth (i.e., gross domestic product) and carbon dioxide emissions,
- a measure of the climate's responsiveness to increased concentrations of greenhouse gases in the atmosphere—known as equilibrium climate sensitivity,[27] and
- discount rates.

Several participants told us that different meetings focused on different modeling inputs and included technical presentations by participants with expertise in each technical area. For example, due to their previous experience working with the models, EPA officials made presentations on how each model works. OMB staff stated that the technical presentations focused on the academic materials cited in the Technical Support Document, including dozens of peer-reviewed journal articles. They also said that all technical decisions discussed in the Technical Support Document were arrived at by consensus through this process. Several participants said that a significant amount of the group's discussions focused on selecting discount rates that best reflect the most current academic literature, while also comporting with OMB's guidance in Circular A-4. The Technical Support Document cites guidance from Circular A-4 in its discussion of many technical topics, including its selection of discount rates. It states that the discount rate (i.e., 3 percent) used to calculate the central value of the social cost of carbon estimates is consistent with Circular A-4 guidance. Some working group participants told us that they recognized the importance of using OMB guidance, including Circular A-4, in developing the Technical Support Document. The Technical Support Document states that the working group decided

[26]The Stanford Energy Modeling Forum is an international forum for sharing and facilitating discussions on energy policy and global climate issues among researchers.

[27]Equilibrium climate sensitivity is the long-term increase in the annual global-average surface temperature from a sustained doubling of the concentration of carbon dioxide in the atmosphere relative to preindustrial levels of the concentration of carbon dioxide in the atmosphere.

to calculate estimates for several discount rates (2.5, 3, and 5 percent) because the academic literature shows that the social cost of carbon is highly sensitive to the discount rate chosen, and because no consensus exists on the appropriate rate. It further states that, in light of such uncertainties, the working group determined that these three discount rates reflect reasonable judgments about the appropriate rate to use. Several participants stated that the working group chose this approach to capture varied concerns and interests, including participants' respective knowledge of the academic literature, on selecting the discount rate.

Once the working group agreed on these modeling inputs, EPA officials supervised their use in running the models to calculate the social cost of carbon estimates. All other model assumptions and features were unchanged by the working group, which weighted each model equally to calculate the final estimates. Several participants stated that an important principle for the leaders of the working group was that the working group reach consensus on the modeling inputs before running the models and agree, in advance, to accept the results based on the inputs selected, whatever the outcome. Through this approach, the working group developed a set of four social cost of carbon estimates for use in regulatory impact analyses. The first three values are based on the average of the estimates produced by all three models and selected modeling inputs at the three discount rates chosen. The fourth value was included to represent higher-than-expected economic impacts from climate change, and it is based on an average of certain values produced by each model at a 3 percent discount rate.[28] To capture uncertainties involved in regulatory impact analysis, the Technical Support Document emphasizes the importance of agencies considering all four estimates when conducting analyses.

According to EPA documentation and several participants, groups from outside the federal government did not participate in the working group, but the working group used some outside resources, specifically technical assistance. As noted in the Technical Support Document, the working group explored technical literature in relevant fields for developing the social cost of carbon estimates. Members of the working group

[28]According to the Technical Support Document, the working group determined the fourth value by combining the values appearing at the furthest reaches of the distributions produced by each model. For this purpose, the working group used values produced from all three models for the 95th percentile at a 3 percent discount rate.

sometimes contacted researchers or developers of key data in an effort to ensure that the working group had a clear understanding of the information and how to use it. For example, according to several participants, members of the working group consulted with lead authors of a chapter on climate sensitivity that appears in the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*.[29] According to the Technical Support Document, after consulting with the chapter authors, the working group was able to make some decisions to assist with statistical analyses needed to develop the social cost of carbon estimates. Many participants stated that the working group also consulted with the developers of the models used by the group to develop the estimates. For example, EPA officials told us that, while they conducted runs for one model that was readily available to the public, they spent a few days training with the developer of a second model before using it to conduct runs. They also contracted with the developer of a third model to run the model according to the decisions reached by the working group. They stated that they ran all of the 2013 estimates themselves, but that they continued to consult with the model developers to do so.

According to many participants and the 2013 update to the Technical Support Document, the only changes made to the models used for the 2013 revisions were those that the model developers incorporated into the latest versions of the models and that were subsequently used in peer-reviewed academic literature. Specifically, the developers updated the academic models to reflect new scientific information, such as in sea level rise and associated damages, resulting in higher estimates.[30] The working group did not make changes in the modeling inputs that it used

[29]Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (S. Solomon, et al. [eds.])(Cambridge, UK: Cambridge University Press, 2007).

[30]This new scientific information included an explicit representation of sea level rise and associated damages, updated climate change adaptation assumptions, and updated damage functions for agricultural impacts.

for the 2010 estimates.[31] Several participants said that, while the original working group included frequent, hours-long meetings over several months, the working group assembled to discuss the 2013 revisions only met a few times. According to the 2010 Technical Support Document, the working group is committed to updating its estimates as the science and economic understanding of climate change and its impacts on society improve over time.

Took Steps to Disclose Limitations and Incorporate New Information

According to several participants and the Technical Support Document, the working group's processes and methods took steps to disclose limitations and incorporate new information by considering public comments and revising the estimates as updated economic and scientific research became available. The Technical Support Document discusses several limitations of its estimates and areas that the working group identified as being in particular need of additional exploration and research. For example, it points out that none of the three models accounts for damages from wildlife loss or ocean acidification caused by carbon dioxide emissions. Also, the models cannot completely predict how technology may adapt to warmer temperatures. In addition, according to the Technical Support Document, the models may not fully consider the effects of damages due to potential catastrophic events, such as the melting of Antarctic ice sheets. As a result of such limitations, the models may underestimate damages from increased carbon emissions, according to the Technical Support Document. The Technical Support Document states that, as a result of these limitations, the social cost of carbon estimates should continue to evolve as knowledge is gained, and available models improve. Some of the participating agencies have incorporated discussions of these limitations into regulatory impact analyses using social cost of carbon estimates. For example, in a 2012 rule setting pollution standards for certain power plants, EPA noted that

[31]In January 2014, a former coleader of the working group discussed some of the reasons behind this approach in a presentation before the annual meeting of the American Economic Association, a leading economic interest group. See Cass Sunstein, "On Not Revisiting Official Discount Rates: Institutional Inertia and the Social Cost of Carbon" (paper presented at the annual meeting of the American Economic Association, Philadelphia, PA, Jan. 3, 2014). In 2013, another former coleader of the working group published a paper detailing the working group's methodology. *See* Greenstone, Michael et al., "Developing a Social Cost of Carbon for U.S. Regulatory Analysis: A Methodology and Interpretation," *Review of Environmental Economics and Policy 7*, no. 1: 23-46 (2013).

the social cost of carbon estimates are subject to limitations and uncertainties.[32]

Over the years, there have been opportunities for public comment on the various individually developed and working group estimates of the social cost of carbon for regulatory impact analysis, and several participants stated that these estimates were developed with input from the public. Since 2008, agencies have published over three dozen regulatory actions for public comment in the *Federal Register* that use various social cost of carbon estimates in regulatory impact analyses. While some of them specifically sought comments on the development of the social cost of carbon estimates used, and others did not, these regulatory actions were open to public comment, in general, for approximately 60 days and, according to OMB staff and other participants, agencies received many comments on the estimates through this process. Several participants stated that, while they discussed such public comments during working group meetings, individual agencies typically do not coordinate formally with other agencies on their reviews of comments received. According to the Technical Support Document, the working group convened, in part, to consider public comments on issues related to the social cost of carbon. After considering public comments on the interim values that agencies used in several rules, the working group developed the Technical Support Document, according to these participants and to the Technical Support Document. Several participants told us that the working group decided to revise the estimates for the first time in 2013 after agencies received a number of public comments encouraging revisions because the models used to develop the 2010 estimates had been subsequently updated and used in peer-reviewed academic literature. OMB staff stated that this theme was reflected in several public comments on regulations using the 2010 estimates.

In November 2013, OMB published a request in the *Federal Register* for public comments on all aspects of the Technical Support Document and

[32]National Emission Standards for Hazardous Air Pollutants From Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units, 77 Fed. Reg. 9304 (Feb. 16, 2012).

its use of the models to develop estimates of the social cost of carbon.[33] The notice stated that OMB is particularly interested in comments on the selection of the models for use in developing the estimates, how the distribution of estimates should be represented in regulatory impact analyses, and the strengths and limitations of the overall approach. OMB staff told us that they decided to issue the request in response to calls for additional transparency, and that they received over 100 unique comments and thousands of identical form-letter comments in response to the request. They said that, since they were still reviewing the comments received, they had not yet decided on steps for responding to them, but that they expect to review them with the working group to determine whether they could inform future updates to the Technical Support Document. OMB staff stated that they have already made most of the comments publicly available online at http://www.regulations.gov/ and that all of the comments would be made available soon.

The Technical Support Document states that the working group would regularly revisit the social cost of carbon estimates as new information becomes available due to improved scientific and economic research. The Technical Support Document set a goal of revisiting the estimates within 2 years, or when substantially updated models become available. Many participants told us that, to revise the estimates in 2013, the working group met only a few times and mostly for participants from EPA to present information about updates made to the models since the group last met in 2010. The updates touched on a variety of issues, including how some models represent damages from sea level rise. The 2013 update to the Technical Support Document states that it acknowledges the continued limitations described in the original Technical Support Document, and that it updates the estimates based on new versions of the underlying models without revisiting the working group's decisions on modeling inputs. Several participants stated that they reviewed drafts of the 2013 update to the Technical Support Document, but that there was little new information to review because only the models had been updated. In addition to stating that the working group would regularly

[33]Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order No. 12866, 78 Fed. Reg. 70,586 (Nov. 26, 2013). In January 2014, OMB extended the public comment period through February 26, 2014. *See* Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order No. 12866, 79 Fed. Reg. 4359 (Jan. 27, 2014).

revisit its estimates, the Technical Support Document states that the working group will continue to support research to improve the estimates and hopes to develop methods to value other greenhouse gases as part of its ongoing work.[34]

Agency Comments

We provided a draft of this report for review and comment to the Departments of Agriculture, Commerce, Energy, Transportation, and the Treasury; EPA; and OMB. Only the Department of the Treasury provided written comments, which we received on July 14, 2014, and are reproduced in appendix II; in its written comments, the Department of the Treasury stated that the draft report does a good job of capturing the interagency process through which the estimates of the social cost of carbon were developed. In oral comments provided on July 15, 2014, OMB staff confirmed that OMB generally agreed with the report findings. OMB staff also provided technical comments, which we incorporated into the report, as appropriate. The Department of Energy and EPA provided technical comments only, which we incorporated into the report, as appropriate. In e-mails received on July 1, July 9, and July 14, 2014, respectively, the liaisons from the Departments of Agriculture, Commerce, and Transportation stated that the departments did not have any comments on the draft report.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees; the Secretaries of Agriculture, Commerce, Energy, Transportation, and the Treasury; the Administrator of EPA; the

[34]In late 2010 and early 2011, EPA and the Department of Energy sponsored two workshops on valuing climate change damages for regulatory analysis. The agencies reported that they sponsored the workshops to prepare for and inform future working group activities. *See* ICF International, *Workshop Report: Improving the Assessment and Valuation of Climate Change Impacts for Policy and Regulatory Analysis – Part 1* (January 2011); summary of workshop sponsored by EPA and the Department of Energy and titled “Modeling Climate Change Impacts and Associated Economic Damages” (Washington, D.C.: Nov. 18-19, 2010) and *Workshop Report: Improving the Assessment and Valuation of Climate Change Impacts for Policy and Regulatory Analysis – Part 2* (March 2011); summary of workshop sponsored by EPA and the Department of Energy and titled “Research on Climate Change Impacts and Associated Economic Damages” (Washington, D.C., Jan. 27-28, 2011).

Director of OMB; and other interested parties. In addition, the report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or gomezj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix III.

J. Alfredo Gómez
Director, Natural Resources and Environment

Appendix I: Regulatory Actions, by Agency and Type of Social Cost of Carbon Estimates Used, 2008-2014

This appendix lists regulatory actions from 2008 to 2014 and the type of social cost of carbon estimates used (i.e., individually developed, interim, 2010, or 2013) in the actions' regulatory impact analyses. For each regulatory action, table 3 lists the date published in the *Federal Register*, the agency conducting the action, the name and status of the rule associated with the action, and the action's citation in the *Federal Register*.

Table 3: Regulatory Actions, by Agency and Type of Social Cost of Carbon Estimates Used in the Regulatory Impact Analysis, 2008-2014

Date published in the *Federal Register*	Agency	Rule	Status of rule	*Federal Register* citation
Individually developed agency estimates				
May 2, 2008	Department of Transportation (Transportation), National Highway Traffic Safety Administration (NHTSA)	Average Fuel Economy Standards, Passenger Cars and Light Trucks; Model Years 2011-2015	Proposed	73 Fed. Reg. 24,352
July 30, 2008	Environmental Protection Agency (EPA)	Regulating Greenhouse Gas Emissions Under the Clean Air Act	Advanced Notice of Proposed Rulemaking	73 Fed. Reg. 44,354
Aug. 25, 2008	Department of Energy (Energy)	Energy Conservation Program for Commercial and Industrial Equipment: Energy Conservation Standards for Commercial Ice-Cream Freezers; Self-Contained Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers Without Doors; and Remote Condensing Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers	Proposed	73 Fed. Reg. 50,072
Oct. 7, 2008	Energy	Energy Conservation Program for Commercial and Industrial Equipment: Packaged Terminal Air Conditioner and Packaged Terminal Heat Pump Energy Conservation Standards	Final	73 Fed. Reg. 58,772

Date published in the *Federal Register*	Agency	Rule	Status of rule	*Federal Register* citation
Oct. 17, 2008	Energy	Energy Conservation Program: Energy Conservation Standards for Certain Consumer Products (Dishwashers, Dehumidifiers, Electric and Gas Kitchen Ranges and Ovens, and Microwave Ovens) and for Certain Commercial and Industrial Equipment (Commercial Clothes Washers)	Proposed	73 Fed. Reg. 62,034
Jan. 9, 2009	Energy	Energy Conservation Program for Commercial and Industrial Equipment: Energy Conservation Standards for Commercial Ice-Cream Freezers; Self-Contained Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers Without Doors; and Remote Condensing Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers	Final	74 Fed. Reg. 1092
Mar. 30, 2009	Transportation, NHTSA	Average Fuel Economy Standards Passenger Cars and Light Trucks Model Year 2011	Final	74 Fed. Reg. 14,196
Apr. 8, 2009	Energy	Energy Conservation Program: Energy Conservation Standards for Certain Consumer Products (Dishwashers, Dehumidifiers, Microwave Ovens, and Electric and Gas Kitchen Ranges and Ovens) and for Certain Commercial and Industrial Equipment (Commercial Clothes Washers)	Final	74 Fed. Reg. 16,040
Apr. 13, 2009	Energy	Energy Conservation Program: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps	Proposed	74 Fed. Reg. 16,920
May 26, 2009	EPA	Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program	Proposed	74 Fed. Reg. 24,904
May 29, 2009	Energy	Energy Conservation Program: Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines	Proposed	74 Fed. Reg. 26,020

Date published in the *Federal Register*	Agency	Rule	Status of rule	*Federal Register* citation
July 14, 2009	Energy	Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps	Final	74 Fed. Reg. 34,080
July 22, 2009	Energy	Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards and Test Procedures for Commercial Heating, Air-Conditioning, and Water-Heating Equipment	Final	74 Fed. Reg. 36,312
Interim governmentwide estimates				
Aug. 31, 2009	Energy	Energy Conservation Program: Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines	Final	74 Fed. Reg. 44,914
Sep. 28, 2009	EPA and Transportation, NHTSA	Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards	Proposed	74 Fed. Reg. 49,454
Nov. 9, 2009	Energy	Energy Conservation Program: Energy Conservation Standards for Certain Consumer Products (Dishwashers, Dehumidifiers, Microwave Ovens, and Electric and Gas Kitchen Ranges and Ovens) and for Certain Commercial and Industrial Equipment (Commercial Clothes Washers)	Supplemental Notice of Proposed Rulemaking	74 Fed. Reg. 57,738
Nov. 24, 2009	Energy	Energy Conservation Program: Energy Conservation Standards for Small Electric Motors	Proposed	74 Fed. Reg. 61,410
Dec. 11, 2009	Energy	Energy Conservation Program: Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters	Proposed	74 Fed. Reg. 65,852
Jan. 8, 2010	Energy	Energy Conservation Program: Energy Conservation Standards for Certain Consumer Products (Dishwashers, Dehumidifiers, Microwave Ovens, and Electric and Gas Kitchen Ranges and Ovens) and for Certain Commercial and Industrial Equipment (Commercial Clothes Washers)	Final	75 Fed. Reg. 1122

Date published in the *Federal Register*	Agency	Rule	Status of rule	*Federal Register* citation
Mar. 26, 2010	EPA	Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program	Final	75 Fed. Reg. 14,670
June 21, 2010	EPA	Hazardous and Solid Waste Management System; Identification and Listing of Special Wastes; Disposal of Coal Combustion Residuals From Electric Utilities	Proposed	75 Fed. Reg. 35,128
2010 governmentwide estimates				
Mar. 9, 2010	Energy	Energy Conservation Program: Energy Conservation Standards for Small Electric Motors	Final	75 Fed. Reg. 10,874
Apr. 16, 2010	Energy	Energy Conservation Program: Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters	Final	75 Fed. Reg. 20,112
May 7, 2010	EPA and Transportation, NHTSA	Light Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards	Final	75 Fed. Reg. 25,324
May 28, 2010	Transportation, Federal Aviation Administration	Automatic Dependent Surveillance—Broadcast (ADS-B) Out Performance Requirements to Support Air Traffic Control (ATC) Service	Final	75 Fed. Reg. 30,160
Aug. 2, 2010	EPA	Federal Implementation Plans To Reduce Interstate Transport of Fine Particulate Matter and Ozone	Proposed	75 Fed. Reg. 45,210
Sep. 9, 2010	EPA	National Emission Standards for Hazardous Air Pollutants from the Portland Cement Manufacturing Industry and Standards of Performance for Portland Cement Plants	Final	75 Fed. Reg. 54,970
Oct. 14, 2010	EPA	Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Sewage Sludge Incineration Units	Proposed	75 Fed. Reg. 63,260
Nov. 30, 2010	EPA and Transportation, NHTSA	Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles	Proposed	75 Fed. Reg. 74,152

Date published in the *Federal Register*	Agency	Rule	Status of rule	*Federal Register* citation
Mar. 14, 2011	EPA	National Emission Standards for Hazardous Air Pollutants: Mercury Emissions from Mercury Cell Chlor-Alkali Plants	Supplemental Proposed Rule	76 Fed. Reg. 13,852
Mar. 21, 2011	EPA	Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Sewage Sludge Incineration Units	Final	76 Fed. Reg. 15,372
Mar. 21, 2011	EPA	National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters	Final	76 Fed. Reg. 15,608
Apr. 11, 2011	Energy	Energy Conservation Program: Energy Conservation Standards for Fluorescent Lamp Ballasts	Proposed	76 Fed. Reg. 20,090
Apr. 21, 2011	Energy	Energy Conservation Program: Energy Conservation Standards for Residential Clothes Dryers and Room Air Conditioners	Direct Final	76 Fed. Reg. 22,454
June 27, 2011	Energy	Energy Conservation Program: Energy Conservation Standards for Residential Furnaces and Residential Central Air Conditioners and Heat Pumps	Direct Final	76 Fed. Reg. 37,408
Aug. 8, 2011	EPA	Federal Implementation Plans: Interstate Transport of Fine Particulate Matter and Ozone and Correction of SIP Approvals[a]	Final	76 Fed. Reg. 48,208
Sep. 15, 2011	EPA and Transportation, NHTSA	Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles	Final	76 Fed. Reg. 57,106
Sep. 15, 2011	Energy	Energy Conservation Program: Energy Conservation Standards for Residential Refrigerators, Refrigerator-Freezers, and Freezers	Final	76 Fed. Reg. 57,516
Nov. 14, 2011	Energy	Energy Conservation Program: Energy Conservation Standards for Fluorescent Lamp Ballasts	Final	76 Fed. Reg. 70,548
Dec. 1, 2011	EPA and Transportation, NHTSA	2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards	Proposed	76 Fed. Reg. 74,854

Date published in the *Federal Register*	Agency	Rule	Status of rule	*Federal Register* citation
Dec. 23, 2011	EPA	Commercial and Industrial Solid Waste Incineration Units: Reconsideration and Proposed Amendments; Non-Hazardous Secondary Materials That Are Solid Waste	Proposed	76 Fed. Reg. 80,452
Jan. 17, 2012	Energy	Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards and Test Procedures for Commercial Heating, Air-Conditioning, and Water-Heating Equipment	Proposed	77 Fed. Reg. 2356
Feb. 10, 2012	Energy	Energy Conservation Program: Energy Conservation Standards for Distribution Transformers	Proposed	77 Fed. Reg. 7282
Feb. 14, 2012	Energy	Energy Conservation Program: Energy Conservation Standards for Standby Mode and Off Mode for Microwaves	Supplemental Notice of Proposed Rulemaking	77 Fed. Reg. 8526
Feb. 16, 2012	EPA	National Emission Standards for Hazardous Air Pollutants from Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units	Final	77 Fed. Reg. 9304
Mar. 27, 2012	Energy	Energy Conservation Program: Energy Conservation Standards for Battery Chargers and External Power Supplies	Proposed	77 Fed. Reg. 18,478
Apr. 13, 2012	EPA	Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units	Proposed	77 Fed. Reg. 22,392
May 30, 2012	Energy	Energy Conservation Program: Energy Conservation Standards for Residential Dishwashers	Direct Final	77 Fed. Reg. 31,918
May 31, 2012	Energy	Energy Conservation Program: Energy Conservation Standards for Residential Clothes Washers	Direct Final	77 Fed. Reg. 32,308
Oct. 15, 2012	EPA and Transportation, NHTSA	2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards	Final	77 Fed. Reg. 62,624

Date published in the *Federal Register*	Agency	Rule	Status of rule	*Federal Register* citation
Apr. 18, 2013	Energy	Energy Conservation Program: Energy Conservation Standards for Distribution Transformers	Final	78 Fed. Reg. 23,336
June 7, 2013	EPA	Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category	Proposed	78 Fed. Reg. 34,432
2013 revised governmentwide estimates				
June 17, 2013	Energy	Energy Conservation Program: Energy Conservation Standards for Standby Mode and Off Mode for Microwave Ovens	Final	78 Fed. Reg. 36,316
Aug. 20, 2013	Energy	Energy Conservation Program: Energy Conservation Standards for Metal Halide Lamp Fixtures	Proposed	78 Fed. Reg. 51,464
Sep. 11, 2013	Energy	Energy Conservation Program: Energy Conservation Standards for Walk-In Coolers and Freezers	Proposed	78 Fed. Reg. 55,782
Sep. 11, 2013	Energy	Energy Conservation Program: Energy Conservation Standards for Commercial Refrigeration Equipment	Proposed	78 Fed. Reg. 55,890
Oct. 25, 2013	Energy	Energy Conservation Program for Consumer Products: Energy Conservation Standards for Residential Furnace Fans	Proposed	78 Fed. Reg. 64,068
Dec. 6, 2013	Energy	Energy Conservation Program: Energy Conservation Standards for Commercial and Industrial Electric Motors	Proposed	78 Fed. Reg. 73,590
Jan. 8, 2014	EPA	Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Utility Generating Units	Proposed	79 Fed. Reg. 1430
Feb. 10, 2014	Energy	Energy Conservation Program: Energy Conservation Standards for Metal Halide Lamp Fixtures	Final	79 Fed. Reg. 7746
Feb. 10, 2014	Energy	Energy Conservation Program: Energy Conservation Standards for External Power Supplies	Final	79 Fed. Reg. 7846
Mar. 4, 2014	Energy	Energy Conservation Program: Energy Conservation Standards for Commercial Clothes Washers	Proposed	79 Fed. Reg. 12,302

Date published in the *Federal Register*	Agency	Rule	Status of rule	*Federal Register* citation
Mar. 17, 2014	Energy	Energy Conservation Program: Energy Conservation Standards for Automatic Commercial Ice Makers	Proposed	79 Fed. Reg. 14,846
Mar. 28, 2014	Energy	Energy Conservation Program: Energy Conservation Standards for Commercial Refrigeration Equipment	Final	79 Fed. Reg. 17,726
Apr. 29, 2014	Energy	Energy Conservation Program: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps	Proposed	79 Fed. Reg. 24,068
May 29, 2014	Energy	Energy Conservation Program: Energy Conservation Standards for Commercial and Industrial Electric Motors	Final	79 Fed. Reg. 30,934
June 3, 2014	Energy	Energy Conservation Program: Energy Conservation Standards for Walk-In Coolers and Freezers	Final	79 Fed. Reg. 32,050
June 18, 2014	EPA	Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units	Proposed	79 Fed. Reg. 34,830

Sources: Environmental Protection Agency and *Federal Register*. | GAO-14-663

Notes:

Regulatory actions in this table are as of June 18, 2014.

In 2008 and early 2009, individual estimates of the social cost of carbon were developed by each agency and typically based on estimates published in academic literature. The interim governmentwide estimates were developed in early 2009 by the Interagency Working Group on Social Cost of Carbon and derived from an average of selected estimates published in academic literature. The 2010 governmentwide estimates were developed by the Interagency Working Group on Social Cost of Carbon and issued in its February 2010 Technical Support Document. The 2013 revised governmentwide estimates were developed by the Interagency Working Group on Social Cost of Carbon and issued in a May 2013 update to the Technical Support Document, which was reissued with minor technical corrections in November 2013.

[a]SIP refers to State Implementation Plan.

Appendix II: Comments from the Department of the Treasury

DEPARTMENT OF THE TREASURY
WASHINGTON, D.C.

JUL 14 2014

TO: Director J. Alfredo Gomez, Government Accountability Office

FROM: Leonardo Martinez-Diaz, Deputy Assistant Secretary for Energy and Environment

RE: Draft report on Development of Social Cost of Carbon Estimate (361544)

Dear Director Gomez,

Thank you for the opportunity to review the draft report on the Development of the Social Cost of Carbon Estimates (361544). The report does a good job of capturing the interagency process through which the estimates of the social cost of carbon were developed. We have no further comments on the draft.

Sincerely,

Leonardo Martinez-Diaz

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

J. Alfredo Gómez, (202) 512-3841, or gomezj@gao.gov

Staff Acknowledgments

In addition to the individual named above, Janet Frisch (Assistant Director), Elizabeth Beardsley, Stephanie Gaines, Cindy Gilbert, Chad M. Gorman, Tim Guinane, Patricia Moye, Susan Offutt, Alison O'Neill, and Kiki Theodoropoulos made key contributions to this report.

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Exhibit 7

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN 06 2011

ASSISTANT ADMINISTRATOR
FOR ENFORCEMENT AND
COMPLIANCE ASSURANCE

Mr. Jose W. Fernandez
Assistant Secretary
Economic, Energy and Business Affairs
U.S. Department of State
Washington, DC 20520

Dr. Kerri-Ann Jones
Assistant Secretary
Oceans and International Environmental and Scientific Affairs
U.S. Department of State
Washington, DC 20520

Dear Mr. Fernandez and Dr. Jones:

In accordance with our authorities under the National Environmental Policy Act (NEPA), the Council on Environmental Quality (CEQ) NEPA regulations, and Section 309 of the Clean Air Act, EPA has reviewed the Supplemental Draft Environmental Impact Statement (SDEIS) for TransCanada's proposed Keystone XL Project ("Project").

EPA reviewed the Draft Environmental Impact Statement (DEIS) for this project and submitted comments in July of 2010. At that time EPA rated the DEIS as "Inadequate-3" because potentially significant impacts were not evaluated and additional information and analyses were necessary to ensure that the EIS fully informed decision makers and the public about potential consequences of the Keystone XL Project. Since that time, the State Department has worked diligently to develop additional information and analysis in response to EPA's comments and the large number of other comments received on the DEIS. The State Department also made a very constructive decision to seek further public review and comment through publication of the SDEIS, to help the public and decision makers carefully weigh the environmental costs and benefits of transporting oil sands crude from Canada to delivery points in Oklahoma and Texas. The consideration of the environmental impacts associated with constructing and operating this proposed pipeline is especially important given that current excess pipeline capacity for transporting oil sands crude to the United States will likely persist until after 2020, as noted in the SDEIS.

While the SDEIS has made progress in responding to EPA's comments on the DEIS and providing information necessary for making an informed decision, EPA believes additional analysis is necessary to fully respond to our earlier comments and to ensure a full evaluation of the potential impacts of proposed Project, and to identify potential means to mitigate those impacts. As EPA and the State Department have discussed many times, EPA recommends that the State Department improve the analysis of oil spill risks and alternative pipeline routes, provide additional analysis of potential impacts to communities along the pipeline route and adjacent to refineries and the associated environmental justice concerns, together with ways to mitigate those impacts, improve the discussion of lifecycle greenhouse gas emissions (GHGs) associated with oil sands crude, and improve the analysis of potential impacts to wetlands and migratory bird populations. We are encouraged by the State Department's agreement to include some of these additional analyses in the Final Environmental Impact Statement (Final EIS). We have noted those agreements in this letter, and look forward to working with you to develop these analyses for the Final EIS.

Pipeline Safety/Oil Spill Risks

EPA is the lead federal response agency for responding to oil spills occurring in and around inland waters. As part of that responsibility, we have considerable experience working to prevent and respond to oil spills. Pipeline oil spills are a very real concern, as we saw during the two pipeline spills in Michigan and Illinois last summer. Just in the last month, the Keystone Pipeline experienced two leaks (in North Dakota and Kansas), one of which was brought to the company's attention by a local citizen. These leaks resulted in shut-downs and issuance of an order to TransCanada from the Pipeline and Hazardous Materials Safety Administration (PHMSA), requiring that corrective measures be taken prior to the subsequently approved restart of operations. PHMSA's Order of June 3, 2011 for the Keystone Pipeline – which also carries Canadian oil sands crude oil and is operated by the same company as the proposed Keystone XL Project – was based on the hazardous nature of the product that the pipeline transports and the potential that the conditions causing the failures that led to the recent spills were present elsewhere on the pipeline. These events, which occurred after EPA's comment letter on the DEIS, underscore the comments about the need to carefully consider both the route of the proposed Keystone XL Pipeline and appropriate measures to prevent and detect a spill.

We have several recommendations for additional analyses that relate to the potential for oil spills, as well as the potential impacts and implications for response activities in the event of a pipeline leak or rupture. We recommend and appreciate your agreement that the Final EIS use data from the National Response Center, which reports a more comprehensive set of historical spill events than the Pipeline and Hazardous Material Safety Administration's incident database, to assess the risk of a spill from the proposed pipeline. With respect to the spill detection systems proposed by the applicant, we remain concerned that relying solely on pressure drops and aerial surveys to detect leaks may result in smaller leaks going undetected for some time, resulting in potentially large spill volumes. In light of those concerns, we also appreciate your agreement that the Final EIS consider additional measures to reduce the risks of undetected leaks. For example, requiring ground-level inspections of valves and other parts of the system several times per year, in addition to aerial patrols, could improve the ability to detect leaks or spills and minimize any damage.

The SDEIS indicates that there may be a "minor" increase in the number of mainline valves installed to isolate pipeline segments and limit impacts of a spill, compared to what was originally reported in the DEIS (SDEIS, pg. 2-4). However, no detailed information or decision criteria are provided with regard to the number of valves, or their location. In order to evaluate potential measures to mitigate accidental releases, we appreciate your agreement to provide additional information in the Final EIS on the number and location of the valves that will be installed and to evaluate the feasibility of increasing the number of valves in more vulnerable areas. For example, it may be appropriate to increase the number of valves where the water table is shallow, or where an aquifer is overlain by highly permeable soils, such as the Ogallala aquifer. We also recommend consideration of external pipe leak detection systems in these areas to improve the ability to detect pinhole (and greater) leaks that could be substantial, yet below the sensitivity of the currently proposed leak detection systems. In addition, while we understand that valves are not proposed to be located at water crossings that are less than 100 feet wide, we recommend that the Final EIS nevertheless consider the potential benefits of installing valves at water crossings less than 100 feet wide where there are sensitive aquatic resources.

Predicting the fate and transport of spilled oil is also important to establish potential impacts and develop response strategies. While the SDEIS provides additional information about the different classes of crude oils that may transported, we recommend the Final EIS evaluate each class of crude that will be transported, how it will behave in the environment, and qualitatively discuss the potential issues associated with responding to a spill given different types of crude oils and diluents used.

With regard to the chemical nature of the diluents that are added to reduce the viscosity of bitumen, the SDEIS states "the exact composition may vary between shippers and is considered proprietary information" (SDEIS, pg. 3-104). We believe an analysis of potential diluents is important to establish the potential health and environmental impacts of any spilled oil, and responder/worker safety, and to develop response strategies. In the recent Enbridge oil spill in Michigan, for example, benzene was a component of the diluent used to reduce the viscosity of the oil sands crude so that it could be transported through a pipeline. Benzene is a volatile organic compound, and following the spill in Michigan, high benzene levels in the air prompted the issuance of voluntary evacuation notices to residents in the area by the local county health department. Similarly, although the SDEIS provides additional information on the potential impact of spills on groundwater, we recommend that the Final EIS improve the risk assessment by including specific information on the groundwater recharge areas along the pipeline route, recognizing that these areas are more susceptible to groundwater contamination from oil spills.

We appreciate that the SDEIS provides additional information about the feasibility of alternative pipeline routes that would reduce the risk of adverse impacts to the Ogallala aquifer, by re-routing the pipeline so it does not cross the aquifer. Many commenters, including EPA, expressed concerns over the potential impacts to this important resource during the review of the DEIS. If a spill did occur, the potential for oil to reach groundwater in these areas is relatively high given shallow water table depths and the high permeability of the soils overlying the aquifer. In addition, we are concerned that crude oil can remain in the subsurface for decades, despite efforts to remove the oil and natural microbial remediation.

However, the SDEIS concludes that the alternative routes that avoid the Ogallala aquifer are not reasonable, and consequently does not provide a detailed evaluation of the environmental impacts of routes other than the applicant's proposed route. The SDEIS indicates that no other alternatives are considered in detail because, in part, they do not offer an overall environmental advantage compared to other routes. In support of this conclusion the SDEIS presents a limited analysis of the potential environmental impacts of the alternative routes and offers qualitative judgments about the relative severity of impacts to different resources, e.g., considering potential impacts from spills to the Ogallala aquifer less important than impacts to surface waters from a spill associated with an additional crossing of the Missouri River. We think this limited analysis does not fully meet the objectives of NEPA and CEQ's NEPA regulations, which provide that agencies rigorously explore and objectively evaluate reasonable alternatives. CEQ guidance states that reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense.[1] Recognizing the regional significance of these groundwater resources, we recommend that the State Department re-evaluate the feasibility of these alternative routes and more clearly outline the environmental, technical and economic reasons for not considering other alternative routes in more detail as part of the NEPA analysis.

Oil Spill Impacts on Affected Communities and Environmental Justice Concerns

The communities facing the greatest potential impact from spills are of course the communities along the pipeline route. We are concerned that the SDEIS does not adequately recognize that some of these communities may have limited emergency response capabilities and consequently may be more vulnerable to impacts from spills, accidents and other releases. This is particularly likely to be true of minority, low-income and Tribal communities or populations along the pipeline route. We appreciate your agreement to address this issue in the Final EIS by clarifying the emergency response capability of each county along the pipeline route using the plans produced by Local Emergency Planning Committees. We also appreciate your agreement to identify potential mitigation measures in the Final EIS based on this information. We look forward to working with your staff to identify data sources and approaches for addressing these issues.

As part of this analysis, we are concerned that the SDEIS may have underestimated the extent to which there are communities along the pipeline with less capacity to respond to spills and potentially associated health issues, particularly minority, low-income or Tribal communities. We appreciate your agreement to re-evaluate in the Final EIS which communities may have such capacity issues by adopting the more commonly-used threshold of 20% higher low-income, minority or Tribal population compared to the general population, instead of the 50% used in the SDEIS.

With respect to data on access to health care, we are encouraged that the SDEIS provided critically important information on medically underserved areas and on health professional shortage areas. We will provide recommendations on methods to present this data to make it

[1] 40 CFR 1502.14; "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 18026 (1981) - Question 2a: Alternatives Outside the Capability of Applicant or Jurisdiction of Agency.

more meaningful to reviewers and will work with your staff as you move towards publishing a Final EIS.

The SDEIS does recognize that minority, low-income or Tribal populations may be more vulnerable to health impacts from an oil spill, and we appreciate the applicant's commitment to provide an alternative water supply "if an accidental release from the proposed Project that is attributable to Keystone's actions contaminates groundwater or surface water used as a source of potable water or for irrigation or industrial purposes..." (SDEIS, pg. 3-154). Further, the SDEIS states that impacts would be mitigated by the applicant's liability for costs associated with cleanup, restoration and compensation for any release that could affect surface water (SDEIS, pg. 3-154). We believe that this mitigation measure should also apply for releases that could affect groundwater. Finally, we recommend that the Final EIS evaluate additional mitigation measures that would avoid and minimize potential impacts through all media (i.e., surface and ground water, soil, and air) to minority, low-income and Tribal populations rather than rely solely on after-the-fact compensation measures. Some examples of additional mitigation include developing a contingency plan before operations commence for emergency response and remedial efforts to control the contamination. This would also include providing notification to individuals affected by soil or groundwater contamination, ensuring the public is knowledgeable and aware of emergency procedures and contingency plans (including posting procedures in high traffic visibility areas), and providing additional monitoring of air emissions and conducting medical monitoring and/or treatment responses where necessary.

Environmental and Health Impacts to Communities Adjacent to Refineries

We are also concerned with the conclusion that there are no expected disproportionate adverse impacts to minority or low-income populations located near refineries that are expected to receive the oil sands crude, particularly because many of these communities are already burdened with large numbers of high emitting sources of air pollutants. It is not self-evident that the addition of an 830,000 barrels per day capacity pipeline from Canada to refineries in the Gulf Coast will have no effect on emissions from refineries in that area. We recommend that the Final EIS re-examine the potential likelihood of increased refinery emissions, and provide a clearer analysis of potential environmental and health impacts to communities from refinery air emissions and other environmental stressors. As part of this re-evaluation, we encourage the State Department to provide more opportunities for people in these potentially affected communities to have meaningful engagement, including additional public meetings, particularly in Port Arthur, Texas, before publication of the Final EIS. Public meetings in these potentially affected communities provide an opportunity for citizens to present their concerns, and also for the State Department to clearly explain its analysis of potential impacts associated with the proposed project to the people potentially affected.

Lifecycle GHG Emissions

We appreciate the State Department's efforts to improve the characterization of lifecycle GHG emissions associated with Canadian oil sands crude. The SDEIS confirms, for example, that Canadian oil sands crude are GHG-intensive relative to other types of crude oil, due primarily to increased emissions associated with extraction and refining.

The SDEIS also includes an important discussion of lifecycle GHG emissions associated with oil sands crude and provides quantitative estimates of potential incremental impacts associated with the proposed Project. For example, the SDEIS (pg. 3-198) states that under at least one scenario, additional annual lifecycle GHG emissions associated with oil sands crude compared to Middle East Sour crude are 12 to 23 million metric tons of CO_2 equivalent (CO_2-e) at the proposed Project pipeline's full capacity (roughly the equivalent of annual emissions from 2 to 4 coal-fired power plants).[2] While we appreciate the inclusion of such estimates, EPA believes that the methodology used by the State Department and its contractors to calculate those estimates may underestimate the values at the high-end of the ranges cited in the lifecycle GHG emissions discussion by approximately 20 percent. We will continue to work with your staff to address this concern as you move towards publishing a Final EIS.

Further, in discussing these lifecycle GHG emissions, the SDEIS concludes "on a global scale, emissions are not likely to change" (SDEIS, pg. 3-197). We recommend against comparing GHG emissions associated with a single project to global GHG emission levels. As recognized in CEQ's draft guidance concerning the consideration of GHG emissions in NEPA analyses, "[T]he global climate change problem is much more the result of numerous and varied sources, each of which might seem to make a relatively small addition to global atmospheric GHG concentrations."[3]

Moreover, recognizing the proposed Project's lifetime is expected to be at least fifty years, we believe it is important to be clear that under at least one scenario, the extra GHG emissions associated with this proposed Project may range from 600 million to 1.15 billion tons CO_2-e, assuming the lifecycle analysis holds over time (and using the SDEIS' quantitative estimates as a basis). In addition, we recommend that the Final EIS explore other means to characterize the impact of the GHG emissions, including an estimate of the "social cost of carbon" associated with potential increases of GHG emissions.[4] The social cost of carbon includes, but is not limited to, climate damages due to changes in net agricultural productivity, human health, property damages from flood risk, and ecosystem services due to climate change. Federal agencies use the social cost of carbon to incorporate the social benefits of reducing CO_2 emissions into analyses of regulatory actions that have a marginal impact on cumulative global emissions; the social cost of carbon is also used to calculate the negative impacts of regulatory actions that increase CO_2 emissions.

Finally, we continue to be concerned that the SDEIS does not discuss opportunities to mitigate the entire suite of GHG emissions associated with constructing the proposed Project. We appreciate your agreement to identify practicable mitigation measures in the Final EIS for

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[2] http://www.epa.gov/cleanenergy/energy-resources/calculator.html

[3] "Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions," (February 18, 2010)

[4] "Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866;" Interagency Working Group on Social Cost of Carbon, United States Government, February 2010. Presents four estimates of estimated monetized damages associated with a ton of CO_2 released in 2010 ($5, $21, $35, $65) ($2007); these estimates grow over time and are associated with different discount rates.

GHG emissions associated with operation of the pipeline in the United States. As part of that analysis, we recommend consideration of opportunities for energy efficiency and utilization of green power for pipeline operations. In addition, we recommend a discussion of mitigation approaches for GHG emissions from extraction activities that are either currently or could be employed to help lower lifecycle GHG emissions to levels closer to those of conventional crude oil supplies. We recommend that this discussion include a detailed description of efforts ongoing and under consideration by producers, as well as the government of Alberta, to reduce GHG emissions from oil sands production.

Wetlands Impacts

EPA co-administers the Clean Water Act Section 404 regulatory program, which regulates the discharge of dredged or fill material into waters of the United States, including wetlands. While we appreciate that the U.S. Army Corps of Engineers is responsible for day-to-day processing of permit applications, our review of aerial photography recently posted on the Project's website indicates that the DEIS may have underestimated the extent of ecologically valuable bottomland hardwood wetlands in Texas. We appreciate your agreement to evaluate these wetland estimates in the Final EIS and to display the location of the bottomland hardwood wetlands with maps and aerial photography. Given their ecological importance, we recommend the same evaluation be done for prairie pothole wetlands that may be impacted by the proposed Project. EPA also recommends that the Final EIS discuss whether it is possible to make further pipeline route variations to avoid both bottomland hardwood and prairie pothole wetlands.

Our review of the aerial photography also indicates that there may be numerous wetland crossings that would impact more than 0.5 acres of wetlands, which is the upper threshold for impacts under the US Army Corps of Engineers' (Corps) nationwide general permit for utility line crossings in waters of the United States. In that light, and recognizing that there will be several hundred acres of wetlands affected along the entire pipeline route, we recommend that the Corps review the proposed wetland impacts as a single project requiring an individual Clean Water Act Section 404 permit. Consolidating each of these crossings into one individual permit review would also provide for more transparency as to the project impacts and allow for more effective mitigation planning, as well as compliance monitoring of the entire project.

Finally, we appreciate your agreement to provide a discussion of potential mitigation measures for project activities that permanently convert forested wetlands to herbaceous wetlands. We continue to recommend providing a conceptual wetland mitigation plan in the Final EIS, including a monitoring component that would, for a specified period of time, direct field evaluations of those wetlands crossed by the pipeline (and mitigation sites) to ensure wetland functions and values are recovering. We also recommend that the Final EIS evaluate the feasibility of using approved mitigation banks to compensate for wetlands impacts.

Migratory Birds

The SDEIS includes a summary of regulatory and other programs aimed at protecting migratory bird populations that may be affected by oil sands extraction activities in Canada. However, we recommend that the Final EIS provide additional information that would address potential impacts to specific migratory species, with an emphasis on already-vulnerable species, and we appreciate your agreement to provide that information in the Final EIS. Data found in the North American Breeding Bird Survey (a partnership between the U.S. Geological Survey's Patuxent Wildlife Research Center and the Canadian Wildlife Service's National Wildlife Research Center), which monitors bird populations and provides population trend estimates, should be helpful. We also recommend that the Final EIS discuss mitigation measures that are either currently or could be employed for identified impacts.

Conclusion

Based on our review, we have rated the SDEIS as "Environmental Objections - Insufficient Information (EO-2)" (see enclosed "Summary of Rating Definitions and Follow-up Actions"). As explained in this letter, we have a number of concerns regarding the potential environmental impacts of the proposed Project, as well as the level of analysis and information provided concerning those impacts. Our concerns include the potential impacts to groundwater resources from spills, as well as effects on emission levels at refineries in the Gulf Coast. In addition, we are concerned about levels of GHG emissions associated with the proposed Project, and whether appropriate mitigation measures to reduce these emissions are being considered. Moreover, the SDEIS does not contain sufficient information to fully assess the environmental impacts of the proposed Project, including potential impacts to groundwater resources and communities that could be affected by potential increases in refinery emissions.

We look forward to continuing to work with you to strengthen the environmental analysis of this project and to provide any assistance you may need to prepare the Final EIS. In addition, we will be carefully reviewing the Final EIS to determine if it fully reflects our agreements and that measures to mitigate adverse environmental impacts are fully evaluated. We look forward as well to working with you as you consider the determination as to whether approving the proposed project would be in the national interest under the provisions of Executive Order 13337.

Please feel free to contact me at (202) 564-2400, or have your staff contact Susan Bromm, Director, Office of Federal Activities, at (202) 564-5400, if you have any questions or would like to discuss our comments.

Sincerely,

Cynthia Giles

Cynthia Giles

Enclosure

Summary of Rating Definitions and Follow-up Action

Environmental Impact of the Action

LO--Lack of Objections
The EPA review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposal.

EC–Environmental Concerns
The EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce the environmental impact. EPA would like to work with the lead agency to reduce these impacts.

EO--Environmental Objections
The EPA review has identified significant environmental impacts that must be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts.

EU--Environmentally Unsatisfactory
The EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of public health or welfare or environmental quality. EPA intends to work with the lead agency to reduce these impacts. If the potentially unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommended for referral to the CEQ.

Adequacy of the Impact Statement

Category 1--Adequate
EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis or data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

Category 2--Insufficient Information
The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analyses, or discussion should be included in the final EIS.

Category 3–Inadequate
EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the NEPA and/or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ.

Exhibit 8

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Miles City Field Office
111 Garryowen Road
Miles City, Montana 59301-7000
www.blm.gov/mt

In Reply Refer To:

October 2014 Comp Sale
3160 (MTC023)

May 19, 2014

Dear Reader:

The Bureau of Land Management (BLM) Miles City Field Office has prepared an environmental assessment (EA) to analyze the potential effects from offering 18 nominated lease parcels for competitive oil and gas leasing in a sale tentatively scheduled to occur on October 21, 2014.

The EA with an unsigned Finding of No Significant Impact (FONSI) is available for a 30-day public comment period. Written comments must be postmarked by June 18, 2014, to be considered. Comments may be submitted using one of the following methods:

Email: BLM_MT_Miles_CityFO_Lease_EA@blm.gov

Mail: Miles City Field Office
Attn: Jon David
111 Garryowen Road
Miles City, Montana 59301-7000

Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment – including your personal identifying information – will be available for public review. If you wish to withhold personal identifying information from public review or disclosure under the Freedom of Information Act (FOIA), you must clearly state, in the first line of your written comment, "CONFIDENTIALITY REQUESTED." While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so. All submissions from organizations, from businesses, and from individuals identifying themselves as representatives of organizations or businesses, will be available for public review.

Upon review and consideration of public comments, the EA will be updated as needed. Based on our analysis, parcels recommended for leasing in our assessment would be included as part of a competitive oil and gas lease sale tentatively scheduled to occur on October 21, 2014.

Prior to issuance of any leases, the Decision Record and FONSI will be finalized and posted for public review on our BLM website. Please refer to the Montana/Dakotas BLM website at http://blm.gov/qtld. Current and updated information about our EAs, Lease Sale Notices, and corresponding information pertaining to this sale can be found at the link referenced above.

If you have any questions or would like more information about lease sale notices or the issuance of the EA, Decision Record and FONSI, please contact me at 406-233-2837.

Sincerely,

Todd D. Yeager
Field Manager

United States Department of the Interior
Bureau of Land Management

Environmental Assessment DOI-BLM-MT-C020-2014-0091-EA
May 19, 2014

Project Title: Oil and Gas Lease Parcel, October 21, 2014 Sale

Location: Miles City Field Office (see Appendix A for list of lease parcels by number and legal description and Maps 1-6)

BLM

Miles City Oil and Gas Lease Sale EA
DOI-BLM-MT-C020-2014-0091-EA

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Miles City Field Office Oil and Gas Lease Sale Parcel Reviews
DOI-BLM-MT-C020-2014-0091-EA

1.0 PURPOSE AND NEED

1.1 Introduction

It is the policy of the Bureau of Land Management (BLM) to make mineral resources available for use and to encourage development of mineral resources to meet national, regional, and local needs. This policy is based on various laws, including the Mineral Leasing Act of 1920 and the Federal Land Policy and Management Act of 1976. The Federal Onshore Oil and Gas Leasing Reform Act of 1987 Sec. 5102(a)(b)(1)(A) directs the BLM to conduct quarterly oil and gas lease sales in each state whenever eligible lands are available for leasing. The Montana State Office conducts mineral estate lease auctions for lands managed by the Federal Government, whether the surface is managed by the Department of the Interior (BLM or Bureau of Reclamation), United States Forest Service, or other departments and agencies. In some cases the BLM holds subsurface mineral rights on split estate lands where the surface estate is owned by another party, other than the Federal Government. Federal mineral leases can be sold on such lands as well. The Montana State Office has historically conducted five lease sales per year.

Members of the public file Expressions of Interest (EOI) to nominate parcels for leasing by the BLM. From these EOIs, the Montana State Office provides draft parcel lists to the appropriate field offices for review. The BLM field offices then review legal descriptions of nominated parcels to determine: if they are in areas open to leasing; if new information has come to light which might change previous analyses conducted during the land use planning process; if there are special resource conditions of which potential bidders should be made aware; and which stipulations should be identified and included as part of a lease. Ultimately, all of the lands in proposed lease sales are nominated by private individuals, companies, or the BLM, and therefore represent areas of high interest.

This environmental assessment (EA) has been prepared to disclose and analyze the potential environmental consequences from leasing all 18 nominated lease parcels encompassing a total of 7,945.28 surveyed Federal mineral acres located in the Miles City Field Office (MCFO), to be included as part of a competitive oil and gas lease sale tentatively scheduled to occur in October 21, 2014.

The analysis area includes the 18 nominated parcels in Richland, Roosevelt, McCone, Prairie, and Powder River counties (Map 1).

1.2 Purpose and Need for the Proposed Action

The purpose of offering parcels for competitive oil and gas leasing is to provide opportunities for private individuals or companies to explore for and develop Federal oil and gas resources in Richland, Roosevelt, McCone, Prairie, and Powder River counties after receipt of necessary approvals and to sell the oil and gas in public markets.

This action is needed to help meet the energy needs of the people of the United States. By conducting lease sales, the BLM provides for the potential increase of energy reserves for the U.S., a steady source of income, and at the same time meets the requirement identified in the Energy Policy Act, Sec. 362(2), Federal Oil and Gas Leasing Reform Act of 1987, and the Mineral Leasing Act of 1920, Sec. 17. Oil and gas companies filed Expressions of Interest (EOI) to nominate parcels for leasing by the BLM Montana. The BLM needs to respond to the EOIs by determining whether or not to recommend these lease parcels for competitive oil and gas lease sale and, if so, with any stipulations attached.

The decision to be made is whether to sell oil and gas leases on the lease parcels identified, and, if so, identify stipulations that would be included with specific lease parcels at the time of lease sale.

1.3 Conformance with Land Use Plan(s)
This EA is tiered to the information and analysis and conforms to the decisions contained in the Big Dry Resource Management Plan (RMP/EIS) of April 1996 and the Powder River RMP/EIS of March 1985, as amended (1994 Oil and Gas RMP/EIS Amendment, 2003 Final Statewide Oil and Gas Environmental Impact Statement and proposed Amendment of the Powder River and Billings RMPs, and the 2008 Final Supplement to the Montana Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings RMPs). The Big Dry and Powder River RMPs are the governing land use plans for the MCFO. The lease parcels to potentially be offered for sale are within areas determined to be open to oil and gas leasing in the Big Dry and Powder River RMPs. An electronic copy of the Big Dry RMP/EIS and the Powder River RMP/EIS, as amended, can be located via the internet on the BLM home page, www.blm.gov/mt. On the home page, locate the heading titled "*Montana/Dakotas*," then select "*What We Do*", then click on the "*Planning*" link.

A more complete description of activities and impacts, related to oil and gas leasing, development, production, etc. can be found at pages 111 to 156 of the Big Dry RMP and pages 55 to 77 of the 1994 Oil and Gas Amendment of the Powder River RMP (for leasing decisions), and pages 4-1 to 4-310 of the 2008 Final Supplement to the Montana Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings RMPs (for development, production, etc).

Analysis of the 18 parcels is documented in this EA, and was conducted by MCFO resource specialists who relied on professional knowledge of the areas involved, review of current databases, file information, and some site visits to ensure that appropriate stipulations were recommended for a specific parcel. Analysis may have also identified the need to defer entire or partial parcels from leasing pending further environmental review.

At the time of this review it is unknown whether a particular parcel will be sold and a lease issued. It is unknown when, where, or if future well sites, roads, and facilities might be proposed. Assessment of potential activities and impacts was based on potential well densities discerned from the Reasonably Foreseeable Development (RFD) Scenario developed for this environmental assessment (Appendix C), which is based on information contained in the MCFO RFD developed in 2005 and revised in 2012; it is an unpublished report that is available by contacting the MCFO. The RFD contains projections of the number of possible oil and gas wells that could be drilled and produced in the MCFO area and used to analyze projected wells for the 18 nominated lease parcels. Detailed site-specific analysis and mitigation of activities associated with any particular lease would occur when a lease holder submits an application for permit to drill (APD). A more complete description of mitigation, BMPs, and conditions of approval related to oil and gas lease activities can be found at pages 302-326 of the Big Dry RMP, pages 130-137 of the 1994 Oil and Gas Amendment of the Powder River RMP, pages 3-6 of the 2008 Record of Decision for the Final Supplement to the Montana Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings RMPs, Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development-The Gold Book, and online at http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices.html. Offering the parcels for sale and issuing leases would not be in conflict with any local, county, or state laws or plans.

1.4 Public Scoping and Identification of Issues

Public scoping for this project was conducted through a 15-day scoping period advertised on the BLM Montana State Office website and posted on the MCFO website National Environmental Policy Act (NEPA) notification log. Scoping was initiated March 25, 2014.

The BLM coordinates with Montana Fish, Wildlife, and Parks (MFWP), and the United States Fish and Wildlife Service (USFWS) to manage wildlife habitat because BLM management decisions can affect wildlife populations which depend on the habitat. The BLM manages habitat on BLM lands, while MFWP is responsible for managing wildlife species populations. The USFWS also manages some wildlife populations but only those Federal trust species managed under mandates such as the Endangered Species Act, Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act. Managing wildlife is factored into project planning at multiple scales and is to be implemented early in the planning process.

Coordination with Montana Fish Wildlife and Parks (MFWP) was conducted for the 18 lease parcels being reviewed and in the completion of this EA in order to prepare the analysis, identify protective measures, and apply stipulations and lease notices associated with these parcels being analyzed. A letter was sent to the USFWS and MFWP during the 15-day scoping and 30-day public comment periods requesting comments on the 18 parcels being reviewed. Refer to Section 5.2 of this EA for a more complete summary of the scoping comments received from MFWP.

The BLM consults with Native Americans under various statues, regulations, and executive orders, including the American Indian Religious Freedom Act, the National Historic Preservation Act, the Native American Graves Protection and Repatriation Act, the National Environmental Policy Act, and Executive Order 13175-Consultation and Coordination with Indian Tribal Governments. The BLM sent letters to tribes in Montana, North and South Dakota and Wyoming for the 15-day scoping period informing them of the potential for the 18 parcels to be leased and inviting them to submit issues and concerns BLM should consider in the environmental analysis. Letters were sent to the Tribal Presidents and the Tribal Historical Preservation Officer (THPO) or other cultural contacts for the Cheyenne River Sioux Tribe, Crow Tribe of Montana, Crow Creek Sioux Tribe, Eastern Shoshone Tribe, Ft. Peck Tribes, Lower Brule Sioux Tribe, the Mandan, Hidasta, and Arkira Nation, Northern Arapaho Nation, Northern Cheyenne Tribe, Oglala Sioux Tribe, Rosebud Sioux Tribe of Indians, Standing Rock Sioux Tribe, and Turtle Mountain Band of Chippewa. In addition to scoping letters, THPOs also received file search results from the preliminary review of parcels conducted by BLM. The BLM sent a second letter with a copy of the EA to the tribes informing them about the 30 day public comment period for the EA and solicit any information BLM should consider before making a decision whether to offer any or all of the nominated parcels for sale.

Site specific resource concerns were identified by the BLM through the preliminary review process conducted prior to a 15-day public scoping period. Lease stipulations (as required by Title 43 Code of Federal Regulations 3131.3) were added as necessary to each parcel as identified by the BLM to address site specific resource concerns.

The BLM focuses its analysis on issues that are truly significant to the action in question, rather than amassing needless detail" (40 CFR 1500.1(b)). Issues have a relationship with the proposed action; are within the scope of analysis; and are amenable to scientific analysis.

The issues carried forward through analysis in this EA are associated with air resources, greenhouse gas emission and climate change, economic resources, socioeconomics, cultural resources, paleontological resources, water resources, recreation and visual resources, wildlife habitat, Special Status and Sensitive Species, vegetation , livestock grazing management, invasive, non-invasive species and noxious weeds,

The BLM considered other issues, listed below, but decided not to analyze those in further detail. The aspects of the existing environment that the BLM determined to not be present or not potentially impacted by this project include: coal, locatable minerals, salable minerals, lands with wilderness characteristics, cave and karst resources, wild and scenic rivers; wilderness study areas. Thus, the EA contains no further discussion of these issues.

2.0 DESCRIPTION OF ALTERNATIVES, INCLUDING PROPOSED ACTION

2.1 Alternative A - No Action

For EAs on externally initiated Proposed Actions, the No Action Alternative generally means that the Proposed Action would not take place. In the case of a lease sale, this would mean that all expressions of interest to lease (parcel nominations) would be denied or rejected.

The No Action Alternative would exclude all 18 lease parcels, covering 7,945.28 surveyed Federal mineral acres (3,637.97 surveyed BLM administered surface and 4,307.31 surveyed private/State surface), from the competitive oil and gas lease sale (Maps 1-6). Surface management would remain the same and ongoing oil and gas development would continue on surrounding Federal, private, and State leases.

2.2 Alternative B – Proposed Action

The Proposed Action Alternative would be to offer 18 lease parcels of Federal minerals for oil and gas leasing, covering 7,945.28 surveyed Federal mineral acres (3,637.97 surveyed BLM administered surface and 4,307.31 surveyed private surface), in conformance with the existing land use planning decisions. Parcel number, size, and detailed locations and associated stipulations are listed in Appendix A. Maps 1-6 indicate the detailed location of each parcel.

2.3 Alternative C -BLM Preferred

Under the BLM Preferred Alternative, 2 whole and 5 partial parcels of the 18 lease parcels, 1,396.87 surveyed Federal mineral acres (680 surveyed BLM administered surface and 716.87 surveyed private surface) would be offered with RMP lease stipulations and/or lease notices as necessary (Appendix A) for competitive oil and gas lease sale and lease issuance.

A total of 11 lease parcels in whole and 5 partial lease parcels, encompassing 6,549.15 surveyed Federal mineral acres (2,958.73 surveyed BLM administered surface and 3,590.42 private surveyed surface), are recommended for deferral. These lease parcels contain sage grouse, big game winter range, badlands rock outcrop, and sensitive soil protection areas being analyzed in the current MCFO RMP effort; therefore, 11 whole lease parcels and 5 partial lease parcels would be deferred at this time pending further review and analysis. This would provide for consideration of alternatives in the current MCFO RMP planning.

2.4 Additional Considerations for Alternatives B and C

For the split-estate lease parcels, the BLM provided courtesy notification to private landowners that the Federal oil and gas estate under their surface would be included in this lease sale. In the event of activity on such split estate lease parcels, the lessee and/or operator would be responsible for adhering to BLM requirements as well as reaching an agreement with the private surface landowners regarding access, surface disturbance, and reclamation.

The terms and conditions of the standard federal lease and federal regulations would apply to each parcel offered for sale in each of the two Alternatives. Stipulations shown in Appendix A would be included with identified parcels offered for sale. Standard operating procedures for oil and gas operations on federal leases include measures to protect the environment and resources such as groundwater, air, wildlife, historical and prehistorical concerns, and others as mentioned in the Big Dry and Powder River RMPs at pages 9 to 40 and 302 to 330 of the Minerals Appendix (Big Dry) and 2-1 to 2-28 and the Minerals Appendix Min-36 to Min-42 (2008 Final Supplement to the Montana Statewide Oil and Gas EIS and Proposed Amendment of the Powder River and Billings RMPs). Conditions of Approval (COAs) would be attached to permits issued to explore and develop the parcels to address site-specific concerns or new information. Standard operating procedures, best management practices (BMPs), COAs, and lease stipulations can change over time to meet RMP objectives, resource needs or land use compatibility.

Federal oil and gas leases would be issued for a 10-year period and would remain valid for as long thereafter as oil or gas is produced in paying quantities, required payments are made and lease operations are conducted in compliance with regulations and approved permits. If a lessee fails to produce oil and gas by the end of the initial 10 year period, does not make annual rental payments, or does not comply with the terms and conditions of the lease, the BLM would terminate the lease. The lessee can relinquish the lease. The oil and gas resources could be offered for sale at a future lease sale.

Drilling of wells on a lease would not be permitted until the lessee or operator secures approval of a drilling permit and a surface use plan as specified in 43 CFR 3162.

3.0 AFFECTED ENVIRONMENT

3.1 Introduction

This chapter describes the existing environment (i.e., the physical, biological, social, and economic values and resources) within the analysis area, which includes the 18 nominated parcels in Richland, Roosevelt, McCone, Prairie, and Powder River counties (Map 1), that could be affected by implementation of the alternatives described in Chapter 2.

The existing environment is described by the different resources found throughout the counties listed above. Within each resource description, lease parcels containing the resource will be listed and analyzed further in Chapter 4. If the lease parcel does not contain the resource, then the lease parcel will be omitted from the description of that specific resource.

Unless otherwise stated, resource analysis in this chapter, and Chapter 4, will be described in approximate acres due to the scaling and precision parameters associated with the Geographic Information System (GIS), in addition to being referenced to a different land survey.

Most of the analysis area consists of open expanses characteristic of the Northern Great Plains. This area is largely comprised of herbaceous vegetation (e.g., grasses) with interspersed shrubs (e.g., sagebrush). Lands with greater moisture or slopes exhibit ponderosa pine, limber pine, limited Douglas fir, and juniper species. Some hardwood trees grow along riparian areas and are common along the Missouri River. The analysis area experiences extreme weather variations on a yearly basis due to its semiarid continental climate. Most of the public lands are scattered throughout the analysis area. The public lands are rich in natural resources, such as wildlife and livestock forage, minerals, cultural resources, paleontological resources, recreation opportunities, and watershed values.

3.2 Air Resources

Air resources include air quality, air quality related values (AQRVs), and climate change. As part of the planning and decision making process, BLM considers and analyzes the potential effects of BLM and BLM-authorized activities on air resources.

The Environmental Protection Agency (EPA) has the primary responsibility for regulating air quality, including seven criteria air pollutants subject to National Ambient Air Quality Standards (NAAQS). Pollutants regulated under NAAQS include carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ozone, particulate matter with a diameter less than or equal to 10 microns (PM_{10}), particulate matter with a diameter less than or equal to 2.5 microns ($PM_{2.5}$), and sulfur dioxide (SO_2). Two additional pollutants, nitrogen oxides (NO_x) and volatile organic compounds (VOCs) are regulated because they form ozone in the atmosphere. Regulation of air quality is also delegated to some states. Air quality is determined by pollutant emissions and emission characteristics, atmospheric chemistry, dispersion meteorology, and terrain. AQRVs include effects on soil and water, such as sulfur and nitrogen deposition and lake acidification, and aesthetic effects, such as visibility.

Climate is the composite of generally prevailing weather conditions of a particular region throughout the year, averaged over a series of years. Climate change includes both historic and predicted climate shifts that are beyond normal weather variations.

3.2.1 Air Quality

The EPA air quality index (AQI) is an index used for reporting daily air quality (http://www.epa.gov/oar/data/geosel.html) to the public. The index tells how clean or polluted an area's air is and whether associated health effects might be a concern. The EPA calculates the AQI for five criteria air pollutants regulated by the Clean Air Act (CAA): ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established NAAQS to protect public health. An AQI value of 100 generally corresponds to the primary NAAQS for the pollutant. The following terms help interpret the AQI information:

- **Good** – The AQI value is between 0 and 50. Air quality is considered satisfactory and air pollution poses little or no risk.
- **Moderate** – The AQI is between 51 and 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- **Unhealthy for Sensitive Groups** – When AQI values are between 101 and 150, members of "sensitive groups" may experience health effects. These groups are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range.
- **Unhealthy** – The AQI is between 151 and 200. Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects.
- **Very Unhealthy** – The AQI is between 201 and 300. This index level would trigger a health alert signifying that everyone may experience more serious health effects.

AQI data show that there is little risk to the general public from air quality in the analysis area (Table 1). Based on available 2010–2012 data for Richland County in the northern portion of the planning area, 88 percent of the days were rated "good" and the three-year median daily AQI was 35. In the southern portion of the planning area, 2010–2012 data for Powder River County indicated that 82 percent of the days were rated good and the three-year median daily AQI was 37.

Table 1. US EPA – Air Data Air Quality Index Report (2010–2012)

County[1]	# Days in Period	# Days Rated Good or No Data	Percent of Days Rated Good or No Data	# Days Rated Moderate	# Days Rated Unhealthy for Sensitive Groups	# Days Rated Unhealthy	# Days Rated Very Unhealthy
Powder River	1,092	898	82%	194	0	0	0
Richland	1,096	968	88%	128	0	0	0

[1]The Powder River and Richland County monitors are located near Broadus and Sidney, respectively.
Source: EPA 2013b.

The area managed by the MCFO is in compliance with all NAAQS. Based on monitoring data available for 2010 through 2012, maximum concentrations as a percentage of the NAAQS are summarized in Table 2. Data are not provided for CO and lead which are not monitored within the analysis area.

Table 2. Monitored Concentrations Representative of the Study Area [a]

Pollutant	Averaging Time	Applicable Standard [b]	Concentration [d]	
			Powder River County	Richland County
NO2	1 hour	100 ppb	16 ppb (16%)	9 ppb (9%)
O3	8 hour	0.075 ppm	0.055 ppm (73%)	0.057 ppm (76%)
PM10	24 hour	150 $\mu g/m^3$	100 $\mu g/m^3$ (67%)	100 $\mu g/m^3$ (67%)
PM2.5	24 hour	35 $\mu g/m^3$	16 $\mu g/m^3$ (46%)	15 $\mu g/m^3$ (43%)
	Annual	12 $\mu g/m^3$	6 $\mu g/m^3$ (51%)	7 $\mu g/m^3$ (55%)
SO_2	1 hour	75 ppb	N/A	5 ppb (7%)
	24 hour	140 ppb	N/A	1 ppb (21%)

[a] Representative concentrations are based on data from the Sidney monitoring station in Richland County and the Broadus monitor in Powder River County.
[b] Most restrictive national or State standard.
[c] Monitored concentrations are the 2nd highest for 24-hour PM_{10} and 24-hour SO_2; three-year average of the annual 4th highest daily maximum for 8-hour O3; three-year average of the 98th percentile for 24-hour $PM_{2.5}$ and 1-hour NO_2; and three-year arithmetic mean for annual PM2.5.
[d] Values in parentheses are monitored concentrations as a percentage of the most restrictive applicable standard.
Source: EPA 2013b.

Although ozone concentrations above the NAAQS have been monitored in some rural areas in other states with oil and gas activity, moderate ozone concentrations have been monitored in Montana oil and gas areas. Based on 2010-2012 data from monitors located near Sidney and Broadus, Montana, ozone concentrations are approximately 75 percent of the ozone NAAQS (MDEQ 2013).

Hazardous air pollutants (HAPs) would also be emitted from oil and gas operations, including well drilling, well completion, and gas and oil production. Recent air quality modeling performed for the MCFO indicates that concentrations of benzene, ethylbenzene, formaldehyde, n-hexane, toluene, and xylene would be less than 14 percent of applicable health-based standards and that the additional risk of cancer would be less than 0.18 in one million (BLM 2013).

Air resources also include visibility, which can be degraded by regional haze due in part to sulfur, nitrogen, and particulate emissions. Based on trends identified during 2005-2009, visibility has degraded slightly at the Medicine Lake National Wildlife Refuge IMPROVE monitor in Sheridan County on the haziest days (20 percent worse days). On the 20 percent best (clearest) days, visibility at this monitor has been improving, as shown by decreasing haze in Figure A.

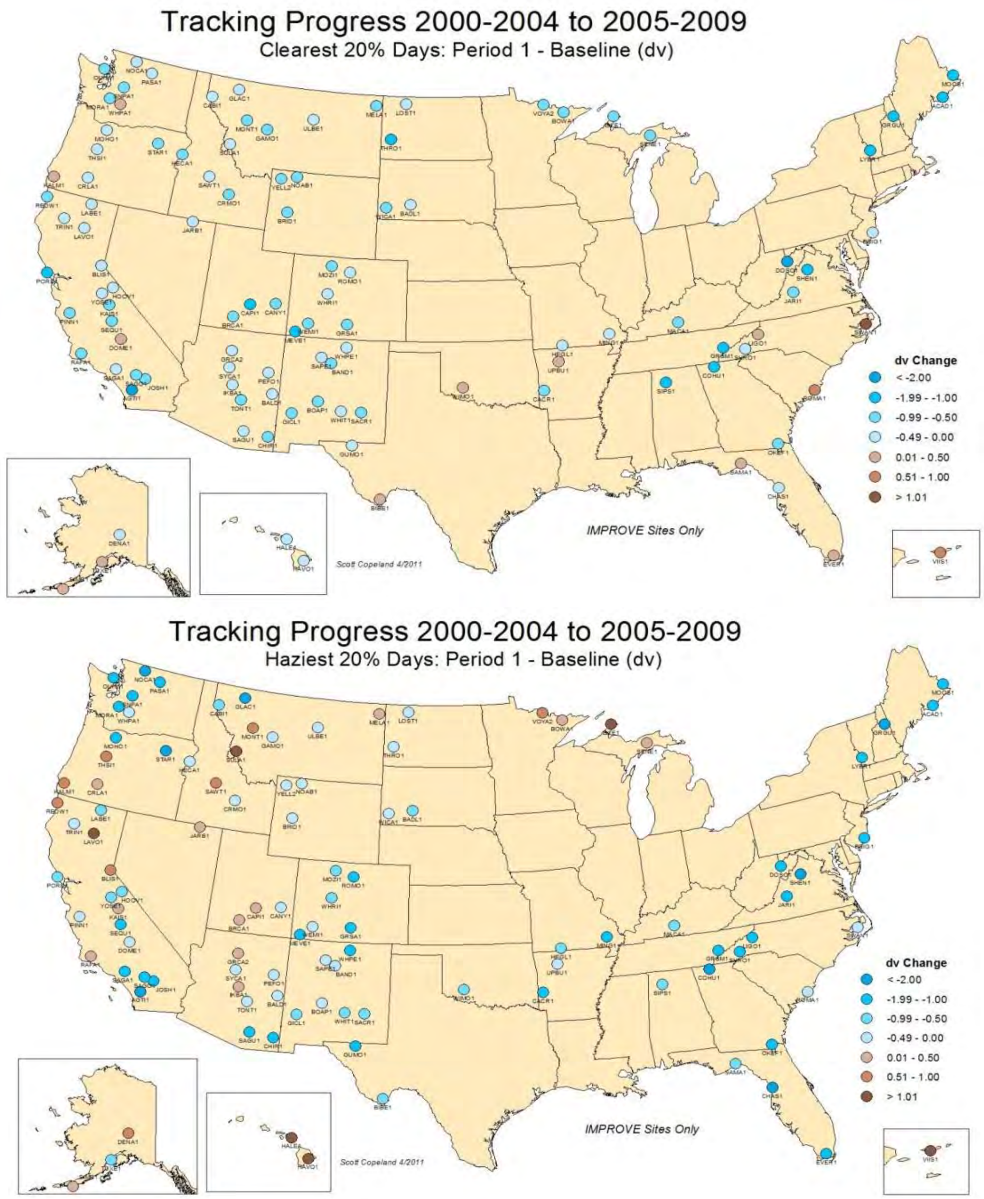

Figure A. Trends in haze index (deciview) on haziest and clearest days, 2005-2009. Source: IMPROVE 2011.

3.2.2 Climate Change

Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use." (IPCC 2013). Climate change and climate science are discussed in detail in the climate change Supplementary Information Report for Montana, North Dakota, and South Dakota, Bureau of Land Management (Climate Change SIR 2010). This document is incorporated by reference into this EA.

The IPCC states: "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased." (IPCC 2013). The global average surface temperature has increased approximately 1.5°F from 1880 to 2012 (IPCC 2013). Warming has occurred on land surfaces, oceans and other water bodies, and in the troposphere (lowest layer of earth's atmosphere, up to 4-12 miles above the earth). Other indications of global climate change described by the IPCC (Climate Change SIR 2010) include:

- Rates of surface warming increased in the mid-1970s and the global land surface has been warming at about double the rate of ocean surface warming since then;
- Eleven of the last 12 years rank among the 12 warmest years on record since 1850;
- Lower-tropospheric temperatures have slightly greater warming rates than the earth's surface from 1958-2005.

As discussed and summarized in the climate change SIR, earth has a natural greenhouse effect wherein naturally occurring gases such as water vapor, CO2, methane, and N2O absorb and retain heat. Without the natural greenhouse effect, earth would be approximately 60°F cooler (Climate Change SIR 2010). Current ongoing global climate change is caused, in part, by the atmospheric buildup of greenhouse gases (GHGs), which may persist for decades or even centuries. Each GHG has a global warming potential that accounts for the intensity of each GHG's heat trapping effect and its longevity in the atmosphere (Climate Change SIR 2010). The buildup of GHGs such as CO2, methane, N2O, and halocarbons since the start of the industrial revolution has substantially increased atmospheric concentrations of these compounds compared to background levels. At such elevated concentrations, these compounds absorb more energy from the earth's surface and re-emit a larger portion of the earth's heat back to the earth rather than allowing the heat to escape into space than would be the case under more natural conditions of background GHG concentrations.

A number of activities contribute to the phenomenon of climate change, including emissions of GHGs (especially CO2 and methane) from fossil fuel development, large wildfires, activities using combustion engines, changes to the natural carbon cycle, and changes to radiative forces and reflectivity (albedo). It is important to note that GHGs will have a sustained climatic impact over different temporal scales due to their differences in global warming potential (described above) and lifespans in the atmosphere. For example, CO2 may last 50 to 200 years in the atmosphere while methane has an average atmospheric life time of 12 years (Climate Change SIR 2010).

With regard to statewide GHG emissions, Montana ranks in the lowest decile when compared to all the states (http://assets.opencrs.com/rpts/RL34272_20071205.pdf, Ramseur 2007). The estimate of Montana's 2005 GHG emissions of 37 million metric tons (MMt) of gross consumption-based carbon dioxide equivalent (CO_2e) account for approximately 0.6 percent of the U.S. GHG emissions (CCS 2007).

Some information and projections of impacts beyond the project scale are becoming increasingly available. Chapter 3 of the climate change SIR describes impacts of climate change in detail at various scales, including the state scale when appropriate. The EPA identifies eastern Montana as part of the Great Plains region. The following summary characterizes potential changes identified by the EPA (EPA 2008) that are expected to occur at the regional scale, where the Proposed Action and its alternatives are to occur.

- The region is expected to experience warmer temperatures with less snowfall.
- Temperatures are expected to increase more in winter than in summer, more at night than in the day, and more in the mountains than at lower elevations.
- Earlier snowmelt means that peak stream flow would be earlier, weeks before the peak needs of ranchers, farmers, recreationalist, and others. In late summer, rivers, lakes, and reservoirs would be drier.
- More frequent, more severe, and possibly longer-lasting droughts are expected to occur.
- Crop and livestock production patterns could shift northward; less soil moisture due to increased evaporation may increase irrigation needs.
- Drier conditions would reduce the range and health of ponderosa and lodgepole pine forests, and increase the susceptibility to fire. Grasslands and rangelands could expand into previously forested areas.
- Ecosystems would be stressed and wildlife such as the mountain lion, black bear, long-nose sucker, marten, and bald eagle could be further stressed.

Other impacts could include:
- Increased particulate matter in the air as drier, less vegetated soils experience wind erosion.
- Shifts in vegetative communities which could threaten plant and wildlife species.
- Changes in the timing and quantity of snowmelt which could affect both aquatic species and agricultural needs.

Projected and documented broad-scale changes within ecosystems of the U.S. are summarized in the Climate Change SIR. Some key aspects include:
- Large-scale shifts have already occurred in the ranges of species and the timing of the seasons and animal migrations. These shifts are likely to continue (USGCRP 2009, as cited by Climate Change SIR 2010). Climate changes include warming temperatures throughout the year and the arrival of spring an average of 10 days to 2 weeks earlier through much of the U.S. compared to 20 years ago. Multiple bird species now migrate north earlier in the year.

- Fires, insect epidemics, disease pathogens, and invasive weed species have increased and these trends are likely to continue. Changes in timing of precipitation and earlier runoff would increase fire risks.
- Insect epidemics and the amount of damage that they may inflict have also been on the rise. The combination of higher temperatures and dry conditions have increases insect populations such as pine beetles, which have killed trees on millions of acres in western U.S. and Canada. Warmer winters allow beetles to survive the cold season, which would normally limit populations; while concurrently, drought weakens trees, making them more susceptible to mortality due to insect attack.

More specific to Montana, additional projected changes associated with climate change described in Section 3.0 of the Climate Change SIR (2010) include:

- Temperature increases in Montana are predicted to be between 3 to 5°F at the mid-21st century. As the mean temperature rises, more heat waves are predicted to occur.
- Precipitation increases in winter and spring in Montana may be up to 25 percent in some areas. Precipitation decreases of up to 20 percent may occur during summer, with potential increases or decreases in the fall.
- For most of Montana, annual median runoff is expected to decrease between 2 and 5 percent. Mountain snowpack is expected to decline, reducing water availability in localities supplied by meltwater.
- Wind power production potential is predicted to decline in Montana based on modeling focused on the Great Falls area.
- Water temperatures are expected to increase in lakes, reservoirs, rivers, and streams. Fish populations are expected to decline due to warmer temperatures, which could also lead to more fishing closures.
- Wildland fire risk is predicted to continue to increase due to climate change effects on temperature, precipitation, and wind. One study predicted an increase in median annual area burned by wildland fires in Montana based on a 1°C global average temperature increase to be 241 to 515 percent.

While long-range regional changes might occur within this analysis area, it is impossible to predict precisely when they could occur. The following example summarizing climate data for northeastern Montana (Montana Climate Division 6) illustrates this point. A potential regional effect of climate change is earlier snowmelt and associated runoff. This is directly related to spring-time temperatures. Over a 118-year record, overall warming is clearly evident with temperatures increasing 0.2°F per decade (Figure B). Similar temperature increases occurred in southeastern Montana (Montana Climate Division 7).

However, data from 1991-2005 indicate a cooling trend of -1.3 degrees per decade (Figure C) in the northern and southern portions of the MCFO. This example is not an anomaly, as several other 15-year windows can be selected to show either warming or cooling trends. Substantial year-to-year fluctuations in temperature are due to natural processes, such as the effects of El Ni os , La Ni as, a nd the eruption of large volcanoes (Climate Change SIR 2010). Annual fluctuations illustrate the difficulty of predicting actual short-term regional changes or conditions which may be due to climate change during any specific time frame.

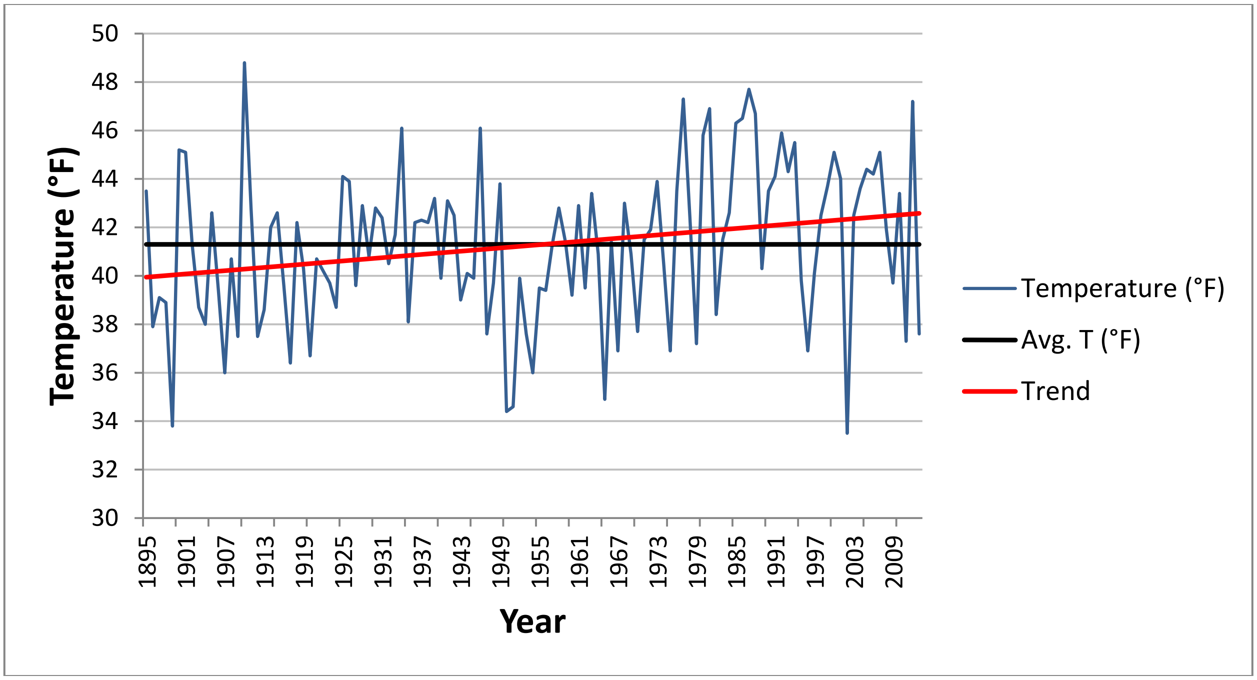

Figure B. Northeastern Montana spring temperatures (March-May, 1895-2013). (Source: National Climatic Data Center (NCDC) website – http://www.ncdc.noaa.gov/cag/)

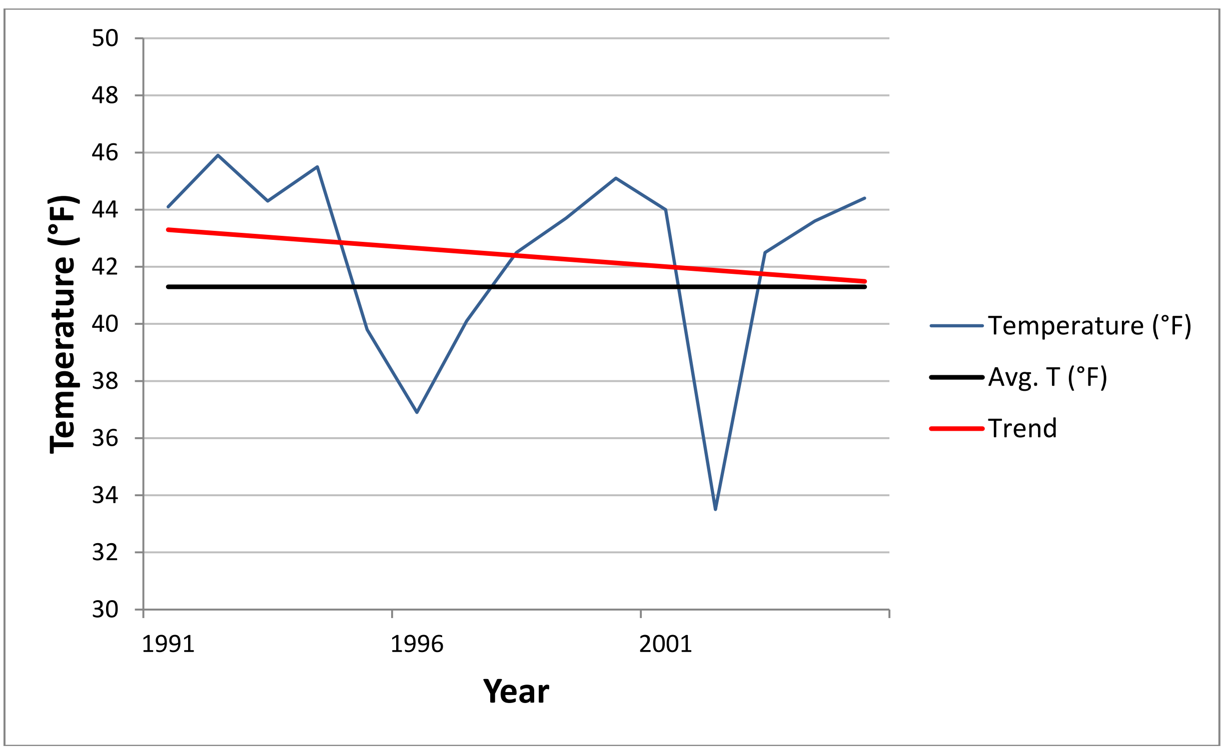

Figure C. Northeastern Montana spring temperatures (March-May, 1991-2005). (Source: National Climatic Data Center (NCDC) website – http://www.ncdc.noaa.gov/cag/)

From 1895–2013, annual precipitation decreased 0.06 inches per decade in the northern portion of the MCFO, while precipitation remained relatively constant in the southern portion. Throughout the MCFO, precipitation trends show increased during spring and fall seasons, while precipitation decreased during summer and winter.

3.3 Soil Resources

The soil-forming factors (climate, parent material, topography, biota, and age) are variable across the planning area, which results in soils with diverse physical, chemical, and biotic properties. Important properties of naturally functioning soil systems include biotic activity, diversity, and productivity; water capture, storage, and release; nutrient storage and cycling; contaminant filtration, buffering, degradation, immobilization, and detoxification; and biotic system habitat.

The lease parcels are located within 5 counties including Prairie, Roosevelt, Richland, Powder River, and McCone. The acreage of the lease parcels comprises less than 1 percent of each county. Soils considered prime farmlands if irrigated occur within lease parcels MTM 102757-WT, MTM 105431-HB, MTM 105431-HD, MTM 105431-HF, MTM 105431-HG, MTM 105431-HH, MTM 105431-HJ, MTM 105431-HK, MTM 105431-HL, and MTM 105431-HM. The following describes the common soil properties of lease parcels within each county:

Prairie County contains proposed parcels MTM 102757-WT and MTM 102757-WW. Parcel soils generally developed from the Fort Union Formation. Ecological sites within these parcels fall within MLRA 58A, 14-19 p. z. It is an area of old plateaus and terraces that have been eroded. Slopes generally are gently rolling to steep and wide belts of steeply sloping badlands. In some areas flat-topped, steep-sided buttes rise sharply above the general level of the plains. Most of soils in the parcels are rated high for soil restoration potential with a small percentage approximately 10 to 15 percent being rated low.

Roosevelt County contains proposed parcels MTM 105431-H9 and MTM 105431-JA. Parcel soils generally developed from the Fort Union Formation. Ecological Site Descriptions for these parcels are found with MLRA 53A, 14-18 p. z. Terrain in the Northern Dark Brown Glaciated Plains are gently undulating to rolling till plains in this area are interrupted by more strongly rolling and steep slopes adjacent to kettle holes, kames, moraines, and major stream valleys. All soils within these parcels are rated high for Soil Restoration Potential.

Richland County contains proposed parcels MTM 105431-HB, MTM 105431-H6 and MTM 105431-H8. Parcel soils generally developed from the Fox Hills, Hell Creek and Fort Union Formations. Ecological sites are typical of MLRA 53A, 14-18 p. z. or MLRA 58A, 14-18 p.z. Soils in these parcels are rated moderate to high for Soil Restoration Potential.

Powder River County contains proposed parcels MTM 105431-HC, MTM 105431-HD, MTM 105431-HE, MTM 105431-HF, MTM 105431-HG, MTM 105431-HH, MTM 105431-HK, MTM 105431-HL, MTM 105431-HM and MTM 105431-HJ. Parcel soils generally developed from the Fort Union Formation. Ecological sites within these parcels fall within MLRA 58B, 14-18 p. z. Slopes generally are gently rolling to steep and wide belts of steeply sloping badlands. In some areas flat-topped, steep-sided buttes rise sharply above the general level of the plains.

Most of the soils are rated moderate to high for Soil Restoration Potential with a smaller percentage being rated low.

McCone County contains proposed parcels MTM 105431-HA. Soils generally developed from Hell Creek and Fort Union Formations. Ecological Site Descriptions for these parcels are found with MLRA 53A, 14-18 p. z. Terrain in the Northern Dark Brown Glaciated Plains are gently undulating to rolling till plains in this area are interrupted by more strongly rolling and steep slopes adjacent to kettle holes, kames, moraines, and major stream valleys. Soils in this parcel are rated high for Soil Restoration Potential however some have not been rated.

3.4 Water Resources

3.4.1 Surface Hydrology

Surface water resources across the MCFO are present as lakes, reservoirs, rivers, streams, wetlands, and springs. Water resources are essential to the residents of eastern Montana to support agriculture, public water supplies, industry, and recreation. Water resources and riparian areas are crucial to the survival of many BLM-sensitive fish, reptiles, birds, and amphibians.

Perennial streams retain water year-round and have variable flow regimes. Intermittent streams flow during the part of the year when they receive sufficient water from springs, groundwater, or surface sources such as snowmelt or storm events. Ephemeral streams flow only in direct response to precipitation. Intermittent and ephemeral streams play an important role in the hydrologic function of the ecosystems within the lease parcels by transporting water, sediment, nutrients, and debris and providing connectivity within a watershed. They filter sediment, dissipate energy from snowmelt and storm water runoff, facilitate infiltration, and recharge groundwater (Levick et al. 2008). The pools of intermittent streams retain water in the summer months, supporting riparian vegetation and providing water resources for wildlife and livestock.

Stream morphology is influenced by a number of factors including: stream flow regime, geology, soils, vegetation type, climate, and land use history. Stream conditions reflect a number of historic and current impacts, ranging from agriculture to mining. Surficial geology is generally represented by Tertiary sandstones, siltstones, and shales, with some alluvium and glacial till which tends to form fine grain soils (loams to clays), that are highly erosive. Streambeds consist typically of sand and silt, with few bedrock channels. Stream morphology is highly influenced by the presence and type of riparian vegetation because streambeds and stream banks generally lack control features (e.g., rocks, cobles, bedrock).

Approximately 90 acres of 100-year floodplains are present within 5 of the proposed lease parcels. These floodplains are generally associated with Crow Rock Creek and various unnamed intermittent streams. Floodplain function is essential to watershed function, water quality, soil development, stream morphology, and riparian-wetland community composition. Floodplains reduce flood peaks and velocities, thereby reducing erosion; enhancing nutrient cycling; reducing frequency and duration of low flows; and increasing infiltration, water storage, and aquifer recharge. Floodplains enhance water quality by facilitating sedimentation and filtering overland flow. Floodplains support high plant productivity, high biodiversity, and habitat for wildlife.

The lease parcels are located within 5 watersheds [HUC 8 (Hydrological Unit Code); subbasins]: Big Muddy Creek (HUC 10060006), Charlie-Little Muddy Creeks (HUC 10060005), Little Dry Creek (HUC 10040106), Little Powder River (HUC 10090208), and Redwater River (HUC 10060002). The acreage of the lease parcels comprises between less than 0.1 percent and 0.36 percent of each watershed (USGS 2009).

The Big Muddy watershed contains proposed parcels MTM 105431-H9 and JA; comprising less than 0.1 percent of the watershed. The lease parcels are located in Roosevelt County. The Charlie-Little Muddy Creeks watershed contains proposed parcels MTM 105431-HB, H6, and H8; comprising 0.15 percent of the watershed. The lease parcels are located in Richland County. The Little Dry Creek watershed contains proposed parcels MTM 102757-WT and WW; comprising 0.24 percent of the watershed. The parcels are located in Prairie County. The Little Powder River contains proposed parcels MTM 105431-HC, HD, HE, HF, HG, HH, HJ, HK, HL, and HM; comprising 0.36 percent of the watershed. The lease parcels are located in Powder River County. The Redwater River watershed contains proposed parcel MTM 105431-HA; comprising less than 0.1 percent of the watershed. The lease parcel is located in McCone County. Any beneficial use of produced water requires water rights to be issued by Montana Department of Natural Resources and Conservation (MDNRC) as established by law. Water used for oil well development may come from several different sources. It may be purchased from municipalities under certain conditions, appropriated from a surface water source under a new appropriation or by making changes to an existing water right, or by extracting groundwater from either a permitted or exempt well.

3.4.2 Groundwater

The quality and availability of groundwater varies greatly across the region. Residents in eastern Montana commonly get their ground water from aquifers consisting of unconsolidated, alluvial valley-fill materials, glacial outwash, or consolidated sedimentary rock formations and some coal beds.

Alluvial aquifers within the area generally consist of Quaternary alluvium and undifferentiated Quaternary/Tertiary sediments, which include sand and gravel deposits. Alluvial aquifers occur in terrace deposits and within the floodplains, and along the channels of larger streams, tributaries, and rivers, and are among the most productive sources of groundwater. They are typically 0-40 feet thick. The quality of groundwater from alluvial aquifers is generally good, but can be highly variable [approximately 100 mg/l to 2,800 mg/l TDS, specific conductance (SC) of 500 to 125,000 microsiemens/centimeter (uS/cm), and sodium adsorption ratio (SAR) of 5.0 to 10]. Wells completed in coarse sand and gravel alluvial aquifers can yield as much as 100 gallons per minute (gpm), although the average yield is 15 gpm. Alluvial deposits associated with abandoned river channels or detached terraces are topographically isolated and have limited saturation and yield as much as 20 gpm (Zelt et al. 1999).

Within the analysis area, the primary bedrock aquifers occur in sandstones and coal beds of the Tertiary Fort Union Formation (Cenozoic rocks) and the sandstones of the Cretaceous Hell Creek and Fox Hills formations (Mesozoic rocks). Wells within the Fort Union formation aquifers are typically 100 to 200 feet deep, but can be up to 1,500 feet in depth. These wells may produce as much as 40 gpm, but yields of 15 gpm are typical. Where aquifers are confined and artesian conditions exist, wells in the Fort Union Formation will generally flow less than 10 gpm. Well depths within the Hells Creek and Fox Hills formation aquifers are highly variable, but typically range from 200 to 1,000 feet in depth. Groundwater yields from these aquifers may be as much as 200 gpm, but are generally less than 100 gpm. Artesian wells within these aquifers may flow as high as 20 gpm (Zelt et al. 1999). Groundwater yields from the deeper Paleozoic Madison formation aquifer can range from 20 to 6,000 gpm, or can be higher, in karst areas. The depth to the Madison formation aquifer in the planning area can exceed 6,000 feet. Due to the extreme depth of this aquifer, it is rarely accessed for water use. Water quality of this aquifer is highly variable and is dependent on depth, bedrock type, recharge rate, and other factors.

3.5 Vegetation Resources

The vegetation within the analysis area is characteristic of the Eastern Sedimentary Plains of Montana in the 10 to 14-inch precipitation zone and the Northern Dark Brown Glaciated Plains in the 10 to 14-inch precipitation zone, which lie within the Northern Great Plains. The Northern Great Plains is known for its diverse vegetation types, soil types, and topography. Vegetation is comprised of both tall and short grasses as well as both warm and cool season grasses. A variety of grass-like plants, forbs, shrubs and trees also add to the vegetation diversity of this rangeland type. Plant species diversity increases in woody draws and riparian/wetland zones.

Existing influences on local distribution of plant communities include soils, topography, surface disturbance, availability of water, management boundary fence lines, and soil salinity. Vegetation communities have been affected by human activities for over a century. Some of these activities include: infrastructure developments (roads, powerlines, pipelines, etc.), chemical applications, logging, livestock grazing, farming, and wildfire rehabilitation, prevention, manipulation, and suppression.

The BLM Standards of Rangeland Health (Standards) for BLM administered lands address upland health, riparian health, air quality, water quality, and habitat for native plants and animals. Meeting these Standards ensures healthy, productive, and diverse vegetative resources on public lands. The BLM's policy for implementing the Standards for Rangeland Health (43 CFR §4180.2) provides that all uses of public lands are to complement the established rangeland standards. Application of 43 CFR §4180.2 provides the mechanism to adjust livestock grazing to meet or progress towards meeting Standards for Rangeland Health. Effects of other uses such as oil and gas development or off- highway vehicle use are evaluated against the Standards to provide rationale directing management of these uses.

Six vegetation communities have been identified within the analysis area: native mixed grass prairie, sagebrush/mixed grasslands, ponderosa pine-mixed grassland, agricultural lands, improved or restored pastures, and riparian-wetlands.

There are numerous ecological sites identified within the analysis area, but the primary ones include the following; Sandy (Sy), Shallow (Sw), Silty (Si), Clayey (Cy) and Overflow (Ov). The total dry-weight production expected to be found on these sites during a normal growing season ranges from approximately 800 to 1,500 lbs. /acre.

The native mixed grassland community is dominated by perennial grasses. Perennial grasses can be both warm season and cool season grasses. These perennial grasses can also be both tall and short grasses. Some of the more common grasses include western wheatgrass **(***Pascopyrum smithii*), needle-and-thread (*Hesperostipa comata*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*), and prairie junegrass (*Koeleria macrantha).* Various forbs and shrubs are present but, occur as a minor species composition component throughout the community.

The sagebrush/ mixed grassland community occurs on lower valley slopes near drainages, especially where soils are deeper. This community can include a combination of silver sagebrush (*Artemisia cana*) and Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*). This setting is common throughout the analysis area. The sagebrush/grassland vegetation community has a perennial grass and forb understory, similar to the species found in a mixed native grassland community. The expected species composition on this community consists of 70-75 percent native grass species, 10-15 percent forbs, and 5-10 percent shrubs and half-shrubs.

The ponderosa pine-mixed grassland community generally occurs on moderate-to-steep upland slopes on shallow soils. Ponderosa pine is a minor component of the community canopy cover but is characteristic of the type. Fifty-two percent of canopy cover is provided by grasses, including bluebunch wheatgrass (*Pseudoroegneria spicata)*, western wheatgrass, and prairie junegrass, with forbs comprising about 41 percent of cover and 50 percent of herbaceous production. This community type is very limited within the analysis area.

Improved or restored pastures consists of cultivated areas planted with introduced grasses (crested wheatgrass, smooth brome (*Bromus inermis*), intermediate wheatgrass (*Thinopyrum intermedium*), and alfalfa (*Medicago sativa), specifically for the improved vegetation production for livestock consumption.* This setting is limited in the analysis area.

The cultivated plant community is comprised of monocultures of crops which may include small grains, alfalfa, or other crops grown primarily as supplemental feed sources for livestock production operations. These areas have been completely disturbed from the native vegetation potentials. This setting is absent or very limited in the analysis area.

Wetland areas are defined as "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient, and which, under normal circumstances, do support, a prevalence of vegetation adapted for life in saturated soil conditions." Riparian areas are defined as "a form of wetland transition between permanently saturated wetlands and upland areas. These areas exhibit vegetation or physical characteristics reflective of permanent surface or subsurface water influence. Lands along, adjacent to, or contiguous with perennially and intermittently flowing rivers and streams, glacial potholes, and the shores of lakes and reservoirs with stable water levels are typical riparian areas. Excluded are such sites as ephemeral streams or washes that do not exhibit the presence of vegetation dependent upon free water in the soil" (Prichard et. al 1995).

Within the analysis area, riparian and wetland areas would be associated with lakes, reservoirs, potholes, springs, bogs, and wet meadows as well as ephemeral, intermittent, or perennial streams. Riparian and wetland areas are among the most productive and important ecosystems (Prichard et. al. 1995). Characteristically, riparian and wetland areas display a greater diversity of plant, fish, wildlife, and other animal species and vegetative structure than adjoining ecosystems. Adequate, healthy riparian and wetland vegetative buffers protect associated waterbodies from accelerated erosion and sedimentation and reduce or eliminate non-point source pollution from upland areas (MDEQ 2012). Healthy riparian and wetland systems filter and purify water as it moves through the riparian-wetland zone, reduce sediment loads and enhance soil stability, provide micro-climate moderation when contrasted to temperature extremes in adjacent areas, and contribute to groundwater recharge and base flow (Eubanks, 2004).

Riparian areas are considered to be some of the most biologically diverse habitats (FSEIS 2008). Some of the more common vegetative species that occur in riparian-wetland areas include prairie cordgrass (*Spartina pectinata*), switchgrass (*Panicum virgatum*), Canada wildrye (*Elymus canadensis*), American licorice (*Glycyrrhiza lepidota*), sedges (*Carex spp*.), rushes (*Juncus spp*.), willow (*Salix spp.*), chokecherry (*Prunus virginiana*), buffaloberry (*Shepherdia argentea*), cottonwood (*Populus spp.*), needleleaf sedge (*Carex duriuscula*), sandbar willow (*Salix exigua*), Nebraska sedge (*Carex nebrascensis*), softstem bulrush (*Schoenoplectus tabernaemontani*), beaked sedge (*Carex rostrata*), yellow willow (*Salix lutea*), common three-square (*Schoenoplectus pungens*), and green ash (*Fraxinus pennsylvanica*). Weedy and invasive species common to riparian areas are knapweed (*Centaurea stoebe*), leafy spurge (*Euphorbia esula*), Russian olive (*Elaeagnus augustifolia*), saltcedar (*Tamarisk ramosissima*), kochia (*Bassia prostrata)*, thistle (*Cirsium arvense)*, sweet clover (*Melilotus officinalis*), cocklebur (*Xanthium strumarium)*, and gumweed (*Grindelia squarrosa)*.

Wetlands provide watering points for wildlife and livestock and provide habitat diversity. Species include sedges (*Carex spp*.), rushes (*Juncus spp*.), bulrush (*Schoenoplectus spp.)*, cattail (*Typha spp.)*, wild rose (*Rosa spp.)*, and snowberry (*Symphoricarpos spp.)*. At higher elevations they are associated primarily with springs, seeps, and intermittent streams. Precipitation-dependent wetland sites fluctuate annually, in a range from dry to wet, in direct response to seasonal moisture, temperature, and wind.

From the Montana Natural Heritage Program (MTNHP) provisional mapping GIS data and the USFWS National Wetland Inventory (NWI) GIS data, 8 proposed lease parcels contain approximately 31 acres of delineated riparian or wetland areas (see Table 3). This list is not comprehensive because complete GIS data was not available for 1 of the lease parcels: MTM 105431-WW.

Table 3: MTNHP and USFWS Riparian and Wetland Areas by Lease Parcel[1,2]

Riparian/Wetland Type	Classification	Acres
Freshwater Emergent Wetland	Palustrine, Emergent, Temporary Flooded	6.8
	Palustrine, Emergent, Temporary Flooded, Diked/Impounded	<0.1

Riparian/Wetland Type	Classification	Acres
	Palustrine, Emergent, Seasonally Flooded	6.4
	Palustrine, Emergent, Seasonally Flooded, Diked/Impounded	0.8
	Palustrine, Emergent, Semipermanently Flooded, Diked/Impounded	0.5
Freshwater Pond	Palustrine, Aquatic Bed, Semipermanently Flooded	5.8
	Palustrine, Aquatic Bed, Semipermanently Flooded, Diked/Impounded	3.3
	Palustrine, Unconsolidated Shore, Temporary Flooded, Diked/Impounded	0.2
	Palustrine, Unconsolidated Shore, Seasonally Flooded	<0.1
	Palustrine, Unconsolidated Shore, Seasonally Flooded, Diked/Impounded	2.6
Riparian	Riparian, Lotic, Forested	4.8

[1](USFWS 2009) [2] This list is not comprehensive because complete GIS data was not available for lease parcels MTM 105431-WW.

Competition from invasive, non-native plants constitutes a potential threat to native plant species and wildlife habitat within the analysis area. Several invasive, non-native plant species are found in the analysis area including: crested wheatgrass (*Agropyron cristatum*), Japanese brome (*Bromus japonicas*), cheatgrass (*Bromus tectorum*), and foxtail barley (*Hordeum jubatum*). Crested wheatgrass occurs in areas as a result of being planted to increase forage production or to stabilize soils by reducing erosion. Cheatgrass, Japanese brome, and foxtail barley are all aggressive invasive species that out-compete desirable vegetation for water and soil nutrients.

Noxious weeds are invasive species and occur in scattered isolated populations throughout the analysis area. The most common species of noxious weeds are leafy spurge, Russian knapweed, spotted knapweed, field bindweed and Canada thistle. Noxious weed control is the responsibility of the land owner or land managing agency. Chemical and biological control methods are utilized, with chemical control being the more predominant.

3.6 Special Status Species

3.6.1 Special Status Plant Species

According to the MTNHP, there are no known threatened or endangered plant species located within the lease parcels. Ten plant species on the Montana Plant Species of Concern list have been identified as having suitable habitat in areas near these parcels (MTNHP, 2014). These species are listed in the Table 4 and have the potential to exist on the lease parcels. Three of these species are also identified as BLM "Sensitive" plants.

According to the MTNHP field guide, these plants are typically found in very specific habitats and do not occur predictably across the landscape. Following is a list of Montana's species of concern that may have existing populations and/or suitable habitat on or near the lease parcels by county:

Table 4. MT Species of Concern and BLM Sensitive Plants in or near lease parcels

Plant Name	Common Name	County	Habitat Description
Carex gravida	Pregnant sedge	Richland	wetland/riparian
Dalea enneandra	Nine-anther prairie clover	Richland	grasslands (plains)
Dalea villosa	Silky prairie clover	Richland	sandy sites
Dalea enneandra	Nine-anther prairie clover	Richland	grasslands (plains)
Dalea villosa	Silky prairie clover	Richland	sandy sites
Lobelia spicata *	Pale-spiked Lobelia	Richland	Moist meadow
Solidago ptarmicoides	Prairie Goldenrod	Richland	Moist meadow
Suckleya suckleya*	Suckleya suckleana	Richland, Roosevelt	wetland/riparian
Viburnum lentago*	Nannyberry	Richland	Riparian forests
Teucrium canadense	American Germander	Roosevelt	Moist meadow
Carex crawei*	Crawe's Sedge	Prairie	wetland/riparian
Astragalus barrii*	Barr's Milkvetch	Powder River	Sparsely vegetated knobs and buttes
* BLM Sensitive			

3.6.2 Special Status Animal Species

Special status species (SSS), collectively, are USFWS Federally listed or proposed species, and the BLM sensitive species from the 2009 Montana/Dakota's sensitive species list. The BLM sensitive species also include both Federal candidate species and delisted species within 5 years of delisting.

3.6.2.1 Aquatic Wildlife

For aquatic wildlife in the analysis area there are 9 fish, 3 amphibians, and 2 aquatic reptile species that are special status or are sensitive species (Table 5). All of these species depend on perennial and intermittent streams or rivers with intact floodplains, wetlands, and riparian areas that have functional habitat. One fish species, the pallid sturgeon (*Scaphirhyncus albus*), was federally listed as endangered by the U.S. Fish and Wildlife Service in 1990. Threats to the pallid sturgeon are habitat modification, small population size, limited natural reproduction, hybridization, pollution and contaminants, and commercial harvest. The pallid sturgeon inhabits the large river systems of the analysis area. In the analysis area the Yellowstone River (from the MT/ND border upstream to near Forsyth, MT) and Missouri River (from the MT/ND border upstream to near Fort Benton) are considered pallid sturgeon habitat. Additionally, these large rivers are classified as having the highest concern for fish species (particularly ESA species and species of concern) habitat under the MFWP Crucial Area Planning System (CAPS 2010). The USFWS recently took further action by listing the shovelnose sturgeon (*Scaphirhynchus platorynchus*), which closely resembles the pallid sturgeon, as a threatened species where its range overlaps with the Pallid sturgeon (FWS 2010). In Table 6, endangered or sensitive aquatic wildlife species that occur within each of the lease parcels are listed.

Table 5. Aquatic sensitive or special status wildlife species in the analysis area.

Species	USFWS Status	BLM Sensitive	In Range	Suitable Habitat Present
Pallid Sturgeon	Endangered	Special Status	Yes	Yes
Blue Sucker	None	Sensitive	Yes	Yes
Northern Redbelly Dace *	None	None	Yes	Yes
Northern Redbelly X Finescale Dace	None	Sensitive	No	N/A
Paddlefish	None	Sensitive	Yes	Yes
Pearl Dace	None	Sensitive	Yes	Yes
Sauger	None	Sensitive	Yes	Yes
Iowa Darter *	None	None	Yes	Yes
Sicklefin Chub *	None	None	Yes	Yes
Sturgeon Chub	None	Sensitive	Yes	Yes
Snapping Turtle	None	Sensitive	Yes	Yes
Spiny Softshell	None	Sensitive	Yes	Yes
Plains Spadefoot	None	Sensitive	Yes	Yes
Great Plains Toad	None	Sensitive	Yes	Yes
Northern Leopard Frog	None	Sensitive	Yes	Yes

***Iowa darter, northern redbelly dace, and sicklefin chub are listed as species of concern by the Montana Fish, Wildlife, and Parks.**

Table 6. Endangered or sensitive aquatic wildlife species that occur in, or their ranges overlap with, the lease parcels.

Lease Parcel	Endangered or Sensitive Species
MTM 102757-WT	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle
MTM 102757-WW	Blue sucker, Sauger, Northern redbelly dace, Northern leopard frog, Plains spadefoot, Great plains toad
MTM 105431-HA	Pallid sturgeon, Paddle fish, Blue sucker, Sturgeon chub, Sicklefin chub, Sauger, Iowa darter, Northern redbelly dace, Pearl dace, Northern leopard frog, Plains spadefoot, Great plains toad
MTM 105431-HB	Pallid sturgeon, Paddle fish, Blue sucker, Sturgeon chub, Sicklefin chub, Sauger, Iowa darter, Northern redbelly dace, Pearl dace, Northern leopard frog, Plains spadefoot, Great plains toad
MTM 105431-H6	Pallid sturgeon, Paddle fish, Blue sucker, Sturgeon chub, Sicklefin chub, Sauger, Iowa darter, Northern redbelly dace, Pearl dace, Northern leopard frog, Plains spadefoot, Great plains toad
MTM 105431-H8	Pallid sturgeon, Paddle fish, Blue sucker, Sturgeon chub, Sicklefin chub, Sauger, Iowa darter, Northern redbelly dace, Pearl dace, Northern leopard frog, Plains spadefoot, Great plains toad
MTM 105431-H9	Sauger, Iowa darter, Northern redbelly dace, Pearl dace, Northern leopard frog, Plains spadefoot, Great plains toad
MTM 105431-JA	Sauger, Iowa darter, Northern redbelly dace, Pearl dace, Northern leopard frog, Plains spadefoot, Great plains toad

Lease Parcel	Endangered or Sensitive Species
MTM 105431-HC	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle
MTM105431-HD	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle
MTM 105431-HE	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle
MTM 105431-HG	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle
MTM 105431-HH	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle
MTM 105431-HJ	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle
MTM 105431-HF	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle
MTM 105431-HK	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle
MTM 105431-HL	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle
MTM 105431-HM	Blue sucker, Sauger, Northern leopard frog, Plains spadefoot, Great plains toad, Spiny softshell, Snapping turtle

Note: The sauger, northern leopard frog, plains spadefoot, and great plains toad may occur in all lease parcels.

3.6.2.2 Terrestrial Wildlife

Evaluating wildlife values at the landscape scale is key to understanding potential impacts of a project. Wildlife values, including terrestrial conservation species, species richness, game quality, and aquatic conservation connectivity, have been mapped at the landscape level for Montana by MFWP through their Crucial Areas Planning System (CAPS) 2010.

The lease parcels were reviewed in the CAPS GIS website as an overlay to potential aquatic, terrestrial, and habitat values. This course-scale landscape analysis of wildlife resources provides one tool for understanding the context of the wildlife values at a large scale. Fine-scaled tools, data, and resource information based on inventory and monitoring data, as well as local knowledge from BLM and MFWP employees, are used to further examine resource issues at the site-specific level for the specific resources contained in the lease parcels considered in this EA.

The analysis area covers a variety of habitat consistent with the Northern Great Plains. Lease parcels are located within short and mixed grass prairies, riparian habitats, cultivated lands, and others. See Section 3.5 for a detailed description of vegetation.

Some of these analysis areas provide habitat for species considered as BLM "special status species". Table 6 presents the following: a list of species; whether the analysis area is within the current range of the species; and if so, whether suitable habitat is present within the lease parcels.

Table 7. Analysis area occurrence of BLM terrestrial sensitive species and USFWS threatened, endangered, candidate or proposed terrestrial species.

Species	USFWS Status	Special Status Species (SSS) and BLM Sensitive Species	In Current Range	Suitable Habitat Present
Mammals				
Gray Wolf*	None	Sensitive	No	Not applicable (N/A)
Grizzly Bear**	Threatened	Special Status Species (SSS)	No	N/A
Black-footed ferret	Endangered	SSS	No	No
Black-tailed prairie dog	None	Sensitive	Yes	No
Swift fox	None	Sensitive	Yes	Yes
Fisher	None	Sensitive	No	NA
Meadow Jumping Mouse	None	Sensitive	Yes	Yes
Great Basin Pocket Mouse	None	Sensitive	No	N/A
North American Wolverine	None	Sensitive	No	N/A
Pygmy rabbit	None	Sensitive	No	N/A
Long-legged Myotis	None	Sensitive	Yes	Yes
Long-eared Myotis	None	Sensitive	Yes	Yes
Fringed Myotis	None	Sensitive	No	N/A
Fringe-tailed Myotis	None	Sensitive	No	N/A
Pallid bat	None	Sensitive	No	N/A
Northern long-eared bat	Proposed Endangered	SSS	No	N/A
Townsend's big-eared bat	None	Sensitive	Yes	Yes
White-tailed prairie dog	None	Sensitive	No	N/A
Birds				
Common loon	None	Sensitive	Yes	Yes

Species	USFWS Status	Special Status Species (SSS) and BLM Sensitive Species	In Current Range	Suitable Habitat Present
Franklin's gull	None	Sensitive	Yes	Yes
Interior least tern	Endangered	SSS	Yes	No
Black tern	None	Sensitive	Yes	Yes
White-faced ibis	None	Sensitive	Yes	Yes
Whooping crane	Endangered	SSS	Yes	Yes
Yellow rail	None	Sensitive	Yes	Yes
Piping plover	Threatened, with critical habitat	SSS	Yes	No
Mountain plover	None	Sensitive	Yes	No
Marbled godwit	Bird of Conservation Concern (BCC)	Sensitive	Yes	Yes
Long-billed curlew	BCC	Sensitive	Yes	Yes
Black-crowned night heron	None	Sensitive	Yes	Yes
Bobolink	None	Sensitive	Yes	Yes
Greater sage-grouse	Candidate	Sensitive	Yes	Yes
Burrowing owl	BCC	Sensitive	Yes	No
Great gray owl	None	Sensitive	No	NA
Three-toed woodpecker	None	Sensitive	No	NA
Trumpeter swan	None	Sensitive	yes	unlikely
Flammulated owl	None	Sensitive	No	NA
Bald eagle	BCC	Sensitive	Yes	Yes
Golden eagle	None	Sensitive	Yes	Yes
Ferruginous hawk	None	Sensitive	Yes	Yes
Swainson's hawk	None	Sensitive	Yes	Yes
Peregrine falcon	None	Sensitive	Yes	unlikely
Northern goshawk	None	Sensitive	No	NA
Sage thrasher	BCC	Sensitive	Yes	Yes
Sprague's pipit	Candidate	Sensitive	Yes	Yes
Sedge wren	None	Sensitive	Yes	Yes
Loggerhead shrike	BCC	Sensitive	Yes	Yes
Chestnut-collared longspur	BCC	Sensitive	Yes	Yes
McCown's longspur	BCC	Sensitive	Yes	Yes
Baird's sparrow	BCC	Sensitive	Yes	Yes
Brewer's sparrow	BCC	Sensitive	Yes	Yes
LeConte's sparrow	None	Sensitive	Yes	Yes
Nelson's Sharp-tailed sparrow	None	Sensitive	Yes	Yes
Horned grebe	BCC	None	Yes	Yes
American bittern	BCC	None	Yes	Yes
Prairie falcon	BCC	None	Yes	Yes
Upland sandpiper	BCC	None	Yes	Yes

Species	USFWS Status	Special Status Species (SSS) and BLM Sensitive Species	In Current Range	Suitable Habitat Present
Yellow-billed Cuckoo	BCC	SSS	Yes	possible
Short-eared owl	BCC	None	Yes	Yes
Lewis's woodpecker	BCC	None	No	NA
Red-headed woodpecker	BCC	Sensitive	Yes	Yes
Black-backed woodpecker	None	Sensitive	No	NA
Sage sparrow	BCC	Sensitive	Yes	unlikely
Grasshopper sparrow	BCC	None	Yes	Yes
Dickcissel	BCC	Sensitive	Yes	Yes
Blue-gray natcatcher	None	Sensitive	No	N/A
Harlequin duck	None	Sensitive	No	N/A
Amphibians				
Great Plains toad	None	Sensitive	Yes	Yes
Northern leopard frog	None	Sensitive	Yes	Yes
Plains spadefoot toad	None	Sensitive	Yes	Yes
Boreal/Western Toad	None	Sensitive	No	N/A
Coeur d'Alene salamander	None	Sensitive	No	N/A
Reptiles				
Snapping turtle	None	Sensitive	Yes	Yes
Spiny softshell	None	Sensitive	Yes	Yes
Greater short-horned lizard	None	Sensitive	Yes	Yes
Milk snake	None	Sensitive	Yes	Yes
Western hog-nosed snake	None	Sensitive	Yes	Yes

Table 6 sources: Montana Bird Distribution Committee 2012; Werner, Maxell, Hendricks, and Flath. 2004; Foresman 2001; MTNHP, 2010; BLM, 2009; USDA – NRCS Plants Database, 2010
*Gray wolf has been delisted so has been moved to the sensitive list
**Grizzly bear has been delisted for the Greater Yellowstone ecosystem. In that area it is a Bureau sensitive species.

3.6.2.3 Threatened, Endangered, Candidate, and Proposed Species

Threatened, endangered, or candidate wildlife species may occupy habitat infrequently or seasonally within the analysis area. These species include the whooping crane, sage grouse, and Sprague's pipit.

The USFWS has identified a primary migration corridor for the Aransas-Wood Buffalo population of whooping cranes (http://ecos.fws.gov/docs/recovery_plan/070604_v4.pdf). Lease parcels H6, H8, H9, and JA are located within this primary migration corridor. Nesting by whooping cranes has not been documented in the analysis area; however, stopover observations have been documented in eastern MT.

Two species recently classified as USFWS candidate species occur within the analysis area. These are the Sprague's pipit and the greater sage grouse. Candidate species are those that warrant protection under the Endangered Species Act, but listing the candidate species is precluded by the need to address other listing actions of a higher priority. The USFWS will review the need for listing these species annually and will propose the species for protection when funding and workload for other listing actions allow.

On March 5, 2010, USFWS concluded sage grouse warrants protection under the Endangered Species Act. However, USFWS determined the listing of the species is precluded by the need to take action on higher priority species. Sage grouse was placed on the list of species that are candidates under the Endangered Species Act.

Sage grouse are a native prairie grouse species that are considered sagebrush obligates and depend on sagebrush for survival. Lease parcel WW is located within 0.25 miles of a sage grouse lek location. In addition, 3 other lease parcels are located within 2 miles of lek locations. These include parcels WT, HG, and HF. Instruction Memorandum (IM) No. 2012-043 (BLM, 2011) identified Preliminary Priority Habitat (PPH), and Preliminary General Habitat (PGH) polygons for sage grouse in the planning area. In addition, IM No. 2012-043 provides conservation policies and procedures for sage grouse management within these polygons. None of the parcels are proposed within the PPH polygon; however, parcels HD, HE, HG, HH, HJ, HF, HK, HL, and HM are located within the PGH polygon.

Sprague's pipit was recently classified as USFWS candidate species and occurs within the analysis area. Candidate species are those that warrant protection under the Endangered Species Act, but listing the candidate species is precluded by the need to address other listing actions of a higher priority. The USFWS will review the need for listing these species annually and will propose the species for protection when funding and workload for other listing actions allow. Sprague's pipits were found warranted, but precluded as a threatened or endangered species on September 15, 2010. Sprague's pipits are strongly tied to native prairie (land which has never been plowed) throughout their life cycle (Owens and Myres 1973, pp. 705, 708; Davis 2004, pp. 1138-1139; Dechant et al. 1998, pp. 1-2; Dieni et al. 2003, p. 31; McMaster et al. 2005, p. 219). They are rarely observed in cropland (Koper et al. 2009, p. 1987; Owens and Myres 1973, pp. 697, 707; Igl et al. 2008, pp. 280, 284) or land in the Conservation Reserve Program (a program whereby marginal farmland is planted primarily with grasses) (Higgins et al. 2002, pp. 46-47). Sprague's pipits will use nonnative planted grassland (Higgins et al. 2002, pp. 46-47; Dechant et al. 1998, p. 3; Dohms 2009, pp. 77-78, 88). Vegetation structure may be a better predictor of occurrence than vegetation composition (Davis 2004, pp. 1135, 1137). (Federal Register: September 15, 2010 (Volume 75, Number 178)) Montana Natural Heritage Tracker has documented observations of Sprague's pipits in Daniels, Sheridan, Roosevelt, McCone, Richland, Dawson, Prairie, Custer, and Fallon Counties within the Miles City Field Office. Therefore, the proposed lease parcels have been identified as providing potential suitable habitat for Sprague's pipits based on a Sprague's pipit suitable habitat model utilized by the Montana Department of Fish, Wildlife, and Parks (http://apps.fwp.mt.gov/gis/maps/caps/), and aerial photography (NAIP, 2011). Ground-truthing of the parcels has not occurred to document actual habitat use by Sprague pipits, or that suitable habitat exists within all of the parcels identified by the model. However, it is likely that at least portions of these parcels provide suitable habitat for Sprague's pipits. These include parcels H8, H6, H9, JA, HB, HA, WW, and WT.

3.6.2.4 Other Sensitive Species

As noted in Table 6 above, up to 51 wildlife species considered as BLM "sensitive" have the potential to occur within the analysis area. These include 37 birds, 6 mammals, 3 amphibians, and 5 reptiles. This list is a combination of recent and historic observations. In some instances, historic observations are the only known record. If a species is noted as in range, it signifies that habitat within the field office would be considered within the documented range of occupation of habitat by a particular species during some phase of its life cycle. This might be only for a short time frame, during migrations, seasonally, or possibly year-round. Documentation of occupation of habitat by specific wildlife species is considered good across this area for some species, (e.g., sage grouse) and lacking for other species (small mammals, herptiles, raptors, etc.). However, the table documents the potential for wildlife species occurrence if at least one lease parcel is located within a particular sensitive species' known range of habitat occupation based on available science and research.

Various bird surveys throughout different years have been conducted across the MCFO, which may have included some of the lease parcel areas or at least similar habitats. Surveys have been conducted by the United States Geological Survey, University of Montana Avian Science Center, Rocky Mountain Bird Observatory, MTNHP, and other interested "birders." Migratory bird species diversity varies across the MCFO area. According to P.D. Skaar's Montana Bird Distribution, 6th edition (Lenard et al., 2003) species diversity ranges from less than 40 species per "latilong" (~3,200 square miles) to more than 200 across the analysis area.

The analysis area provides potential nesting, foraging, and migratory habitat for various species of raptors; however, recent surveys for raptor nests have not occurred. Two lease parcels, WT and HG, are located within 0.5 miles of one historic Ferruginous hawknest. In addition, parcel WW is located within 0.5 miles of a Swainson's hawk nest. Other species that would be expected within the analysis area include red-tailed hawks, great-horned owls, northern harriers, bald and golden eagles, sharp-shinned hawks, and coopers hawks. . Peregrine falcons are also known to migrate through eastern Montana.

3.7 Fish and Wildlife

3.7.1 Aquatic Wildlife

The aquatic resources in the analysis area include aquatic wildlife and habitat for fish, aquatic arthropods (insects and crustaceans), amphibians, reptiles, and bivalves. The habitat consists of rivers, streams, and reservoirs that provide habitat for a variety of aquatic wildlife and riparian communities (and their varying lifecycle stages).

Based on known fish presence (MFWP 2010), there are approximately 20 miles of fish-bearing streams within the analysis area, but due to ongoing inventory efforts, the discovery of more prairie streams that support native fish and other aquatic wildlife would occur. Additionally, prairie fish are constantly moving through a landscape that balances, at the local and landscape scale, between drying and flooding stages. Consequently, the ability to migrate during high flows is a crucial life history strategy.

Aquatic resource conditions of streams are strongly related to riparian vegetation, upland range conditions, land use impacts, and quality and quantity of in-stream water. Habitat conditions throughout the analysis area vary between and within water bodies; the upper and middle reaches of smaller streams may be intermittent, while the lower reaches may receive perennial flows, resulting in different habitat conditions and different aquatic communities within the same stream. Prairie fish are adapted to these cycles of drying and flooding and thrive in these intermittent pools, provided land-use impacts are not severe (Bramblett et al. 2005). However, prairie streams are highly sensitive to disturbance, and due to this factor many prairie stream ecosystems are already imperiled due to anthropogenic activities (Dodds et al. 2004).

Riparian vegetation is a critical component in maintaining aquatic wildlife habitat and is a source of organic nutrients and food items for the prairie stream ecosystem, provides in-stream habitat for fish, amphibians, reptiles, and invertebrates, adds structure to the banks, and reduces erosion; when riparian vegetation senesces and falls into the stream, it adds cover, habitat complexity, and moderates water temperatures. In some cases throughout the analysis area, riparian habitats have been degraded, and the results include increases in erosion and sedimentation, shallower and wider streams (which increases evaporation and thus decreases water quality and quantity), increases in temperature fluctuations, and critically low oxygen content levels; these effects collectively reduce or degrade available aquatic wildlife habitat.

Existing factors limiting or affecting aquatic resources in the analysis area include the lack of a normative flow regime primarily through extensive reservoir development; loss or degradation of riparian habitat; habitat fragmentation; livestock grazing damage; past and current oil and gas development; un-passable fish & aquatic wildlife culverts, oil skimmers, and other stream crossings; and excess siltation due to the various land use activities.

3.7.2 General Wildlife

A diversity of topography and vegetation types exists across the analysis area. This diversity provides habitat for many wildlife species in addition to those previously mentioned.

Current and historic land uses within or adjacent to the lease parcels include grazing, farming, hunting, energy development, and others. A few areas contain blocks of well-functioning habitats, while other areas are composed of small, fragmented patches of native habitat and cultivated lands. In some areas, existing anthropogenic disturbance at some frequency can be expected to reduce habitat suitability for some species of wildlife intolerant to human activities.

The analysis area supports a variety of game and nongame species. Limited wildlife species and habitat surveys have been conducted within a portion of the analysis area. Although the entire area has not been comprehensively surveyed for all wildlife resources, past surveys document what species occur, and provides insight into what other species can be expected to occur within existing habitat types.

Mule deer are the most abundant big game species and use the greatest variety of habitats, generally preferring sagebrush, grassland, and conifer types (BLM 1984). Habitat diversity appears to be a good indicator of intensity of deer use. In mule deer habitats, diversity of vegetation usually followed topographic diversity; thus, rugged topography may be the ultimate factor influencing mule deer use of an area (Mackie et. al. 1998). Habitat such as riparian bottoms, agricultural areas, and forests are used as well, both yearlong or seasonally. Habitat to support mule deer exists within all of the lease parcels.

Winter range is often part of year-round habitat in eastern Montana. Winter ranges are typically in areas of rougher topography and are often dominated by shrub species that provide crucial browse during winter months. Rough topography also provides critical escape and thermal cover important for maintenance and survival. Of the 18 proposed lease parcels, 6 of those are located within mule deer winter range. These include parcels H8, H6, HB, HK, HL, and HM.

White-tailed deer are common in the analysis area. White-tailed deer prefer riparian drainage bottoms, hardwood draws, and conifer areas, but they will also use a variety of other habitats including farmlands. During the winter, white-tailed deer using forested areas prefer dense canopy classes, moist habitat types, uncut areas, and low snow depths. Suitable winter range is a key habitat factor for white-tailed deer, and winter concentration areas occur almost exclusively in riparian and wetland habitats and dense pine (Youmans and Swenson 1982). Although white-tailed deer move on and off winter range, as dictated by seasonal habitat requirements, the animals do not migrate for long distances (Hamlin 1978). One parcel, HM, is proposed for lease within delineated crucial white-tailed deer winter range.

Pronghorn antelope are widely distributed across the analysis area. They are generally associated with grasslands and shrublands, but they also seasonally use agricultural fields. Winter ranges for pronghorn antelope generally occur within sagebrush grasslands with at least greater densities of big sagebrush than the surrounding areas. Crucial winter ranges for pronghorn exists within parcels WW, WT, HC, HD, HE, HG, HH, HJ, and HF. The potential exists for other big game species to occupy the areas. Species include elk, moose, mountain lion, and black bear although presence would likely occur as individual's transition to preferred habitats elsewhere.

The potential for big game movements or migrations through eastern Montana are not fully understood. At a local level, it is reasonable to assume big game movements occur at least seasonally. Migration corridors have not been identified through any of the lease parcels.

Sharp-tailed grouse are the other native prairie grouse species in the analysis area. Sharp-tailed grouse generally prefer hardwood draws, riparian areas, and prairie grasslands intermixed with shrubs such as chokecherry and buffaloberry. Lease parcels H8 and WW are located within 0.25 miles of sharp-tailed grouse dancing grounds. In addition, portions or all of 10 lease parcels are located within 2 miles of sharp-tailed grouse leks, and most of these parcels would be expected to provide at least seasonal habitat for sharp-tailed grouse. These parcels include H8, H6, WW, WT, HC, HD, HE, HK, HL, and HM.

Wild turkeys, pheasants, and Hungarian partridge are all species that have been introduced to eastern Montana and would be expected to utilize available habitats within some of the parcels.

3.8 Cultural Resources

The BLM is responsible for identifying, protecting, managing, and enhancing cultural resources located on public lands or those that may be affected by BLM management actions on non-Federal lands. Cultural resources include archaeological, historic, architectural properties, and traditional lifeway values important to Native Americans. Sites can vary with regard to their intrinsic value as well as their significance to scientific study; therefore, management practices employed are commensurate with their designation. Significant cultural resource values include; their use to gather scientific information on human culture, history, interpretive and educational value, values associated with important people and events of significance in history, and often aesthetic value, as in a prehistoric rock art panel or an historic landscape.

A generalized prehistory of eastern Montana can be categorized in a chronological framework, and time periods are distinguished on the basis of differences in material culture traits or artifacts and subsistence patterns: the PaleoIndian period (ca. 12,500 BP-7800 BP), Archaic period (ca. 7800 BP-1500 BP), Prehistoric period (ca. 1500 BP-200 BP), Protohistoric period (ca. 250 BP-100 BP), and Historic Periods (A.D. 1805-A.D. 1960) (Aaberg et al 2006).

Cultural sites are evaluated with reference to their eligibility for listing on the National Register of Historic Places (NRHP). Each site is considered on a case-by-case basis.

A recent Class I overview of cultural resources was prepared for the analysis area (Aaberg et al 2006). The cultural environment of the MCFO as of May 2005 contained 7,065 prehistoric and 2,869 historic archeological sites as well as 1,929 paleontological localities. Archeological properties (historic and prehistoric sites) occur in all counties encompassed by the field office. The five counties with nominated lease parcels contain 33.8 percent of all prehistoric and 29.9 percent of all historic resources within the MCFO. Each of the five counties contains the following percentages of resource site types within its boundaries: McCone 2.3 percent prehistoric, 4.2 percent historic, Powder River 23.2 percent prehistoric, 8.1 percent historic, Prairie 2.6 percent prehistoric, 5.2 percent historic, Richland 1.9 percent prehistoric, 6.1 percent historic and Roosevelt 3.7 percent prehistoric, 6.2 percent historic.

The overall archeological site density of the MCFO (historic and prehistoric) is estimated at one site per 93 acres (Aaberg et al 2006). Prehistoric sites are estimated to be distributed at one site per 130.8 acres (4.9 per square mile) and historic sites at one site per 322 acres (two per square mile) for all surveyed acres within the MCFO. Approximately 10% to 15% of all sites are found to be or have the potential to be eligible for listing in the National Register of Historic Places.

A review of the Montana State Historical Preservation Office (SHPO) Cultural Resource Information System (CRIS) and Cultural Resource Annotated Bibliography System (CRABS), as well as BLM Cultural Resource databases and GIS data, indicates one (1) lease parcel (MTM 105431-H9) contains recorded cultural sites within the lease parcel boundaries. Inventory data is not available for a majority of individual lease parcels; however some parcels have incomplete coverage of cultural resource inventory.

The one parcel with identified sites contains three sites, all of the same site type within the boundaries of the reviewed parcel. Each site is a stone circle site. None of the sites have been evaluated for eligibility for inclusion in the National Register of Historic Places and may be of interest to Native American concerns, See Section 3.9.

3.9 Native American Religious Concerns

The BLM's management of Native American Religious concerns is guided through its 8120 Manual: *Tribal Consultation Under Cultural Resources Authorities* and 8120 Handbook: *Guidelines for Conducting Tribal Consultation*. Further guidance for consideration of fluid minerals leasing is contained in BLM Washington Office Instruction Memorandum 2005-003: Cultural Resources, Tribal Consultation, and Fluid Mineral Leasing. The 2005 memo notes leasing is considered an undertaking as defined in the National Historic Preservation Act. Generally areas of concern to Native Americans are referred to as "Traditional Cultural Properties" (TCPs) which are defined as cultural properties eligible for the National Register of Historic Places because of its association with cultural practices or beliefs that (a) are rooted in that community's history and (b) are important in maintaining the continuing cultural identity of the community.

Areas of tribal concern in southeast Montana are listed in Appendices B-E of the Ethnographic Overview of Southeast Montana (Peterson and Deaver 2002). Based on input from various tribes, the 2002 Ethnographic Overview also identified 12 sensitive site types. These include battlefield and raiding sites, burials, cairns, communal kills, fasting beds (vision quests), homesteads, medicine lodges, rock art, settlements (campsites), stone rings, spirit homes, and environmental places (plant gathering areas, mineral and fossil collection areas).

The Crow Tribe's 2002 document noted rock art, fasting sites, siege sites, camp sites, mourning sites, final resting places (burials), buffalo jumps, and environmental areas, including animal habitats and natural areas of concern such as springs. The Northern Cheyenne Tribe in its 2002 document noted large ring sites (both in terms of ring diameters and ring numbers), isolated fasting beds, rock art sites, and large diameter fasting structure as having religious significance to the tribe.

One parcel (MTM 105431-H9) contains three stone circle sites (24RV141-24RV143). The sites are currently unevaluated for listing on the National Register of Historic Places. A review of 2009 aerial imagery shows the well was not drilled and the sites have not been impacted by fluid mineral development. Prior to surface any surface disturbance the sites require a reevaluation of National Register eligibility including tribal participation.

3.10 Paleontology

According to Section 6301 of the Paleontological Resource Protection Act of 2009 Omnibus Public Lands Bill, Subtitle D, SEC. 6301, paleontological resources are defined as "any fossilized remains, traces, or imprints of organisms, preserved in or on the earth's crust, that are of paleontological interest and that provide information about the history of life on earth" (Paleontological Resource Protection Act of 2009 Omnibus Lands Bill, Subtitle D, SEC. 6301-3612 (P.L. 59-209; 34 Stat. 225; 16 U.S.C. 431-433). All vertebrate fossils, be they fossilized remains, traces, or imprints of vertebrate organisms, are considered significant. Paleontological resources do not include archaeological and cultural resources.

The BLM utilizes the Potential Fossil Yield Classification (PFYC) as a planning tool for identifying areas with high potential to yield significant fossils. The system consists of numbers ranging from 1-5 (low to high) assigned to geological units, with 1 being low potential and 5 being high potential to have significant fossil resources. It should be pointed out that the potential to yield significant fossil resources is never 0. Rock units not typically fossiliferous can in fact contain fossils in unique circumstances.

The BLM classified geologic formations that have a high Potential Fossil Yield Classification (PFYC) of 3 or higher should be specifically reviewed for paleontological resources. The MCFO has the following classifications on the relevant geologic units:

Quaternary deposits	Class 2 and 3
Ft Union	Class 4
Hell Creek	Class 5

All or part of the 18 parcels include geologic units rated as PFYC 3-5 and should be evaluated for fossil resources before and potentially during ground-disturbing activities.

3.11 Visual Resources

BLM Visual Resource classifications are only applied to BLM surface acres, as such the affected environment for visual resources only consists of approximately 3,640 acres of BLM - administered surface in the analysis area (Table 7).

A Class II VRM area classification means that the character of the landscape has unique combinations of visual features such as land, vegetation, and water. The existing character of the landscape should be retained. Activities or modifications of the environment should not be evident or attract the attention of the casual observer. Changes caused by management activities must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

A Class III VRM area classification means the level of change to the character of the landscape should be moderate. Changes caused by management activities should not dominate the view of the casual observer and should not detract from the existing landscape features. Any changes made should repeat the basic elements found in the natural landscape such as form, line, color and texture.

A Class IV VRM area classification means that the characteristic landscape can provide for major modification of the landscape. The level of change in the basic landscape elements can be high. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

Table 8: VRM Classes for the analysis area by lease parcel

Leasing Areas	VRM Class II Acres	VRM Class III Acres	VRM Class IV Acres
RICHLAND COUNTY	***0 total acres***	***722 total acres***	***37 total acres***
MTM 105431-HB	0	600	0
MTM 105431-H6	0	122	0
MTM 105431-H8	0	0	37
PRAIRIE COUNTY	***0 total acres***	***961 total acres***	***958 total acres***
MTM 102757-WT	0	961	0
MTM 102757-WW	0	0	958

POWDER RIVER COUNTY	*0 total acres*	*0 total acres*	*960 total acres*
MTM 105431-HD	0	0	80
MTM 105431-HE	0	0	160
MTM 105431-HK	0	0	640
MTM 105431-HL	0	0	80

3.12 Forest and Woodland Resources

Evergreen forest habitat types occurring in the analysis area include ponderosa pine (*Pinus ponderosa*) and Rocky Mountain juniper (*Juniperus scopulorum*). Deciduous forest habitat types include Green ash (*Fraxinus pennsylvanica*)/Chokecherry (*Prunus virginiana)*, and Great Plans Cottonwood (*Populus deltoids)/*Herbaceous Communities. The deciduous habitat types occur along streams, rivers, lakes springs, and ponds, occupying terraces, fans, and floodplain positions. The Green ash/Choke cherry habitat types occur in V-shaped ravines (also called woody draws), where sites may occasionally be flooded by storm runoff flows. Table 9, summarizes forest and woodland acres in the analysis area by forest type and individual parcel.

Table 9. Forestland Acreage and Forest Type by Lease Parcel

Lease Parcel	Evergreen Forest	Deciduous Forest	Mixed Forest	Total Acres
MTM 102757-WT				
MTM 102757-WW				
MTM 105431-H6		123		123
MTM 105431-H8				
MTM 105431-H9				
MTM 105431-HA				
MTM 105431-HB	66			66
MTM 105431-HC	1006	235	7	1248
MTM 105431-HD	591		57	648
MTM 105431-HE				
MTM 105431-HF			4	4
MTM 105431-HG				
MTM 105431-HH			5	5
MTM 105431-HJ		3	7	10
MTM 105431-HK				
MTM 105431-HL			4	4
MTM 105431-HM	8			8
MTM 105431-JA				
Total	**1671**	**361**	**84**	**2116**

Source: GAP Vegetation Cover Types

The deciduous forest habitats add to the overall diversity of the landscape. They also attract wildlife and livestock for thermal cover, nesting habitat, moisture, browse and, and hiding cover. Because of this, these woodlands are focal points for some of the livestock and wildlife management. The evergreen forests occur in a mosaic patters across the grasslands. These evergreen habitats commonly occur on moderate to steep slopes. Ponderosa pine species tolerates dry environments more successfully than other native confer except Rocky Mountain juniper. Rocky Mountain juniper has an interesting ecological role in the northern Great Plans.

In some cases, it can be the dominant species present in the stand or can be the understory of Ponderosa pine stands and some deciduous stands.

3.13 Livestock Grazing

Nine of the parcels (MTM 105431-H8, MTM 105431-H6, MTM 105431-HB, MTM 105431-HD MTM 105431-HE, MTM 105431-HK, MTM 105431-HL, MTM 102757-WW, and MTM 102757-WT) in whole or part have BLM surface ownership within currently permitted grazing allotments. These parcels occur in Richland, Prairie and Powder River counties and include portions of ten separate grazing allotments. Cattle are the only class of livestock authorized to graze these allotments. Of the ten allotments, seven of the grazing authorizations do not restrict the grazing season or number of livestock due to the small percentage of public land within the allotment. Three allotments are authorized under active use which has strict seasons and numbers and are typically made up of a higher percentage of public land. None of the allotments are under an Allotment Management Plan (AMP). These allotments contain range improvements such as fences and reservoirs that have access roads for livestock management purposes. The remainder of the lease parcels does not contain any BLM administered lands and are primarily lands with private surface ownership.

3.14 Recreation and Travel Management

The BLM only manages recreational opportunities and experiences on BLM-administered surface. The affected environment consists of approximately 3,640 acres of BLM-administered surface. Recreational activities enjoyed by the public on BLM lands within the analysis area include hunting, hiking, camping, fishing, photography, picnicking, and winter activities such as snowshoeing and snowmobiling. Benefits and experiences enjoyed by recreational users include opportunities for solitude, spending time with families, enhancing leisure time, improving sports skills, enjoying nature and enjoying physical exercise.

Out of the approximately 3,640 BLM-administered acres proposed for lease, less than 950 acres have legal public access. The types of public use on the 950 acres lease parcels can be characterized as casual dispersed recreational activities including hiking, hunting (including outfitters), camping, and wildlife viewing. The rest of the BLM- administered acres have no public easements or rights-of-way across private property for legal land access. The lack of public access limits use of the BLM parcels for recreational use by the general public.

3.15 Lands and Realty

The analysis area consists of 18 parcels that include 7,945.28 surveyed surface acres of which 3,637.97 surveyed acres are BLM administered surface and 4,307.31 surveyed acres are Non-Federal surface (private). Table 10 below categorizes the 18 parcels by surface ownership and county.

There are three lease parcels with authorized BLM Rights-of Way (ROWs) approved on BLM administered surface, MTM-102757-WT, MTM-105431-HB and MTM-105431-H8.

Table 10. Number of parcels, surface ownership, and acres by county.

County	Parcels	Owner-ship	Acres
MCCONE			
	1 parcel (MTM-105431-HA)	Non-Federal	40
	1 TOTAL		**40**
RICHLAND			
	3 partial parcels (MTM-105431-HB, MTM-105431-H6, MTM-105431-H8)	BLM	758.73
	3 partial parcels (MTM-105431-HB, MTM-105431-H6, MTM-105431-H8)	Non-Federal	430.48
	3 TOTAL		**1189.21**
ROOSEVELT			
	1 parcel (MTM-105431-H9)	Non-Federal	160.02
	1 parcel (MTM-105431-JA)	Non-Federal	39.94
	2 TOTAL		**199.96**
PRAIRIE			
	1 parcel (MTM-102757-WT)	BLM	961.22
	1 parcel (MTM-102757-WW)	BLM	958.02
	2 TOTAL		**1,919.24**
POWDER RIVER			
	1 parcel (MTM-105431-HC)	Non-Federal	640
	1 partial parcel (MTM-105431-HD)	Non-Federal	560
	1 partial parcel (MTM-105431-HD)	BLM	80
	1 parcel (MTM-105431-HE)	BLM	160
	1 parcel (MTM-105431-HG)	Non-Federal	160
	1 parcel (MTM-105431-HH)	Non-Federal	440
	1 parcel (MTM-105431-HJ)	Non-Federal	316.87
	1 parcel (MTM-105431-HF)	Non-Federal	640
	1 parcel (MTM-105431-HK)	BLM	640
	1 parcel (MTM-105431-HL)	Non-Federal	640
	1 parcel (MTM-105431-HM)	Non-Federal	320
	10 TOTAL		**4,596.87**

***parcels MTM-105431-HB, H6, H8 and HD contain both Federal and Non-Federal surface.**

3.16 Minerals

3.16.1 Fluid Minerals

It is the policy of the BLM to make mineral resources available for development and to encourage development of these resources to meet national, regional, and local needs, consistent with national objectives of an adequate supply of minerals at reasonable prices. At the same time, the BLM strives to assure that mineral development occurs in a manner which minimizes environmental damage and provides for the reclamation of the lands affected.

Currently there are 1,560 Federal oil and gas leases covering approximately 955,572.612 acres in the MCFO. The number of acres leased and the number of leases can vary on daily basis as leases are relinquished, expired, or are terminated. Existing production activity occurs on approximately 20.4 (195,497.180 acres) percent of this lease acreage. Information on numbers and status of wells on these leases and well status and numbers of private and State wells within the external boundary of the field office is displayed in Table 11. Numbers of townships, lease acres within those townships, and development activity for all jurisdictions are summarized in Table 12.

Exploration and development activities would only occur after a lease is issued and the appropriate permit is approved. Exploration and development proposals would require completion of a separate environmental document to analyze specific proposals and site-specific resource concerns before BLM approved the appropriate permit.

Table 11. Existing Development Activity

	FEDERAL WELLS	PRIVATE AND STATE WELLS
Drilling Well(s)	9	125
Producing Gas Well(s)(including CBNG)	453	470
Producing Oil Well(s)	418	1890
Water Injection Well(s)	154	357
Shut-in Well(s)	154	1430
Temporarily Abandoned Well(s)	87	219

Table 12. Oil and Gas Leasing and Existing Development within Townships Containing Parcels

	Richland	Roosevelt	McCone
Number of Townships Containing Lease Parcels	6	7	2
Total Acres Within Applicable Township(s)	119,455	52,610	23,072
Acres of Federal Oil and Gas Minerals	28,834	309	2778
Percent of Township(s)	24.1%	0.6%	12.0%
Acres of Leased Federal Oil and Gas Minerals	24,076	141	2,698
Percent of Township(s)	20.2%	0.3%	11.7
Acres of Leased Federal Oil and Gas Minerals Suspended	Zero	Zero	Zero
Percent of Township(s)	0.0%	0.0%	0.0%
Federal Wells	7 producing oil wells (6 are horizontal wells), 3 shut in wells, 1 P&A wells, 5 temporarily abandoned wells.	1 P&A well	Zero
Private and State Wells	36 producing oil wells (35 are horizontal), 16 P&A wells, 1 service wells, 6 temporarily abandoned wells.	29 producing oil wells (24 are horizontal wells), 35 P&A wells, 4 service wells, 2 shut in wells, 8 temporarily abandoned wells.	1 P&A well.

	Prairie	Powder River
Number of Townships Containing Lease Parcels / Total Acres Within Applicable Township(s)	4 / 61,180	4 / 91,845
Acres of Federal Oil and Gas Minerals / Percent of Township(s)	26,576 / 43.4	50,833 / 55.3
Acres of Leased Federal Oil and Gas Minerals / Percent of Township(s)	Zero / 0.0%	24,981 / 27.2
Acres of Leased Federal Oil and Gas Minerals Suspended / Percent of Township(s)	Zero / 0.0%	Zero / 0.0%
Federal Wells	Zero	2 Producing oil wells, 58 P&A wells.
Private and State Wells	3 P&A wells.	34 P&A wells, 2 service wells.

3.17 Special Designations

3.17.1 Lewis and Clark National Historic Trail

Two Lease parcels, MTM 105431-H8 and HB (947.3 acres), are located within a 3 mile sensitive Setting Consideration Zone (SCZ) around the Lewis and Clark National Historic Trail (NHT) and SRMA. The Lewis and Clark NHT is managed in accordance with the National Trail System Act of 1968, as amended (16 USC 1241-1251) to identify and protect the historic route and its historic remnants and artifacts for public use and enjoyment. The trail would be managed to preserve the historic and cultural resources that are related to the events that occurred during the Lewis and Clark Expedition. The National Park Service (NPS), who is the lead agency for trail administration, established the overall management vision through their Comprehensive Management Plan (1982) and Foundation Document (2012). BLM works collaboratively with NPS to manage trail resources in conformance with these plans and guidance thought BLM Manual 6280.

Any changes in the landscape within view of the Lewis and Clark NHT will be guided by Class II visual resource management objectives and the Lewis and Clark SRMA.

3.18 Social and Economic Conditions

3.18.1 Social and Environmental Justice

The social section focuses on the areas in the immediate vicinity of the parcels proposed for leasing. This area includes seven counties in eastern Montana: Daniels, Garfield. McCone, Prairie, Richland, Roosevelt, and Rosebud 80% of acres examined for leasing located in Prairie County. In 2010 this seven county region was reported to have a population of 35,274 people, with more than 80% of the region's population living within Richland (10,425), Roosevelt (9,746), and Rosebud (9,233) Counties. Smaller Populations were reported in Daniels (1,751), Garfield (1,206), McCone (1,734), and Prairie (1,179) Counties (U.S. Census, 2010). Census data indicated that populations within this region declined between 2000 and 2010. Although all seven counties reported population losses during this time period, losses in Daniels (13.2%), Garfield (5.7%) and McCone (12.3%) counties were substantially greater than those in Prairie (1.7%), Richland (0.8%), Roosevelt (1.8%), and Rosebud (1.6%) (US Department of Commerce, 2012). While Montana is often characterized as a rural state with a population density of 6.8 persons per square mile, all of the seven counties with land proposed for oil and gas leasing were reported to have fewer than 6.8 persons per square mile in 2010. Of these seven counties, only Daniels (1.2), Richland (4.7), Roosevelt (4.4), and Rosebud (1.8) had population densities greater than 1. The county seats for these counties include Scobey in Daniels County (1,107), Jordan in Garfield County (352), Circle in McCone County (526), Terry in Prairie County (605), Sidney in Richland County (4,843), Wolf Point in Roosevelt County (2,621), and Forsyth in Rosebud County (1,777) (U.S. Census, 2010).

Currently oil and gas leasing and production are taking place on public and private lands within these seven counties. Approximately half of the acres being considered for this lease sale are under BLM ownership, with an addition 2,876 acres under split ownership between BLM and private estates. Interest in oil and gas development in this region has significantly increased over the last five years because of its proximity to the Bakken formation which extends from the Williston Basin in western North Dakota to northeastern Montana. Richland, MT, which is adjacent to the Williston Basin, has had the highest oil and gas production on federal lands of any of county in eastern Montana. Most of the oil and gas industry support services for eastern Montana occur in Glendive, Sidney, and Miles City, Montana, and Williston and Dickinson, North Dakota.

According to the 2010 Census populations in the seven counties with land proposed for oil and gas leasing were made up of individuals who identified with one of three racial groups: White alone, American Indian alone, or of Two or more races. While 70% of the total population in this seven-county region identified themselves as White alone, individuals identifying themselves at White accounted for more than 95% of the total population in five of the seven counties (Daniels, Garfield, McCone, Prairie, and Richland) (U.S. Department of Commerce, 2012). Populations in Roosevelt and Rosebud counties were more diverse in 2010 with large American Indian populations from the Cheyenne and Sioux tribes. Roosevelt and Rosebud counties 2010 populations were made up of 37% and 61% White alone, 49% and 33% American Indian alone, and 13% and 3% two or more races (U.S. Department of Commerce, 2012). While the percent of Montana residents (14.5%) living below the poverty line in 2010 was comparable to the nation poverty rate (13.8%), the poverty rate of the seven-county region in eastern Montana (17%) was above state and national levels. The relatively high regional poverty rate was driven by poverty levels in Prairie (16.9%), Roosevelt (21.5%), and Rosebud (18.5%) counties; while poverty in Daniels (14.1%), Garfield (10.7%), McCone (8.6), and Richland (13.5%) counties remained relatively low in 2010 (U.S. Department of Commerce, 2012).

The social environment of these counties is described in detail in the Socioeconomic Baseline Report for the Miles City Field Office RMP and EIS (prepared for the DOI, BLM, MCFO, June, 2005).

3.18.2 Economics

Certain existing demographic and economic features influence and define the nature of local economic and social activity. Among these features are the local population, the presence and proximity of cities or regional business centers, longstanding industries, infrastructure, predominant land and water features, and unique area amenities. Several additional parcels in McCone, Power River, Prairie, Richland and Roosevelt counties have been nominated for leasing in the October 2014 lease sale. While the majority of nominated land is unoccupied there are social and economic linkages which connect nominated parcels to communities in the surrounding area. To examine how leasing proposed under the alternatives will affect the local economy, the analysis area was expanded to include Williams County, North Dakota since Williston, ND is the largest business center near the affected communities, especially for oil and gas related activities, and is the major oil and gas service center for activity in the five counties above. Custer and Dawson counties in Montana were also included to create a contiguous analysis area.

In 2012, the 8-county analysis area was estimated to have a total population of 74,192 people, with 32,624 households earning an average annual household income of $149,626 (IMPLAN, 2014). Twenty-five percent of the area's total population lived in Williston, ND (18,532 people). In 2012, the 8-county area economy supported approximately 71,948 jobs in 183 industrial sectors, equating to approximately 2.3 people or 2.2 jobs per household. The top five industries operating in the local economy included: support activities for oil and gas operations, wholesale trade, drilling oil and gas wells, State and local government, and truck transportation (IMPLAN, 2014). A large share of the economic activity in the region occurs in Williams County which contains Williston, ND, the largest business center and the epicenter of recent oil and gas exploration and development.

Parcels nominated for leasing in October 2014 are located in the eastern Montana counties of McCone, Powder River, Prairie, Richland and Roosevelt. Between 2009 and 2013, these counties produced an annual average of 16.4 million bbls of oil and 16.5 million mcf of natural gas, with the majority of production occurring in Richland County. Over the last 24 months (4/2012-4/2014), the Montana Board of Oil and Gas reported that 372 permits for activities associated with oil and gas wells were processed for these five counties. Of the 372 permits processed for this area, 35% were associated with existing producing wells and 28% were related to recently spudded wells. While these permits can be associated with several types of well, only 4% were reported to be unrelated to oil (i.e natural gas, injection or monitoring, or dry hole) (MT DNRM, 2014). While some oil and gas related activities have been permitted in the Southeastern county of Powder River, more than 99% of permitted activity is associated with wells in the Three Forks Group. These subsurface deposits stretch across the Williston Basin from southern Saskatchewan, Canada to eastern Montana and western North Dakota. The overwhelming majority of recently completed wells are located in the sub-unit of the Three-Forks known as the Bakken formation.

The widespread adoption of horizontal drilling and other recent technological advances have significantly increased the capability and cost effectiveness of extracting fluid minerals across the Williston Basin. The recent surge of interest in commercial development of the Bakken's deposits has rapidly transformed the region's physical, cultural and economic landscapes. Eastern Montana and Western North Dakota have become increasingly specialized in industries that support and service the oil and gas sector, enabling the oil and gas industry to become the driving force behind the region's economy. The exploration, development, and production of fluid minerals directly and indirectly support thousands of jobs and millions of dollars in labor income throughout Eastern Montana and Western North Dakota. Although Federal minerals in the five counties with parcels nominated for leasing are associated with only a fraction of the region's oil and gas activity, the leasing and development of these minerals supports local employment and income and generates public revenue for many surrounding communities. The economic contributions of Federal fluid minerals are largely influenced by the number of acres leased and estimated levels of production and can be measured in terms of the jobs, income, and public revenue it generates.

Mineral rights can be owned by private individuals, corporations, Indian tribes, or by local, State, or Federal Governments. Typically companies specializing in the development and extraction of oil and gas lease the mineral rights for a particular parcel from the owner of the mineral rights. As of April, 2014, 434,866 acres were leased from the BLM for oil and gas development in McCone, Powder River, Prairie, Richland, and Roosevelt counties. Federal oil and gas leases are generally issued for 10 years unless drilling activities result in one or more producing wells or the lease is part of a collective agreement and incorporated into a field or unit. Once production of federal minerals from a lease has begun, the lease is considered to be held by production and the lessee is required to make royalty payments to the Federal Government. Of 434,866 acres leased from the BLM in the five counties, 57,664 acres were held by production at the time of this analysis.

Leasing mineral rights for the development of Federal minerals generates public revenue through the bonus bids paid at lease auctions and annual rents collected on leased parcels not held by production. Nominated parcels approved for leasing are offered by the BLM at a minimum rate of $2.00 per acre at the lease sale. These sales are competitive and parcels with high potential for oil and gas production command bonus bids in excess of the minimum bid. Auctions for mineral rights from 2009 to 2013 in the five counties have yielded an average bonus bid of $295 per acre. In addition to bonus bids, lessees are required to pay rent annually until production begins on the leased parcel, or until the lease expires. These rent payments are equal to $1.50 an acre for the first five years and $2.00 an acre for the second five years of the lease. Total annual lease bonus and rental revenue to the Federal Government from leasing Federal minerals in the five counties with nominated parcels is estimated to be approximately $865,000.

Forty-nine percent of these Federal leasing revenues from public domain minerals are distributed to the State who distributes 25 percent of federal revenue from public domain minerals back to the counties where the leases exist. About 94 percent of the leased Federal minerals within the Miles City Field Office are leased on public domain minerals. With federally acquired minerals (acquired under Bankhead Jones authority), 25 percent of Federal revenues are distributed directly to the appropriate counties. The Federal Government collects an estimated annual average of about $865,000 in bonus bids and rent from BLM leased minerals in the five counties. Under current conditions, it is estimated that about $411,000 in public revenue is redistributed back to the State who then distributes a portion of this revenue back to McCone, Powder River, Prairie, Richland and Roosevelt Counties. Between leasing revenue collected from public domain and acquired minerals, it is estimated that these five counties receive more than $112,000 from federal mineral leasing auction and rent revenue on annual average.

As mentioned above, Federal oil and gas production in Montana is subject to production taxes or royalties. The Federal oil and gas royalties on production from public domain minerals equal 12.5 percent of the value of production (43 CFR 3103.3.1). Forty-nine percent of these royalties from public domain minerals are distributed to the State, of which 25 percent is distributed back to the county of production (Title 17-3-240, MCA). If production comes from acquired Federal minerals under the Bankhead Jones authority, 25 percent of the Federal revenues are distributed directly to the counties of production.

Although the MCFO's October 2014 lease sale could result in additional mineral leasing in McCone, Powder River, Prairie, Richland, and Roosevelt counties, many of the workers and companies likely to provide support services for the exploration and development of newly leased minerals will spread throughout an 8-county area which includes Williams, ND and Custer and Dawson, MT. The economic contribution of oil and gas related activities to this 8-county local economy can be measured by estimating the employment and labor income generated by 1) payments to counties associated with the leasing and rent of Federal minerals, 2) local royalty payments associated with production of Federal oil and gas, and 3) economic activity generated from drilling and associated activities. Activities related to oil and gas leasing, exploration, development, and production form a basic industry that brings money into the State and region and creates jobs in other sectors. As of 2012, the extraction of oil and natural gas (NAICS sector 20), drilling oil and gas wells (NAICS sector 28), and support activities for oil and gas operations (NAICS sector 29) supported an estimated 14,280 jobs1 and $1.57 billion in employee compensation and proprietor income in the 8-county local economy (IMPLAN, 2014).

Currently, the BLM leases 434,866 acres of Federal minerals in McCone, Powder River, Prairie, Richland, and Roosevelt counties. Total Federal revenues from Federal oil and gas leasing, rents, and royalty payments associated with the leasing of these Federal minerals averages an estimated $12 million. Federal revenues disbursed to the State of Montana on annual average is estimated $5.8 million per year and those redistributed back to the five counties are estimated to be $1.6 million on annual average. These revenues help fund traditional county functions such as enforcing laws, administering justice, collecting and disbursing tax funds, providing for orderly elections, maintaining roads and highways, providing fire protection, and/or keeping records. Other county functions that may be funded include administering primary and secondary education and operating clinics/hospitals, county libraries, county airports, local landfills, and county health systems.

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[1] IMPLAN job estimates are not full-time equivalents and include all full-time, part-time, and temporary positions supported oil and gas activities within the planning area. These activities may support, or partially support a number of jobs annually. In this respect, 1 job in IMPLAN lasting 12 months = 2 jobs lasting 6 months each = 3 jobs lasting 4 months

On annual average the leasing, development, and extraction of Federal minerals administered by the BLM supports 46 local jobs (full and part-time) and about $3 million in local labor income within the 8-county local economy. This amounts to about 0.06 percent of the local employment and 0.06 percent of local labor and proprietor's income. Table 13 shows the current contributions of leasing BLM oil and gas minerals and the associated exploration, development, and production of the MCFO of BLM oil and gas minerals to the eight counties that make up the local economy.

Table 13. Current Contributions of BLM Oil and Gas Leasing, Exploration, Development, and Production to the 8-County Local Economy

Industry	Employment (Jobs) Area Totals	Employment (Jobs) BLM O&G-Related	Labor Income (Thousands of 2012 dollars) Area Totals	Labor Income (Thousands of 2012 dollars) BLM O&G-Related
Agriculture	5,737	0	$148,789	$1
Mining	14,442	17	$1,583,665	$1,501
Utilities	416	0	$46,173	$27
Construction	6,051	3	$481,624	$271
Manufacturing	1,295	0	$77,629	$5
Wholesale Trade	4,097	1	$412,553	$57
Transportation & Warehousing	4,925	1	$441,881	$34
Retail Trade	5,407	2	$203,717	$67
Information	554	0	$25,846	$12
Finance & Insurance	1,938	1	$70,248	$23
Real Estate & Rental & Leasing	1,958	0	$173,992	$26
Prof, Scientific, & Tech Services	2,371	1	$151,847	$72
Mngt of Companies	41	0	$3,541	$2
Admin, Waste Mngt & Rem Serv	1,591	1	$78,164	$20
Educational Services	578	0	$10,752	$4
Health Care & Social Assistance	4,513	2	$210,468	$81
Arts, Entertainment, and Rec	1,040	0	$15,411	$3
Accommodation & Food Services	4,278	1	$108,610	$30
Other Services	3,141	1	$98,698	$31
Government	7,576	14	$371,145	$659
Total	71,948	46	$4,714,754	$2,927
BLM as Percent of Total	---	0.06%	---	0.06%

IMPLAN, 2014 database

4.0 ENVIRONMENTAL IMPACTS

4.1 Assumptions and Reasonably Foreseeable Development Scenario Summary

This chapter describes the environmental effects (direct, indirect, and cumulative) that would result from the alternatives. This analysis is tiered to the final environmental impact statement (EIS) for the Dillon RMP/ROD. The analysis contained within that RMP/FEIS remains adequate. The RMP determined which areas are available for oil and gas leasing and under what conditions those leases are to be offered and sold.

The act of leasing parcels would not impact the resources. The only direct effects of leasing are creation of valid existing right and related to revenue generated by the lease sale receipts.

Potential indirect effects associated with a lease sale would result from any future developments. The BLM assumes there is a high interest in development of any leased parcels but,even if lease parcels are leased, it is speculative to assume development would actually occur, and if so, it is speculative to assume where specific wells would be drilled and where facilities would be placed. This would not be determined until the BLM receives an APD in which detailed information about proposed wells and facilities would be provided for particular leases.

Upon receipt of an APD, the BLM would initiate a more site-specific NEPA analysis with public review opportunities to more fully analyze and disclose site-specific effects of specifically identified activities. In all potential exploration and development scenarios, the BLM would require the use of BMPs documented in "Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development" (USDI and USDA 2007), also known as the "Gold Book." The BLM could also identify APD COAs, based on site-specific analysis that could include moving the well location, restrict timing of the project, or require other reasonable measures to minimize adverse impacts (43 CFR 3101.1-2 Surface use rights; Lease Form 3100-11, Section 6) to protect sensitive resources, and to ensure compliance with laws, regulations, and land use plans.

For split-estate leases, the BLM would notify the private landowners that oil and gas exploration or development activities are proposed on their lands and they are encouraged to attend the onsite inspection to discuss the proposed activities. In the event of activity on such split estate leases, the lessee and/or operator would be responsible for adhering to BLM requirements as well as reaching an agreement with the private surface landowners regarding access, surface disturbance, and reclamation.

The RFD for this EA (Appendix C) is based on information contained in the RFD developed in 2005 and revised in 2012 for the MCFO RMP. The RFD prepared for the MCFO RMP contains the number of potential oil and gas wells that could be drilled and produced in the MCFO area and used to analyze the potential number of wells drilled for the 18 nominated lease parcels. The projected number of wells is used to conduct analysis for economic resources. These well numbers are only an estimate based on historical drilling and geologic data. A detailed description of the RFD forecast for this EA is found in Appendix C.

No surface disturbance would occur as a result of issuing leases. For analysis purposes, cultural resources use the potential number of acres disturbed by exploration and development activities is shown in Tables D-1 in Appendix D to determine the number of cultural site potentially impacted within the nominated lease parcels. The potential acres of disturbance reflect acres typically disturbed by construction, drilling, and production activities, including infrastructure installation throughout the MCFO. Typical exploration and development activities and associated acres of disturbance were used as assumptions for analysis purposes in this EA.

The assumptions were not applied to Alternative A because the lease parcels would not be offered for lease; therefore, no wells would be drilled or produced on the lease parcel, and no surface disturbance would occur on those lands from exploration and development activities).

Environmental consequences are discussed below by alternative to the extent possible at this time for the resources described in Chapter 3. As per NEPA regulations at 40 CFR 1502.14(f), 40 CFR 1502.16(h), and 40 CFR 1508.20, mitigation measures to reduce, avoid, or minimize potential impacts are identified by resource below.

4.2 Alternative A (No Action Alternative)

4.2.1 Direct Effects Common to All Resources, not including Economics

Under Alternative A, the 18 parcels, covering 7,945.28 surveyed Federal mineral acres (3,637.97 surveyed BLM administered surface and 4,307.31 surveyed private surface), would not be offered for competitive oil and gas lease sale. Under this alternative, the State and private minerals could still be leased in surrounding areas. Surface management would remain the same and ongoing oil and gas development would continue on surrounding Federal, private, and State leases.

There would not be new impacts from oil and gas exploration or production activities on the Federal lease parcel lands at this time. No additional natural gas or crude oil would enter the public markets, and no royalties would accrue to the Federal or State treasuries from the parcel lands. The No Action Alternative would result in the continuation of the current land and resource uses on the lease parcels.

Except for Economic resources, described below, no further analysis of the No Action Alternative is presented for resources on parcel lands.

4.2.2 Economics

4.2.2.1 Direct and Indirect Effects:

The economic contributions of activities associated with oil and gas development on BLM administered Federal minerals are measured in terms of the employment and labor income generated by 1) payments to counties associated with the leasing and rent of Federal minerals, 2) royalty payments associated with production of Federal oil and gas, and 3) economic activity generated from drilling and associated activities. The first two described contributions would occur upon issuance of the lease; the third contribution would only occur if development occurred. Forward and backward linkages between businesses and people in communities surrounding parcels leased for the development of Federal minerals has enabled the oil and gas industry to attract new revenue to the region, growing the local economy and creating new employment and income opportunities in a wide range of industrial sectors. Table 14 is a summary of local revenues, employment, and labor income impacts of each alternative.

Alternative A is the no action alternative. Under Alternative A, no additional parcels would be leased and no additional public revenue would be generated. The economic contributions of activities associated with oil and gas development would remain consistent with existing conditions described in the Economics section of Chapter 3. Economic effects are summarized and displayed in comparative form in Table 14.

Table 14. Summary Comparison of Estimated Average Annual Economic Impacts

Alternative	Acres Leased	Change in Local Revenue to Counties	Change in Total Employment (full and part-time jobs)	Change in Total Labor Income
A	0	0	0	0
B	7,945	$38,399	2	$61,000
C	1,397	$5,465	0	$12,000

***These impacts would be in addition to impacts from existing Federal leases, rents, royalties and related activities.**

4.2.2.2 Cumulative Effects:

Cumulative Effects:

The lack of measurable direct and indirect effects to economic conditions under the No Action Alternative translates to a lack of measurable cumulative effects. Under this alternative the BLM will not make any additional Federal minerals available for leasing and Federal minerals leased from the MCFO will likely continue at existing levels. Current levels of BLM mineral leasing in McCone, Powder River, Prairie, Richland, and Roosevelt counties support jobs and income in the 8-county local economy and the economic contributions of oil and gas activities associated with these leases will continue to be similar to those discussed in Chapter 3.

Cumulative economic impacts associated with Federal mineral leasing under the alternatives are shown below in Table 15 and Table 16.

Table 15. Summary Comparison of Cumulative Annual Economic Impacts by Alternative

Activity	A	B	C
Existing Acres leased	434,866	434,866	434,866
Acres that would be leased based on this EA	0	7,945	1,397
Total acres leased	434,866	442,811	436,263
Acres held by production	57,664	57,664	57,664
Total acres leased for which lease rents would be paid	377,202	385,147	378,599
Total average annual Federal lease and rental revenue	$660,104	$954,961	$871,313
Average annual distribution to State*	$313,945	$454,179	$414,397
Average annual distribution to Counties**	$85,912	$124,288	$113,401
Average annual oil production (bbl)***	868,935	884,810	871,726
Average annual gas production (MCF)***	2,188,938	2,228,930	2,195,970

Total Average annual Federal O&G royalties	$11,250,381	$11,455,925	$11,286,522
Average annual distribution to State*	$5,350,681	$5,448,438	$5,367,870
Average annual distribution to Counties**	$1,464,237	$1,490,989	$1,468,941
Total average annual Federal Revenues	$11,910,484	$12,410,885	$12,157,835
Total average annual State Revenues	$5,664,626	$5,902,617	$5,782,267
Total average annual revenue distributed to counties	$1,550,149	$1,615,277	$1,582,342

*49 percent of Federal revenue from public domain minerals and 25 percent of Federal revenue from acquired minerals are distributed back to the State.
**Montana distributes 25 percent of public domain revenue and all of acquired mineral revenue received from the Federal Government back to the counties where revenue was generated.
***Estimated as BLM's share of Federal minerals production in McCone, Powder River, Prairie, Richland and Roosevelt counties.

Table 16. Summary Comparison of Employment and Income Supported by BLM Minerals in McCone, Powder River, Prairie, Richland and Roosevelt Counties.

Industry	Total Jobs Supported			Total Income Supported ($1000)		
	Alt. A	Alt. B	Alt. C	Alt. A	Alt. B	Alt. C
Total Contribution of BLM Minerals	45	47	45	$2,894	$2,969	$2,920

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4.3 Alternative B (Proposed Action)

Under Alternative B, 18 lease parcels of Federal minerals for oil and gas leasing, covering 7,945.28 surveyed Federal mineral acres (3,637.97 surveyed BLM administered surface and 4,307.31 surveyed private surface) would be offered for competitive oil and gas lease sale. No parcels would be deferred.

4.3.1 Direct Effects Common to All Resources

The action of leasing the parcels in Alternative B would, in and of itself, have no direct impact on resources. Direct effects of leasing are the creation of a valid existing right and those related to the revenue generated by the lease sale receipts.

4.3.2 Indirect Effects Common to All Resources

Any potential effects on resources from the sale of leases would occur during lease exploration and development activities, which would be subject to future BLM decision-making and NEPA analysis upon receipt of an APD or sundry notice.

Oil and gas exploration and development activities such as construction, drilling, production, infrastructure installation, vehicle traffic and reclamation could be indirect effects from leasing the lease parcels in Alternative B. As mentioned above, it is speculative to make assumptions about whether a particular lease parcel would be sold and, even if so, it is speculative to assume when, where, how, or if future surface disturbing activities associated with oil and gas exploration and development such as well sites, roads, facilities, and associated infrastructure would be proposed. It is also not known how many wells, if any, would be drilled and/or completed, the types of technologies and equipment would be used and the types of infrastructure needed for production of oil and gas. Thus, the types, magnitude and duration of potential impacts cannot be precisely quantified at this time, and would vary according to many factors.

Typical impacts to resources from oil and gas exploration and development activities such as well sites, roads, facilities, and associated infrastructure are described in the Miles City Oil & Gas Amendment/EIS (1994), the Big Dry RMP (1996), the Powder River RMP (1985), the Montana Statewide Oil & Gas Amendment/EIS (2003) and the Supplement (2008) to that document.

4.3.3 Air Resources
4.3.3.1 Direct and Indirect Effects
4.3.3.1.1 Air Quality
Leasing the parcels would have no direct impacts on air quality. Any potential effects from sale of lease parcels could occur at the time the leases are developed.

Potential impacts of development could include increased airborne soil particles blown from new well pads or roads; exhaust emissions from drilling equipment, compressors, vehicles, and dehydration and separation facilities, as well as potential releases of GHGs and VOCs during drilling or production activities. The amount of increased emissions cannot be precisely quantified at this time since it is not known for certain how many wells might be drilled, the types of equipment needed if a well were to be completed successfully (e.g., compressor, separator, dehydrator), or what technologies may be employed by a given company for drilling any new wells. The degree of impact would also vary according to the characteristics of the geologic formations from which production occurs, as well as the scope of specific activities proposed in an APD.

Current monitoring data show that criteria pollutants concentrations are below applicable air quality standards, indicating good air quality. The potential level of development and mitigation described below is expected to maintain this level of air quality by limiting emissions. In addition, pollutants would be regulated through the use of State-issued air quality permits or air quality registration processes developed to maintain air quality below applicable standards.

4.3.3.1.2 Greenhouse Gas Emissions at the MCFO and Project Scales
Sources of GHGs associated with development of lease parcels could include construction activities, operations, and facility maintenance in the course of oil and gas exploration, development, and production. Estimated GHG emissions are discussed for these specific aspects of oil and gas activity because the BLM has direct involvement in these steps. However, the current proposed activity is to offer parcels for lease. No specific development activities are currently proposed or potentially being decided upon for any parcels being considered in this EA. Potential development activities would be analyzed if the BLM receives an APD on any of the parcels considered here.

Anticipated GHG emissions presented in this section are taken from the Climate Change SIR, 2010. Data are derived from emission calculators developed by air quality specialists at the BLM National Operations Center in Denver, Colorado, based on methods described in the

Climate Change SIR (2010). Based on the assumptions summarized in the SIR for the MCFO RFD, Table 16 discloses projected annual GHG source emissions from BLM-permitted activities associated with the RFD.

Table 17. The BLM Projected Annual GHG Emissions Associated With Oil and Gas Exploration and Development Activity in the MCFO.

Source	BLM Long-Term GHG Emissions in tons/year				Emissions (metric tons/yr)
	CO_2	CH_4	N_2O	CO_2e	CO_2e
Conventional Natural Gas	158,154.7	1,572.8	1.2	190,984.1	173,817.6
Coal Bed Natural Gas	268,477.4	5,194.6	0.9	377,826.5	342.855.24
Oil	91,689.0	562.6	0.5	103,663.3	94,068.3
Total	**518,321.1**	**7,330**	**2.6**	**672,473.9**	**610,741.1**

To estimate GHG emissions associated with the action alternatives, the following approach was used:

1. The proportion of each alternative relative to the total RFD was calculated based on total acreage of parcels under consideration for leasing relative to the total acreage of Federal mineral acreage available for leasing in the RFD.
2. This ratio was then used as a multiplier with the total estimated GHG emissions for the entire RFD (with the highest year emission output used) to estimate GHG emissions for that particular alternative.

Under Alternative B, approximately 7,945 acres of lease parcels with Federal minerals would be leased. These acres constitute approximately 0.14 percent of the total Federal mineral estate of approximately 5,798,000 acres identified in the MCFO RFD. Therefore, based on the approach described above to estimate GHG emissions, 0.14 percent of the RFD for this EA total estimated BLM emissions of approximately 610,741 metric tons/year would be approximately 837 metric tons/year of CO_2e if the parcels within Alternative B were to be developed.

4.3.3.1.3 Climate Change

The assessment of GHG emissions and climate change is in its formative phase. As summarized in the Climate Change SIR, climate change impacts can be predicted with much more certainty over global or continental scales. Existing models have difficulty reliably simulating and attributing observed temperature changes at small scales. On smaller scales, natural climate variability is relatively larger, making it harder to distinguish changes expected due to external forcings (such as contributions from local activities to GHGs). Uncertainties in local forcings and feedbacks also make it difficult to estimate the contribution of GHG increases to observed small-scale temperature changes (Climate Change SIR 2010).

It is currently not possible to know with certainty the net impacts from lease parcel development on climate. The inconsistency in results of scientific models used to predict climate change at the global scale, coupled with the lack of scientific models designed to predict climate change on regional or local scales, limits the ability to quantify potential future impacts of decisions made at this level. It is therefore beyond the scope of existing science to relate a specific source of

GHG emission or sequestration with the creation or mitigation of any specific climate-related environmental effects. Although the effects of GHG emissions in the global aggregate are well-documented, it is currently impossible to determine what specific effect GHG emissions resulting from a particular activity might have on the environment. For additional information on environmental effects typically attributed to climate change, please refer to the cumulative effects discussion below.

While it is not possible to predict effects on climate change of potential GHG emissions discussed above in the event of lease parcel development for alternatives considered in this EA, the act of leasing does not produce any GHG emissions in and of itself. Releases of GHGs could occur at the exploration/development stage.

4.3.3.2 Mitigation

The BLM encourages industry to incorporate and implement BMPs to reduce impacts to air quality by reducing emissions, surface disturbances, and dust from field production and operations. Measures would also be required as COAs on permits by either the BLM or the applicable State air quality regulatory agency. The BLM also manages venting and flaring of gas from Federal wells as described in the provisions of Notice to Lessees (NTL) 4A, Royalty or Compensation for Oil and Gas Lost.

Some of the following measures could be imposed at the development stage:

- flaring or incinerating hydrocarbon gases at high temperatures to reduce emissions of incomplete combustion;
- emission control equipment of a minimum 95 percent efficiency on all condensate storage batteries;
- emission control equipment of a minimum 95 percent efficiency on dehydration units, pneumatic pumps, produced water tanks;
- vapor recovery systems where petroleum liquids are stored;
- tier II or greater, natural gas or electric drill rig engines;
- secondary controls on drill rig engines;
- no-bleed pneumatic controllers (most effective and cost effective technologies available for reducing VOCs);
- gas or electric turbines rather than internal combustions engines for compressors;
- NO_x emission controls for all new and replaced internal combustion oil and gas field engines;
- water dirt and gravel roads during periods of high use and control speed limits to reduce fugitive dust emissions;
- interim reclamation to re-vegetate areas of the pad not required for production facilities and to reduce the amount of dust from the pads.
- co-located wells and production facilities to reduce new surface disturbance;
- directional drilling and horizontal completion technologies whereby one well provides access to petroleum resources that would normally require the drilling of several vertical wellbores;
- gas-fired or electrified pump jack engines;
- velocity tubing strings;

- cleaner technologies on completion activities (i.e. green completions), and other ancillary sources;
- centralized tank batteries and multi-phase gathering systems to reduce truck traffic;
- forward looking infrared (FLIR) technology to detect fugitive emissions; and
- air monitoring for NO_x and ozone.

More specific to reducing GHG emissions, Section 6 of the Climate Change SIR identifies and describes in detail commonly used technologies to reduce methane emissions from natural gas, coal bed natural gas, and oil production operations. Technologies discussed in the Climate Change SIR and as summarized below in Table 17 (reproduced from Table 6-2 in Climate Change SIR) display common methane emission technologies reported under the EPA Natural Gas STAR Program and associated emission reduction, cost, maintenance and payback data.

Table 18. Selected Methane Emission Reductions Reported Under the USEPA Natural Gas STAR Program [1]

Source Type / Technology	Annual Methane Emission Reduction [1] (Mcf/yr)	Capital Cost Including Installation ($)	Annual Operating and Maintenance Cost ($)	Payback (Years or Months)	Payback Gas Price Basis ($/Mcf)
Wells					
Reduced emission (green) completion	7,000 [2]	$1K – $10K	>$1,000	1 – 3 yr	$3
Plunger lift systems	630	$2.6K – $10K	NR	2 – 14 mo	$7
Gas well smart automation system	1,000	$1.2K	$0.1K – $1K	1 – 3 yr	$3
Gas well foaming	2,520	>$10K	$0.1K – $1K	3 – 10 yr	NR
Tanks					
Vapor recovery units on crude oil tanks	4,900 – 96,000	$35K – $104K	$7K – $17K	3 – 19 mo	$7
Consolidate crude oil production and water storage tanks	4,200	>$10K	<$0.1K	1 – 3 yr	NR
Glycol Dehydrators					
Flash tank separators	237 – 10,643	$5K – $9.8K	Negligible	4 – 51 mo	$7
Reducing glycol circulation rate	394 – 39,420	Negligible	Negligible	Immediate	$7
Zero-emission dehydrators	31,400	>$10K	>$1K	0 – 1 yr	NR
Pneumatic Devices and Controls					
Replace high-bleed devices with low-bleed devices					
End-of-life replacement	50 – 200	$0.2K – $0.3K	Negligible	3 – 8 mo	$7
Early replacement	260	$1.9K	Negligible	13 mo	$7
Retrofit	230	$0.7K	Negligible	6 mo	$7
Maintenance	45 – 260	Negl. to $0.5K	Negligible	0 – 4 mo	$7
Convert to instrument air	20,000 (per facility)	$60K	Negligible	6 mo	$7
Convert to mechanical control systems	500	<$1K	<$0.1K	0 – 1 yr	NR

Table 18. Selected Methane Emission Reductions Reported Under the USEPA Natural Gas STAR Program [1]

Source Type / Technology	Annual Methane Emission Reduction [1] (Mcf/yr)	Capital Cost Including Installation ($)	Annual Operating and Maintenance Cost ($)	Payback (Years or Months)	Payback Gas Price Basis ($/Mcf)
Valves					
Test and repair pressure safety valves	170	NR	$0.1K – $1K	3 – 10 yr	NR
Inspect and repair compressor station blowdown valves	2,000	<$1K	$0.1K – $1K	0 – 1 yr	NR
Compressors					
Install electric compressors	40 – 16,000	>$10K	>$1K	>10 yr	NR
Replace centrifugal compressor wet seals with dry seals	45,120	$324K	Negligible	10 mo	$7
Flare Installation	2,000	>$10K	>$1K	None	NR

Source: Multiple EPA Natural Gas STAR Program documents. Individual documents are referenced in Climate Change SIR (2010).
[1] Unless otherwise noted, emission reductions are given on a per-device basis (e.g., per well, per dehydrator, per valve, etc).
[2] Emission reduction is per completion, rather than per year.
K = 1,000
mo = months
Mcf = thousand cubic feet of methane
NR = not reported
yr = year

In the context of the oil sector, additional mitigation measures to reduce GHG emissions include methane reinjection and CO_2 injection. These measures are discussed in more detail in Section 6.0 of the Climate Change SIR (2010).

In an effort to disclose potential future GHG emission reductions that might be feasible, the BLM estimated GHG emission reductions based on the RFD for the MCFO. For emission sources subject to BLM (Federal) jurisdiction, the estimated emission reductions represent approximately 51 percent reduction in total GHG emissions compared to the estimated MCFO Federal GHG emission inventory (Climate Change SIR, as updated October 2010, Section 6.5 and Table 6-3). The emission reductions technologies and practices are identified as mitigation measures that could be imposed during development. Furthermore, the EPA is expected to promulgate new Federal air quality regulations that would require GHG emission reductions from many oil and gas sources.

4.3.4 Soil Resources

4.3.4.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on soil resources. Any potential effects from the sale of leases would occur at the time the leases are developed.

Land uses associated with oil and gas exploration and development could cause surface disturbances. Such acts result in reduced ground cover, soil mixing, compaction, or removal, exposing soils to accelerated erosion by wind and water, resulting in the irretrievable loss of topsoil and nutrients and potentially resulting in mass movement or sedimentation. Surface disturbances also change soil structure, heterogeneity (variable characteristics), temperature regimes, nutrient cycling, biotic richness, and diversity. Along with this, mixed soils have decreased bulk density, and altered porosity, infiltration, air-water relationships, salt content, and pH (Perrow and Davy, 2003; Bainbridge 2007). Soil compaction results in increased bulk density, and reduced porosity, infiltration, moisture, air, nutrient cycling, productivity, and biotic activity (Logan 2001; 2003; 2007). Altering such characteristics reduces the soil system's ability to withstand future disturbances (e.g., wildfire, drought, high precipitation events, etc.).

The probability and magnitude of these effects are dependent upon local site characteristics, climatic events, and the specific mitigation applied to the project. Within 2-5 years following restoration, vegetative cover and rates of erosion would return to pre-disturbance conditions (FSEIS 2008). Exceptions would be sites that have a low potential for restoration (apx. less than 1 percent), which would require unconventional and/or site-specific restoration measures.

4.3.4.2 Mitigation

Measures would be taken to reduce, avoid, or minimize potential impacts to soil resources from exploration and development activities. Prior to authorization, proposed actions would be evaluated on a case-by-case basis and would be subject to mitigation measures in order to maintain the soil system. Mitigation would include avoiding areas poorly suited to reclamation, limiting the total area of disturbance, rapid reclamation, erosion/sediment control, soil salvage, decompaction, revegetation, weed control, slope stabilization, surface roughening, and fencing.

4.3.5 Water Resources

4.3.5.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on water resources. Any potential effects from sale of lease parcels would occur at the time the leases are developed.

Surface Water:

The magnitude of the impacts to water resources would be dependent on the specific activity, season, proximity to waterbodies, location in the watershed, upland and riparian vegetation condition, effectiveness of mitigation, and the time until reclamation success. Surface disturbance effects typically are localized, short-term, and occur from the time of implementation through vegetation reestablishment. As acres of surface-disturbance increase within a watershed, so would the potential effects on water resources.

Oil and gas exploration and development of a lease parcel would cause the removal of vegetation, soil compaction, and soil disturbance in uplands within the watershed, 100-year floodplains of non-major streams, and non-riparian, ephemeral waterbodies. The potential effects from these activities would be accelerated erosion, increased overland flow, decreased infiltration, increased water temperature, channelization, and water quality degradation associated with increased sedimentation, turbidity, nutrients, metals, and other pollutants. Erosion potential could be further increased in the long term by soil compaction and low permeability surfacing (e.g., roads and well pads) which increases the energy and amount of overland flow and decreases infiltration, which in turn changes flow characteristics, reduces groundwater recharge, and increases sedimentation and erosion (MDEQ 2012).

Groundwater:
Spills or produced fluids could have long-term impacts to surface and ground water resources. Oil and gas exploration/development could potentially contaminate aquifers with salts, drilling fluids, fluids and gases from other formations, detergents, solvents, hydrocarbons, metals, and nutrients; change vertical and horizontal aquifer permeability; and increase hydrologic communication with adjacent aquifers (EPA 2004). Groundwater removal could result in a depletion of flow in nearby streams and springs if the aquifer is hydraulically connected to such features. Typically, produced water from conventional oil and gas wells is from a depth below useable aquifers or coal seams (FSEIS 2008).

Well bores would most likely pass through useable groundwater. Potential impacts to groundwater resources could occur if proper cementing and casing programs are not followed. This could include loss of well integrity, surface spills, or loss of fluids in the drilling and completion process. It is possible for chemical additives used in drilling activities to be introduced into the water-producing formations without proper casing and cementing of the well bore. Changes in porosity or other properties of the rock being drilled through can result in the loss of drilling fluids. When this occurs, drilling fluids can be introduced into groundwater without proper cementing and casing. Site specific conditions and drilling practices determine the probability of this occurrence and determine the groundwater resources that could be impacted. In addition to changing the producing formations' physical properties by increasing the flow of water, gas, and/or oil around the well bore, hydraulic fracturing can also introduce chemical additives into the producing formations. Types of chemical additives used in drilling activities may include acids, hydrocarbons, thickening agents, lubricants, and other additives that are operator- and location-specific. These additives are not always used in these drilling activities and some are likely to be benign such as bentonite clay and sand. Concentrations of these additives also vary considerably since different mixtures can be used for different purposes in oil and gas development and even in the same well bore. If contamination of aquifers from any source occurs, changes in groundwater quality could impact springs and residential wells that are sourced from the affected aquifers. Onshore Order #2 requires that the proposed casing and cementing programs shall be conducted as approved to protect and/or isolate all usable water zones.

Known water bearing zones in the lease area are protected by drilling requirements and, with proper practices, contamination of ground water resources is highly unlikely. Casing along with cement is extended well beyond fresh-water zones to insure that drilling fluids remain within the well bore and do not enter groundwater.

Potential impacts to ground water at site specific locations are analyzed through the NEPA review process at the development stage when the APD is submitted. This process includes geologic and engineering reviews to ensure that cementing and casing programs are adequate to protect all downhole resources.

All water used would have to comply with Montana State water rights regulations and a source of water would need to be secured by industry that would not harm senior water rights holders.

4.3.5.2 Mitigation

Stipulations addressing steep slopes, waterbodies, streams, 100-year floodplains of major rivers, and riparian areas would minimize potential impacts and would be included with the lease when necessary (Appendix A). In the event of exploration or development, measures would be taken to reduce, avoid, or minimize potential impacts to water resources including application of appropriate mitigation. Mitigation measures that minimize the total area of disturbance, control wind and water erosion, reduce soil compaction, maintain vegetative cover, control nonnative species, and expedite rapid reclamation (including interim reclamation) would maintain water resources.

Methods to reduce erosion and sedimentation could include reducing the area of surface disturbance; installing and maintaining adequate erosion control; proper road design, road surfacing, and culvert design; road/infrastructure maintenance; use of low water crossings; and use of isolated or bore crossing methods for waterbodies and floodplains. In addition, applying mitigation to maintain adequate, undisturbed, vegetated buffer zones around waterbodies and floodplains could reduce sedimentation and maintain water quality. Appropriate well completion, the implementation of Spill Prevention Plans, and Underground Injection Control regulations would mitigate groundwater impacts. Site-specific mitigation and reclamation measures would be described in the COAs.

4.3.6 Vegetation Resources

4.3.6.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on vegetation resources. Any potential effects from sale of lease parcels could occur at the time the leases are developed.

Impacts to vegetation depend on the vegetation type/community, soil community and the topography of the lease parcels. Disturbance to vegetation is of concern because protection of soil resources, maintenance of water quality, conservation of wildlife habitat, and livestock production capabilities could be diminished or lost over the long-term through direct loss of vegetation (including direct loss of both plant communities and specific plant species).

Other direct impacts, such as invasive species invasion, could result in loss of desirable vegetation. Invasive species and noxious weeds could also reduce livestock grazing forage, wildlife habitat quality, and native species diversity. In addition, invasive species are well known for changing fire regimes.

Additionally, surface disturbing activities directly affect vegetation by destroying habitat, churning soils, impacting biological crusts, disrupting seedbanks, burying individual plants, and generating sites for competitive species. Other vegetation impacts could also be caused from soil erosion and result in loss of the supporting substrate for plants, or from soil compaction resulting in reduced germination rates. Impacts to plants occurring after seed germination but prior to seed set could be particularly harmful as both current and future generations would be affected.

Fugitive dust generated by construction activities and travel along dirt roads could affect nearby plants by depressing photosynthesis, disrupting pollination, and reducing reproductive success. Oil, fuel, wastewater or other chemical spills could contaminate soils as to render them temporarily unsuitable for plant growth until cleanup measures were fully implemented. If cleanup measures were less successful, longer term vegetation damage could be expected.

Oil and gas development activity could reduce BLM's ability to manage livestock grazing while meeting or progressing towards meeting the Standards of Rangeland Health. Development and associated disturbances could reduce available forage or alter livestock distribution leading to overgrazing or other localized excess grazing impacts. Construction of roads, especially in areas of rough topography could cause significant changes in livestock movement and fragment suitable habitat for some plant communities.

4.3.6.2 Mitigation

Mitigation would be addressed at the site specific APD stage of exploration and development. If needed, COAs would potentially include, but not limited to, revegetation with desirable plant species, soil enhancement practices, direct live haul of soil material for seed bank revegetation, reduction of livestock grazing, fencing of reclaimed areas, and the use of seeding strategies consisting of native grasses, forbs, and shrubs. In areas infested with noxious weeds, weed management plans with special conditions would be required.

4.3.7 Riparian-Wetland Habitats

4.3.7.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on riparian-wetland habitats. Any potential effects from sale of lease parcels could occur at the time the leases are developed.

The exploration and development of oil and gas within uplands or adjacent to riparian-wetland areas could reduce riparian-wetland functionality by changing native plant productivity, composition, richness, and diversity; accelerating erosion; increasing sedimentation; and changing hydrologic characteristics. Impacts that reduce the functioning condition of riparian and wetland areas could impair the ability of riparian/wetland areas to reduce nonpoint source pollution (MDEQ 2012) and provide other ecosystem benefits. The magnitude of these effects would be dependent on the specific activity, season, proximity to riparian-wetland areas, location in the watershed, upland and riparian-wetland vegetation condition, mitigation applied, and the time until reclamation success. Increases in erosion are typically localized, short term, and occur from the beginning of implementation through vegetation reestablishment. As acres of surface disturbance increase within a watershed, so could the effects on riparian-wetland resources.

4.3.7.2 Mitigation

Stipulations addressing steep slopes, waterbodies, streams, 100-year floodplains of major rivers, and riparian areas would minimize potential impacts and would be included with the lease when necessary (Appendix A). In the event of exploration or development, site-specific mitigation measures would be identified which would avoid or minimize potential impacts to riparian-wetland areas at the APD stage. Mitigation measures that minimize the total area of disturbance, control wind and water erosion, reduce soil compaction, maintain vegetative cover, control nonnative species, maintain biodiversity, maintain vegetated buffer zones, and expedite rapid reclamation (including interim reclamation) would maintain riparian-wetland resources.

4.3.8 Special Status Plant Species

4.3.8.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on special status plant species. Any potential effects from the sale of leases could occur at the time the leases are developed.

4.3.8.2 Mitigation

Stipulations applied to wildlife resources, steep slopes, waterbodies, streams, 100-year floodplains of major rivers, riparian areas, and wetlands would likely also provide protections for special status plant species. Proposed development would be analyzed on a site-specific basis prior to approval of oil and gas exploration or development activities at the APD stage**.** Mitigation would also be addressed at the site-specific APD stage. Surveys to determine the existence of federally listed species could occur on BLM-administered surface or minerals prior to approval of exploration and development activities at the APD stage.

4.3.9 Wildlife

4.3.9.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on wildlife. Any potential effects from the sale of lease parcels would occur at the time the leases are developed.

The use of standard lease terms and stipulations on these lands (Appendix A) would minimize, but not preclude impacts to wildlife. Oil and gas development which results in surface disturbance could directly and indirectly impact aquatic and terrestrial wildlife species. These impacts would include loss or reduction in suitability of habitat, improved habitat for undesirable (non-native) competitors, species or community shift to species or communities more tolerant of disturbances, nest abandonment, mortalities resulting from collisions with vehicles and power lines, electrocutions from power lines, barriers to species migration, habitat fragmentation, increased predation, habitat avoidance, and displacement of wildlife species resulting from human presence. The scale, location, and pace of development, combined with implementation of mitigation measures and the tolerance of the specific species to human disturbance all influence the severity of impacts to wildlife species and habitats, including threatened, endangered, candidate, proposed, and other special status species.

4.3.9.1.1 Threatened, Endangered, and Candidate Species

Habitat within the lease parcels exists to support USFWS threatened, endangered, or candidate, species including the whooping crane, pallid sturgeon, sage grouse, and Sprague's pipit.

The BLM has determined that the act of issuing leases within the whooping crane migration corridor will not affect the whooping crane. However, impacts to whooping cranes are possible from subsequent oil and gas development activities permitted at the APD stage. At this time, stipulations do not currently exist to protect any known whooping crane migration staging areas. Line strikes, collisions with vehicles, habitat fragmentation, and other anthropogenic activities could disturb, displace, or cause direct mortality of whooping cranes.

Therefore, if development on any of the leases within the whooping crane migration corridor is proposed within suitable whooping crane staging, stopover or roosting habitat, BLM would consult with the USFWS pursuant to section 7(a)(2) of ESA. An outcome of the consultation process could be that conditions of approval are attached to the permit or the permit could not be approved. Other BMP's could also be developed through consultation, including minimizing disturbance, adherence to Avian Powerline Interaction Committee (APLIC) guidelines, and others as deemed appropriate.

Pallid sturgeon individuals and their habitat would occur in or near lease parcel MTM 105431-H6, H8, HA, and HB (based on year-round range and observation maps (MTNHP)) and have the potential to be affected by the development of oil and gas wells. Potential impacts from development could include: overland oil spills, underground spills from activities associated with horizontal drilling or other practices, spills from drilling mud or other extraction and processing chemicals, and surface disturbance activities that create a localized erosion zone. Oil spills and other pollutants from the oil extraction process could harm the endangered pallid sturgeon in two different ways. First, toxicological impacts from direct contact could have immediate lethal effects to eggs, juveniles, and adults. Second, toxic effects to lower food web levels (e.g. aquatic macro-invertebrates) could indirectly affect the pallid sturgeon species by degrading water quality and degrading or eliminating food resources. Additionally, surface disturbing activities that decrease the availability or input of organic material, large woody debris, and trees could decrease cover, food-web compartments and fluxes, and holding areas for pallid sturgeon. Other aquatic species could experience the same type of direct and indirect impacts.

Currently, in the Big Dry RMP there are no stipulations specific to Pallid sturgeon habitat. However, a floodplain stipulation (NSO 11-2) would not allow surface occupancy in the 100-year floodplain boundary of the Missouri and Yellowstone Rivers
The BLM has determined that issuing a lease for the four parcels along the Missouri River will have no effect on the pallid sturgeon. If development were to occur, additional mitigation would be included as conditions of approval at the APD stage. These conditions include the placement of earthen berms and oil skimmers (a culvert device placed in drainages which is intended to block oil from entering streams) to help protect pallid sturgeon habitat in case of oil spills by greatly reducing the potential for spills to reach pallid sturgeon habitat. If oil and gas development is proposed for these four parcels, BLM would consult with the USFWS pursuant to section 7(a)(2) of ESA.

Sage grouse are offered species specific protections through a stipulation. Under Alternative B, ¼ mile NSO buffers and 2 mile timing buffers would apply where relevant. Based on research, these stipulations for sage grouse are considered ineffective to ensure that sage grouse can persist within fully developed areas. With regard to existing restrictive stipulations applied by the BLM, (Walker et al. 2007a) research has demonstrated that the 0.4-km (0.25 miles) NSO lease stipulation is insufficient to conserve breeding sage-grouse populations in fully developed gas fields because this buffer distance leaves 98 percent of the landscape within 3.2 km (2 miles) open to full-scale development. Full-field development of 98 percent of the landscape within 3.2 km (2 miles) of leks in a typical landscape in the Powder River Basin reduced the average probability of lek persistence from 87 percent to 5 percent (Walker et al. 2007a).

Other studies also have assessed the efficacy of existing BLM stipulations for sage grouse. Impacts to leks from energy development are most severe near the lek, and remained discernable out to distances more than 6 km (3.6 miles) (Holloran 2005, Walker et al. 2007a), and have resulted in the extirpation of leks within gas fields (Holloran 2005, Walker et al. 2007a). Holloran (2005) shows that lek counts decreased with distance to the nearest active drilling rig, producing well, or main haul road, and that development influence counts of displaying males to a distance of between 4.7 and 6.2 km (2.9 and 3.9 miles). All well-supported models in Walker et al. (2007a) indicate a strong effect of energy development, estimated as proportion of development within either 0.8 km (0.5 miles) or 3.2 km (2 miles), on lek persistence. Buffer sizes of 0.25 mi., 0.5 mi., 0.6 mi. and 1.0 mi. result in an estimated lek persistence of 5 percent, 11 percent, 14 percent, and 30 percent. Lek persistence in the absence of CBNG development averages approximately 85 percent. Models with development at 6.4 km (4 miles) had considerably less support, but the regression coefficient indicated that impacts were still apparent out to 6.4 km (4 miles) (Walker et al. 2007a). Tack (2009) found impacts of energy development on lek abundances (numbers of males per lek) out to 7.6 miles.

The 2 mile timing stipulation attached to the respective parcels in this proposal only applies between March 1 to June 15, and development can occur within the 2 miles outside of those dates. Not all lease parcels would be expected to see full field development as noted in the range of RFD, although effects would most likely mirror these studies to some degree proportionate to the amount of development that occurs outside of the stipulated timeframe.

Noise has been shown to affect sage-grouse and associated sagebrush obligates. Sage-grouse are known to select highly visible leks with good acoustic properties. Effects to sage-grouse would be a decrease in numbers of males on leks and activity levels and lower nest initiation near oil and gas development. Sage-grouse numbers on leks within 1.6 km (1 mile) of coal bed natural gas compressor stations in Campbell County, Wyoming were shown to be consistently lower than on leks not affected by this disturbance (Braun et al. 2002). Holloran (2005), Holloran et al (2005a, 2005b), and Anderson (2005) reported that lek activity by sage-grouse decreased downwind of drilling activities, suggesting that noise had measurable negative impacts on sage-grouse. The actual level of noise (measured in decibels) that would not affect greater sage-grouse breeding and nesting activities is presently unknown. Timing restriction (TL 13-3) is applied within 2 miles of leks within the MCFO, which provides some mitigation for noise level effects to sage-grouse during this timeframe.

Recent inventories for sage grouse leks have not been conducted within some of the parcels. Therefore, inventories would be conducted at the APD stage of development to determine the presence or absence of sage grouse leks. This alternative also includes the attachment of a sage grouse lease notice (LN 14-11) when the lease parcel is located within 2 miles of a lek. The lease notice would require an operator to implement specific measures to reduce impacts of oil and gas operations on sage grouse populations and habitat quality. The application of this lease notice would be expected to reduce, but not eliminate, impacts to sage grouse and habitats.

Energy development (oil, gas, and wind) and associated roads and facilities increase the fragmentation of grassland habitat. A number of studies have found that Sprague's pipits appear to avoid non-grassland features in the landscape, including roads, trails, oil wells, croplands, woody vegetation, and wetlands (Dale et al. 2009, pp. 194, 200; Koper et al. 2009, pp. 1287, 1293, 1294, 1296; Greer 2009, p. 65; Linnen 2008, pp. 1, 9-11, 15; Sutter et al. 2000, pp. 112-114). Sprague's pipits avoid oil wells, staying up to 350 meters (m) (1148 feet (ft.)) away

(Linnen 2008, pp. 1, 9-11), magnifying the effect of the well feature itself. Oil and gas wells, especially at high densities, decrease the amount of habitat available for breeding territories. (Federal Register: September 15, 2010 (Volume 75, Number 178))

Potential suitable habitat exists for the Sprague's pipit across some of the proposed lease parcels; however, inventories have not been conducted within the parcels. Therefore, inventories would be conducted at the APD stage of development to determine the presence or absence of Sprague's pipits. The Sprague's pipit lease notice, LN 14-15, is issued with those leases and would be applied if Sprague's pipits are found in the area. If Sprague's pipits are found, protective measures would be applied as conditions of approval to minimize impacts to Sprague's pipits and their habitat. In the event oil and gas development is proposed within Sprague's pipit habitat, at the APD stage BLM would conference with the USFWS pursuant to section 7(a)(4) of ESA, or if the Sprague's pipit has been listed as threatened or endangered, BLM would consult with the USFWS pursuant to section 7(a)(2).

4.3.9.1.2 Other Special Status Species

As noted, up to 51 wildlife species that BLM has designated as "sensitive" have the potential to occur within the parcel areas. Stipulations are not provided for all BLM sensitive species in the current RMPs. Stipulations are provided for 7 out of the 46 "non-TE&P" sensitive species. For those species afforded some protections through existing stipulations, impacts could be minimized, but not eliminated. Impacts to BLM sensitive species would be similar to those described above, unless they are afforded protective measures from other regulations such as the Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703.) or the Bald and Golden Eagle Protection Act (BGEPA) (16 U.S.C. 668-668c). The BLM does not consult with the USFWS on "sensitive" species and likewise would not receive terms and conditions from USFWS requiring additional protections of those species.

Numerous species of birds were identified as potential inhabitants across the analysis area. With the impacts associated with development, it is reasonable to assume there would be impacts to nesting and migrating bird species. The primary impacts to these species would include disturbance of preferred nesting habitats, improved habitat for undesirable competitors and/or a species shift to disturbance associated species, and increased vehicle collisions.

Research in Sublette County, Wyoming on the effects of natural gas development on sagebrush steppe passerines documented negative impacts to sagebrush obligates such as Brewer's sparrows, sage sparrows, and sage thrashers (Ingelfinger 2001). The impacts were reported greatest along roads where traffic volumes are high and within 100 meters of these roads. Sagebrush obligates were reduced within these areas by as much as 60%. Sagebrush obligate density was reduced by 50% within 100 meters of a road even when traffic volumes were less than 12 vehicles /day. It would be expected that similar population declines would occur to other native prairie species within the analysis area.

Stipulations do not exist specifically for the protection of BLM sensitive songbirds. The MBTA prohibits the take, capture or kill of any migratory bird, any part, nest or eggs of any such bird (16 U.S.C 703 (a)). NEPA analysis pursuant to Executive Order 13186 (January 2001) requires BLM to ensure that MBTA compliance and the effects of Bureau actions and agency plans on migratory birds are evaluated, should reduce take of migratory birds and contribute to their conservation.

Effects to migratory birds from oil and gas development at the APD stage could include direct loss of habitat from roads, well pads and other infrastructure, disturbance, powerline strikes and unintended direct mortality, fragmentation of habitat, change in use of habitats, and potential threats and competition from edge species. Field surveys for nesting birds at proposed development sites would be conducted for activities planned in between April 15 and July 15. Mitigation measures would be assigned at the APD stage to minimize negative effects on migratory bird populations, in compliance with Executive Order 13186 and MBTA. These mitigation measures would be required as COAs. An NSO stipulation for oil and gas surface disturbing activities in riparian and wetland areas would prohibit any potential oil and gas development in those habitats unless approval was granted through the Waivers, Exceptions, and Modifications (WEM) process. The BLM would coordinate WEMs with USFWS to assure MBTA compliance.

Take of bald and golden eagles and any other migratory raptors would not occur as a result of the act of leasing parcels. However, as development occurs after permits to drill are issued, there would be potential for take to occur as a result of raptor collisions with vehicles, power lines, and other development-related actions. Therefore, field surveys for raptors at proposed development sites would be conducted for activities planned between March 1 and August 1. To comply with MBTA and BGEPA, BLM would require protective measures and stipulations at the APD stage to prevent or minimize impacts to individual raptors and raptor populations, including bald and golden eagles. The protective measures would be required as COAs.

4.3.9.1.3 Other Fish and Wildlife

The types and extent of impacts to other wildlife species and habitats from development are similar to those described above for other species. Based on the RFD scenarios, direct habitat loss is possible. Initial disturbance could change the occupation of those areas to disturbance-oriented species (e.g., horned larks), or species with more tolerance for disturbances. These changes could also be expected to decrease the diversity of wildlife. Although bladed corridors would be reclaimed after the facilities are constructed, some changes in vegetation could occur along the reclaimed areas. The goal of reclamation is to restore disturbed areas to pre-disturbed conditions. The outcome of reclamation, unlike site restoration, will therefore not always mimic pre-disturbance conditions and offer the same habitat values to wildlife species. Sagebrush obligates, including some species of songbirds and sage grouse, could be most affected by this change.

It is anticipated that some development could occur adjacent to existing disturbances of some type. Depending on proximity and species tolerance, wildlife species within these areas could either have acclimated to the surrounding conditions, previously been displaced by construction activities, or could be caused to be displaced to other areas with or without preferred habitat.

Potential impacts to aquatic wildlife from development could include: overland oil spills, underground spills from activities associated with horizontal drilling or other practices, spills from drilling mud or other extraction and processing chemicals, and surface disturbance activities that create a localized erosion zone. Oil spills and other pollutants from the oil extraction process could harm the aquatic wildlife species in two different ways if the spill substances enter the habitat. First, toxicological impacts from direct contact could have immediate lethal effects to eggs, larvae, juveniles, and adults. Second, toxic effects to lower food web levels (e.g. aquatic macro-invertebrates) could indirectly affect fish, amphibian, and reptile species by degrading water quality and degrading or eliminating food resources.

Additional mitigation could occur as COAs at the APD stage. These conditions could include the placement of earthen berms and oil skimmers (in ephemeral drainages where fish passage will not be blocked) to help protect aquatic wildlife habitat in case of oil spills.

Oil and gas development is allowed within big game crucial winter range with a timing restriction from December 1 to March 31. This stipulation does not apply to operation and maintenance of production facilities. The goal of this stipulation is to protect crucial big game habitats from disturbance during the winter use season. This stipulation provides protection to big game winter habitats and species only during that timeframe, and does not provide protection during the long-term operation and maintenance periods. Development can occur outside of those dates and will exist thereafter until reclamation, thus only delaying impacts until after that year of construction.

Mule deer could be impacted by this project from habitat fragmentation and disturbance. Mule deer winter range habitat has been identified within 6 lease parcels. Development could affect mule deer use of winter range habitat in those areas. Studies conducted in the Pinedale anticline of Wyoming found that mule deer avoided areas in close proximity to well pads with no evidence of well-pad acclimation during 3 out of 4 years. During year 4 of development habitat selection patterns were influenced more by road density, and not proximity of well pads. The authors attributed this to an unusually severe winter, where movement options and available habitat was limited. Densities of mule deer decreased by an estimated 46% within the developed area over the four years, and indirect impacts were observed out to 2.7-3.7 km of well sites. Mule deer distribution shifted toward less preferred and presumably less suitable habitat. (Sawyer et al. 2005) Similar impacts could be expected from development with this proposal.

White-tailed deer could also be expected to be impacted by this project from habitat fragmentation and disturbance. Winter range for white-tailed deer exists across the analysis area, but covers much less area than other big game ranges. White-tailed deer winter range has been identified within 1 lease parcel.

Pronghorn could be impacted by this project from habitat fragmentation and disturbance. Pronghorn winter range habitat has been identified within 9 lease parcels. Preliminary studies in the upper green river basin in Wyoming report that some pronghorn exhibit movement patterns that suggest almost complete avoidance of gas field areas of intensive development in the Jonah field during the winter, whereas pronghorn in the Pinedale Anticline Project Area (PAPA) apparently have not been avoiding human activities. It is speculated that the difference may exist due to different levels in well densities, as the Jonah field was reported as 1 well/57 acres, and the PAPA at 1 well/124 acres (Berger et al. 2007). Effects to winter range within existing and future oil and gas development and exploration would be similar to those referenced above and could depend on rate and location of development.

Sharp-tailed grouse dancing grounds exist on 2 proposed lease parcels, and ¼ mile NSO buffers are applied to these parcels. In addition, all or portions of 10 lease parcels are located within 2 miles of sharp-tailed grouse leks where timing stipulations from March 1 to June 15 were applied. This timing does not apply to operation and maintenance of production facilities. Recent inventories for sharp-tailed grouse dancing grounds have not been conducted within some of the parcels. Therefore, inventories would be conducted at the APD stage of development to determine the presence or absence of sharp-tailed grouse dancing grounds. Although limited research exists that documents impacts to sharp-tailed grouse from development activities, it is expected that sharp-tailed grouse could be impacted by this project from habitat fragmentation and disturbance. Vehicles and human activity during breeding and nesting seasons could reduce breeding activity, displace nesting hens and reduce the suitability of habitat for brood-rearing. Mortality could increase as a result of collisions with vehicles.

Wild turkeys, pheasants, and Hungarian partridge could also be affected by disturbance and direct mortality through nest destruction and vehicle collisions during the development stages.

4.3.9.2 Mitigation

Measures would be taken to prevent, minimize, or mitigate impacts to fish and wildlife animal species from exploration and development activities. Prior to authorization, activities would be evaluated on a case-by-case basis, and the project would be subject to mitigation measures. Mitigation could include rapid revegetation, project relocation, or pre-disturbance wildlife species surveying. If oil and gas development is proposed in suitable habitat for threatened or endangered species, consultation with the USFWS would occur to determine if additional terms and conditions would need to be applied.

4.3.10 Cultural Resources

4.3.10.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on cultural resources. Any potential effects from the sale of leases would occur at the time the leases are developed.

Potential effects from surface disturbance associated with exploration and development activities have the potential to alter the characteristics of a significant cultural or historic property by diminishing the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Other effects to cultural resources from proposed surface disturbance activities include the destruction, damage, or alteration to all or part of the cultural resource and diminishing the property’s significant historic features as a result of the introduction of visual, atmospheric, or audible elements. Cultural resource investigations associated with development potentially adds to our understanding of the prehistory/history of the area and discovery of sites that would otherwise remain undiscovered due to burial or omission. Indirect effects to cultural resources within the analysis area by county are as follows:

The following lease parcels have sites within their boundaries: MTM 105431-H9- within Roosevelt County.

One lease parcel (MTM 105431-HA) is located in McCone County consisting of 40.0 acres. Based on modeling, the parcel might contain less than one cultural site (.43 sites) of which less than one could have the potential to be eligible or considered eligible for listing on the National Register of Historic Places.

Ten lease parcels (MTM 105431-HC, HD, HE, HG, HH, HJ, HF, HK, HL and HM) are located in Powder River County consisting of 4,597 acres (4596.87 acres). Based on modeling, the parcels might contain up to 49.4 cultural sites of which 5 to 8 could have the potential to be eligible or considered eligible for listing on the National Register of Historic Places.

Two lease parcels (MTM 102757-WT and WW) are located in Prairie County consisting of 1,919 acres (1,919.24 acres). Based on modeling, the parcels might contain up to 20.6 cultural sites of which two to three could have the potential to be eligible or considered eligible for listing on the National Register of Historic Places.

Three lease parcels (MTM 105431-HB, H6 and H8) are located in Richland County consisting of 1,189 acres (1,189.21 acres). Based on modeling, the parcels might contain up to 13 cultural sites (12.7) of which one to two could have the potential to be eligible or considered eligible for listing on the National Register of Historic Places.

Two lease parcels (MTM 105431-H9 and JA) are located in Roosevelt County consisting of 200acres (199.96 acres). Based on modeling, the parcels might contain 2 cultural sites of which less than one could have potential to be eligible or considered eligible for listing on the National Register of Historic Places.

Leasing approximately 7,945 acres of Federal minerals within the five counties described above could indirectly affect 85.4 cultural sites based upon modeling (Aaberg et al 2006). Of the modeled 85 cultural sites, 8 to 13 sites may have the potential to be eligible or considered eligible for listing on the National Register of Historic Places.

The Reasonable Foreseeable Development (RFD and Appendix D) scenario for the lease parcels predicts 7 wells and 29.4 acres of disturbance as a result from leasing the parcels which may affect 1 site which may have the potential to be eligible for listing on the National Register of Historic Places.

4.3.10.2 Mitigation

Application of standard lease terms, stipulations, and cultural lease notices provide mechanisms to protect vulnerable significant cultural resource values on these lease parcels (Appendix A). Lease notice LN 14-2 would be applied to 1 lease parcel (MTM 105431-H9). Lease notice LN 14-14 would be applied to 3 lease parcels (MTM 105431-H8, H9 and HB). The cultural resource lease stipulation CR16-1 would be applied to all the lease parcels. The inclusion of these requirements at the leasing stage provide notification to the lessee that potentially valuable cultural resources are or are likely to be present on the lease parcels and potential mitigation measures may be required. The application and implementation of these stipulations and lease notices at the development stage would provide the necessary measures to protect cultural resources.

Specific mitigation measures, include but are not limited to, site avoidance, excavation or data recovery would have to be determined when site-specific development proposals are received. Most surface-disturbing situations for cultural resources would be avoided by project redesign or relocation. Unavoidable, significant properties would be site-specifically mitigated with concurrence with the State Historic Preservation Office prior to implementation of a project.

4.3.11 Native American Religious Concerns

4.3.11.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on Native American religious concerns. Any potential effects from the sale of leases could occur at the time the leases are developed.

Leasing parcels located near the Fort Peck Reservation in Richland and Roosevelt Counties and Turtle Mountain Public Domain Allotments in Roosevelt County would not interfere with the performance of traditional ceremonies and rituals pursuant to the American Indian Religious Freedom Act (AIRFA) or EO 13007. Leasing parcels in this area would not prevent tribes from visiting sacred sites or prevent possession of sacred objects.

4.3.11.2 Mitigation

Mitigation would be the same as section 4.3.10.2 above. For those parcels where no inventory data is available or where no information is available for TCPs, BLM would apply the cultural lease notice (CR 16-1). The sites in parcel MTM 105431-H9 would be revisited and reevaluated for National Register eligibility prior to any surface disturbance.

4.3.12 Paleontology

4.3.12.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on paleontological resources. Any potential effects from the sale of leases could occur at the time the leases are developed.

Indirect impacts from the sale of leases would be from the surface disturbances associated with oil and gas exploration and development activities. It is anticipated that most significant fossil resources are located in those geologic units with a Potential Fossil Yield Classification (PFYC) of 3 or higher. However, significant fossil resources could be discovered anywhere. Surface-disturbing activities could potentially alter the characteristics of paleontological resources through damage, fossil destruction, or disturbance of the stratigraphic context in which paleontological resources are located, resulting in the loss of important scientific data. Identified paleontological resources could be avoided by project redesign or relocation before project approval which would negate the need for the implementation of mitigation measures. Conversely, surface-disturbing activities could potentially lead to the discovery of paleontological localities that would otherwise remain undiscovered due to burial or omission during review inventories. The scientific retrieval and study of these newly discovered resources would expand our understanding of past life and environments of Montana.

4.3.12.2 Mitigation

The application of lease terms, the paleontological no surface occupancy stipulation (NSO 11-12), and the paleontological lease notices (LN 14-3 and LN 14-12) at leasing, provides protection to paleontological resources during development. The paleontological lease notice LN 14-12 is applied to those lease parcels that fall within geological units with a PFYC Class of 3 or higher, usually requiring a field survey prior to surface disturbance. These inventory requirements could result in the identification of paleontological resources. Avoidance of significant paleontological resources or implementation of mitigation prior to surface disturbance would protect paleontological resources. However, the application of lease terms only allows the relocation of activities up to 200 meters, unless documented in the NEPA document, and cannot result in moving the activity off lease.

Specific mitigation measures could include, but are not limited to, site avoidance or excavation. Avoidance of paleontological properties would be a best management practice. However, should a paleontological locality be unavoidable, significant fossil resources must be mitigated prior to implementation of a project. Also, significant fossil resources could be discovered in areas that had not been evaluated (PFYC of less than 3) during surface disturbance. Those resources must also be professionally mitigated. These mitigation measures and contingencies would be determined when site specific development proposals are received.

In order to protect paleontological resources, 18 of the parcels are recommended to have the Paleontological lease notice 14-12 applied per guidance identified in IM 2009-011 and 2008-009. No parcels are recommended for the no surface occupancy lease stipulation (NSO 11-12) based upon paleontological resources. See section 3.10 Paleontology for list of parcels.

4.3.13 Visual Resources

4.3.13.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on visual resources. Any potential effects from the sale of leases could occur at the time the leases are developed.

The lease parcels fall into VRM classes II, III and IV, as demonstrated in Section 3.11, Visual Resources, Table 7. While the act of leasing federal minerals produces no visual impacts, development of a lease parcel could result in some level of modification to the existing landscape at the time of development.

4.3.13.2 Mitigation

All new oil and gas development would implement, as appropriate for the site, BLM BMPs for VRM, regardless of the VRM class. This includes, but would not be limited to, proper site selection, reduction of visibility, minimizing disturbance, selecting color(s)/color schemes that blend with the background and reclaiming areas that are not in active use. Repetition of form, line, color and texture when designing projects would reduce contrasts between landscape and development. Wherever practical, no new development would be allowed on ridges or mountain tops. Overall, the goal would be to not reduce the visual qualities or scenic value that currently exists.

There are no lease parcels that fall within a VRM Class II management objective. Measures would be taken to mitigate the visual impacts within a Class III and Class IV area to protect the scenic value.

4.3.14 Forest and Woodland Resources

4.3.14.1 Direct and Indirect Effects

Potential impacts from oil and gas development could include the cutting and subsequent removal of forest and woodland vegetation from drill-site development areas; including roads, pads, surface facilities, pipelines, and power-lines. The degree of impact would vary according to the precise location of development activities in the parcel area and is directly related to topography, miles of road construction, standing timber volume per acre, and total acres of surface facilities development. A total of approximately 2,116 forest and woodland acres could potentially be impacted under this alternative; 1,671 acres of evergreen, 361 acres of deciduous, and 84 acres of mixed evergreen-deciduous forest.

4.3.14.2 Mitigation

Measures would be taken to prevent, minimize, or mitigate impacts to forest and woodland resources from exploration and development activities. Prior to authorization, activities would be evaluated on a case-by-case basis, and the project would be subject to mitigation measures. The road construction and maintenance BMPs outlined in the Gold Book are consistent with the Water Quality BMPs for Montana Forests (Logan 2001) which are designed to protect water quality and forest soils. Other mitigation measures could include the artificial planting of bareroot or containerized nursery stock seedlings.

All severed forest and woodland vegetative material would need to be removed or reduced to acceptable standards meeting Montana's Control of Timber Slash and Debris Law (Title 76, Chapter 13, Part 4), commonly referred to as the "Slash" Law; therefore, requiring burning, grinding, chipping, burying, or hauling residual debris off-site to a designated landfill or other location for disposal.

4.3.15 Livestock Grazing

4.3.15.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on livestock grazing. Any potential effects from the sale of leases would occur at the time the leases are developed.

Oil and gas development could result in a loss of vegetation for livestock grazing (e.g., direct removal, introduction of unpalatable plant species, etc.), decrease the palatability of vegetation due to fugitive dust, disrupt livestock management practices, involve vehicle collisions, and decrease grazing capacity. Direct losses of forage could also result from construction of roads, well pads and associated infrastructure and would vary depending on the extent of development. These impacts could vary from short-term impacts to long-term impacts depending on the type of exploration or development, the success of reclamation, and the type of vegetation removed for the oil and gas activities.

If development activity is reducing vegetative resources for livestock grazing and the grazing activity is resulting in the allotment not meeting the standards for rangeland health, then the authorized officer would have to take action prior to the next grazing season to ensure the BLM lands are progressing towards meeting the standards. This could result in the change of livestock grazing activities in order to improve vegetative conditions.

4.3.15.2 Mitigation

Measures would be taken to prevent, minimize, or mitigate impacts to livestock grazing from exploration and development activities. Prior to authorization, activities would be evaluated on a case-by-case basis, and the project would be subject to mitigation measures. Mitigation could potentially include controlling livestock movement by maintaining fence line integrity, fencing of facilities, re-vegetation of disturbed sites, and fugitive dust control.

4.3.16 Recreation and Travel Management

4.3.16.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on recreation and travel management. Any potential effects from the sale of leases could occur at the time the leases are developed.

Recreation indirect effects could exist where oil and gas development and recreational user conflicts could occur. More specifically, in areas of high oil and gas development potential, there could be user conflicts between motorized recreationists (OHV activities), hunting, target shooting, camping, fishing, river use, picnicking, and winter activities (e.g., snowmobiling) and associated oil and gas activities. These impacts could exist in both the short-term (exploration and construction phases of oil and gas development) and in the long-term (producing wells, maintenance of facilities, etc.). Oil and gas wells, equipment, and facilities could affect the general solitude (space and noise) and scenic value of the area.

Areas frequented by recreationists, where there is other land use activities occurring, in addition to oil and gas development, the public could perceive these areas as inaccessible or unavailable because of the existing facilities. As oil and gas development occurs, new routes are created which often attract recreationists seeking additional or new areas to explore for motorized recreational opportunities. Motorized recreational opportunities could be enhanced through the additional opportunities to explore; however, user conflicts and public safety issues could result from the use of the new travel routes. The creation of routes from oil and gas activities could lead to a proliferation of user-created motorized routes, resulting in adverse impacts to the scenic qualities of the area and increased level of surface disturbance.

For those areas with isolated tracks of BLM public lands that generally do not have existing public access, recreation opportunities that occur in these areas are limited to use with adjacent land owner permission or hunting by an outfitter; therefore, oil and gas activities would have little or no impact on recreational experiences in these isolated tracks.

Foreseeable changes in recreation use levels would be an increase on the demand for recreational use of public land. Increases could be expected in, but not limited to, hunting, fishing, hiking, camping, wildlife viewing, and dispersed recreational uses. This could increase the incidence of conflict between recreationists involved in motorized activities and non-motorized activities.

4.3.16.2 Mitigation
Additional measures would be taken to minimize, avoid, or mitigate impacts to recreation from oil and gas exploration and development activities. Prior to authorization, activities would be evaluated on a case-by-case basis, and the project would be subject to mitigation measures. Mitigation measures could potentially include, but are not limited to, reclamation of industrial routes/areas when no longer needed, fencing of facilities, and installing signs along roads.

4.3.17 Lands and Realty
4.3.17.1 Direct and Indirect Effects
Leasing the parcels would have no direct impacts on lands and realty. Any potential effects from the sale of leases could occur at the time the leases are developed.

Under this alternative 18 parcels that include 7,945.28 surveyed surface acres of which 3,637.97 surveyed acres are BLM administered surface and 4,307.31 surveyed acres are Non-Federal surface would be offered for lease.

Facilities associated with oil and gas development could cause disturbance to the existing rights-of-way (ROWs). There are four existing ROWs located on the following three lease parcels; MTM-102757-WT, MTM-105431-HB and MTM-105431-H8. A ROW for a county road (MTM-99365) on MTM-102757-WT, a ROW for an overhead power line (MTM-55529) on MTM-105431-H6, and a ROW for an oil and gas road (MTM-103251) and oil pipeline (MTM-103965) on MTM-105431-H8. Additional ROWs could be required across Federal surface for "off-lease" or third party facilities required for potential development of the parcels.

4.3.17.2 Mitigation
Measures would be taken to avoid disturbance to or impacts to existing rights-of-way, in the event of any oil and gas exploration and development activities. Any new "off-lease" or third party rights-of-way required across federal surface for exploration and/or development of the 18 parcels would be subject to lands and realty stipulations to protect other resources as determined by environmental analyses. In order to protect the existing rights-of-way it is recommended that LN 14-1 be applied to lease parcels MTM-102757-WT, MTM-105431-HB and MTM-105431-H8.

4.3.18 Minerals
4.3.18.1 Fluid Minerals
4.3.18.1.1 Direct and Indirect Effects
Leasing the parcels would have no direct impacts on fluid minerals. Any potential effects from the sale of leases could occur at the time the leases are developed.

Issuing a lease provides opportunities to explore for and develop oil and gas resources; however, exploration and development activities must be conducted in accordance with an approved APD. Additional natural gas or crude oil produced from any or all of the 18 parcels in Alternative B would enter the public markets. Additional subsurface information would be obtained from drilling wells. Royalties and taxes could accrue to the Federal and State treasuries from the lease parcel lands.

Under Alternative B, all of the lease parcels would be offered for lease subject to major (NSO) or moderate (CSU) constraints and/or standard lease terms and conditions.

Stipulations applied to various areas with respect to occupancy, timing limitation, and control of surface use could affect oil and gas exploration and development, both on and off the Federal lease parcel. Leases issued with major constraints (NSO stipulations) could decrease some lease values, increase operating costs, and require relocation of well sites, and modification of field development. Leases issued with moderate constraints (timing limitation and controlled surface Use (CSU) stipulations) could result in similar but reduced impacts, and delays in operations and uncertainty, on the part of operators, regarding restrictions.

Hydraulic Fracturing

Hydraulic fracturing has been utilized by the oil and gas industry since the late 1940's. Within the planning area, hydraulic fracturing, in conjunction with horizontal drilling described above, has allowed for development of unconventional zones that were once considered uneconomical, like the Bakken and Three Forks Formations in the Williston Basin area.

Hydraulic fracturing is a technique used to create additional space and connecting existing fractures and existing rock pores with newly created fractures that are located in deep underground geologic formations. The induced space allows the rock to more readily release oil and natural gas so it can flow to the surface via the well bore that would otherwise be uneconomical to develop. Wells that undergo hydraulic fracturing may be drilled vertically, horizontally, or directionally and the resultant fractures induced by the hydraulic fracturing can be vertical, horizontal, or both. The typical steps of hydraulic fracturing can be described as follows:

1. Water, sand and additives are pumped at high pressures down the wellbore.
2. The liquid goes through perforated sections of the wellbore and into the surrounding formation, fracturing the rock and injecting sand or other proppants into the cracks to hold them open.
3. Experts continuously monitor and gauge pressures along with the volume of fluids and proppants, while studying how the sand reacts when it hits the bottom of the wellbore; slowly increasing the density of sand to water as the frac progresses.
4. This process may be repeated multiple times, in "stages" to reach maximum areas of the wellbore. When this is done, the wellbore is temporarily plugged between each stage to maintain the highest water pressure possible and get maximum fracturing results in the rock.
5. Frac plugs are drilled or removed from the wellbore and the well is tested for results.
6. The water pressure is reduced and fluids are returned up the wellbore for disposal or treatment and re-use, leaving the sand in place to prop open the cracks and allow the oil/gas to flow to the well bore.

Fracturing fluid is typically more than 98 percent water and sand, with small amounts of readily available chemical additives used to carry the proppant and control the chemical and mechanical properties of the water and sand mixture. Proppant, consisting of synthetic or natural silica sand, may be used in quantities of few hundred tons for a vertical well to a few thousand tons for a horizontal well. The amount of water needed to fracture a well in the planning area depends on the geologic basin, the formation, and depth and type of well (vertical, horizontal, directional), and the proposed completion process.

Several sources of water are available for hydraulic fracturing in the planning area. The Fluid Minerals Operations and Procedures Appendix contain further details on sources of water that could potentially be used for hydraulic fracturing or drilling operations. The use of any specific water source on a federally administered well, requires the proposal be reviewed and analyzed through the NEPA process for BLM approval during the APD stage to ensure compliance with Montana water laws and federal regulations.

Before hydraulic fracturing takes place, all surface casing and some deeper, intermediate zones are required to be cemented from the bottom of the cased hole to the surface in accordance to Onshore Order #2, MBOGC rules and regulations, and API standards. The cemented well is pressure tested to ensure there are no leaks and a cement bond log is run to ensure the cement has bonded to the casing and the formation.

MBOGC regulations also ensure that all resources including groundwater are protected. The MBOGC regulations require new and existing wells, which will be stimulated by hydraulic fracturing, must demonstrate suitable and safe mechanical configuration for the stimulation treatment proposed. If the operator proposes hydraulic fracturing through production casing or through intermediate casing, the casing must be tested to the maximum anticipated treating pressure. In accordance with MBOGC Rule 36.22.1015 operators are required to disclose and report the amount and type of fluids used in well stimulation to the Board or, if approved by the Board, to the Interstate Oil and Gas Compact Commission/Groundwater Protection Council hydraulic fracturing web site (FracFocus.org).

4.3.19 Special Designations

4.3.19.1 National Historic/Scenic Trails

There are no lease parcels located within the Lewis and Clark National Historic Scenic Trail or the Lewis and Clark Special Recreation Management Area (SRMA). However, two Lease parcels, MTM 105431-H8 and HB (947.3 acres), are located within a 3 mile sensitive Setting Consideration Zone (SCZ) around the Lewis and Clark National Historic Trail (NHT) and SRMA.

Potential effects from surface disturbances associated with exploration and development activities after leasing have the potential to alter the characteristics of the significant Lewis and Clark National Historic Trail, a cultural and historic property, by diminishing the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. The effects to the Lewis and Clark National Historic Trail cultural resource from proposed surface disturbance activities include the destruction, damage, or alteration to all or part of the cultural resource and diminishing significant historic features of the property by the introduction of visual, atmospheric, or audible elements. This could alter or diminish the elements of this nationally significant site diminish the property’s significance. These same concerns apply to a National Register eligible property and would diminish the property’s eligibility status. Cultural resource investigations associated with development potentially adds to our understanding of the prehistory/history of the area and discovery of sites that would otherwise remain undiscovered due to burial or omission.

4.3.19.2 Areas of Critical Environmental Concern (ACECs)
None of the 18 parcels are situated within a proposed or designated Area of Critical Environmental Concern (ACEC). There will be no affect to ACEC's through the proposed alternative.

4.3.19.3 Mitigation
Two Lease parcels, MTM 105431-H8 and HB, are located near the Lewis and Clark NHT. These parcels are on split-estate lands outside of the Lewis and Clark NHT, greater than ½ mile from the Trail centerline, and within the three mile potential viewshed of the river and Lewis and Clark NHT. For these parcels, BLM would apply its Best Management Practices similarly to those that pertain to Cultural Resource management.

Since the Lewis and Clark NHT is a congressionally designated component of the NHT system, BLM would apply the same kind of analysis that is applied to determining an effect to a property eligible for the National Register of Historic Places. That process includes determining whether an undertaking would have an adverse effect on the historic nature of the Lewis and Clark NHT by altering, directly or indirectly, any of the characteristics of the historic nature of the Lewis and Clark NHT in a manner that would diminish the integrity of the Trail's location, setting, feeling, or association. Adverse effects may include reasonably foreseeable effects caused by an undertaking that may occur later in time, be farther removed in distance or be cumulative.

Examples of adverse effects on the historic nature of the Lewis and Clark NHT include, but are not limited to change of the character of the Trail's historic nature or physical features within Trail's corridor setting that contribute to diminishing the Trail's historic significance; and the introduction of visual, atmospheric or audible elements that diminish the integrity of the Trail's historic significance. If it is determined that an undertaking within the viewshed of the Lewis and Clark NHT would have an adverse effect on the historic character of the Trail where the integrity of the setting is a contributing element of the historic character of the Trail, then surface occupancy or use and surface disturbance would be restricted.

Prior to surface disturbance, occupancy or use a mitigation plan (Plan) would need to be submitted to the BLM by the applicant as a component of the APD (BLM Form 3160-3) or Sundry Notice (BLM Form 3160-5) – Surface Use Plan of Operations. The operator may not initiate surface-disturbing activities unless the BLM authorized officer has approved the Plan or approved it with conditions. The Plan would need to demonstrate to the authorized officer's satisfaction that the infrastructure will either not be visible or will result in a weak contrast rating and would not have an adverse effect on the setting of the historic character of the Lewis and Clark NHT.

4.3.20 Social and Economic Conditions
4.3.20.1 Social
4.3.20.1.1 Direct and Indirect Effects
Leasing the parcels would have no direct impacts on social resources. Any potential effects from the sale of leases could occur at the time the leases are developed.

While the act of leasing Federal minerals itself would result in no social impact, subsequent exploration and development may generate impacts to people living near or using the area in the vicinity of the lease. Exploration, drilling or production could create an inconvenience to people living adjacent to leases due to increased traffic and traffic delays, and light, noise and visual impacts. This could be especially noticeable in rural areas where oil and gas development has not occurred previously. The amount of inconvenience would depend of the activity affected, traffic patterns within the area, noise and light levels, length of time and season these activities occur, etc. In addition, competition for housing could occur in some communities. However, residents living in areas that have been experiencing ongoing population losses may support the increased employment and population related to oil and gas development. Residents of counties where the development actually occurs would also benefit from the additional revenues to counties due to oil and gas leasing and development.

There is potential for disproportionate effects to low income or minority populations, specifically American Indian populations. Consultation with potentially affected Tribes would occur at the APD stage.

4.3.20.2 Economics
4.3.20.2.1 Direct and Indirect Effects
Under Alternative B, 18 parcels in counties would be made available for leasing at the October 2014 lease auction. The leasing of an additional 7,945 acres of BLM administered minerals in these counties would generate additional public revenue, stimulate economic activity, and boost production associated with Federal minerals. It is estimated that the leasing of all minerals nominated for the October auction would generate more than $756,000 in one-time bonus bids and $14,000 annually in rent revenue for the Federal government. Forty-nine percent of Federal revenue collected from public domain minerals and 25 percent of Federal revenue from acquired minerals (acquired under Bankhead Jones authority) are redistributed to the State. Montana then distributes 25 percent of public domain revenue and all of acquired mineral revenue back to the counties where the leases exist. Approximately 94 percent of federal minerals leased by the BLM within McCone, Powder River, Prairie, Richland and Roosevelt counties are public domain minerals. If these additional parcels were to be leased, an additional $43,000 would be paid to the State of Montana and the five counties would receive an additional $12,000 from the redistribution of federal revenue.

Once oil and gas extraction begins, annual rent payments on leased minerals stops and lessees begin to pay royalties equal to 12.5 percent of the value of production (43 CFR 3103.3.1). Royalties associated with future development of nominated minerals is estimated to generate an additional $206,000 annually in federal oil and gas royalties. Of this new federal revenue, an estimated $98,000 could be disbursed to the State and $27,000 is estimated to be redistributed back to the five counties.

In addition to generating additional public revenue, leasing an additional 7,945 acres of federal minerals in McCone, Powder River, Prairie, Richland and Roosevelt counties will stimulate economic activity in the private sector of the local 8-county economy. Increased local demand for oil and gas drilling and support activities will create a ripple effect in the local economy as new employment and income opportunities in oil and gas related industries indirectly creates opportunities in nearly all other sectors of the local economy.

The total economic impact of leasing activities proposed under Alternative B is equal to direct and indirect effects of drilling activities, as well as the direct and indirect effects of additional public revenue redistributed back to the five counties. As shown in Table 14, the bonus bids, rents, royalties, and drilling and support activities associated with leasing an additional 7,945 acres of federal minerals is estimated to support 2 additional jobs and $61,000 in labor income across the 8-county local economy (IMPLAN, 2014).

Disclosure of the direct, indirect, and cumulative effects of GHG emissions provides information on the potential economic effects of climate change including effects that could be termed the "social cost of carbon" (SCC). The EPA and other federal agencies developed a method for estimating the SCC and a range of estimated values (EPA 2014). The SCC estimates damages associated with climate change impacts to net agricultural productivity, human health, property damage, and ecosystems. Using a 3 percent average discount rate and year 2020 values, the incremental SCC is estimated to be $46 per metric ton of annual CO_2e increase. Based on the GHG emission estimate provided in Section 4.3.3.1.2, the annual SCC associated with potential development on lease sale parcels is $38,499 (in 2011 dollars). Estimated SCC is not directly comparable to economic contributions reported above, which recognize certain economic contributions to the local area and governmental agencies but do not include all contributions to private entities at the regional and national scale. Direct comparison of SCC to the economic contributions reported above is also not appropriate because costs associated with climate change are borne by many different entities.

4.3.21 Cumulative Impacts- Alternative B

Cumulative impacts are those impacts resulting from the incremental impact of an action when added to other past, present, and reasonably foreseeable actions regardless of what agency or person undertakes such other actions (40 CFR 1508.7). This section describes cumulative impacts associated with this project on resources. The ability to assess the potential cumulative impacts at the leasing stage for this project is limited for many resources due to the lack of site-specific information for potential future activities. Upon receipt of an APD for any of the lease parcels addressed in this document, more site-specific planning would be conducted in which the ability to assess contributions to cumulative impacts in a more detailed manner would be greater due to the availability of more refined site-specific information about proposed activities.

4.3.21.1 Past, Present and Reasonably Foreseeable Future Actions

Past, present, or reasonably foreseeable future actions that affect the same components of the environment as the Proposed Action are: grazing, roads, wildfire and prescribed fire, range improvement projects, and utility rights-of-way.

4.3.21.2 Cumulative Impacts by Resource

Cumulative effects for all resources in the MCFO are described in the final Big Dry RMP/EIS (pgs. 111 to 156) and the 1992 Oil and Gas Amendment of the Billings, Powder River, and South Dakota Resource Management Plans and Final Environmental Impact Statement and the 1994 Record of Decision and the 2008 Final Supplement to the Montana Statewide Oil and Gas Environmental Impact with a development alternative for coal bed natural gas production (4-1 to 4-310). Anticipated exploration and development activities associated with the lease parcels considered in this EA are within the range of assumptions used and effects described in this cumulative effects analysis for resources other than air, climate, and socio-economics resources. This previous analysis is hereby incorporated by reference for resources other than for air, climate, and economics resources.

4.3.21.2.1 Greenhouse Gas Emissions and Cumulative Impacts on Climate Change

The cumulative effects analysis area is the MCFO, with additional discussion at state-wide, national, and global scales for GHG emissions and climate change.

This section incorporates an analysis of the contributions of the Proposed Action to GHG emissions, followed by a general discussion of potential impacts to climate change. Potential emissions relate to those derived from potential exploration and development of fluid minerals. Additional emissions beyond the control of the BLM, and outside the scope of this analysis, would also occur during any needed refining processes, as well as end uses of final products.

Projected GHG emissions for this project and the MCFO RFD are compared below with recent, available inventory data at the State, national, and global scales. GHG emissions inventories can vary greatly in their scope and comprehensiveness. State, national, and global inventories are not necessarily consistent in their methods or in the variety of GHG sources that are inventoried (Climate Change SIR 2010). However, comparisons of emissions projected by the BLM for its oil and gas production activities are made with those from inventories at other scales for the sake of providing context for the potential contributions of GHGs associated with this project.

As discussed in the Air Quality section of Chapter 4, total projected BLM GHG emissions from the RFD are 610,741.1 metric tons/year CO_2e. Potential emissions under Alternative B would be approximately 0.041 percent of this total. Table 15 displays projected GHG emissions from non-BLM activities included in the Miles City RFD. Total projected emissions of non-BLM activities in the RFD in Appendix B are 1,382,890 metric tons/year of CO_2e. When combined with projected annual BLM emissions, this totals 1,383,139 metric tons/year CO_2e. Potential GHG emissions under Alternative B would be 0.042 percent of the estimated emissions for the entire RFD. Potential incremental emissions of GHGs from exploration and development of fluid minerals on parcels within Alternative B, and Alternative C, would be minor in the context of projected GHG contributions from the entire RFD for the MCFO.

Table 19. Projected non-BLM GHG Emissions Associated With the MCFO Reasonably Foreseeable Development Scenario for Fluid Mineral Exploration and Development.

Source	Non-BLM Long-Term GHG Emissions in tons/year				Emissions (metric tons/yr)
	CO_2	CH_4	N_2O	Co_2e	CO_2e
Conventional	545,689.1	5425.9	2.1	658,344.3	599,170.7

Natural Gas					
Coal Bed Natural Gas	274,925.2	5,330.5	0.9	387,135.7	351,302.8
Oil	422,033.9	2,576.2	1.2	476,522.7	432,416.3
Total	**1,242,648.3**	**13,332.6**	**4.2**	**1,522,002.7**	**1,382,889.8**

Montana's Contribution to U.S. and Global GHGs
Montana's GHG inventory (http://www.eia.doe.gov/oiaf/1605/archive/gg04rpt/emission.html, Center for Climate Strategies [CCS] 2007) shows that activities within the State contribute 0.6 percent of U.S and 0.076 percent of global GHG emissions (based on 2004 global GHG emission data from the IPCC, summarized in the Climate Change SIR 2010). Based on 2005 data in the state-wide inventory, the largest source of Montana's emissions is fossil fuel combustion to generate electricity, which accounts for approximately 27 percent of Montana's emissions. The next largest contributors are the agriculture and transportation sectors (each at approximately 22 percent) and fossil fuel production (13.6 percent).

GHG emissions from all major sectors in Montana in 2005 added up to a total of approximately 37 million metric tons of CO_2e (CCS 2007). Potential emissions from development of BLM lease parcels included in Alternative B would represent approximately 0.002 percent of the state-wide total of GHG emissions based on the 2005 state-wide inventory (CCS 2007).

The EPA published an inventory of U.S. GHG emissions, indicating gross U.S. emissions of 6,702 million metric tons, and net emissions of 5,797 million metric tons (when CO_2 sinks were considered) of CO_2e in 2011 (EPA 2013a). Potential annual emissions under Alternative B of this project would amount to approximately 0.000012 percent of gross U.S. total emissions. Global GHG emissions for 2004 (IPCC 2007, summarized by the Climate Change SIR 2010) indicated approximately 49 gigatonnes (10^9 metric tons) of CO_2e emitted. Potential annual emissions under Alternative B would amount to approximately 0.000002 percent of this global total.

As indicated above, although the effects of GHG emissions in the global aggregate are well-documented, it is currently not possible to determine what specific effect GHG emissions resulting from a particular activity might have on climate or the environment. If exploration and development occur on the lease parcels considered under Alternative B, potential GHG emissions described above could incrementally contribute to the total volume of GHGs emitted to the atmosphere, and ultimately to climate change.

Mitigation measures identified in the Chapter 4 Air Quality section above may be in place at the APD stage to reduce GHG emissions from potential oil and gas development on lease parcels under Alternative B. This is likely because many operators working in Montana, South Dakota, and North Dakota are currently USEPA Natural Gas STAR Program Partners and future regulations may require GHG emission controls for a variety of industries, including the oil and gas industry (Climate Change SIR 2010).

4.3.21.2.2 Cumulative Impacts of Climate Change
As previously discussed in the Air Quality section of Chapter 4, it is impossible to identify specific impacts of climate change on specific resources within the analysis area. As

summarized in the Climate Change SIR (2010), climate change impacts can be predicted with much more certainty over global or continental scales. Existing models have difficulty reliably simulating and attributing observed temperature changes at small scales. On smaller scales, natural climate variability is relatively larger, making it harder to distinguish changes expected due to external forcings (such as contributions from local activities to GHGs). Uncertainties in local forcings and feedbacks also make it difficult to estimate the contribution of GHG increases to observed small-scale temperature changes (IPCC 2007, as cited by the Climate Change SIR 2010). Effects of climate change on resources are described in Chapter 3 of this EA and in the Climate Change SIR (2010).

4.3.21.3 Cumulative Impacts to Wildlife

For wildlife species, past and presently on-going oil and gas development, fire, farming, livestock grazing, traffic, and any other form of human and natural disturbances result in cumulative impacts to wildlife.

Construction of roads, production well pads, and other facilities would result in long term (>5 years) loss of habitat and forage in the analysis area. This would be in addition to acres disturbed, or habitats fragmented from various other adjacent activities. As new development occurs, direct and indirect impacts could continue to stress wildlife populations, most likely displacing the larger, mobile animals into adjacent habitat, and increasing competition with existing local populations. Non-mobile animals could be affected by increased habitat fragmentation and interruptions to preferred habitats.

Certain species are localized to some areas and rely on very key habitats during critical times of the year. Disturbance or human activities that could occur in winter range for big game, nesting and brood-rearing habitat for grouse and raptors could displace some or all of the species using a particular area or disrupt the normal life cycles of species. Wildlife and habitat in and around the project could be influenced to different degrees by various human activities. Some species and/or a few individuals from a species group could be able to adapt to these human influences over time.

4.3.21.4 Cumulative Impacts to Economic Conditions

The cumulative effects of Alternative B are summarized in Table 15 and Table 16. The leasing of an additional 7,945 acres of Federal minerals by the MCFO would result in a total of 442,811 acres leased from the MCFO within McCone, Powder River, Prairie, Richland and Roosevelt counties. The leasing of Federal minerals in these counties by the BLM would generate about $1 million in Federal revenue. The redistribution of Federal revenue associated with leasing of these Federal minerals is estimated to generate nearly $500,000 in State revenue for Montana and $124,000 in local public revenue in the five counties. Federal oil and gas production associated with BLM minerals in these counties is also anticipated to increase as a result of leasing under Alternative B. Royalties associated with BLM minerals in these counties are estimated to generate $11.5 million in Federal revenue. The redistribution of Federal royalty payments resulting from extraction of BLM minerals in the five counties would provide the State of Montana with $5.5 million in public revenue while $1.5 million would be distributed directly back to these producing counties.

Oil and gas related activities associated with Federal minerals leased from the MCFO generates millions in public revenue, stimulates economic activity in the public and private sectors, and can be attributed with supporting employment and income opportunities throughout the local rural economy. Total Federal revenue associated with the leasing and production of BLM administered minerals in McCone, Powder River, Prairie, Richland and Roosevelt counties under Alternative B is estimated to exceed $12.4 million. The redistribution of Federal revenue from these minerals is anticipated to generate $5.9 million in State revenue for Montana, and more than $1.6 million will likely be returned to the five counties to fund law enforcement and fire departments, roads and highway maintenance, public education, local clinics/hospitals and county libraries. Public services and infrastructure investments by the State and local municipalities with redistributed Federal dollars supports employment and income in the public sector and in industries providing goods and services to the public sector. The drilling, servicing, and production resulting from BLM leasing of Federal minerals in the five counties also stimulates economic activity in the private sector, directly and indirectly supporting local employment and income in nearly every part of the economy. The total economic contribution of oil and gas related activities and public revenue associated with BLM leased minerals in McCone, Powder River, Prairie, Richland and Roosevelt counties under Alternative B is estimated to be 47 jobs and $3 million in local wages and proprietor's income across the 8-county local economy.

4.4 Alternative C (BLM Preferred)

Under Alternative C, 2 whole and 5 partial parcels of the 18 lease parcels totaling 1,396.87 surveyed Federal mineral acres (680 surveyed BLM administered surface and 716.87 surveyed private surface) would be offered for competitive oil and gas lease sale. The remaining 11 lease parcels in whole and 5 partial lease parcels, encompassing 6,549.15 surveyed Federal mineral acres (2,958.73surveyed BLM administered surface and 3,590.42private surveyed surface) would be deferred pending further review.

4.4.1 Direct Effects Common to All Resources

The action of leasing the parcels in Alternative C would, in and of itself, have no direct impact on resources. Direct effects of leasing are the creation of a valid existing right and those related to the revenue generated by the lease sale receipts.

4.4.2 Indirect Effects Common to All Resources

Any potential effects on resources from the sale of leases would occur during lease exploration and development activities, which would be subject to future BLM decision-making and NEPA analysis upon receipt of an APD or sundry notice.

Oil and gas exploration and development activities such as construction, drilling, production, infrastructure installation, vehicle traffic and reclamation could be indirect effects from leasing the lease parcels in Alternative B. As mentioned above, it is speculative to make assumptions about whether a particular lease parcel would be sold and, even if so, it is speculative to assume when, where, how, or if future surface disturbing activities associated with oil and gas exploration and development such as well sites, roads, facilities, and associated infrastructure would be proposed. It is also not known how many wells, if any, would be drilled and/or completed, the types of technologies and equipment would be used and the types of infrastructure needed for production of oil and gas. Thus, the types, magnitude and duration of potential impacts cannot be precisely quantified at this time, and would vary according to many factors.

Typical impacts to resources from oil and gas exploration and development activities such as well sites, roads, facilities, and associated infrastructure are described in the Miles City Oil & Gas Amendment/EIS (1994), the Big Dry RMP (1996), the Powder River RMP (1985), the Montana Statewide Oil & Gas Amendment/EIS (2003) and the Supplement (2008) to that document.

4.4.3 Air Resources
4.4.3.1 Air Quality
4.4.3.1.1 Direct and Indirect Effects
Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced by 82 percent due to approximately 6,549 acres of parcels proposed for deferral pending further review. Air quality impacts would likely be slightly less than those for Alternative B. Fewer leased acres would likely result in less future development and fewer emissions than Alternative B.

4.4.3.1.2 Mitigation
Mitigation would be the same as Alternative B.

4.4.3.2 GHG Emissions
4.4.3.2.1 Direct and Indirect Effects
Alternative C CO_2e emissions are estimated to be 690 mtpy less than those for Alternative B.

4.4.3.2.2 Mitigation
Mitigation would be the same as Alternative B.

4.4.3.3 Climate Change
4.4.3.3.1 Direct and Indirect Effects
Under Alternative C, climate change impacts would likely be slightly less than those for Alternative B.

4.4.3.3.2 Mitigation
Mitigation would be the same as Alternative B.

4.4.4 Soil Resources
4.4.4.1 Direct and Indirect Effects
Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced by 82 percent due to approximately 6,549 acres of parcels proposed for deferral pending further review. Less than one percent of the soils rated as low potential for restoration would be deferred. There are no CSU 12-1 soils stipulations applied to the deferred parcels. Soils are the same as those described in the Effected Environment section 3.3.

4.4.4.2 Mitigation
Mitigation would be the same as Alternative B.

4.4.5 Water Resources
4.4.5.1 Direct and Indirect Effects
Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced by 82 percent, due to approximately 6,549 acres of the lease parcels proposed for deferral pending further review.

The potentially impacted acres on water resources would be decreased by 6,549.15 acres.

4.4.5.2 Mitigation
Mitigation would be the same as Alternative B.

4.4.6 Vegetation Resources
4.4.6.1 Direct and Indirect Effects
Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced by 82%, due to approximately 6,549 acres of the lease parcels proposed for deferral pending further review.

4.4.6.2 Mitigation
Mitigation would be the same as Alternative B.

4.4.7 Riparian-Wetland Habitats
4.4.7.1 Direct and Indirect Effects
Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced by 82 percent, due to approximately 6,549 acres of the lease parcels proposed for deferral pending further review.

The potentially impacted acres on riparian resources would be decreased by 26 acres.

4.4.7.2 Mitigation
Mitigation would be the same as Alternative B.

4.4.8 Special Status Plant Species
4.4.8.1 Direct and Indirect Effects
Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced by 82%, due to approximately 6,549 acres of the lease parcels proposed for deferral pending further review.

4.4.8.2 Mitigation
Mitigation would be that same as Alternative B.

4.4.9 Wildlife & Fisheries/Aquatics
4.4.9.1 Direct and Indirect Effects
Direct and indirect impacts would be similar to Alternative B; however, the area impacted would be reduced by 82%, due to these lease parcels proposed for deferral pending further review. If deferred, this alternative would reduce the amount of parcels/acreage proposed in white-tailed deer, mule deer, and pronghorn winter ranges, whooping crane potential suitable habitat, Sprague's pipit habitat, and within both sage grouse and sharp-tailed grouse habitat. Potential impacts to these resources would be reduced under this alternative. The parcels proposed for deferral overlap with the range of eleven BLM sensitive/special status aquatic species (pallid sturgeon, paddle fish, blue sucker, sturgeon chub, sauger, pearl dace, snapping turtle, spiny softshell, northern leopard frog, plains spadefoot and great plains toad). If deferred, this alternative would reduce the impacts to these BLM sensitive aquatic species' habitat.

4.4.9.2 Mitigation
Mitigation would be the same as Alternative B.

4.4.10 Cultural
4.4.10.1 Direct and Indirect Effects
Impacts would be similar to those disclosed in Alternative B; however, the area impacted would be reduced by 82%, due to these lease parcels proposed for deferral pending further review. Specifically, potential effects would not occur on the 16 whole or partial lease parcels consisting of 6,549 acres proposed for deferral. The new analyses for parcels to be leased are as follows below.

Based on modeling, all or portions of four lease parcels (MTM 105431-HF (120 acres); MTM 105431-HG (160 acres); MTM 105431-HH (80 acres); MTM 105431-HJ (317 acres)), in Powder River County (677 acres) might contain 8 cultural sites of which one to two could have the potential to be eligible or considered eligible for listing on the National Register of Historic Places.

Based on modeling, all or portions of two lease parcels (MTM 102757-WT (319 acres); MTM 102757-WW (361 acres)), in Prairie County (680 acres) might contain up to 8 cultural sites of which one to two could have the potential to be eligible or considered eligible for listing on the National Register of Historic Places.

Based on modeling, a portion of one lease parcel (MTM 105431-H9 (40 acres)) located in Roosevelt County (40 acres) might contain one cultural site which could have potential to be eligible or considered eligible for listing on the National Register of Historic Places.

Leasing the 1,397 acres of federal minerals within the above Counties could directly or indirectly affect 15 cultural sites with 1 to 3 sites having the potential to be eligible or considered eligible for listing on the National Register of Historic Places.

The Reasonable Foreseeable Development (RFD and Appendix D) scenario for the lease parcels is the same as Alternative B.

4.4.10.2 Mitigation
Mitigation would be the same as Alternative B where the application of standard lease terms, stipulations, and cultural lease notices provide mechanisms to protect vulnerable significant cultural resource values on these lease parcels (Appendix A). Lease notice LN 14-2 would be applied to 1 lease parcel (MTM 105431-H9).

4.4.11 Native American Religious Concerns
4.4.11.1 Direct and Indirect Effects
Direct and indirect impacts would be the same as Alternative B. Areas potentially impacted would be reduced by approximately 82 % due to 6,549 acres being deferred pending further analysis. The deferred parcels include Parcel MTM 105431-H9 which contains the three stone circle sites mentioned in Chapter 3.

4.4.11.2 Mitigation
If the parcels are leased, mitigation would be the same as Alternative B.

4.4.12 Paleontology
4.4.12.1 Direct and Indirect Effects
Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced by 82 percent, due to approximately 6,549 acres of lease parcels proposed for deferral pending further review. Specifically, effects would not occur on the lease parcels in whole or part proposed for deferral.

4.4.12.2 Mitigation
Mitigation would be the same as Alternative B, except the recommendation to apply Paleontological lease notice 14-12 would only apply to 2 whole leases and portions of 5 others because lease parcels in whole or part are proposed for deferral.

4.4.13 Visual Resources
4.4.13.1 Direct and Indirect Effects
Under this alternative, 2 whole and 5 partial parcels that include 1,396.87 surveyed surface acres of which 680 acres are BLM administered surface and 716.87 acres are non-federal surface would be offered for lease.

Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced, due to approximately 6,549.15 surface acres of 11 whole and 5 partial lease parcels being proposed for deferral, pending further review. The parcels or portions of parcels proposed for deferral consist of 2,958.73 BLM administered surface acres and 3,590.42 non-federal surface acres.

There are no areas located within a VRM Class II management objective.

4.4.13.2 Mitigation
Mitigation would be the same as Alternative B.

4.4.14 Forest and Woodland Resources

4.4.14.1 Direct and Indirect Effects

Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced substantially, due to approximately 6,549 acres of lease parcels proposed for deferral pending further review. Under this alternative, acreage potentially impacted would be approximately 10 acres of riparian woodland.

4.4.14.2 Mitigation

Mitigation would be the same as Alternative B.

4.4.15 Livestock Grazing

4.4.15.1 Direct and Indirect Effects

Direct and indirect impacts would be the same as Alternative B. The deferred parcels pending further review do not have grazing authorizations.

4.4.15.2 Mitigation

Mitigation would be the same as Alternative B.

4.4.16 Recreation and Travel Management

4.4.16.1 Direct and Indirect Effects

Under this alternative, 2 whole and 5 partial parcels that include 1,396.87 surveyed surface acres of which 680 acres are BLM administered surface and 716.87 acres are non-federal surface would be offered for lease.

Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced, due to approximately 6,549.15 surface acres of 11 whole and 5 partial lease parcels being proposed for deferral, pending further review. The parcels or portions of parcels proposed for deferral consist of 2,958.73 BLM administered surface acres and 3,590.42 non-federal surface acres.

There are no Special Recreation Management Areas or current Travel Management Areas within any of the proposed leased areas or deferred areas.

4.4.16.2 Mitigation

Mitigation would be the same as Alternative B.

4.4.17 Lands and Realty

4.4.17.1 Direct and Indirect Effects

Under this alternative, 2 whole and 5 partial parcels that include 1,396.87 surveyed surface acres of which 680 acres are BLM administered surface and 716.87 acres are non-federal surface would be offered for lease.

Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced, due to approximately 6,549.15 surface acres of 11 whole and 5 partial lease parcels being proposed for deferral, pending further review. The parcels or portions of parcels proposed for deferral consist of 2,958.73 BLM administered surface acres and 3,590.42 non-federal surface acres.

Based on the Master Title plats and LR2000 reports, parcel MTM-102757-WT would be affected by authorized BLM ROWs on BLM administered surface.

4.4.17.2 Mitigation

Measures would be taken to avoid disturbance to or impacts to existing rights-of-way, in the event of any oil and gas exploration and development activities. Any new "off-lease" or third party rights-of-way required across federal surface for exploration and/or development of the 18 parcels would be subject to lands and realty stipulations to protect other resources as determined by environmental analyses. In order to protect the existing rights-of-way it is recommended that LN 14-1 be applied to lease parcel MTM-102757-WT.

4.4.18 Minerals

4.4.18.1 Fluid Minerals

4. 4.18.1.1 Direct and Indirect Effects

Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced by 82%, due to approximately 6,549.15 acres of lease parcels proposed for deferral pending further review. The remaining 11 whole and 5 partial lease parcels would be offered for lease subject to major (NSO) or moderate (CSU) constraints and/or standard lease terms and conditions.

Deferring lease parcels would result in delays of some development plans, relocation of development to state or private leases, or completely eliminate development plans because of the need to include federal acreage as part of a plan. In addition, less natural gas or crude oil would enter the public markets.

4.4.19 Special Designations

4.4.19.1 Direct and Indirect Effects

Under this alternative, 2 whole parcels and parts of 5 would be offered for lease. Totaling 1,397 surveyed surface acres of which are 680 BLM administered surface and 717 acres of non-federal surface.

Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced to 17.6% of Alternative B acres (1,397 acres) due to approximately 6,548 surface acres of all or portions of 16 lease parcels being proposed for deferral, pending further review. The parcels or portions of parcels proposed for deferral consist of 2,958 BLM administered surface acres and 3,590 non-federal surface acres.

There are no Lease parcels, located within the 3 mile sensitive Setting Consideration Zone (SCZ) around the Lewis and Clark National Historic Trail Corridor.

4.4.19.2 Mitigation

Since no parcels would be offered, under Alterative C that would be in the Lewis and Clark NHT no mitigation measures would be necessary.

4.4.20 Social and Economic Conditions

4.4.20.1 Social

4.4.20.1.1 Direct and Indirect Effects

Direct and indirect impacts would be the same as Alternative B; however, the area potentially impacted would be reduced by less than 82%, due to the deferral of 6,549.15 acres of lease parcels in McCone, Richland, Roosevelt, Prairie, and Powder River Counties.

4.4.20.2 Economics

4.4.20.2.1 Direct and Indirect Impacts

Economic impacts associated with Alternative C would be very similar to those described for Alternative B. Under this alternative, leasing an additional 1,397 acres of federal minerals could increase average annual oil and gas leasing and rent revenues to the federal government by an estimated $6,000. Average annual leasing and rent revenues that could be distributed to the state government could increase by an estimated $3,000. Average annual federal oil and gas royalties would increase by an estimated $36,000. Average annual royalties distributed to the state could increase by an estimated $17,000 and revenue distributed to the five counties could increase by $5,000.

Total average annual federal revenues and associated annual rent and royalty revenues related to average annual production of federal minerals could amount to an estimated $42,000. Total average annual revenues from leasing, rent, and royalties distributed to the state could be an estimated $20,000. Total estimated revenues distributed to the counties could be about $5,000.

The estimated combined total average annual employment and income supported by additional federal oil and gas leasing, distributions of royalties to local governments, drilling wells, and production would amount to no change in employment and an additional $12,000 labor income within the local economy (IMPLAN, 2014).

The annual SCC associated with Alternative C oil and gas development is $6,769 (in 2011 dollars). As noted earlier, the estimated SCC is not directly comparable to economic contributions.

Total federal contribution under Alternative C and anticipated related exploration, development, and production of oil and gas could cause local employment and labor income to be very similar to impacts expected from Alternative B.

4.4.21 Cumulative Impacts- Alternative C

Direct and indirect impacts would be similar to Alternative B. Under this alternative, the cumulative effects of federal mineral leasing within the local economy as well as the specific effects of leasing an additional 1,397 acres are summarized in Table 15 and Table 16. These tables also display in comparative form the cumulative effects of alternatives A, B, and C.

4.4.21.1 Past, Present and Reasonably Foreseeable Future Actions

Past, present, or reasonably foreseeable future actions that affect the same components of the environment as the Proposed Action are: grazing, roads, wildfire and prescribed fire, range improvement projects, and utility right-of-ways.

4.4.21.2 Cumulative Impacts by Resource

Cumulative effects for all resources in the MCFO are described in the final Big Dry RMP/EIS (pgs. 111 to 156) and the 1992 Oil and Gas Amendment of the Billings, Powder River, and South Dakota Resource Management Plans and Final Environmental Impact Statement and the 1994 Record of Decision and the 2008 Final Supplement to the Montana Statewide Oil and Gas Environmental Impact with a development alternative for coal bed natural gas production (4-1 to 4-310). Anticipated exploration and development activity associated with the lease parcels considered in this EA are within the range of assumptions used and effects described in this cumulative effects analysis for resources other than climate, wildlife, and economics resources.

4.4.21.3 Greenhouse Gas Emissions and Cumulative Impacts on Climate Change

CO_2e emissions are estimated to be 690 metric tons/year less than Alternative B.

4.4.21.4 Cumulative Impacts of Climate Change

Due to the slight decrease in CO_2e emissions under Alternative C, cumulative climate change impacts on resources would be slightly less than those for Alternative B.

4.4.21.5 Cumulative Impacts to Wildlife & Fisheries/Aquatics

Cumulative impacts would be the same as Alternative B; however, the area potentially impacted would be reduced by 11 whole parcels and portions of 5 other parcels pending further review. If the remaining lease parcels are developed, potential additional cumulative impacts to wildlife would occur over less area than what is described in Alternative B.

4.4.21.6 Cumulative Impacts to Economic Conditions:

Direct and indirect impacts would be similar to Alternative B. Under this alternative, the cumulative effects of federal mineral leasing within the local economy as well as the specific effects of leasing an additional 1,397 acres are summarized in Table 15 and Table 16. These tables also display in comparative form the cumulative effects of alternatives A, B, and C.

5.0 CONSULTATION AND COORDINATION

5.1 Persons, Agencies, and Organizations Consulted

Coordination with MFWP was conducted for the 18 lease parcels being reviewed and in the completion of this EA in order to prepare the analysis, identify protective measures, and apply stipulations and lease notices associated with these parcels being analyzed. Recommendations by the USFWS applied in previous lease sale EAs were also applied to the 18 lease parcels being reviewed. A letter was sent to the USFWS and MFWP during the 15-day scoping and 30-day public comment periods requesting comments on the 18 parcels being reviewed.

The BLM consults with Native Americans under Section 106 of the National Historic Preservation Act. The BLM sent letters to tribes in Montana, North and South Dakota and Wyoming at the beginning of the 15 day scoping period informing them of the potential for the 18 parcels to be leased and inviting them to submit issues and concerns BLM should consider in the environmental analysis. Letters were sent to the Tribal Presidents and THPO or other cultural contacts for the Cheyenne River Sioux Tribe, Crow Tribe of Montana, Crow Creek Sioux Tribe, Eastern Shoshone Tribe, Ft. Peck Tribes, Lower Brule Sioux Tribe, the Mandan, Hidasta, and Arkira Nation, Northern Arapaho Nation, Northern Cheyenne Tribe, Oglala Sioux Tribe, Rosebud Sioux Tribe of Indians, Standing Rock Sioux Tribe, and Turtle Mountain Band of Chippewa. In addition to scoping letters, THPOs also received file search results from the preliminary review of parcels conducted by BLM. The BLM sent a second letter with a copy of the EA to the tribes informing them about the 30 day public comment period for the EA and solicit any information BLM should consider before making a decision whether to offer any or all of the 18 parcels for sale.

5.2 Summary of Public Participation

5.2.1 Scoping

Public scoping for this project was conducted through a 15-day scoping period advertised on the BLM Montana State Office website and posting on the field office website NEPA notification log. Scoping was initiated March 25, 2014. Montana Fish Wildlife and Parks (MFWP) submitted comments on the October 2014 lease sale.

MFWP recommended applying a 1/4 mile buffer along the parcels along Schoolhouse Coulee, Renz Creek, and the tributary to Two-mile creek in parcels MTM 105431-HB and MTM 105431-H8. In review, the BLM have already applied a No Surface Occupancy (NSO 11-2) for parcel MTM 105431 HB where Schoolhouse Coulee and Renz Creek occur. The Big Dry RMP does not have a stipulation for a ¼ mile buffer along tributaries of waterways. After reviewing nominated lease parcel MTM 105431-H8, it is determined that the No Surface Occupancy stipulation for waterbodies, floodpains, and riparian areas should not be applied. Two-mile Creek does run through the parcel, but according to the best available information, it is ephemeral at this location and appears to lack defined channel. If this lease was to be developed and sensitive resources were identified at the proposed well location, BLM would use its regulatory authority to move the proposed well location up to 660 feet in order to protect sensitive resources.

MFWP recommend applying timing limitation 13-1 for big game winter ranges. In review, the BLM have already applied this timing stipulation to the necessary parcels. MFWP recommend surveys for sharp-tailed grouse leks and sage grouse leks to occur prior to development of some of the parcels. The Big Dry RMP or Powder River RMP does not have a stipulation for pre-development surveys for sage grouse or sharp-tailed grouse. However, in some cases where necessary, the BLM has had required companies to conduct these surveys prior to authorizing development at the Application for Permit to Drill (APD) stage before development. Recent inventories for sage grouse leks have not been conducted within some of the parcels. If the leases were to be developed, inventories would be conducted if the leases were to be developed at the APD stage of development to determine the presence or absence of sage grouse leks. Similarly, recent inventories of sharp-tailed grouse dancing grounds have not been conducted within some of the parcels. Thus, inventories would be conducted prior to development at the APD stage before development to determine the presence or absence of sharp-tailed grouse dancing grounds.

5.3 List of Preparers

Table 20. List of Preparers

Name	**Title**	**Responsible for the Following Section(s) of this Document**
Susan Bassett	Air Specialist	Air Resources
Bobby Baker	Wildlife Biologist	Wildlife
Chris Robinson	Hydrologist	Water Resources/Riparian Vegetation
Will Hubbell	Archaeologist	Cultural/Special Designations
Josh Halpin	Range Management Specialist	Soils
Shane Findlay	Supervisory Land Use Specialist	Recreation/VRM/Travel Management
Russell Slatton	Natural Resource Specialist	GIS
Kirk Anderson	Rangeland Management Specialist	Livestock Grazing/Vegetation/Invasive Species
Doug Melton	Archeologist	Native American Religious Concerns
Greg Liggitt	Paleontologist	Paleontology
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Paul Helland	Petroleum Engineer	Fluid Minerals/RFD
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Kathy Bockness	Planning & Environmental Coordinator	NEPA
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Jennifer Dobbs	Economist	Economic Analysis
Samantha Iron Shirt	Legal Land Examiner-Sale Lead	Expressions of Interest/Lease Sale

In addition to the primary preparers listed above, the following individuals provided document review:

Todd Yeager	Field Manager
Diane Friez	District Manager

6.0 REFERENCES

50 CFR Part 17 [Docket No. FWS–R6–ES–2009–0081] [MO 92210-0-0008]

Aaberg, S.A., R. Hanna, C. Crofutt, J. Green, and M. Vischer. 2006. Miles City Resource Management Plan (RMP) and Environmental Impact Statement (EIS) Class I Overview of Paleontological & Cultural Resources in Eastern Montana (March 2006). Prepared by Aaberg Cultural Resource Consulting Service under subcontract to ALL Consulting and prepared for the United States Department of the Interior, Bureau of Land Management, Miles City Field Office. March 2006, Billings, MT.

Adair, Ann and Scott Rickard, 2005 "The Economic and Fiscal Impacts of Montana's Petroleum and Natural Gas Industry in 2003", Montana State University-Billings, Center for Applied Research.

All census data: http://quickfacts.census.gov/qfd/index.html 10/20/2010

Arno, Stephen F. and George E. Gruell. 1983. Fire history at the forest grassland ecotone in southwestern Montana. Journal of Range Management. 36(3): 332-336.

Bainbridge, DA. 2007. A Guide for Dryland Restoration: New Hope for Arid Lands. Island Press. Washington, DC.

Bald Eagle Protection Act of 1940 (16 U.S.C. 668-668d, 54 Stat. 250) as amended -- Approved June 8, 1940, and amended by P.L 86-70 (73 Stat. 143) June 25, 1959; P.L. 87-884 (76 Stat. 1346) October 24, 1962; P.L. 92-535 (86 Stat. 1064) October 23, 1972; and P.L. 95-616 (92 Stat. 3114) November 8, 1978.

Barton, B. and S. Crispin. 2003. Globally Significant Plants in Southeastern Big Horn and Southwestern Rosebud Counties, Montana. Montana Natural Heritage Program, Helena, MT. 27pp. + app.

Berger, K.M., J.P. Beckmann, and J. Berger. 2007. Wildlife and Energy Development: Pronghorn of the Upper Green River Basin – Year 2 Summary. Wildlife Conservation Society, Bronx, NY.

BLM Annual Report, 2008, Federal Oil and Gas Leases Issued in FY2008

BLM Annual Report, 2008, Federal Total Reported Royalty Revenues

BLM Federal Land Status Records (LSR), 2012, Montana Master Title Plats (MTPs), October 1, 2012

BLM LR2000, 2010, Authorized Leases/Leases Held by Production, April 4, 2011

BLM LR2000, 2012, Authorized Rights-of-Way, October 1, 2012.

Bramblett, R.G., T.R. Johnson, A.V. Zale, and D.G. Heggem. 2005. Development and evaluation of a fish assemblage index of biotic integrity for Northwestern Great Plains streams. Transactions of the American Fisheries Society. 134: 624-640.

Braun, C.E., O.O. Oedekoven, and C.L. Aldridge. 2002. Oil and gas development in western North America: effects on sagebrush steppe avifauna with particular emphasis on sage grouse. Transactions of the North American Wildlife and Natural Resources Conference 67:337-349

Bureau of Land Management. 1998. Areas of Critical Environmental Concern Environmental Assessment and Proposed Amendment of the Billings, Powder River and South Dakota Resource Management Plans. August 1998. Bureau of Land Management, Miles City Field Office. Miles City, MT.

Canadian Wildlife Service and U.S. Fish and Wildlife Service. 2007. International recovery plan for the whooping crane. Ottawa: Recovery of Nationally Endangered Wildlife (RENEW), andU.S. Fish and Wildlife Service, Albuquerque, New Mexico. 162 pp. http://ecos.fws.gov/docs/recovery_plan/070604_v4.pdf

CAPS, 2010. Montana, Fish, Wildlife and Parks Crucial Area Planning System. http://fwp.mt.gov/gis/maps/caps/

Carlson, J. C. and S. V. Cooper. 2003. Plant and Animal resources and Ecological Condition of the Forks Ranch Unit of the Padlock Ranch, Big Horn County, Montana and Sheridan County, Wyoming. Report to the Padlock Ranch and Montana BLM. Montana Natural Heritage Program, Helena, MT. 27pp. + app.

Center for Climate Strategies (CCS). 2007. Montana Greenhouse Gas Inventory and Reference Case Projections 1990-2020. Center for Climate Stragies and Montana Department of Environmental Quality. September 2007.

Clark, Lance R. and R. Neil Sampson. 1995. Forest Ecosystem Health in the Inland West: A Science and Policy Reader. Forest Policy Center, American Forests.

Climate Change SIR. 2010. Climate Change Supplementary Information Report for Montana, North Dakota, and South Dakota, Bureau of Land Management. Report on Greenhouse Gas Emissions and Climate Change for Montana, North Dakota, and South Dakota. Technical report prepared for the Montana/Dakotas Bureau of Land Management by URS Corporation. URS Project 22241790.

Coates, Ladd. 2005. Personal communication with Ladd Coates, Miles City Field Office Outdoor Recreation Planner, on recreation in the Miles City Field Office area. January, 27, 2005.

Cymore, J. 2011. Personal communication with Martin Miller, Data Assistant, Montana Natural Heritage Program (MTNHP) 9/28/2011.

Division, Annual Review 2000-2008County Drilling and Production Statistics

Dodds, W.K., K. Gido, M.R. Whiles, K.M. Fritz, and W.J. Matthews.

EIA, 2010. Energy Information Administration, Montana Quick Facts, 6/3/2010

EPA, 2004 Study to Evaluate the Impacts to USDWs by Hydraulic Fracturing of Coalbed Methane Reservoirs http://www.epa.gov/safewater/uic/wells_coalbedmethanestudy.html accessed 5/26/10.

EPA, 2008. http://www.epa.gov/Region8/climatechange/pdf/ClimateChange101FINAL.pdf

EPA. 2013a. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2011. EPA 430-R-13-001. April 13. http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html.

EPA. 2013b. AirData Website (http://www.epa.gov/airdata/). Accessed December 13.

EPA. 2014. The Social Cost of Carbon Website. (http://www.epa.gov/climatechange/EPAactivities/economics/scc.html). Accessed April 4, 2014.

Eubanks, Ellen. 2004. Riparian Restoration. 0423 1201P. San Dimas, CA: U.S. Department of Agriculture, Forest Service, San Dimas Technology and Development Center. 137 p. http://www.fs.fed.us/t-d/php/library_card.php?p_num=0423%201201P

Federal Register: September 15, 2010 (Volume 75, Number 178)]

Foresman, K.R. 2001. The Wild Mammals of Montana. Special publication No 12. American Society of Mammalogists. Lawrence, KS.: Allen Press.

Friesen, Nathan. 2010. E-mail dated 10/06/2010 from Nathan Friesen of the Heritage Resources Branch of Saskatchewan Tourism, Parks, Culture and Sport to Mark Sant, BLM Montana State Office concerning Montana Oil and Gas lease near the Canadian Border.

Hamlin, K.L. 1978. Population ecology and habitat relationships of mule deer and white-tailed deer in the prairie agricultural habitats of eastern Montana. Montana Deer Studies. Montana Department of Fish, Wildlife and Parks, Project W-120-R-10, Job Progress Report.

Hanebury, L. 2010. Personal communication. Fish and Wildlife Biologist, USFWS, March 11, 2010.

Hansen, P.L., W. H. Thompson, J. G. Massey, and M. Thompson. 2008. Classification and management of upland, riparian, and wetland sites of USDI Bureau of Land Management's Miles City Field Office, Eastern Montana, USA. Prepared for the Miles City Field Office by Ecological Solutions Group, LLC. Stevensville, MT.

Holloran, M.J. 2005. Greater Sage Grouse (Centrocercus urophasianus) population response to natural gas field development in westernWyoming. Dissertation, University of Wyoming, Laramie, USA.

Holloran, M.J. and S.H. Anderson. 2005a. Greater sage-grouse population response to natural gas development in western Wyoming: are regional populations affected by relatively localized disturbances? In Wildlife Management Institute (Ed.), *Transactions from the 70th North American Wildlife and Natural Resources Conference* (March 16–19, 2005, Arlington, VA). Wildlife Management Institute.

Holloran, M. J, and S. H. Anderson. 2005b. Spatial Distribution of Greater Sage-Grouse nests in Relatively Contiguous Sagebrush Habitats. *The Condor,* 107:742–752.

Hufstetler, Mark, Mitizi Rossillon, Dale Martin, and Alice Emerson. 1992. Draft National Register of Historic Places, Multiple Properties Form: Archaeological and Historic Resources of Sheridan County, Montana. Form prepared for the Montana State Historic Preservation Office, Helena by Renewable Technologies, Inc., Butte, MT.

IMPLAN,2010. Minnesota IMPLAN Group 2010

IMPROVE. 2011. Spatial and Seasonal Patterns and Temporal Variability of Haze and its Constituents in the United States: Report V. Interagency Monitoring of Protected Visual Environments. June.

Independent Petroleum Association of America, Oil and Gas Producing Industry in Your State, pg.70-71.

Ingelfinger, F. 2001. The Effects of Natural Gas Development on Sagebrush Steppe Passerines in Sublette County, Wyoming. Thesis. University of WY, Laramie, Wyoming.

IPPC. 2007. IPCC Fourth Assessment Report: Climate Change 2007 (AR4). Intergovernmental Panel on Climate Change (IPCC).

IPCC, 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Kordecki, Cynthia., McCormick, Mary., Jackson, Carrie F., and Jennifer Bales. April 2000, *Lower Yellowstone Irrigation Project, 1996 and 1997 Cultural Resources Inventory, Dawson and Richland Counties, Montana and McKenzie County, North Dakota.* University of North Dakota, Department of Anthropology, Grand Forks North Dakota.

Lenard, S., J. Carlson, J. Ellis, C. Jones, and C. Tilly. 2003. P.D. Skaar's Montana Bird Distribution, 6th Edition. Montana Audubon, Helena, Montana.

Levick, L., J. Fonseca, D. Goodrich, M. Hernandez, D. Semmens, J. Stromberg, R. Leidy, M. Scianni, D. P. Guertin, M. Tluczek, and W. Kepner. 2008. The Ecological and Hydrological Significance of Ephemeral and Intermittent Streams in the Arid and Semi-arid American Southwest. U.S. Environmental Protection Agency and USDA/ARS Southwest Watershed Research Center, EPA/600/R-08/134, ARS/233046, 116 pp. http://azriparian.org/docs/arc/publications/EphemeralStreamsReport.pdf accessed 7/22/10.

Life on the edge: The ecology of Great Plains prairie streams. 2004. *BioScience*, 54(3): 205 – 216.

Logan R. 2001. Water Quality BMPs for Montana Forests. Montana State University Extension Service. Bozeman, MT.

MacDonald, Douglas. 2012 *Montana before History: 11,000 Years of Hunter-Gatherers in the Rockies and Plains.* Mountain Press, Missoula.

Mackie, R.J., D. Pac, K. Hamlin, and G. Dusek. 1998. Ecology and Management of Mule Deer and White-tailed Deer in Montana. Fed. Aid in Wildlife Restor. Proj. W-120-R. Mont. Dept. Fish, Wildl. And Parks, Helena. 180 pgs.

Maley T.S., 1979, Handbook of Mineral Law: M.M.R.C. Publications, Boise, Idaho, 2nd ed.

MFWP 2010. Montana Fish, Wildlife and Parks, Fisheries Information System http://fwp.mt.gov/fishing/mFish/

Montana Bird Distribution Committee. 2012. Skaar's Montana Bird Distribution, 7th Edition. Montana Audubon, Helena, Montana 208 pp + foldout map.

Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712; Ch. 128; July 13, 1918; 40 Stat. 755) as amended by: Chapter 634; June 20, 1936; 49 Stat. 1556; P.L. 86-732; September 8, 1960; 74 Stat. 866; P.L. 90-578; October 17, 1968; 82 Stat. 1118; P.L. 91-135; December 5, 1969; 83 Stat. 282; P.L. 93-300; June 1, 1974; 88 Stat. 190; P.L. 95-616; November 8, 1978; 92 Stat. 3111; P.L. 99-645; November 10, 1986; 100 Stat. 3590 and P.L. 105-312; October 30, 1998; 112 Stat. 2956.

Montana Department of Natural Resources and Conservation, Oil and Gas Conservation

Montana Department of Natural Resources and Conservation, Oil and Gas Conservation Division, Annual Review 2000-2009County Drilling and Production Statistics

Montana Department of Revenue, Van Charlton, 2009

Montana Field Guide, 2010. Montana Plants Field Guide (http://fieldguide.mt.gov, 9 November 2010).

Montana Natural Heritage Program, Montana State Library, Helena, Montana. 2010.

Montana Natural Heritage Program. Natural Heritage Tracker Program. Retrieved on March 17, 2014 from http://mtnhp.org/Tracker/NHTMap.aspx.

Montana natural Heritage Program. Natural Heritage Map Viewer. Retrieved on March 17, 2014 from http://mtnhp.org/mapviewer/

Perrow, MR and AJ Davy. 2003. Handbook of Ecological Restoration: Vol. 1 Principles of Restoration. Cambridge University Press. New York, NY.

Peterson L. and S. Deaver. 2002. An Ethnographic Overview of Southeast Montana, February 2001. Prepared for the BLM State Office, Billings, MT.

Prichard, D., et al. 1993, Revised 1995. Riparian Area Management. Process for Assessing Proper Functioning Condition. U.S. Department of the Interior Bureau of Land Management. Technical Reference 1737-9. 51 pp. ftp://ftp.blm.gov/pub/nstc/techrefs/Final%20TR%201737-7.pdf

Ramseur, J.L. 2007. State greenhouse gas emissions: Comparison and analysis. Congressional Research Service Report RL34272 for Congress. December 5, 2007.

Sawyer, H., R. Nielson, D. Strickland, and L. McDonald. 2005. Annual Report. Sublette Mule Deer Study(Phase II): Long-term monitoring plan to assess potential impacts of energy development on mule deer in the Pinedale Anticline Project Area. Western Ecosystems Technology, Inc. Cheyenne, WY.

Smeins, F. E. and S. D. Fuhlendorf. 1997. Biology and ecology of Ashe juniper. *In:* Juniper Symposium Proceedings. Texas A&M University, College Station, Texas, USA.

Socioeconomic Baseline Report for the Miles City Field Office RMP & EIS Planning Effort prepared for the DOI, BLM, Miles City Field Office, June 2005.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [9/25/2013].

Source Water Protection Program. 2002. Source Water Delineation and Assessment Report – Town of Culbertson Public Water System PWSID #MT0000192. Helena, MT: Montana Department of Environmental Quality.

Source Water Protection Program. 2003. Source Water Delineation and Assessment Report – Montana Dakota Utilities Company Public Water Supply PWSID #MT0003326. Helena, MT: Montana Department of Environmental Quality.

State of Montana, Census and Economic Information Center, 2010 Census Data, 2011

Tack, J.D. 2010. Sage Grouse and the Human Footprint: Implications for Conservation of Small and Declining Populations. Thesis. University of Montana, Missoula, MT. USA.

U. S. Fish and Wildlife Service. 2010. Black-footed ferret website http://www.fws.gov/mountain-prairie/species/mammals/blackfootedferret/

U. S. Fish and Wildlife Service. 2012. Threatened, Endangered, or Candidate Species list by county (http://www.fws.gov/montanafieldoffice/Endangered_Species/Listed_Species.html)

U.S. Fish and Wildlife Service (USFWS) 2010. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. FWS/OBS-79/31. http://www.fws.gov/wetlands/ USGS 2009. National Hydrography Dataset (NHD). http://nhd.usgs.gov/ accessed 11/2009.

U.S. Fish and Wildlife Service (USFWS) 2010. Pallid Sturgeon species description and ESA status and review. http://www.fws.gov/mountain-prairie/missouririver/moriver_pallidsturgeon.htm

U.S. Fish and Wildlife Service. 1989. Black footed ferret survey guidelines for compliance with the Endangered Species Act. 15 pgs.

U.S. Fish and Wildlife Service. 2002. Endangered and Threatened Wildlife and Plants;Designation of Critical Habitat for the Northern Great Plains Breeding Population of the Piping Plover; Final Rule5 0 CFR Part 17. 57638 Federal Register / Vol. 67, No. 176. http://www.fws.gov/mountain-prairie/species/birds/pipingplover/.

U.S. Fish and Wildlife Service. 2010. Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition to List Sprague's Pipit as Endangered or Threatened throughout Its Range.

US Census Bureau, Montana 2010

USDA, NRCS. 2010. The PLANTS Database. National Plant Data Center, Baton Rouge, LA 70874-4490 USA. (http://plants.usda.gov, 9 November 2010)

USDI (United States Department of the Interior) and USDA (United States Department of Agriculture). 2007. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development. BLM/WO/ST-06/021+3071/REV 07. Bureau of Land Management. Denver, Colorado. 84 pp.

USDI (United States Department of the Interior) and USDA (United States Department of Agriculture). 2007. Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development. BLM/WO/ST-06/021+3071/REV 07. Bureau of Land Management. Denver, Colorado. 84 pp.

USDI BLM November 1982, Heffern E.L., Cormier G.P., Hansen D., Geology, Minerals and Paleontology of the Powder River Resource Area Southeastern Montana, Regional Paper.

USDI BLM. 2009. Instruction Memorandum No. MT-2009-039. 2009 Montana/Dakota's Special Status Species List.

USDI Bureau of Land Management. 1984. Powder River Resource Area Resource Management Plan/Environmental Impact Statement for the Powder River Resource Area of the Miles City District. Final. U.S. Department of the Interior, Bureau of Land Management.

USDI Bureau of Land Management. 1992. *Final Oil and Gas RMP/EIS Amendment for the Billings, Powder River and South Dakota Resource Areas.* U.S. Department of the Interior, Bureau of Land Management, Miles City District.

USDI BLM. 2008. Final Supplement to the Montana Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans. U.S. Department of the Interior, Bureau of Land Management, Miles City Field Office. MT

USDI Bureau of Land Management. 1995. Big Dry Resource Management Plan/Environmental Impact Statement for the Big Dry Resource Area of the Miles City District. Final. U.S. Department of the Interior, Bureau of Land Management.

USDI Bureau of Land Management. 2011. Instruction Memorandum No. 2012-043. Greater Sage Grouse Interim Management Policies and Procedures

USEPA. 2010. Knowledge Building Series: Climate Change 101. EPA Climate Change Information, USEPA Region 8.

Walker, B. L., D, E. Naugle, K.E. Doherty. 2007. Greater Sage Grouse Population Response to Energy Development and Habitat Loss. Journal of Wildlife Managment 71(8):2644-2654; 2007)

Watershed Protection Section. 2012. Montana Nonpoint Source Management Plan. Helena, MT: Montana Department of Environmental Quality.

Werner, J. K., B.A. Maxwell, P. Hendricks, D.L. Flath. 2004. Amphibians and Reptiles of Montana. Missoula, MT.: Mountain Press Publishing Company.

Wheaton et al. 2008. Wheaton, J.J., Reddish-Kuzara, S., Meredith, E., Donato, T. A. , 2007 Annual coalbed methane regional ground-water monitoring report: Northern portion of thePowder River Basin, Montana Bureau of Mines and Geology: Open-File Report 576, 99 p., 6 sheet(s).

Wildlife Survey Protocol For Coal Bed Natural Gas Development, Powder River Basin Wildlife Taskforce. 2005. 41pgs.

Youmans, H.B. and Swenson, J.E. 1982. Winter distribution of habitat use by mule deer and white-tailed deer in southeastern Montana. Appendix to Big Game Survey and Inventory (Deer).

Zelt et al. 1999 Environmental Setting of the Yellowstone River Basin, Montana, North Dakota, and Wyoming, Water-Resources Investigations Report 98-4269 http://pubs.usgs.gov/wri/wri984269/ accessed 7/15/10.

7.0 DEFINITIONS

The North American Industry Classification System (NAICS) is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was developed under the auspices of the Office of Management and Budget (OMB), and adopted in 1997 to replace the Standard Industrial Classification (SIC) system and to allow for a high level of comparability in business statistics among the North American countries.

IMPLAN: The IMPLAN Model is the most flexible, detailed and widely used input-output impact model system in the U.S. It provides users with the ability to define industries, economic relationships and projects to be analyzed. It can be customized for any county, region or state, and used to assess "multiplier effects" caused by increasing or decreasing spending in various parts of the economy. This can be used to assess the economic impacts of resource management decisions, facilities, industries, or changes in their level of activity in a given area. The current IMPLAN input-output database and model is maintained and sold by MIG, Inc. (Minnesota IMPLAN Group). The 2007 data set was used in this analysis is.

PARCEL NUMBER	PARCEL DESCRIPTION	PROPOSED FOR LEASING ALTERNATIVE B	PROPOSED FOR LEASING IF EA INCLUDES ALTERNATIVE C	PROPOSED FOR DEFERRAL-NO LEASING
MTM 102757-WT	T. 13 N, R. 45 E, PMM, MT SEC. 18 LOTS 1,2; SEC. 18 NE,E2NW; SEC. 20 ALL; PRAIRIE COUNTY 961.22 AC ACQ	**CR 16-1** (ALL LANDS) **LN-14-1** SEC. 18 W2NE; **LN 14-11** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN 14-15** (ALL LANDS) **NSO 11-2** SEC. 20 E2E2; **NSO 11-8** SEC. 18 LOT 2; SEC. 18 S2NE,SENW; SEC. 20 NWNW; **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** SEC. 18 LOTS 1,2; SEC. 18 NE,E2NW; SEC. 20 N2,NESW,N2SE,SESE;	T. 13 N, R. 45 E, PMM, MT SEC. 18 LOTS 1,2; SEC. 18 NE,E2NW; SEC. 20 SENE;	T. 13 N, R. 45 E, PMM, MT SEC. 20 NENE,W2NE,NW,S2; PRAIRIE COUNTY Pending further review of sensitive soil areas being analyzed in the current MCFO RMP planning effort.

PARCEL NUMBER	PARCEL DESCRIPTION	PROPOSED FOR LEASING ALTERNATIVE B	PROPOSED FOR LEASING IF EA INCLUDES ALTERNATIVE C	PROPOSED FOR DEFERRAL-NO LEASING
MTM 102757-WW	T. 14 N, R. 45 E, PMM, MT SEC. 2 LOTS 3,4; SEC. 2 S2NW,SW; SEC. 4 LOTS 1-4; SEC. 4 S2N2,S2; PRAIRIE COUNTY 958.02 AC ACQ	**CR 16-1** (ALL LANDS **LN 14-11** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN 14-15** (ALL LANDS) **NSO 11-2** SEC. 4 LOTS 1-3; SEC. 4 S2NE,SWNW,W2SW,SE; **NSO 11-4** SEC. 4 SWNE, S2NW, N2SW, SESW,W2SE; **TES 16-2** (ALL LANDS) **TL 13-1** SEC. 2 LOT 4; SEC 2 S2NW, NWNW; SEC. 4 LOTS 1-4; SEC. 4 S2N2, S2; **TL 13-3** (ALL LANDS) **TL 13-4** SEC. 4 LOTS 1,2; SEC. 4 S2NE, SENW, E2SW, SE	T. 14 N, R. 45 E, PMM, MT SEC. 2 LOTS 3,4; SEC. 2 S2,NW; SEC. 4 LOT 4; SEC. 4 SENW,E2SW; PRAIRIE COUNTY	T. 14 N, R. 45 E, PMM, MT SEC. 2 SW; SEC. 4 LOTS 1-3; SEC. 4 S2NE,SWNW,W2SW,SE; PRAIRIE COUNTY Pending further review of sensitive soils and sage grouse areas being analyzed in the current MCFO RMP planning effort.
MTM 105431-HA	T. 26 N, R. 50 E, PMM, MT SEC. 24 SENE; MCCONE COUNTY 40.00 AC PD	**CR 16-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN 14-15** (ALL LANDS) **TES 16-2** (ALL LANDS)	DEFER ALL LANDS	DEFER ALL LANDS Pending further review of badlands rock outcrop areas being analyzed in the current MCFO RMP planning effort.

APPENDIX A

PARCEL NUMBER	PARCEL DESCRIPTION	PROPOSED FOR LEASING ALTERNATIVE B	PROPOSED FOR LEASING IF EA INCLUDES ALTERNATIVE C	PROPOSED FOR DEFERRAL-NO LEASING
MTM 105431-HB	T. 26 N, R. 52 E, PMM, MT SEC. 3 LOTS 1-3; SEC. 3 S2NE,SENW,SE; SEC. 10 E2; SEC. 15 NWNE,W2SW; RICHLAND COUNTY 830.48 AC PD	**CR 16-1** (ALL LANDS) **CSU 12-1** SEC. 10 N2,SE; **LN-14-1** SEC. 10 N2E2; **LN 14-12** (ALL LANDS) **LN 14-14** (ALL LANDS) **LN 14-15** (ALL LANDS) **NSO 11-2** SEC. 3 LOT 2; SEC. 3 S2NE; NESE; **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS)	DEFER ALL LANDS	DEFER ALL LANDS Pending further review of badlands rock outcrop areas being analyzed in the current MCFO RMP planning effort.
MTM 105431-H6	T. 26 N, R. 55 E, PMM, MT SEC. 4 LOT 4; SEC. 4 SWNW,SW; RICHLAND COUNTY 241.91 AC PD	**CR 16-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN 14-15** (ALL LANDS) **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** (ALL LANDS)	DEFER ALL LANDS	DEFER ALL LANDS Pending further review of sensitive soil areas being analyzed in the current MCFO RMP planning effort.
MTM 105431-H8	T. 27 N, R. 55 E, PMM, MT SEC. 30 LOT 4; SEC. 30 S2SE; RICHLAND COUNTY 116.82 AC PD	**CR 16-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN-14-1** SEC. 30 LOT 4; **LN 14-14** (ALL LANDS) **LN 14-15** (ALL LANDS) **NSO 11-4** SEC. 30 LOT 4; **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** (ALL LANDS)	DEFER ALL LANDS	DEEFER ALL LANDS Pending further review of sensitive soil areas being analyzed in the current MCFO RMP planning effort.

PARCEL NUMBER	PARCEL DESCRIPTION	PROPOSED FOR LEASING ALTERNATIVE B	PROPOSED FOR LEASING IF EA INCLUDES ALTERNATIVE C	PROPOSED FOR DEFERRAL-NO LEASING
MTM 105431-H9	T. 30 N, R. 58 E, PMM, MT SEC. 1 LOT 1; SEC. 12 NENE,S2NE; ROOSEVELT COUNTY 160.02 AC PD	**CR 16-1** (ALL LANDS) **LN 14-2** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN 14-14** (ALL LANDS) **LN 14-15** (ALL LANDS) **NSO 11-2** (ALL LANDS) **TES 16-2** (ALL LANDS)	T. 30 N, R. 58 E, PMM, MT SEC. 12 NENE; ROOSEVELT COUNTY	T. 30 N, R. 58 E, PMM, MT SEC. 1 LOT 1; SEC. 12 S2NE; ROOSEVELT COUNTY Pending further review of sensitive soil areas being analyzed in the current MCFO RMP planning effort.
MTM 105431-JA	T. 30 N, R. 59 E, PMM, MT SEC. 6 LOT 4; ROOSEVELT COUNTY 39.94 AC PD	**CR 16-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN 14-15** (ALL LANDS) **NSO 11-2** (ALL LANDS) **TES 16-2** (ALL LANDS)	DEFER ALL LANDS	DEFER ALL LANDS Pending further review of sensitive soil areas that are being analyzed in the current MCFO RMP planning effort.
MTM 105431-HC	T. 8 S, R. 51 E, PMM, MT SEC. 9 SESW,SE; SEC. 10 NENE,S2NE,S2; POWDER RIVER COUNTY 640.00 AC PD	**CR 16-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **NSO 11-2** SEC. 9 SESW,NWSE; SEC. 10 NENE,S2NE,NESE,SWSE; **TES 16-2** (ALL LANDS) **TL 13-1** SEC. 10 ALL; **TL 13-3** SEC. 9 SESW; SEC. 10 S2SE;	DEFER ALL LANDS	DEFER ALL LANDS Pending further review of sensitive soil areas being analyzed in the current MCFO RMP planning effort.
MTM 105431-HD	T. 8 S, R. 51 E, PMM, MT SEC. 11 ALL; POWDER RIVER COUNTY 640.00 AC PD	**CR 16-1** (ALL LANDS) **NSO 11-2** SEC. 11 SWNW,SWSW; **LN 14-12** (ALL LANDS) **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** SEC. 11 N2N2, S2S2;	DEFER ALL LANDS	DEFER ALL LANDS Pending further review of senstive soil areas in current MCFO RMP planning effort.

PARCEL NUMBER	PARCEL DESCRIPTION	PROPOSED FOR LEASING ALTERNATIVE B	PROPOSED FOR LEASING IF EA INCLUDES ALTERNATIVE C	PROPOSED FOR DEFERRAL-NO LEASING
MTM 105431-HE	T. 8 S, R. 51 E, PMM, MT SEC. 26 SW; POWDER RIVER COUNTY 160.00 AC PD	**CR 16-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **NSO 11-2** SEC. 26 NESW; **NSO 11-2** SEC. 26 NESW; **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** (ALL LANDS)	DEFER ALL LANDS	DEFER ALL LANDS Pending further review of senstive soil areas in current MCFO RMP planning effort.
MTM 105431-HG	T. 9 S, R. 51 E, PMM, MT SEC. 11 NE; POWDER RIVER COUNTY 160.00 AC PD	**CR 16-1** (ALL LANDS) **LN 14-11** (ALL LANDS) **LN 14-12** (ALL LANDS) **NSO 11-8** (ALL LANDS) **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** (ALL LANDS)	T. 9 S, R. 51 E, PMM, MT SEC. 11 NE; POWDER RIVER COUNTY	
MTM 105431-HH	T. 9 S, R. 51 E, PMM, MT SEC. 22 E2; SEC. 27 N2NW,SWNW; POWDER RIVER COUNTY 440.00 AC PD	**CR 16-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **NSO 11-2** SEC. 22 W2NE,SENE,NESE; SEC. 27 NENW; **TL 13-1** (ALL LANDS) **TES 16-2** (ALL LANDS)	T. 9 S, R. 51 E, PMM, MT SEC. 22 E2NE; POWDER RIVER COUNTY	T. 9 S, R, 51 E, PMM, MT SEC. 22 W2NE,SE; SEC. 27 N2NW,SWNW; POWDER RIVER COUNTY Pending further review of sensitive soils areas in current MCFO RMP planning effort.
MTM 105431-HJ	T. 9 S, R. 51 E, PMM, MT SEC. 27 S2SW; SEC. 28 SESE; SEC. 33 NENE; SEC. 34 LOT 1; SEC. 34 W2NW,NWSW; POWDER RIVER COUNTY 316.87 AC PD	**CR 16-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **NSO 11-2** SEC. 27 S2SW; SEC. 28 SESE; SEC. 33 NENE; SEC. 34 NWNW,NWSW; **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS)	T. 9 S, R. 51 E, PMM, MT SEC. 27 S2SW; SEC. 28 SESE; SEC. 33 NENE; SEC. 34 LOT 1; SEC. 34 W2NW,NWSW; POWDER RIVER COUNTY	

PARCEL NUMBER	PARCEL DESCRIPTION	PROPOSED FOR LEASING ALTERNATIVE B	PROPOSED FOR LEASING IF EA INCLUDES ALTERNATIVE C	PROPOSED FOR DEFERRAL-NO LEASING
MTM 105431-HF	T. 8 S, R. 52 E, PMM, MT SEC. 32 ALL; POWDER RIVER COUNTY 640.00 AC PD	**CR 16-1** (ALL LANDS) **LN 14-11** (ALL LANDS) **LN 14-12** (ALL LANDS) **NSO 11-2** SEC. 32 N2NE,W2SW,SESW; **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** SEC. 32 SWNE, NWNW, S2NW, SW, W2SE, SESE;	T. 8 S, R. 52 E, PMM, MT SEC. 32 N2NW, SESW; POWDER RIVER COUNTY	T. 8 S, R. 52 E, PMM, MT SEC. 32 NE,S2NW,W2SW,NESW,SE; POWDER RIVER COUNTY Pending further review of sensitive soil areas in current MCFO RMP planning effort.
MTM 105431-HK	T. 9 S, R. 52 E, PMM, MT SEC. 23 ALL; POWDER RIVER COUNTY 640.00 AC PD	**CR 16-1** (ALL LANDS) **NSO 11-2** SEC. 23 SWNE,SWSW; **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** SEC. 23 S2NE, S2;	DEFER ALL LANDS	DEFER ALL LANDS Pending further review of mule deer winter range habitat in the current MCFO RMP planning effort.
MTM 105431-HL	T. 9 S, R. 52 E, PMM, MT SEC. 26 ALL; POWDER RIVER COUNTY 640.00 AC PD	**CR 16-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **NSO 11-2** SEC. 26 S2NE,NENW,NESE; **TES 16-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** (ALL LANDS)	DEFER ALL LANDS	DEFER ALL LANDS Pending further review of mule deer winter range habitat in the current MCFO RMP planning effort.
MTM 105431-HM	T. 9 S, R. 52 E, PMM, MT SEC. 27 E2; POWDER RIVER COUNTY 320.00 AC PD	**CR 16-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **NSO 11-2** SEC. 27 NWSE; **TL 13-1** (ALL LANDS) **TL 13-3** (ALL LANDS) **TES 16-2** (ALL LANDS)	DEFER ALL LANDS	DEFER ALL LANDS Pending further review of mule deer winter range habitat in the current MCFO RMP planning effort.

Appendix B – Miles City Field Office Stipulation Descriptions

Stipulation Number	Stipulation Name/Brief Description
CR 16-1	**CULTURAL RESOURCES LEASE STIPULATION** This lease may be found to contain historic properties and/or resources protected under the National Historic Preservation Act (NHPA), American Indian Religious Freedom Act, Native American Graves Protection and Repatriation Act, E.O. 13007, or other statutes and executive orders. The BLM will not approve any ground disturbing activities that may affect any such properties or resources until it completes its obligations under applicable requirements of the NHPA and other authorities. The BLM may require modification to exploration or development proposals to protect such properties, or disapprove any activity that is likely to result in adverse effects that cannot be successfully avoided, minimized or mitigated.
CSU 12-1	**CONTROLLED SURFACE USE STIPULATION** Surface occupancy or use is subject to the following special operating constraint: Prior to surface disturbance on slopes over 30 percent, an engineering/reclamation plan must be approved by the authorized officer.
CSU 12-4	**CONTROLLED SURFACE USE STIPULATION** All surface-disturbing activities, semi-permanent and permanent facilities in Visual Resource Management (VRM) Class II areas may require special design, including location, painting and camouflage, to blend with the natural surroundings and meet the visual quality objectives for the area.
LN 14-1	**LEASE NOTICE** Land Use Authorizations incorporate specific surface land uses allowed on Bureau of Land Management (BLM) administered lands by authorized officers and those surface uses acquired by BLM on lands administered by other entities. These BLM authorizations include rights-of-way, leases, permits, conservation easements, and recreation and public purpose leases and patents.
LN 14-11	**LEASE NOTICE GREATER SAGE-GROUSE HABITAT** The lease may in part, or in total contain important Greater Sage-Grouse habitats as identified by the BLM, either currently or prospectively. The operator may be required to implement specific measures to reduce impacts of oil and gas operations on the Greater Sage-Grouse populations and habitat quality. Such measures shall be developed during the application for permit to drill on-site and environmental review process and will be consistent with the lease rights granted.
LN 14-12	**LEASE NOTICE PALEONTOLOGICAL RESOURCE INVENTORY REQUIREMENT** This lease has been identified as being located within geologic units rated as being moderate to very high potential for containing significant paleontological resources. The locations meet the criteria for class 3, 4 and/or 5 as set forth in the Potential Fossil Yield Classification System, WO IM 2008-009, Attachment 2-2. The BLM is responsible for assuring that the leased lands are examined to determine if paleontological resources are present and to specify mitigation measures. Guidance for application of this requirement can be found in WO IM 2008-009 dated October 15, 2007, and WO IM 2009-011 dated October 10, 2008. Prior to undertaking any surface-disturbing activities on the lands covered by this lease, the lessee or project proponent shall contact the BLM to determine if a paleontological resource inventory is required. If an inventory is required, the lessee or project proponent will complete the inventory subject to the following: • the project proponent must engage the services of a qualified paleontologist, acceptable to the BLM, to conduct the inventory. • the project proponent will, at a minimum, inventory a 10-acre area or larger to incorporate possible project relocation which may result from environmental or other resource considerations. paleontological inventory may identify resources that may require mitigation to the

Stipulation Number	Stipulation Name/Brief Description
	satisfaction of the BLM as directed by WO IM 2009-011.incorporate possible project relocation which may result from environmental or other resource considerations. paleontological inventory may identify resources that may require mitigation to the satisfaction of the BLM as directed by WO IM 2009-011.
LN 14-14	LEASE NOTICE CULTURAL VISUAL SETTING The lease is located adjacent to known historic properties that are or may be eligible for listing on the National Register of Historic Places (NRHP). The lease may in part or whole contribute to the importance of the historic properties and values, and listing on the NRHP. The operator may be required to implement specific measures to reduce impacts of oil and gas operations on historic properties and values. These measures may include, but are not limited to, project design, location, painting and camouflage. Such measures shall be developed during the on-site inspection and environmental review of the application for permit to drill (APD), and shall be consistent with lease rights. The goal of this Lease Notice is to provide information to the lessee and operator that would help design and locate oil and gas facilities to preserve the integrity and value of historical properties that are or may be listed on the National Register of Historic Places. This notice is consistent with the present Montana guidance for cultural resource protection related to oil and gas operations (NTL-MSO-85-1).
LN 14-15	**LEASE NOTICE SPRAGUE'S PIPIT** The lease area may contain habitat for the federal candidate Sprague's pipit. The operator may be required to implement specific measures to reduce impacts of oil and gas operations on Sprague's pipits, their habitat, and overall population. Such measures would be developed during the application for permit to drill and environmental review processes, consistent with lease rights. If the US Fish and Wildlife Service lists the Sprague's pipit as threatened or endangered under Endangered Species Act, the BLM would enter into formal consultation on proposed permits that may affect the Sprague's pipit and its habitat. Restrictions, modifications, or denial of permits could result from the consultation process.
NSO 11-2	**NO SURFACE OCCUPANCY STIPULATION** No surface occupancy or use is allowed within riparian areas, 100-year flood plains of major rivers, and on water bodies and streams.
NSO 11-4	**NO SURFACE OCCUPANCY STIPULATION** No surface occupancy or use is allowed within one-quarter mile of grouse leks.
NSO 11-8	**NO SURFACE OCCUPANCY STIPULATION** No surface occupancy or use is allowed within one-half mile of known ferruginous hawk nest sites which have been active within the past 2 years.
NSO 11-9	**NO SURFACE OCCUPANCY STIPULATION** No surface occupancy or use is allowed within one-quarter mile of wetlands identified as piping plover habitat.
NSO 11-10	**NO SURFACE OCCUPANCY STIPULATION** No surface occupancy or use is allowed within one-quarter mile of wetlands identified as interior least tern habitat.
NSO 11-13	**NO SURFACE OCCUPANCY STIPULATION** No surface occupancy or use is allowed within developed recreation areas and undeveloped recreation areas receiving concentrated public use.
TES 16-2	**ENDANGERED SPECIES ACT SECTION 7 CONSULTATION STIPULATION** The lease area may now or hereafter contain plants, animals, or their habitats determined to be threatened, endangered, or other special status species. BLM may recommend modifications to exploration and development, and require modifications to or disapprove

Stipulation Number	Stipulation Name/Brief Description
	proposed activity that is likely to result in jeopardy to proposed or listed threatened or endangered species or designated or proposed critical habitat.
TL 13-1	**TIMING LIMITATION STIPULATION** No surface use is allowed within crucial winter range for wildlife for the time period December 1 to March 31 to protect crucial white-tailed deer, mule deer, elk, antelope, moose, bighorn sheep, and sage grouse winter range from disturbance during the winter use season, and to facilitate long-term maintenance of wildlife populations. This stipulation does not apply to operation and maintenance of production facilities.
TL 13-3	**TIMING LIMITATION STIPULATION** No surface use is allowed from March 1 to June 15 in grouse nesting habitat within two miles of a lek. This stipulation does not apply to operation and maintenance of production facilities.
TL 13-4	**TIMING LIMITATION STIPULATION** No surface use is allowed within one-half mile of raptor nest sites which have been active within the past 2 years during the time period March 1 - August 1 to protect nest sites of raptors which have been identified as species of special concern. This stipulation does not apply to operation and maintenance of production facilities.

Appendix C
Reasonably Foreseeable Development Scenario Forecast for the October 21, 2014 Lease Sale

The Reasonably Foreseeable Development (RFD) scenario for the area of analysis is based on information contained in the MCFO RFD developed in 2005 and revised in 2012; it is an unpublished report that is available by contacting the MCFO. The MCFO RFD contains projections of the number of possible oil and gas wells that could be drilled and produced in the MCFO area and it is used to analyze the projected wells for the 18 nominated lease parcels, located in Richland, Roosevelt, McCone, Prairie, and Powder River counties, proposed for the October 21, 2014 lease sale.

The MCFO RFD contains projections of the number of possible oil and gas wells that could be drilled and produced within each of the three development potential areas specified as high, medium, and low potential areas. GIS was used to determine the number of projected new federal wells within each development potential by taking into consideration the same assumptions and methodology used to determine the MCFO RFD. To project the number of Federal wells on the nominated acres, the proportionate percentage of nominated lease acres within the high, medium, or low potential RFD area is multiplied by the respective total number of high, medium, or low potential projected wells. Where the number of wells in a parcel within a county had a projection of equal to or greater than 1 in 1000 (0.001) the well number was rounded up to one, if the number of wells projected in a parcel within a county had a projection of less than 1 in 1000 (.001) the well number was rounded to zero.

These well numbers are only an estimate based on the MCFO RFD which is based on USGS assessments, past and current development, resource expertise, and MBOCG feedback and data, and may change in the future if new technology is developed or new fields and formations are discovered.

High Potential
The 6,005 lease parcel acres located in McCone, Powder River, Richland, and Roosevelt Counties are in the area of High Potential (6,043,000 acres total) development. The RFD scenario forecasts a range of 856 to 1,711 oil wells and 1,004 to 2,009 gas wells in this development area. The range for federal wells is 197 to 394 oil wells and 231 to 462 gas wells. The High Potential lease parcels total approximately 6,005 acres, approximately 0.099 percent of the High Potential project area identified in the RFD.

Medium Potential
No lease parcels nominated lie within the area of Medium development potential.

Low Potential
The 1,599 lease parcel acres located in Prairie County are in the area of Low Potential (13,120,000 acres total) development. The RFD scenario forecasts a range of 325 to 650 oil wells and 382 to 764 gas wells in this development area. The range for federal wells is 197 to 394 oil wells and 231 to 462 gas wells. The Low Potential lease parcels total approximately 1,599 acres, approximately 0.012 percent of the Low Potential project area identified in the RFD.

Table 1. Nominated Lease Parcel Acres Offered within each County by Alternative

Alternative	Richland	Roosevelt	McCone	Prairie	Powder River
Alt A	0	0	0	0	0
Alt B	1148	200	40	1599	4617
Alt C	37	0	0	1039	80

Table 2. Projected Number of Wells within each County by Alternative

Alternative	Richland	Roosevelt	McCone	Prairie	Powder River
Alt A	0	0	0	0	0
Alt B	1	1	1	1	3
Alt C	1	0	0	1	1

Appendix D - Potential Surface Disturbance Associated with Federal Wells

The potential number of acres disturbed by federal wells and associated access road and utility corridor is shown in Table D-1. The potential acres of disturbance reflect acres typically disturbed by construction, drilling, and production activities, including infrastructure installation throughout the MCFO. Typical federal wells and associated access road and utility corridor acres of disturbance were used as assumptions for analysis purposes in this EA. The assumptions were not applied to Alternative A because the lease parcel would not be recommended for lease; therefore, no wells would be drilled or produced on the lease parcel and no surface disturbance would occur on those lands from exploration and development activities.

Estimated average acres of surface disturbance associated with well pad and access road/utility corridor are based on current disturbance of oil, gas, and CBNG APDs being permitted in the MCFO within the last five years.

Standard oil and gas practice typically combines access road and utility corridor (oil/gas/CBNG, water, and power) within the same corridor to minimize surface disturbance which requires a wider corridor but limits overall surface disturbance.

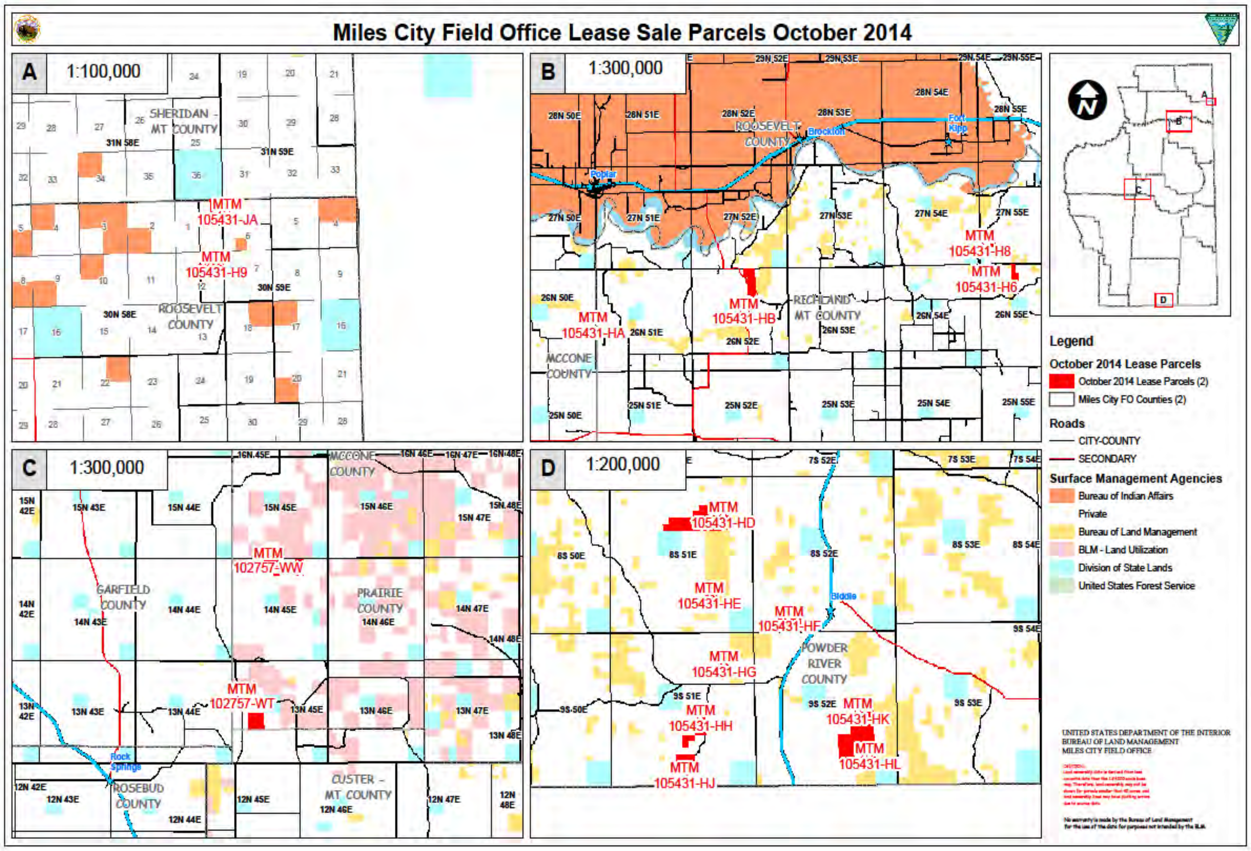
It is unknown how many wells would be drilled on multi-well pads; therefore to assist in determining acres of surface disturbance, it is assumed that one well would be drilled on one well pad.

Table D-1. Estimated Acres of Disturbance Associated with a Federal Well Pad and Access Road and Utility Corridor.

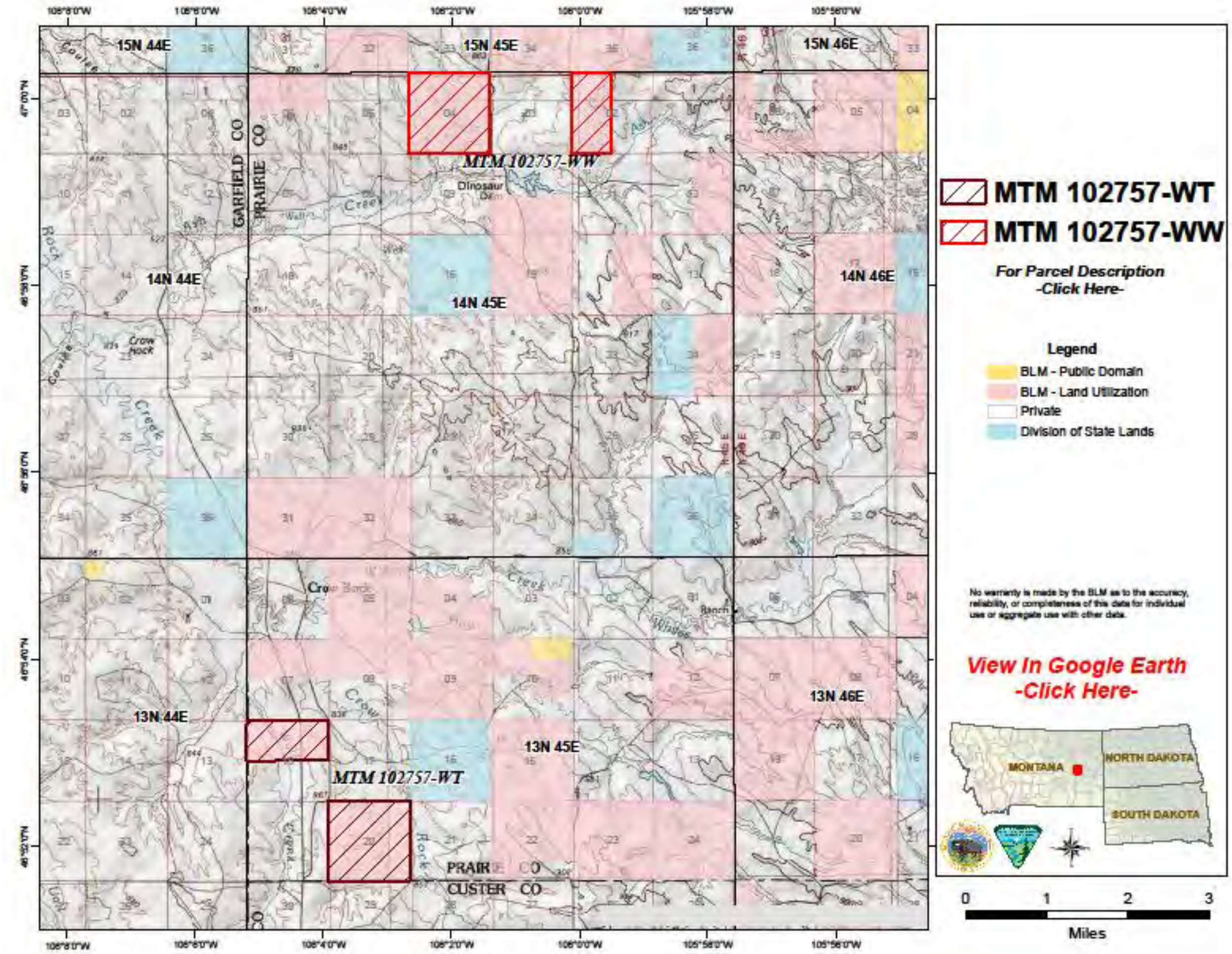
	Well Pad	Access Road/Utility Corridor	Total Disturbance
Oil	3.00	1.20	4.20
Gas	0.50	0.55	1.05
CBNG	0.25	0.55	0.80

Surface disturbance associated with major transportation lines, processing production areas, produced water management areas may not be included as part of the federal APD for permitting. It may be permitted and constructed in association with another APD; therefore, surface disturbance from associated infrastructure it is not included as acres of surface disturbance per well or access road/utility corridor listed in the table.

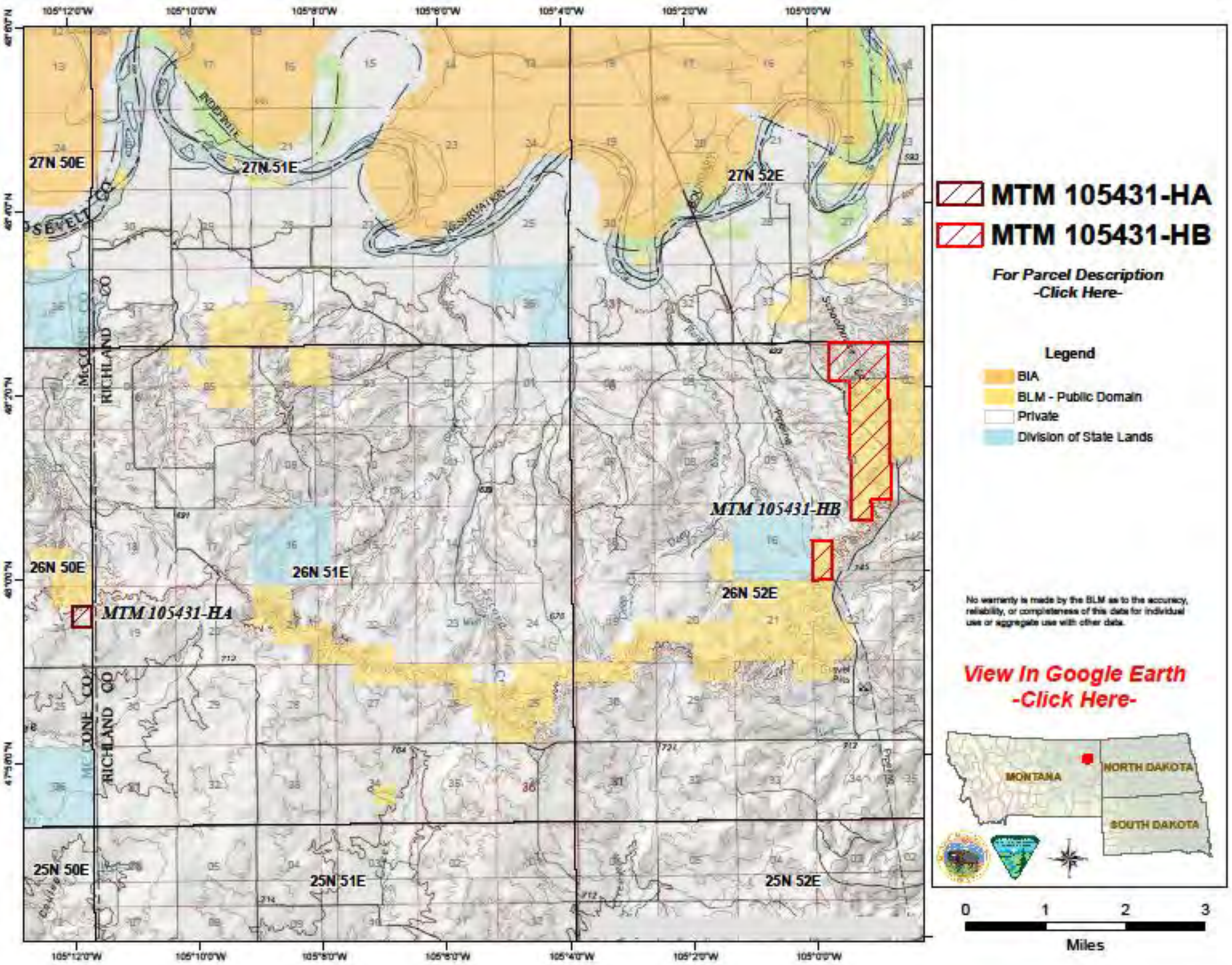
Map 1. All Nominated Lease Parcels



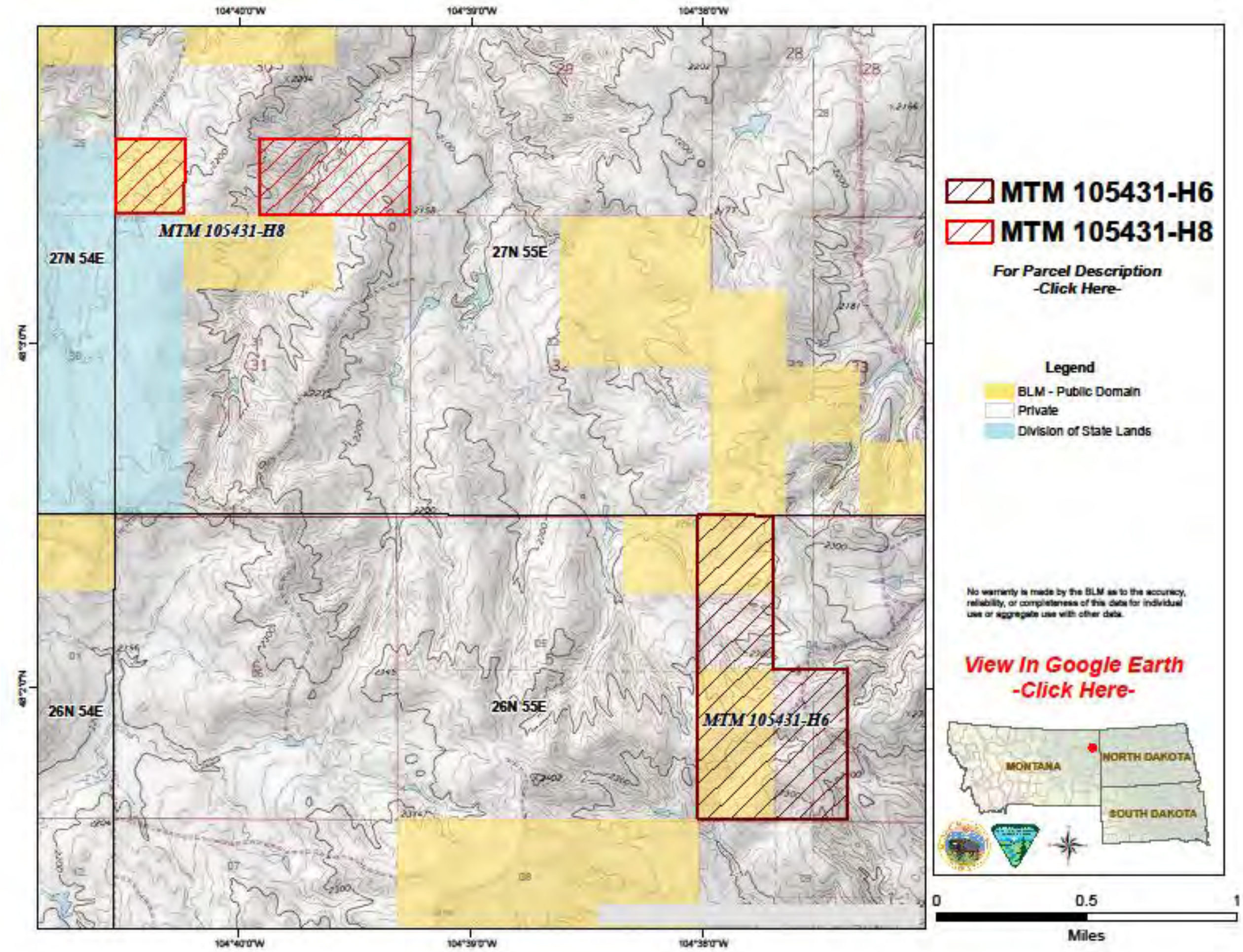
Map 2. Nominated Parcels MTM 102757-WT & MTM 102757-WW



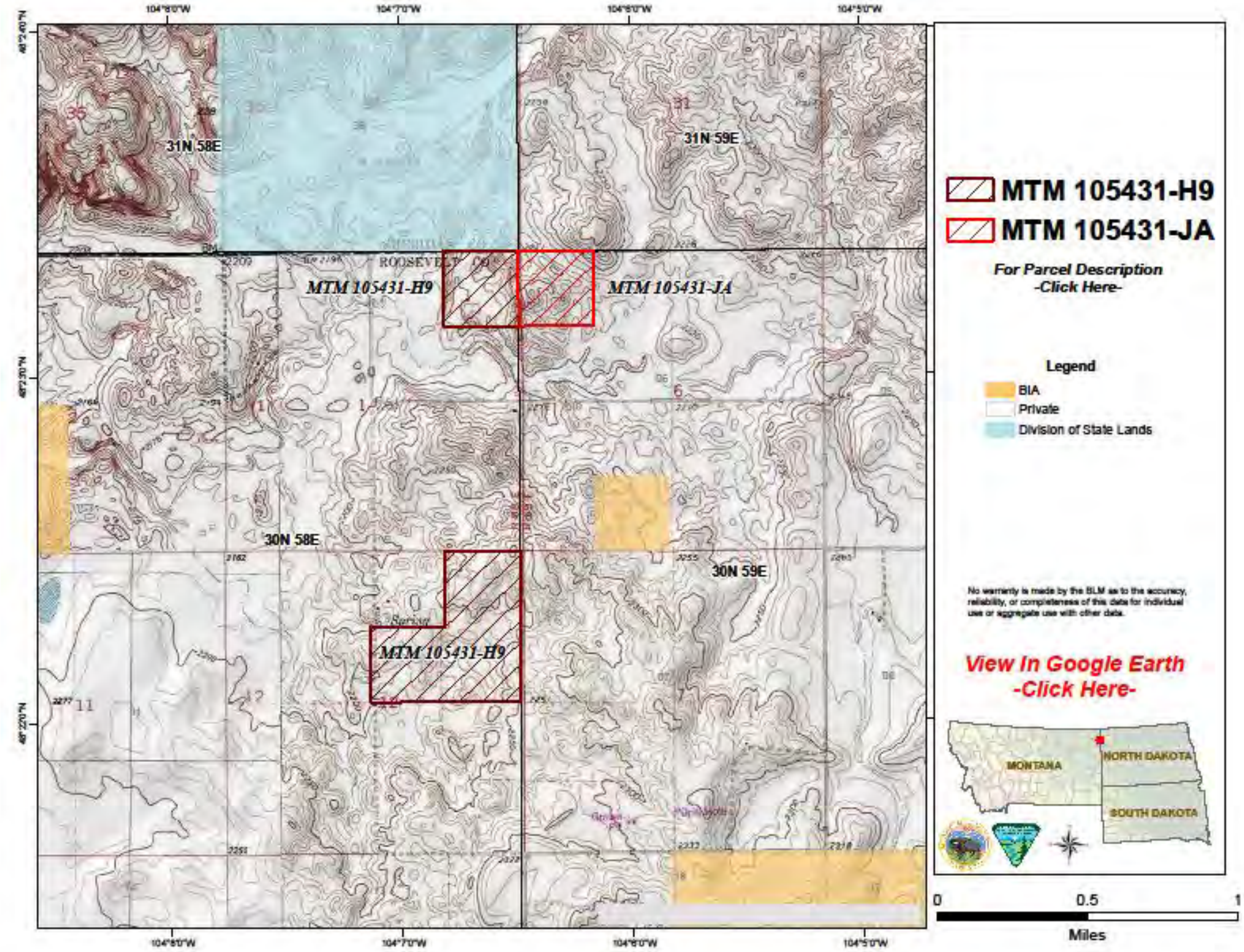
Map 3. Nominated Parcels MTM 105431-HA & MTM 105431-HB



Map 4. Nominated Parcels MTM 105431-H6 & MTM 105431-H8



Map 5. Nominated Parcels MTM 105431-H9 & MTM 105431-JA



Map 6. Nominated Parcels MTM 105431-HC, HD, HE, HF, HG, HH, HJ, HK, HL, & HM

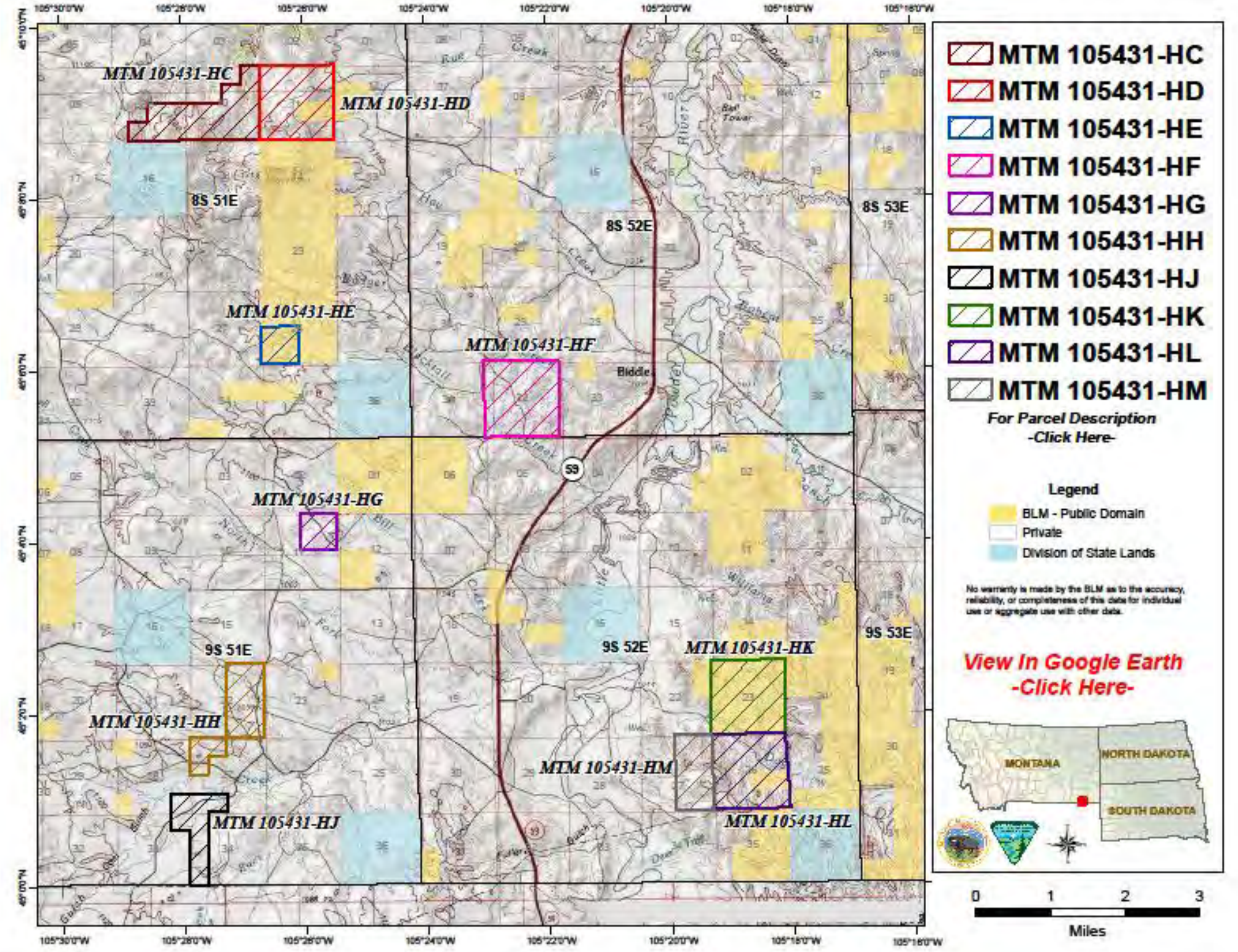


Exhibit 9

BLM

U.S. Department of the Interior
Bureau of Land Management

Environmental Assessment
DOI-BLM-ID-B010-2014-0036-EA

Little Willow Creek
Protective Oil and Gas Leasing

February 10, 2015

U.S. Department of the Interior
Bureau of Land Management
Four Rivers Field Office
3948 Development Avenue
Boise, ID 83705

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT NATIONAL SYSTEM OF PUBLIC LANDS

Environmental Assessment # DOI-BLM-ID-B010-2014-0036-EA
Little Willow Creek Protective Oil and Gas Leasing

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Little Willow Creek Protective Oil and Gas Lease

1.0 Introduction

Leasing

The Mining and Minerals Policy Act of 1970 declares that it is the continuing policy of the Federal Government to foster and encourage private enterprise in the development of a stable domestic minerals industry and the orderly and economic development of domestic mineral resources. The Mineral Leasing Act of 1920, as amended, authorizes the Secretary of the Interior to lease federal oil and gas. The Bureau of Land Management (BLM) is the Interior agency delegated the authority to manage the United States' mineral resources. The BLM's oil and gas leasing programs are codified under 43 CFR 3100, in accordance with the authority of the Mineral Leasing Act of 1920, as amended, the Federal Land Policy and Management Act (FLPMA) of 1976, and the Energy Policy Act of 2005.

The decision as to which public lands and minerals are open for leasing and what leasing stipulations may be necessary is made during the land use planning process. Surface management/use for mineral extraction on non-BLM administered land overlaying federal minerals will be determined by the BLM in consultation with the appropriate surface management agency or the private surface owner at the time such surface use is proposed by the leaseholder or designated agent. Under the Mineral Lease Act, issuing oil and gas leases is a discretionary authority conveyed to the Secretary of Interior. In carrying out the mineral leasing authority conveyed through the Mineral Leasing Act, the BLM must comply with other applicable federal laws and regulations, including, but not limited to the Endangered Species Act, the National Historic Preservation Act, the Clean Water Act, the Clean Air Act, and the Energy Policy Act.

Offering federal mineral estate parcels for lease and subsequently issuing oil and gas leases are strictly administrative actions, which, in and of themselves, do not cause or directly result in any surface disturbance. Issuance of an oil and gas lease does convey to the lessee the exclusive right to use as much of the leased land as is reasonably necessary to explore for and extract oil and gas resources from the lease area, subject to the terms of the lease, including stipulations (43 CFR 3101.1-2 and 3101.1-3), regulations pertaining to oil and gas leasing, Onshore Orders, and with prior approval of the Authorized Officer. However, depending on lease stipulations, post-leasing activities may or may not result in impacts to surface resources. Only where stipulations or conditions do not preclude disturbance to surface resources is the action considered an irretrievable commitment of resources. The BLM may issue leases to protect the public interest when uncompensated drainage is occurring or may occur, provided the lease does not convey an irreversible or irretrievable commitment of resources.

As part of the lease issuance process, nominated parcels are reviewed against the appropriate land use plan, and stipulations are attached to mitigate any known environmental or resource conflicts that may occur on a given lease parcel. As stated above, on-the-ground impacts would potentially occur when a lessee applies for and receives approval to explore, occupy and/or drill on the lease. The BLM cannot determine at the leasing stage whether or not a lease would actually be explored or developed.

Oil and gas leases are issued for a 10-year period and continue for so long thereafter as oil or gas is produced in paying quantities. If a lessee fails to produce oil and/or gas, does not make annual rental payments, does not comply with the terms and conditions of the lease, or relinquishes the lease, then ownership of the minerals leased revert back to the federal government and may be offered for lease again. Drilling wells on a lease is not permitted until the lessee or operator secures BLM's approval of a drilling permit and a surface use plan as specified in 43 CFR 3162.3-1 (Drilling applications and plans) and submits a reclamation bond. Subsequent well operations, such as re-drilling, deepening, repairing casing, plugging-back, performing non-routine fracturing jobs, etc. also require the prior approval of the authorized officer (43 CFR 3162.3-2).

Leasing in the Four Rivers Field Office

While parcels totaling over 180,000 acres of federal land in southwest Idaho have been nominated for competitive oil and gas leasing, BLM has to-date deferred leasing any lands until completion of the Four Rivers Resource Management Plan/EIS (FRMP). Currently, there are no federal oil and gas leases in the field office. The FRMP will replace the 1987 Cascade RMP which currently addresses leasing in the western portion of the Four Rivers Field Office. BLM is considering leasing in this isolated circumstance because of the federal mineral reserve drainage that may occur existing wells are put into production in sections with federal minerals in the Willow Field or on private lands in the proposed leasing area.

There are currently 15 wells that have been drilled on private or State leases in and/or near the Willow and Hamilton Fields and are capable of production, and three wells that have been approved but haven't been drilled. Four existing wells and two proposed wells are within 0.5 miles of federal mineral resources. Several of the wells are located in sections with federal mineral estate (Map 1). The existing wells are classified as "shut in pending a pipeline" indicating that they are capable of production.

The BLM determined the boundary of the proposed leasing area by including all lands with federal minerals in the industry-designated Willow Field, as well as those lands with federal minerals located in sections that are within one mile of a well that has been drilled or permitted. Only the lands with federal minerals would be leased within the proposed leasing area boundary. There are no lands with federal minerals in the Hamilton Field.

In November 2013, Alta Mesa Services, Inc., a company that is currently developing a newly discovered natural gas field, made application to the Idaho Oil and Gas Conservation Commission (IOGCC) to omit federal lands in T. 8 N., R. 4 W., Section 3, from a drilling unit it proposed in Section 3. If the federal minerals are omitted from the drilling unit and a producing well is drilled on the private lands (with private minerals) in Section 3, drainage of the federal mineral estate could occur. The opportunity to recover the underlying resource would be lost, and the federal government, acting on behalf of the American taxpayer, would be unable to collect royalties on the extracted mineral resources.

Leasing would protect the American taxpayers' correlative rights, and production royalties could be collected. The BLM considers Alta Mesa's application to the IOGCC to be evidence of potential drainage in Section 3. Lands that are otherwise unavailable for leasing may be leased if there is an imminent threat of drainage [see 43 CFR 3120.1-1(d)]. Because of this threat and the likelihood of IOGCC receiving more applications to omit the federal mineral estate in sections where wells have been drilled or proposed, BLM is considering leasing the federal mineral estate within this limited area at this time.

1.1 Need for and Purpose of Action

The purpose of this proposal is to protect the federal mineral resource from uncompensated drainage, and surface resources from potential damage, in and near the Willow Field, Payette County, Idaho. Drainage is defined as the migration of oil and gas in an underground reservoir, due to a pressure reduction caused by production from wells bottomed in the reservoir. Because oil and gas are fluids, they can flow underground across property boundaries. Subsurface (i.e. mineral) ownership boundaries are the same as those upon the surface, projected downward to the center of the earth. Sub-surface mineral rights in the U.S. generally belong to the owner of the surface land, unless they have been severed from the surface. According to an old common law concept termed the rule of capture, the first person to gain control over the resource (by extracting the resource from the ground) gains exclusive ownership over that resource. In this way, an operator may permissibly extract, or drain, oil and gas from beneath the land of another, if the extraction is lawfully conducted on his own property. The rule of capture gives land owners an incentive to pump out oil as quickly as possible by speeding up their operations or drilling multiple, closely spaced wells to capture, or drain, the oil or gas resource of their neighbors. Very dense drilling can result in dissipation of the pressure within a reservoir, and therefore incomplete extraction of the resource.

To mitigate this danger, many state governments have sought to supersede the rule of capture with conservation acts that enforce prorationing, pooling, and limits on density of drilling, to avoid physical waste, ensure maximum ultimate recovery, and to protect the correlative rights of neighboring owners. The correlative rights doctrine is a legal doctrine limiting the rights of landowners to an oil or gas reservoir to a reasonable share, based on the amount of land owned by each on the surface above. Correlative rights concepts such as pooling and unitization replace the rule of capture in those states that have them, thereby protecting the rights of mineral estate owners from drainage.

Uncompensated drainage means that federal mineral resources are being produced by wells on adjacent lands without compensation to the United States in the form of royalties that would otherwise be required if the federal mineral estate were leased under the Mineral Leasing Act, as amended. A prime responsibility of the BLM is to protect the United States from the loss of royalty that results from drainage (uncompensated drainage). For unleased lands, the objectives of BLM's drainage protection program may be accomplished by leasing and requiring the lessee to take protective measures to prevent uncompensated drainage of oil or gas from the lease.

This action is needed because natural gas wells have been or are proposed to be drilled on private land adjacent to BLM-administered lands and/or adjacent to lands where BLM owns only the subsurface mineral estate (referred to as split estate). The current and proposed wells in and north of the Willow Field constitute a threat, or potential threat, of uncompensated drainage to the federal mineral estate. Drilling has resulted in the discovery of commercial quantities of natural gas and natural gas condensate in the Willow and Hamilton fields, and those areas are being developed for commercial production. According to the current Idaho well spacing order, only one well can be drilled per 640-acre governmental section (IDAPA 20.07.02.330.02; IOGCC 2013a). The Idaho Department of Lands has approved drilling permit applications for several wells on private lands which would drain minerals reserved to the United States within the well spacing unit designated by the State of Idaho (IOGCC 2014).

In a September 4, 2014 IOGCC hearing, the commission voted 4-1 to reconsider a request by Alta Mesa to omit federal mineral resources. If federal minerals are omitted from a drilling unit, BLM would be unable to collect the royalties it is due for its proportionate share of production from the drilling unit; therefore, the BLM considers these resources threatened by uncompensated drainage. While 43 CFR 3162.2-2 offers several protective measures BLM may take to avoid uncompensated drainage on unleased lands besides leasing, they require the cooperation of the owner-of-interest in the producing well. BLM has offered several times to enter into a communitization or compensatory royalty agreement; however. Alta Mesa has refused to do so, leaving leasing as the only alternative to address drainage.

1.2 Decision to Be Made

The responsible official will decide whether to recommend that the BLM Idaho State Office offer lands in the proposed lease area and which, if any, stipulations and/or notices should be attached to the leases.

1.3 Summary of Proposed Action

The BLM proposes to offer five parcels (totaling 6,349 acres; Map 2) at a spring 2015 competitive oil and gas lease sale. Stipulations and lease notices would apply on BLM-administered surface and subsurface in the lease area. The offering and subsequent issuance of oil and gas leases is strictly an administrative action, which, in and of itself, would not cause or directly result in any surface disturbance.

1.4 Location and Setting

The proposed 15,644-acre Little Willow Creek oil and gas lease area is located 4-12 miles east of Payette, Idaho (Map 1). The topography is characterized by gently rolling hills. Vegetation is dominated by annual and perennial grass with occasional shrub stands. Rural homes and agricultural fields are primarily associated with Little Willow Creek.

In the proposed lease area, only 6% of surface lands are BLM-administered and the remaining are privately owned; however, the BLM administers 41% of the subsurface mineral estate. Two oil and gas fields to the south have been designated by oil and gas developers. The Willow Field overlies a portion of the Little Willow Creek proposed lease area and currently has eight oil and gas wells. Further south, the Hamilton Field has six wells. Most wells in the area are classified as shut in pending a pipeline (IOGCC 2014).

1.5 Conformance with Applicable Land Use Plan

Leasing is in conformance with the 1988 Cascade Resource Management Plan (CRMP) which makes 456,289 acres (94% of area) available for leasable mineral exploration and development (CRMP Record of Decision page 3). The proposed lease parcels are within the area determined available for leasable mineral exploration and development. The CRMP directs the BLM to manage geological, energy, and minerals resources on the public lands so that significant scientific, recreational, ecological and educational values will be maintained or enhanced. Generally, the public lands are available for mineral exploration and development, subject to applicable regulations and Federal and State laws. The CRMP states that: "Approval of an application for lease is subject to an environmental analysis and may include stipulations to protect other resources." Additional NEPA documentation is needed prior to leasing to address new circumstances or information bearing on the environmental consequences of leasing that was not considered within the broad scope analyzed in the CRMP Environmental Impact Statement.

1.6 Relationship to Statutes, Regulations, and Other Requirements

This EA was prepared in accordance with the National Environmental Policy Act of 1969 (NEPA) and in compliance with all applicable laws and regulations, including Council on Environmental Quality (CEQ) regulations (40 CFR Parts 1500-1508), U.S. Department of the Interior (DOI) requirements (Department Manual 516, Environmental Quality), and/or other federal statutes and executive orders.

Other applicable Federal laws to which the lessee must comply include but are not limited to, the following:

Leasable Minerals

It is BLM policy, as derived from various laws, including the Mineral Leasing Act of 1920 (MLA) and the Federal Land Policy and Management Act of 1976 (FLPMA), to make mineral resources available for disposal and to encourage development of mineral resources to meet national, regional, and local needs. Ensuring that the federal mineral estate is protected from uncompensated drainage of fluid mineral resources is a basic BLM function. 43 CFR 3100.2-1 states "Upon a determination by the authorized officer that lands owned by the U.S. are being drained of oil or gas by wells drilled on adjacent lands . . . Such lands may also be offered for lease in accordance with part 3120 of this title." 43 CFR 3120.1-1 states that "All lands available for leasing shall be offered for competitive bidding under this subpart, including but not limited to . . . (d) Lands which are otherwise unavailable for leasing but which are subject to drainage (protective leasing)."

Any purchaser of a federal oil and gas lease is required to comply with all applicable federal, state, and local laws and regulations, including obtaining all necessary permits required prior to the commencement of project activities.

Environmental Quality

Clean Water Act of 1972 (33 U.S.C. §1251 et seq.): Regulates surface water discharges and storm-water runoff. Section 313 requires federal agencies be in compliance with all federal, state, interstate, and local requirements. In Idaho, the Idaho Department of Environmental Quality (IDEQ) implements the Clean Water Act. Additionally, the IDEQ develops total maximum daily loads (TMDLs) for water bodies.

Safe Drinking Water Act of 1974 as amended: Authorizes the U.S. Environmental Protection Agency (EPA) to set national health-based standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water. The EPA, IDEQ, and others work together to make sure that the standards are met.

Clean Air Act of 1970 as amended (42 U.S.C. §7401 et seq.): Sets rules for air emissions from engines, gas processing equipment and other sources associated with drilling and production activities.

Special Status Species

Endangered Species Act (ESA) of 1973 as amended (16 USC 1531): Section 7 of the ESA outlines the procedure for federal interagency cooperation to conserve federally listed species and their designated habitats. Section 7(a) (2) of the ESA states that each federal agency shall, in consultation with Secretary, ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of a listed species' habitat within the project area.

Special Status Species Management Manual for the Bureau of Land Management (BLM Manual 6840): National policy directs BLM State Directors to designate sensitive species in cooperation with the state fish and wildlife agency. This manual establishes policy for management of species listed or proposed for listing pursuant to the ESA and Bureau sensitive species that are found on BLM-administered lands; this policy is to conserve and to mitigate adverse impacts to sensitive species and their habitats. Where relevant to the activities associated with this action, effects to special status species are analyzed in this EA.

Migratory Bird Treaty Act, *Executive Order 13186*, and *BLM Memorandum of Understanding WO-230-2010-04* (between BLM and US Fish and Wildlife Service [USFWS]): Federal agencies are required to evaluate the effects of proposed actions on migratory birds (including eagles) pursuant to the *National Environmental Policy Act of 1969* (NEPA) "or other established environmental review process;" and restore and enhance the habitat of migratory birds, as practicable. Federal agencies are also required to identify where unintentional take reasonably attributable to agency actions is having, or is likely to have, a measurable negative effect on migratory bird populations. With respect to those actions so identified, the agency shall develop and use principles, standards, and practices that will lessen the amount of unintentional take, developing any such conservation efforts in cooperation with the Service. Effects to migratory birds are analyzed in this EA.

Bald and Golden Eagle Protection Act of 1940 as amended (16 USC 668-668d): This act provides for the protection of bald and golden eagles by prohibiting, except under certain specified conditions, the taking, possession and commerce of such birds. Agencies are required to evaluate: 1) whether take is likely to occur from activities associated with the proposed activity and 2) the direct, indirect, and cumulative impacts the proposal may have on the ability to meet the preservation standard of the Act that the USFWS has interpreted to mean "compatible with the goal of stable or increasing breeding populations." Effects to bald and golden eagles are analyzed in this EA.

<u>Cultural Resources</u>
Idaho BLM has the responsibility to manage cultural resources on public lands pursuant to the National Historic Preservation Act of 1966 (as amended), the 2012 Programmatic Agreement Among the Bureau of Land Management, the Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers and the State Protocol Agreement Between the Idaho State Director of the BLM and the Idaho State Historic Preservation Officer (1998) and other internal policies.

<u>Social and Economic</u>
Executive Order 12898 (February 1994): Federal agencies are directed to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations," including tribal populations. The accompanying Presidential Memorandum emphasizes the importance of using the NEPA review process to promote environmental justice.

1.7 Scoping and Development of Issues

<u>Scoping</u>
BLM began scoping for the Little Willow Creek lease sale on July 8, 2014 when the Four Rivers Field Manager sent a scoping packet and/or letter to all land owners with property in or adjacent to the Little Willow Creek proposed lease area and to the Four Rivers Field Office's interested public mailing list seeking scoping comments on the lease proposal. BLM also activated a web page on the BLM NEPA Register to make scoping and informational materials available to the public. The webpage can be reviewed at: https://www.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=39064&dctmId=0b0003e8806d22d8.

On Thursday July 17, 2014 the BLM hosted a public meeting at the Payette County Courthouse. BLM answered questions and accepted comments at the meeting and provided an address and website to send in additional scoping comments about the proposed leasing. Approximately 45 people attended the meeting and 12 individuals and organizations provided scoping comments. Many of the issues were outside the scope of the leasing decision. The public was primarily concerned with drilling which would be analyzed in a subsequent NEPA document if an Application for Permit to Drill (APD) is received by BLM (Appendix 1). The intent of BLMs scoping effort was to identify issues related to the proposed leasing.

Issues Development

Issues may be defined as a point or matter of discussion, debate, or dispute about a proposed action based on the potential environmental effects (BLM Handbook H-1790-1). Issues are concerns directly or indirectly caused by implementing the proposed action; these are used to develop alternatives to the proposed action. Relevant public comments and issues were used in the development of this EA, including those received in response to the Scoping Document mailed July 8, 2014. Comments not considered issues to analyze in this EA are ones that are: 1) outside the scope of the proposed action and thus irrelevant to the decision being made; 2) already decided by law, regulation, RMP, or other higher level decision; 3) conjectural and not supported by scientific or factual evidence; or 4) not necessary for making an informed decision. The following issues were identified from comments and scoping letters received during the scoping effort:

1. Leasing could indirectly impact air quality in the proposed lease area if exploration and development occur.
2. Leasing could indirectly impact water quality in the proposed lease area if exploration and development occur.
3. Leasing could indirectly pollute ground water in the proposed lease area if exploration and development wells require hydraulic fracturing (fracking).
4. Leasing could indirectly impact sensitive plant species in the proposed lease area if exploration and development occur.
5. Leasing could indirectly impact sensitive wildlife species in the proposed lease area if exploration and development occur.

These issues are addressed in Section 3.0. Although development in the Willow and Hamilton fields has not indicated the need for substantial fracking (Johnson et. al. 2013), the issue is addressed primarily in Water Resources (Section 3.5). The IDT also analyzed the indirect effects of leasing on the following resources: soils, vegetation, cultural resources, recreation, visual resources, lands and realty, livestock management, minerals, and social and economics.

2.0 Description of the Alternatives

2.1 Alternative A - No Federal Mineral Estate Leasing/Continue Present Management

The federal mineral estate in a 15,644 acre area in Payette County, including 996.85 (997) acres of BLM-administered lands and 5,352.35 (5,352) acres of split estate, would not be offered for lease. Development of State and private leases could occur in the area; however, the federal mineral estate would not be available at least until the FRMP is completed. State (Appendix 2) or other stipulations developed by the lessor and lessee would apply to other leases.

2.2 Alternative B – Leasing Federal Mineral Estate with No Surface or Subsurface Occupancy Stipulations

The federal mineral estate in a 15,644 acre area in Payette County, including 997 acres of BLM-administered lands and 5,352 acres of split estate, would be offered for lease in up to five parcels[A] (Table 1, Map 2, Appendix 3).

Table 1. Mineral estate acreages by parcel, surface, and subsurface ownership, proposed Little Willow Creek oil and gas leasing area, Payette County, Idaho.

Parcel	Federal Mineral Estate[1]			Other Mineral Estate[2]		Total
	Federal/Federal	Private/Federal	Total	Private/Private	Private/State	
A	212	1,536	1,748	3,811	0	5,549
B	237	312	549	1,353	0	1,903
C	235	1,140	1,374	1,142	0	2,516
D	274	1,311	1,585	1,186	394	3,165
E	39	1,052	1,091	1,313	98	2,502
Total	997	5,352	6,349	8,799	492	15,644

[1]Acreages presented in this table and throughout the document are rounded to the nearest acre. More accurate figures would be developed if a lease is offered.
[2] The BLM has no control over these resources. The values are provided strictly for informational purposes.

The following stipulations would apply to the federal mineral estate:

No Surface Occupancy (NSO) –1: Surface occupancy and use on BLM-administered and split estate lands would be prohibited until the Four Rivers Resource Management Plan (FRMP) is finalized.

No Sub-surface Occupancy (NSSO) –1: Subsurface occupancy and use on federal mineral estate lands would be prohibited until the FRMP is finalized.

Upon finalization of the FRMP, the leases would be modified by replacing NSO-1 and NSSO-1 with stipulations consistent with the FRMP. Development of State and private leases would be as described in Section 2.1; however, drainage of the federal mineral estate would be allowed and typical royalties would be applied.

[A] Because an oil and gas lease cannot be larger than 2,560 acres (43 CFR 3120.2-3), the 6,352-acre federal mineral estate was divided into smaller parcels. BLM has the discretion to parcel the lands in any configuration. During public scoping, at least one split estate land owner expressed a desire to bid on parcels to which he/she owns the surface estate. BLM has addressed the land owner's concern by making the leases smaller, and by dividing the federal mineral estate in a manner that minimizes the number of split estate landowners on a single lease (the only exception to this is Parcel A, which has multiple split estate landowners, but lies entirely within the industry-designated Willow Field).

2.3 Alternative C - Leasing Federal Mineral Estate with Cascade RMP Stipulations and Additional Lease Notices

The federal mineral estate in a 15,644 acre area in Payette County, including 997 of BLM-administered lands and 5,352 acres of split estate, would be offered for lease in up to five parcels (Table 1, Map 2, Appendix 3). The leases would be subject to standard lease terms and the following stipulations associated with listed species (S-1) and cultural resources (S-2), applicable CRMP stipulations, and lease notices. Lease notices were developed for sensitive resources that were not addressed in the CRMP. Development of State and other leases would be as described in Section 2.1. The following stipulations and lease notices would apply where appropriate (Appendix 3):

Freshwater Aquatic Habitat

Controlled Surface Use (CSU) -1: Surface occupancy and use would be prohibited within 500 feet from the edge of reservoirs, ponds, streams, wetlands, and riparian habitat. Introduction of chemical toxicants or sediments to riparian areas as a result of exploration or production would not be allowed.

CSU-2: A minimum 100 foot riparian buffer zone would be provided from the edge of any riparian habitat to protect riparian vegetation, fisheries, and water quality. The following activities would be generally excluded: new road construction that parallels streams. Best management practices would be used when construction cannot be avoided.

Special Status Plant Species

CSU-3: Occupancy and use, including surface and subsurface rights-of-way, would be prohibited in Type 1-4 special status plant element occurrences.

Big Game Range[B]

CSU-4: No surface use would be allowed in crucial winter range from November 15 to May 15 or crucial antelope fawning range between May 1 and June 30.

Sensitive Wildlife Species

CSU-5: No surface use would be allowed within a 0.75 mile radius of ferruginous hawk or Swainson's hawk nests from March 15 to June 30.

CSU-6: No surface use would be allowed within a 0.75 mile radius of an osprey nest from April 15 to August 31.

CSU-7: No surface use would be allowed within a 0.25 mile radius of a burrowing owl nest from March 15 to June 30.

[B] From the CRMP: "Those areas where big game animals have demonstrated a definite pattern of use each year or an area where animals tend to concentrate in significant numbers (from Interagency Guidelines for Big Game Range Investigation-Idaho Department of Fish & Game, Bureau of Land Management, U.S. Forest Service)." For the purposes of this action, the BLM worked in cooperation with IDFG to delineate winter ranges using current animal distribution data.

Wildlife Species of Concern
CSU-8: No surface use would be allowed within a 0.75 mile radius of a golden eagle nest from February 1 to June 30.

CSU-9: No surface use would be allowed within a 0.75 mile radius of a prairie falcon nest from March 15 to June 30.

CSU-10: No surface occupancy would be allowed within a 0.5 mile radius of a heron rookery.

Fragile Soils
Lease Notice (LN) -1: The lessee is hereby notified that special location, design and construction mitigation measures may be required to minimize, to the extent possible, the potential long-term and short-term adverse impacts of oil and gas operations within fragile soils, and to avoid them wherever there is a practicable alternative.

Fragile soil areas, in which the performance objective would be enforced, are defined as follows:

1) Areas rated as highly or severely erodible by wind or water, as described by the National Cooperative Soil Survey for Payette County or as described by on-site inspection.
2) Areas with slopes $\geq$30%, if they also have one of the following soil characteristics:
    a. a surface texture that is sand, loamy sand, very fine sandy loam, fine sandy loam, silty clay or clay;
    b. a depth to bedrock $<$20 inches;
    c. an erosion condition that is rated as poor; or
    d. a K-factor $>$0.32.

Floodplain Management
LN-2: The lessee is hereby notified that special location, design and construction mitigation measures may be required to minimize, to the extent possible, the potential long-term and short-term adverse impacts of oil and gas operations within the 100-year floodplain associated with occupancy and modification of the floodplain, and to avoid direct and indirect floodplain development wherever there is a practicable alternative. Under Executive Order 11988: Floodplain Management; the BLM is required to restore and preserve the natural and beneficial values served by floodplains for actions related to federal activities and programs affecting land use.

Endangered Species (Mandatory)
Stipulation (S) –1: The lease area may now or hereafter contain plants, animals, or their habitats determined to be threatened, endangered, or other special status species. BLM may recommend modifications to exploration and development proposals to further its conservation and management objective to avoid BLM-approved activity that will contribute to a need to list such a species or their habitat. BLM may require modifications to or disapprove proposed activity that is likely to result in jeopardy to the continued existence of a proposed or listed threatened or endangered species or result in the destruction or adverse modification of a designated or proposed critical habitat. BLM will not approve any ground-disturbing activity that may affect any such species or critical habitat until it completes its obligations under applicable

requirements of the Endangered Species Act as amended, 16 U.S.C. § 1531 et seq., including completion of any required procedure for conference or consultation.

Special Status Mammals

LN-3: The lease may, in part or in total, contain important southern Idaho ground squirrel (SIDGS), a candidate species, and pygmy rabbit habitats as identified by the BLM, either currently or prospectively. The operator may be required to implement specific measures to reduce impacts of oil and gas operations on SIDGS populations and habitat quality. Such measures shall be developed during the application for permit to drill on-site and environmental review process and will be consistent with the lease rights granted. Measures may include (in order of priority):

1. Avoid areas occupied by SIDGS and pygmy rabbits.
2. When oil and gas facilities are deemed necessary within unoccupied SIDGS or pygmy rabbit habitat, minimize pad size, road width, and the size of other disturbed areas.
3. New construction of roads, pipelines, and rights-of-way would be planned to minimize the effects of fragmenting wildlife habitat.
4. Restore unneeded areas to native or other appropriate vegetation (shrubs, perennial grasses, and forbs as identified by the SIDGS Working Group) immediately upon vacancy of temporary use sites or permanent closure of well sites to provide forage for nearby SIDGS.
5. Construct power transmission lines outside of SIDGS occupied habitat (including a 0.25-mile buffer) whenever possible. If transmission lines are deemed necessary through or within 0.25 miles of SIDGS colonies, locate poles outside of active burrow systems and consider 1) burying transmission lines, or 2) installing raptor anti-perching devices on transmission lines.

Migratory Birds and Raptors

LN-4: The Operator is responsible for compliance with provisions of the Migratory Bird Treaty Act by implementing one of the following measures: a) avoidance by timing - ground disturbing activities would not occur from April 15 to July 15; b) habitat manipulation - render proposed project footprints unsuitable for nesting prior to the arrival of migratory birds (blading or pre-clearing vegetation must occur prior to April 15 within the year and area scheduled for activities between April 15 and July 15 of that year to deter nesting; or c) survey-buffer-monitor surveys would be conducted by a BLM approved biologist within the area of the proposed action and a 300 foot buffer from the proposed project footprint between April 15 to July 15 if activities are proposed within this timeframe. If nesting birds are found, activities would not be allowed within 0.1 miles of nests until after the birds have fledged. If active nests are not found, construction activities must occur within 7 days of the survey. If this does not occur, new surveys must be conducted. Survey reports would be submitted to the appropriate BLM Office.

CSU-11: No surface occupancy would be allowed within 1 mile of an active bald eagle or peregrine falcon nest. No surface use would be allowed from December 1 and March 31 where wintering bald eagles or peregrine falcons occur.

Water Quality

LN-5: The operator may be required to implement specific measures to reduce impacts of oil and gas operations on water quality and quantity. Such measures shall be developed during the application for permit to drill on-site and environmental review process and will be consistent with the lease rights granted.

Cultural Resources (Mandatory)

S-2: This lease may be found to contain historic properties and/or resources protected under the National Historic Preservation Act (NHPA), American Indian Religious Freedom Act, Native American Graves Protection and Repatriation Act, E.O. 13007, or other statutes and executive orders. The BLM would not approve any ground disturbing activities that may affect any such properties or resources until it completes its obligations under applicable requirements of the NHP A and other authorities. These obligations may include a requirement that you provide a cultural resources survey conducted by a professional archaeologist approved by the State Historic Preservation Office (SHPO). If currently unknown burial sites are discovered during development activities associated with this lease, these activities must cease immediately, applicable law on unknown burials will be followed and, if necessary, consultation with the appropriate tribe/group of federally recognized Native Americans will take place. The BLM may require modification to exploration or development proposals to protect such properties, or disapprove any activity that is likely to result in adverse effects that cannot be successfully avoided, minimized or mitigated.

LN-6: The Surface Management Agency is responsible for assuring that the leased lands are examined to determine if cultural resources are present and to specify mitigation measures.

Lands and Realty

LN-7: Land Use Authorizations incorporate specific surface land uses allowed on BLM-administered lands by authorized officers and those surface uses acquired by BLM on lands administered by other entities. These BLM authorizations include rights-of-way, leases, permits, conservation easements, and recreation and public purpose leases and patents.

Paleontological Resources

CSU-12: No surface occupancy would be allowed on sites with known paleontological values. Surface rights-of-way would be routed to avoid paleontological resources.

LN-7: This lease has is located in geologic units rated as being moderate to very high potential for containing significant paleontological resources. The locations meet the criteria for Class 3, 4 and/or 5 as set forth in the Potential Fossil Yield Classification System, WO IM 2008-009, Attachment 2-2. The BLM is responsible for assuring that the leased lands are examined to determine if paleontological resources are present and to specify mitigation measures. Guidance for application of this requirement can be found in WO IM 2008-009 dated October 15, 2007, and WO IM 2009-011 dated October 10, 2008. Prior to undertaking any surface-disturbing activities on the lands covered by this lease, the lessee or project proponent shall contact the BLM to determine if a paleontological resource inventory is required. If an inventory is required, the lessee or project proponent will complete the inventory subject to the following:

- The project proponent must engage the services of a qualified paleontologist, acceptable to the BLM, to conduct the inventory.
- The project proponent will, at a minimum, inventory a 10-acre area or larger to incorporate possible project relocation which may result from environmental or other resource considerations.

A paleontological inventory may identify resources that may require mitigation to the satisfaction of the BLM as directed by WO IM 2009-011 including possible project relocation which may result from environmental or other resource considerations.

2.4 Additional Considerations for Alternatives B-C

For split estate portions of the lease area, the BLM provided courtesy notification to private landowners that their lands are considered in this NEPA analysis and would be considered for inclusion in an upcoming lease sale. If any activity were to occur on such split estate parcels, the lessee and/or operator would be responsible for adhering to BLM requirements as well as formulating and reaching an agreement with the private surface landowners regarding access, surface disturbance, and reclamation (Onshore Oil and Gas Order No. 1). Standard lease terms, stipulations, conditions, and operating procedures would apply to these parcels (43 CFR 3101 and 3160 and 3162).

Standard operating procedures, best management practices, conditions of approval (COA), and lease stipulations could change over time to meet overall RMP and BLM policy objectives. The COA's would be attached to permits for oil and gas lease operations to address site-specific concerns or new information not previously identified in this environmental assessment process. In some cases new lease stipulations may need to be developed, and these types of changes may require an RMP amendment. For example, if climate change results in hotter and drier conditions, RMP objectives would be unreachable under current management. In this situation, management practices might need to be modified to continue meeting overall RMP management objectives. An example of a climate related modification is the imposition of additional conditions of approval to reduce surface disturbance and implement more aggressive dust treatment measures. Both actions reduce fugitive dust, which would otherwise be exacerbated by the increasingly arid conditions that could be associated with climate change.

Oil and gas leases would be issued for a 10-year period and would continue for as long thereafter as oil or gas is produced in paying quantities. If a lessee fails to produce oil and gas, does not make annual rental payments, does not comply with the terms and conditions of the lease, or relinquishes the lease, ownership of the minerals leased would revert back to the federal government, and the lease could be resold.

Well drilling on a lease would not be permitted until the lease owner or operator secures approval of a drilling permit and a surface use plan specified at 43 CFR 3162.

Drainage

LN-A: Parts of this lease may potentially be subject to drainage by wells located on adjacent private lands. The lessee shall, within 6 months of the drilling and completion of any productive well on the adjacent private lands, submit for approval by the authorized officer:

1. Plans for protecting the lease from drainage (43 CFR § 3162.2-3). The plan must include either (a) a completed Application for Permit to Drill for each of the necessary protective wells, or (b) a proposal for inclusion in a unitization or communitization agreement for the affected portion of the lease. Any agreement should provide for an appropriate share of the production from the offending well to be allocated to the lease; or
2. Engineering, geologic and economic data to demonstrate to the authorized officer's satisfaction that no drainage has occurred or is occurring and/or that a new protective well(s) would have little or no chance of production sufficient to yield a reasonable rate of return in excess of the costs of drilling, completing and operating the well.

If no plan, agreement, or data is submitted and drainage is determined to be occurring, compensatory royalty will be assessed. Compensatory royalty will be assessed on the first day following expiration of the 6-month period, and shall continue until a protective well has been drilled and placed into production status, or until the offending well ceases production, whichever occurs first. The lessee shall be obligated to pay compensatory royalty to the Office of Natural Resources Revenue (ONRR) at a rate to be determined by the BLM authorized officer.

Split Estate

LN-B: Portions of the surface estate of this lease are privately owned (i.e. split estate lands). While the Federal mineral lessee has the right to enter the property for necessary purposes related to lease development, the lessee is responsible for making arrangements, formalized in a Surface Use Agreement, with the surface owner prior to entry upon the lands. Lessee is hereby informed that the United States will not participate as a third party in negotiations between the lessee and the surface owner. Any agreement reached between the lessee and the surface owner(s) will not be binding on the United States.

Prior to submitting an Application for Permit to Drill (APD) for BLM's approval, lessee is required to submit the name, address, and phone number of the surface owner, if known, in its APD. The lessee must also make a good faith effort to provide a copy of their Surface Use Plan of Operations to the surface owner. After the APD is approved, the operator must make a good faith effort to provide a copy of the Conditions of Approval to the surface owner.

The lessee will be required to certify to the BLM in writing that: (1) It made a good faith effort to notify the surface owner before entry; and (2) That a Surface Use Agreement with the surface owner has been reached, or that a good faith effort to reach an agreement failed. If no agreement can be reached with the surface owner, the lessee must submit an adequate bond (minimum of $1,000) to the BLM, for the benefit of the surface owner, sufficient to pay for loss or damages. The surface owner has the right to appeal the sufficiency of the bond.

Once a parcel is leased, the lessee has the right to explore for and develop oil and gas resources, subject to standard lease terms and special stipulations pertaining to the conduct of operations. The conduct of operations by the lessee on all parcels would be subject to the following terms from the back of the standard lease form, which state:

"Conduct of Operations (SF-3100-11, Section 6)

Lessee shall conduct operations in a manner that minimizes adverse impacts to the land, air, and water, to cultural, biological and other resources, and to uses or users. Lessee shall take reasonable measures deemed necessary by the lessor to accomplish the intent of this section. To the extent consistent with lease rights granted, such measures may include, but not limited to, modification to siting or design of facilities, timing of operations, and specification of interim and final reclamation measures. Lessor reserves the right to continue existing uses and to authorize future uses upon or in leased lands, including the approval of easements or right-of-way. Such uses shall be conditioned so as to prevent unnecessary or unreasonable interference with rights of lessee.

Prior to disturbing the surface of the leased lands, lessee shall contact lessor to be apprised of procedures to be followed and modifications or reclamation measures that may be necessary. Areas to be disturbed may require inventories or special studies to determine the extent of impacts to other resources. Lessee may be required to complete minor inventories or short-term special studies under guidelines provided by lessor. If in the conduct of operations, threatened or endangered species, objects of historic or scientific interest, or substantial unanticipated environmental effects are observed, lessee shall immediately contact lessor. Lessee shall cease any operations that would result in destruction of such species or objects."

3.0 Affected Environment and Environmental Consequences

3.1 Introduction

Direct and indirect impacts of the proposed actions will be discussed for BLM-administered and split estate lands. Cumulative impacts for other activities will be discussed for all ownerships in the cumulative impacts analysis area. Analyses will be based on the RFDS created for this document (Table 2, Section 3.1.2, and Appendix 1)

Impact Descriptors

Effects can be temporary (short-term) or long lasting/permanent (long-term). These terms may vary somewhat depending on the resource; therefore, each will be quantified by resource where applicable. Generally speaking:

- **Short-term**: 0-3 years (effects are changes to the environment during and following ground-disturbing activities that revert to pre-disturbance conditions, or nearly so, immediately to within a few years following the disturbance).
- **Long-term**: >3 years (effects are those that would remain beyond short-term ground disturbing activities).

The magnitude of potential effects is described as being major, moderate, minor, negligible, or no effect and is interpreted as follows:

- **Major** effects have the potential to cause substantial change or stress to an environmental resource or resource use. Effects generally would be long-term and/or extend over a wide area.
- **Moderate** effects are apparent and/or would be detectable by casual observers, ranging from insubstantial to substantial. Potential changes to or effects on the resource or resource use would generally be localized and short-term.
- **Minor** effects could be slight but detectable and/or would result in small but measurable changes to an environmental resource or resource use.
- **Negligible** effects have the potential to cause an indiscernible and insignificant change or stress to an environmental resource or use.
- **No effect =** no discernible effect.

3.1.1 General Discussion of Impacts

The act of leasing parcels, itself, does not affect resources. If the proposed parcels are leased, it remains unknown whether development would actually occur, and if so, where specific wells would be drilled and where facilities would be placed. This would not be determined until the BLM receives an application for permit to drill (APD) in which detailed information about proposed wells and facilities would be provided for particular leases. Therefore, this EA discusses potential effects that could occur in the event of development. The amount of development is based on potential well densities and associated activities described in a Reasonably Foreseeable Development Scenario (RFDS) developed for the proposed lease area (Section 3.1.2). As per NEPA regulations at 40 CFR 1502.14(f), 40 CFR 1502.16(h), and 40 CFR 1508.20, mitigation measures to reduce, avoid, or minimize potential impacts are identified by resource below.

Upon receipt of an APD, the BLM would initiate a site-specific NEPA analysis to more fully analyze and disclose site-specific effects of specifically identified activities. In all potential exploration and development scenarios, the BLM would require the use of best management practices (BMP) documented in “Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development” (USDI and USDA 2007), also known as the “Gold Book.” The BLM could also identify APD Conditions of Approval (COA), based on site-specific analysis that could include moving the well location, restrict timing of the project, or require other reasonable measures to minimize adverse impacts (43 CFR 3101.1-2 Surface use rights; Lease Form 3100-11, Section 6) to protect sensitive resources, and to ensure compliance with laws, regulations, and land use plans.

3.1.2 Reasonably Foreseeable Development Scenario Summary and Assumptions

If the proposed area is leased, the RFDS describes four phases of exploration and development that could occur: exploration, drilling, field development and production, and abandonment (Appendix 1). The RFDS and EA use the following assumptions.

1. One well would be drilled per government section of approximately 640 acres (based on State well spacing order).
2. Federal lease wells would require an APD and subsequent site-specific NEPA analysis. Additional site-specific requirements, termed Conditions of Approval (COA), may be attached to the approved APD.
3. The total surface disturbance, including well pad, pipeline, and road construction, is assumed to be approximately 5 acres per well. After the well is drilled, the pad size and road widths would be minimized and unneeded acreage would be reclaimed.
4. The lessee would seek approval for a drilling permit from IDL for fee land wells.
5. Wells would be drilled using conventional drilling techniques (i.e., vertical holes that would not require hydraulic fracturing - based on recent drilling in the adjacent Willow and Hamilton fields and on the geologic characteristics of the reservoir).
6. Producing wells would be incorporated into the Willow Field unit development. Dry wells would be plugged and abandoned in accordance with State and federal requirements, and the site would be reclaimed.
7. Oil and gas leases would be issued for an initial term of 10 years, subject to extension if there is drilling occurring or if there is a producing well on the lease.
8. Where gas is present at more than one layer, dual completion would be identified, targeted, and permitted resulting in 1 well/640 acres.

The level of drilling and associated activities would depend on available lease parcels and the effect of stipulations. Between 2 and 25 wells could be drilled in the proposed lease area resulting in 7 to 87.5 acres of surface disturbance (Table 2). The Lessee on adjacent State and private leases is currently bonded for 11-30 wells and they have drilled eight. A total of 17 wells have been permitted and drilled, three within the proposed lease area (Map 1). Within the boundaries of the Hamilton and Willow (exclusive of the proposed lease area) fields, up to 53 new wells could be developed at 1 well/640 acres (Table 2).

Table 2. Acres of surface disturbance for new wells and associated infrastructure, Little Willow Creek lease area (Alternatives A-C) and potential wells in the Hamilton and Willow fields, Payette County, Idaho.

Activity	Alternative			Field[1]	
	A	B	C	Hamilton	Willow
New Wells (#)	2	22	25	47	6
Well Pad Disturbance (2.5 acres/pad)	5	55	62.5	117.5	15
New Roads (0.25 miles/well)	0.5	5.5	6.25	11.75	1.5
Road Disturbance (4 acres/mile)	2	22	25	47	6
Total Surface Disturbance (acres)	7	77	87.5	164.5	21

[1] Based on 1 well/640 acres for sections that do not currently have a well.

3.2 Soils

3.2.1 Affected Environment – Soils

Detailed soil surveys for Idaho have been published by the Natural Resources Conservation Service (NRCS). The proposed lease area is characterized by sloping lava plateaus with gently to moderately sloping alluvial fans (cone-shaped deposits of sediment crossed and built up by streams), terraces, and bottom lands. Soils in the lease area are mainly coarse sandy loams, sandy loams, and silt loams (USDA NRCS 2014). Soil erosion susceptibility indices (K-factors) are categorized into the following ranges: low (K ≤ 0.15), moderate (K = 0.16 - 0.40), and high (K ≥ 0.41). Erosion potential of these soils ranges from moderate (coarse sandy loams) to high (silt loams). K-factors range from 0.20 to 0.64.

The majority of soils are moderately susceptible to erosion (Table 3, Map 3). Approximately 79% of soils (784 acres) are moderately susceptible and 21% (213 acres) are highly susceptible to erosion in the BLM/BLM category; 65% of soils (3,495 acres) are moderately susceptible and 35% (1,899 acres) are highly susceptible in the Private/BLM category. In the Private/Private category 49% of soils are moderately susceptible to erosion and 51% are highly susceptible to erosion (Table 3).

Table 3. Acres of Ownership Categories (Surface/Subsurface Management) in Each K-factor Range.

K-factor Range	Management or Ownership Surface/Subsurface)[1]			Total
	BLM/BLM	Private/BLM	Private/Private	
Moderate (K = 0.16-0.40)	784 (79%)	3,495 (65%)	4,495 (49%)	8,774 (56%)
High (K ≥ 0.41)	213 (21%)	1,899 (35%)	4,758 (51%)	6,870 (44%)
Total Acres	997	5,394	9,253	15,644
K-factor ≤ 0.32	682 (68%)	3,031 (56%)	3,891 (42%)	7,604 (49%)
K-factor > 0.32	314 (32%)	2,364 (44%)	9,253 (58%)	8,040 (51%)
Total Acres	997	5,394	9,253	15,644

[1]BLM/BLM = BLM manages land surface and subsurface minerals; Private/BLM = BLM manages subsurface minerals (federal mineral estate); Private/Private = land surface and subsurface minerals privately owned.

Alternative C stipulations (Section 2.3) specific to Fragile Soils provide a lease notice (LN-1) indicating mitigation would be required in certain situations. In particular, soils with K-factors greater than 0.32 on slopes greater than 30% would require mitigation to limit erosion. Approximately 51% of the proposed lease area contains soils with K-factors above this threshold (Table 3, Figure 1).

3.2.2 Environmental Consequences – Soils

Impacts to soils are based on the RFDS created for this document (Table 2, Appendix 1).

3.2.2.1 General Discussion of Impacts

Soils are investigated to determine erosion hazard and reclamation suitability by evaluating slope and soil properties such as texture, organic matter content, structure, permeability, depth, available water capacity, and salt concentration. Site specific mitigation would limit but not eliminate impacts to soils in the proposed lease area. The extent of impacts to soils would depend on the amount and type of disturbance associated with particular activity, as well as the erosion risk of a given area. As slopes become steeper, the risk of soil instability increases. Actions that alter soil characteristics such as plant cover and composition (amount and species), soil structure, permeability, and compaction may increase erosion potential.


Figure 1. Typical topography, slope, and soil conditions of BLM land in the proposed lease area.

Direct impacts from exploration and development include mixing and breaking down soil components, compaction, and removal of soils in the short term (0-3 years) and long term (>3 years). Compaction alters soil structure (e.g., reduced porosity, increased bulk density) and, therefore, its functionality (e.g., its ability to support healthy vegetation communities and to properly cycle water and nutrients) over the long term (USDA and USFS 2006). Indirect impacts to soils would include removal of ground cover (e.g., vegetation, microbiotic crusts, and litter) in the short term, thus exposing soil surface to wind and water erosion and colonization by weedy, invasive, disturbance related vegetation (e.g., cheatgrass) and or noxious weeds (e.g., rush skeletonweed) over the long term. Reclamation would be required once wells and infrastructure are no longer in use; therefore, soil structure and function would improve from disturbance related levels over the long term.

Oil and gas exploration and development could increase the potential for fire ignitions due to sparks from heavy equipment and/or vehicles, particularly when soils and vegetation are dry. If a fire burns hot enough, it may impact soil directly by altering its physical properties. Physical properties of soils that are dependent on organic matter (e.g., soil structure, pore space, aggregation) could be affected by heating during a fire (USFS RMRS 2014). Fire could also impact soil hydrology (i.e., infiltration) by increasing water repellency (USFS RMRS 2014). However, fires generally move quickly through shrub and grass communities like those in the proposed lease area. Therefore, it is more likely that soils would be indirectly impacted by the loss of vegetative cover leaving them exposed to erosion, as well as alterations in vegetation which, in turn, could alter soil chemistry and overall productivity over the long term.

3.2.2.2 Alternative A

No BLM managed surface or subsurface/federal mineral estate parcels would be leased, so soils would not be directly impacted in these parcels. Oil and gas activities (wells, well pads, and road construction) on private surface/subsurface could disturb up to 7 acres of soils and remove up to 7 acres of vegetation per the RFDS. Moderate to major, direct and indirect, adverse impacts to soils (compaction, soil loss, loss of structure and function, and colonization by weedy plants) would occur over the short and long term on the 7 acres (<0.1% of the proposed lease area). Soils in the high range for erosion susceptibility would incur greater impacts than soils in the moderate range if disturbed (Table 3). Risk of fire starts would be low because there would be little oil and gas development (two wells plus infrastructure); therefore, fire related soil impacts would be minor. Overall impacts to soils would be negligible due to the very small disturbance footprint possible under this scenario.

3.2.2.3 Alternative B

The BLM would issue leases on 997 BLM surface acres and 5,352 acres of federal mineral estate; however, the NSO and NSSO stipulations would preclude any direct disturbance to soils in these parcels until the FRMP is completed. Impacts to soils, including potential fire related impacts, would be identical to Alternative A (i.e., up to 7 acres of moderate to major disturbance) until implementation of the FRMP.

The RFDS for this alternative indicates up to 22 wells and associated infrastructure would cause direct soil impacts on up to 77 acres (0.5% of the proposed lease area) including BLM surface and federal mineral estate, and private surface/subsurface lands. These soils could sustain moderate to major, adverse, direct impacts, such as compaction and removal, and indirect impacts, such as reduction in productivity, over the short and long term associated with well and well pad development and road building. Minor (e.g., limited vegetation disturbance and wildfires) to major (e.g., roads and activities increase disturbances and wildfires) indirect impacts could occur where vegetation shifts to exotic annual dominated communities (e.g., associated with roads or wildfires) occur and soil protection is reduced or eliminated. These areas would be more susceptible wind and water erosion over the long term. However, the extent (magnitude and scale) of impacts would depend on land use designations and stipulations set forth in the FRMP.

3.2.2.4 Alternative C

Impacts would be similar to those described in Alternative B (Section 3.2.2.3); however, per the RFDS, direct impacts on up to 88 acres (0.6% of the proposed lease area) could occur on BLM surface, federal mineral estate, and private lands. Indirect impacts would be more likely to affect federal mineral estate lands in this scenario because of the increased amount of disturbance and closer proximity of disturbances. Direct and indirect impacts associated with well and road construction could be reduced where fragile soils are avoided (LN-1, Section 2.3).

3.2.3 Mitigation

Prior to authorization, proposed actions (APDs) would be evaluated on a case-by-case basis and would be subject to mitigation measures in order to maintain the soil system. Where residual impacts are expected based on future site specific APD analyses, measures would be taken to reduce, avoid, or minimize potential impacts to soil resources from exploration and development activities. Examples of mitigation include avoiding excessively steep slopes and areas poorly suited to reclamation, limiting the total area of disturbance, rapid reclamation, erosion/sediment control, soil salvage, re-vegetation, weed control, slope stabilization, surface roughening, and protective fencing.

3.2.4 Cumulative Impacts – Soils

Cumulative impacts to soils are based on the RFDS created for this document (Appendix 1), the Willow Field RFDS, and the actions identified below.

3.2.4.1 Scope of Analysis

The cumulative impact analysis area (CIAA) includes the proposed lease area and the Willow Field southwest of the lease area plus a 0.5-mile buffer totaling approximately 32,460 acres (50 square miles) (Map 3). The CIAA contains private, State, and BLM surface and federal mineral estate lands. This area was selected because the lands it encompasses have similar topographic, geologic, and soil attributes; soil condition (due to land use and wildfire) and susceptibility to erosion (K-factors) are also similar.

3.2.4.2 Current Conditions, Effects of Past and Present Actions, and Reasonably Foreseeable Future Actions

Soil conditions in the CIAA are nearly identical to those in the proposed leased area; the proposed lease area makes up the majority of the CIAA and the Willow Field has undergone similar disturbances. The levels and intensities of anthropogenic activities across all land jurisdictions in the CIAA has perpetuated increases of early successional, highly disturbed landscapes (Leu and Hanser 2011) that are at higher risk for cumulative soil impacts. Past, ongoing, and future land uses contributing to soil conditions include livestock grazing, agricultural development, rights-of-way, and oil and gas development. Wildfire, though not a land use, has also influenced soil conditions.

Livestock Grazing - Both BLM and private lands within CIAA, the proposed lease area in particular, encompass portions of the Sand Hollow, Rock Quarry Gulch, Dahnke, Hashegan, and Kaufman grazing allotments. Livestock grazing can damage soils via compaction, disruption of the soil profile, and remove vegetative cover exposing soils to erosion, particularly where livestock tend to congregate. Historic and recent grazing management in these allotments have contributed to overall soil condition. Livestock grazing would continue at current levels into the foreseeable future.

Agricultural Development - Conversion from shrub and grass communities to cultivated croplands on private land has altered soils on approximately 28% (8,962 acres) of the CIAA. Future agricultural development is unlikely (or would be negligible) because water necessary for crop production is limited.

Rights-of-way (power lines, roads) - Three short power line segments totaling approximately one mile are present in the CIAA. Power lines typically have two-track roads associated with them which disturb and impact soils. Approximately 9 miles of developed roads including the Little Willow Road (7.8 miles) and Big Willow Road (1.2 miles) run through the CIAA. These features combined have a disturbance footprint of approximately 40 acres; which, to a small degree, have contributed to present soil conditions across the CIAA. Future roads would be constructed in association with development of wells, well pads, and other infrastructure or facilities necessary to maintain oil and gas production. Road construction and maintenance would continue to affect soil erosion and displacement within maintained buffers. These effects are spatially restricted and occur over a continuous temporal scale.

Oil and Gas Development - Currently there are 11 wells and 1 well surface site in the CIAA. An estimated 30-41 acres (depending on infrastructure) of soils have been disturbed in the CIAA to date due to oil and gas exploration and development. An additional 6 wells could be drilled in the Willow Field portion of the CIAA in the future disturbing 21 acres of soils.

Wildfire - Approximately 16,655 acres (51 %) of the CIAA has burned at least one time. Multiple fires have burned within the CIAA, mainly in the 1980s, with some overlap. These fires have perpetuated increases of disturbance related plants, which are indicative of decreased soil productivity.

3.2.4.3 Alternative A – Cumulative Impacts

Disturbance from two wells and related infrastructure (7-acre footprint) would produce negligible short and long term impacts to soils when combined with ongoing and future land uses and disturbance. An additional 6 wells in the Willow Field portion of the CIAA would disturb soils on approximately 21 acres (<0.1% of the CIAA). Livestock grazing, rights-of-way construction and maintenance, and Willow Field oil and gas development combined would produce overall minor to moderate soil impacts over the short and long term. No or negligible additional impacts would occur from development of agriculture due limited water availability necessary for these actions. Wildfires could produce minor to major direct and indirect impacts to soils depending on their size and frequency.

3.2.4.4 Alternatives B and C– Cumulative Impacts

Development of 22 to 25 wells (77-87.5-acre footprint) and related infrastructure would produce minor short and long term impacts to soils in the CIAA when combined with ongoing and future land uses and disturbance. Cumulative impacts to soils from ongoing and future actions including livestock grazing, agricultural development, roads and ROWs, oil and gas development, and wildfire would be identical to those described for Alternative A.

3.3 Vegetation

3.3.1 Affected Environment – Vegetation

General Vegetation

Two ecological sites comprise the majority of the proposed lease area. South Slope Granitic 8-12 is associated with coarse sandy loams and is the primary ecological site occurring on steeper slopes and upper portions of gentle slopes. Loamy 8-12 is associated with sandy loams and silt loams which are present in the bottoms, on toe slopes, and lower portions of steeper slopes.

Basin big sagebrush and bluebunch wheatgrass vegetation communities are characteristic of South Slope Granitic 8-12 sites, and Wyoming big sagebrush and bluebunch wheatgrass with Thurber's needlegrass are characteristic of Loamy 8-12 sites. However, based on 2014 site visits, current plant communities on BLM-administered lands are largely dominated by cheatgrass, an invasive annual grass, and introduced annual forbs (e.g., tall tumblemustard, tansymustard, and clasping pepperweed); which is a result of frequent wildfires in the 1980s and recurring spring livestock grazing (Map 4). Between 1980 and 1986, approximately 49% of the area burned once, 15% burned twice, and 3% burned three times. Perennial plant species occasionally present include Sandberg bluegrass, crested wheatgrass, rabbitbrush, and small pockets of remnant bitterbrush, stiff sagebrush, and Wyoming big sagebrush. In general, north-facing slopes are wetter and contain slightly more perennial vegetation than south-facing, drier slopes; therefore, northerly slopes tend to be more resistant to disturbance and support more resilient plant communities.

General vegetation cover types mapped for the proposed lease area are consistent with observations made during site visits (
Table 4). Exotic Annuals (i.e., cheatgrass and introduced annual mustards) is the dominant cover type for all ownership configurations (Figure 2). Big Sagebrush (mainly Wyoming big sagebrush and/or basin big sagebrush with cheatgrass and Sandberg bluegrass) is the second most common cover type followed by Bunchgrass (mainly Sandberg bluegrass with cheatgrass and occasionally shrubs) and Stiff Sagebrush (mainly stiff sagebrush with cheatgrass, Sandberg bluegrass, and introduced forbs) on BLM/BLM and Private/BLM. On Private/Private, agriculture is the second most common cover type followed by Big Sagebrush. All remaining cover types comprise 4% each or less for all ownership configurations.

Table 4. Acres of general vegetation cover types[1] and percent composition by mineral ownership, Little Willow Creek proposed lease area, Payette County, Idaho.

General Cover Type	Ownership (Surface/Subsurface)[2]			Total Acres
	BLM/BLM	Private/BLM	Private/Private	
Agriculture	3.3 (<1%)	145.6 (3%)	3,004.6 (33%)	3,153.5 (20%)
Big Sagebrush[3]	258.4 (26%)	1,216.3 (23%)	1,478.6 (16%)	2,953.3 (19%)
Bitterbrush	6.6 (<1%)	15.6 (<1%)	15.8 (<1%)	38.0 (<1%)
Bunchgrass	112.5 (11%)	434.2 (8%)	336.2 (4%)	883.0 (6%)
Exotic Annuals	460.4 (46%)	3,125.0 (59%)	3,756.8 (41%)	7,342.2 (47%)
Greasewood	29.8 (3%)	63.1 (1%)	95.6 (1%)	188.5 (1%)
Salt Desert Shrub	28.2 (3%)	155.3 (3%)	112.9 (1%)	296.4 (2%)
Stiff Sagebrush	91.4 (9%)	162.0 (3%)	346.5 (4%)	599.9 (4%)
Wet Meadow	1.1 (<1%)	3.5 (<1%)	29.0 (<1%)	34.0 (<1%)
Other[4]	3.1 (<1%)	13.9 (<1%)	30.1 (<1%)	47.1 (<1%)
Total Acres[5]	995	5,335	9,206	15,536

[1] Pacific Northwest National Laboratory vegetation mapping data (2002).

[2] BLM/BLM = BLM manages land surface and subsurface minerals; Private/BLM = BLM manages subsurface minerals (federal mineral estate); Private/Private = land surface and subsurface minerals privately owned.
[3] Big Sagebrush Mix and Big Sagebrush were combined because the two have nearly identical components.
[4] Other includes Mountain Big Sagebrush, Mountain Shrubs, Rabbitbrush, Sparse Vegetation, Urban, and Water; which were combined because they represent a small portion (<15 acres in each ownership category) of the proposed lease area.
[5] Total acres are slightly less than 15,644 due to GIS processing of PNNL data set (raster data vs. vector data).

Figure 2. Typical vegetation on BLM surface and mineral estate land in the proposed lease area. Note tall tumble mustard, cheatgrass, and Sandberg bluegrass in the foreground and a patch of green rabbitbrush in the background.

Riparian Vegetation

There are 39 acres (<1% of the total lease acres) in the Wet Meadow cover type, which is indicative of riparian vegetation (e.g., cottonwoods, willows, rushes, and sedges) (Table 4). The vast majority of the Wet Meadow cover type (35 acres) is on private lands with private subsurface; only 1.1 acres are on BLM surface managed lands (BLM/BLM) and 3.5 acres are on federal mineral estate (Private/BLM). These areas are mainly associated with Little Willow Creek and the McIntyre Canal and are primarily on private land with private subsurface (Map 5). Additionally, National Wetland Inventory mapping shows approximately 56 acres (which overlap the Wet Meadow cover type to a small degree) of water features (e.g., emergent wetlands, ponds, seeps, and reservoirs) (Map 6). These features are typically used as livestock water sources and are generally sparsely vegetated as a result.

Special Status Plants (SSP)
Two sensitive plant species are mapped in the proposed lease area, an element occurrence (EO) of Snake River goldenweed (BLM Type 3 SSP) and an historical EO of calcareous buckwheat (BLM Type 3 SSP). Three additional EOs of Snake River goldenweed and one EO of Aase's onion (BLM Type 2 SSP) are present within 1 mile of the proposed lease area (Map 5). The calcareous buckwheat was last observed in 1933 and may no longer exist; further, the mapping precision for this EO is very low (G precision)[C], so it is possible that the EO is actually outside the proposed lease area.

Three of the Snake River goldenweed EOs (which includes the EO in the proposed lease area) were not given condition ranks. However, EO records from 2000 indicated that these EOs occurred in dry grasslands-annual grasslands with some perennial species-within weedy rangeland with occasional fire disturbance. Based on the degradation of the vegetation communities across the proposed lease area, and that these EOs are largely mapped in the annual grass cover type, population viability is likely poor. The fourth EO was given a condition rank of D signifying poor estimated viability; the 2006 EO report indicated that the area had burned multiple times and was dominated by annual weeds with few remaining shrubs, and population numbers were drastically lower than previous years. The Aase's onion EO was ranked B for condition in 1995 indicating good estimated viability; however, the EO report states the area had burned, shrubs had not re-established, and cheatgrass was common.

Noxious Weeds
'Noxious' is a legal designation given by the Director of the Idaho State Department of Agriculture to any plant having the potential to cause injury to public health, crops, livestock, land or other property (Idaho Statute 22-2402). The Boise District BLM has an active weed control program that annually updates the locations of noxious weeds and treats known weed infestations utilizing chemical, mechanical, and biological control techniques. Infestations of noxious weeds are treated contingent upon the BLM annual weed budget, employee availability, and noxious weed priority.

There are no noxious weeds mapped in the proposed lease area according to BLM Boise District noxious weeds database. However, numerous infestations of rush skeletonweed and Scotch thistle have been recorded in the vicinity (within three to five miles). Many of these infestations have been chemically treated at least once since 2001. Although no noxious species have been recorded within the proposed lease area boundary, it is likely that they do occur to some degree based on the degraded state of vegetation communities.

3.3.2 Environmental Consequences – Vegetation
Impacts to vegetation are based on the RFDS created for this document (Table 2, Appendix 1).

[C] G is the lowest precision and is typically applied by the Idaho Fish and Game's Idaho Natural Heritage program to historic observations and or observations lacking GPS data. A large buffer is created around a centroid, indicating that the location of the EO likely occurs/occurred somewhere within the polygon, but confidence is low as to its precise location. This EO is not depicted on the map provided because the location polygon is so large (77miles²).

3.3.2.1 General Discussion of Impacts

Site specific mitigation and stipulations would limit impacts to sensitive vegetation (SSPs) and sensitive areas (riparian areas). The level of impacts to vegetation would depend on the amount and type of disturbance associated with a given activity.

General Vegetation

Lease development would directly impact vegetation by removing, damaging (i.e., breakage, trampling), or burying plants. When vegetation is removed and soil is exposed, noxious and invasive species may spread degrading overall condition of plant communities. The influx of machinery and vehicle travel associated with development, production, and improved access would increase the risk of fire starts, especially once vegetation has cured (late summer). Fire would damage or remove vegetation and potentially further degrade vegetation community structure and function. Burned areas would be more susceptible to noxious and invasive species colonization/spread and overall habitat degradation. Roads and degraded habitats would increase fragmentation by reducing the size of and increasing the distance between native vegetation stands.

Surface disturbing activities could also indirectly affect vegetation by disrupting seed banks and mixing, eroding, or compacting soils. Soil erosion would reduce the substrate available for plants and soil compaction could limit seed germination. Fugitive dust generated by construction activities and travel along dirt roads could affect nearby plants by depressing photosynthesis, disrupting pollination, and reducing reproductive success. Impacts to plants occurring after germination but prior to seed set could be particularly harmful as both current and future generations would be affected.

Riparian Vegetation

Direct and indirect impacts to riparian vegetation by surface disturbing activities would be the same as those described for general vegetation. However, mitigation and stipulations would likely prevent direct impacts to riparian vegetation, except on private lands with private mineral estate.

Special Status Plants

Direct impacts by surface disturbing activities would be the same as those described for general vegetation; however, mitigation and stipulations could prevent direct impacts. Networks of oil and gas infrastructure, roads in particular, could create pollinator and seed dispersal barriers. Vegetation removal and displacement by invasive and/or noxious species would also cause indirect impacts to sensitive plants via habitat degradation. Habitat fragmentation could also lead to a decrease in pollinators over time. All of these factors could decrease long-term EO viability.

Noxious Weeds

Both rush skeletonweed and Scotch thistle are capable of invading and dominating disturbed areas (roadsides, areas burned by wildfire, etc.) over a wide range of precipitation regimes and habitats (Sheley and Petroff 1999). Road building and use would create corridors and seed sources for noxious weed establishment and spread. Noxious weed inventories and treatments could offset some impacts.

3.3.2.2 Alternative A

General Vegetation

Development and production on private surface with private subsurface could disturb up to 7 acres (<0.1% of the proposed lease area) of vegetation. Moderate to major, direct (i.e., removal, breakage, and burying of vegetation) and indirect (e.g., influx of noxious and invasive species, disruption of seed bank, and plant community degradation) impacts would occur over the short (0-3 years) and long (>3 years) term in the isolated areas associated with wells and roads. The federal mineral estate (6,349 acres) would not be leased, so vegetation would not be directly affected in these parcels.

Vegetation in the unleased area could receive similar negligible to minor indirect impacts where invasive annuals, noxious weeds, or fires spread from developed areas. The degree of indirect impacts would depend on the condition and components of plant communities prior to disturbance. Those plant communities maintaining shrubs and native perennial grasses could better resist invasive and noxious weed invasions; however, they would be less resistant if affected by fire. New and upgraded roads would cause minor increased fragmentation.

The threat of fire ignitions could increase a minor amount by equipment use and vehicles travelling on existing and new (0.5 miles) access roads. The extent of impacts to vegetation across all jurisdictions would be influenced by fire size and behavior, as well as the pre-fire vegetation community conditions.

Riparian Vegetation

There would be no impacts to riparian vegetation or habitat on BLM-administered land or federal mineral estate. The extent of short- and long- term direct impacts (i.e., removal or damage) and long-term indirect impacts (i.e., habitat degradation) to riparian vegetation on private mineral estate would depend on the proximity of the disturbance. Any impacts would likely come from access roads associated with wells/well pads.

Special Status Plants

The Snake River goldenweed EO, or other currently mapped special status plant EOs, would not be directly impacted (i.e., removed or damaged). Long-term indirect impacts, such as habitat degradation or fragmentation, would be negligible because overall habitat condition is already relatively poor and the 0.5 mile of new access roads would be $\geq$2.5 miles away.

Noxious Weeds

The 0.5 miles of new roads could serve as minor noxious and invasive species corridors over the long term.

3.3.2.3 Alternative B

General Vegetation

The NSO and NSSO stipulations would apply until the FRMP is finalized and implemented; therefore, until that time, direct impacts to vegetation would be similar to those described for Alternative A (Section 3.3.2.2).

The RFDS for this alternative specifies up to 77 acres (0.5% of the proposed lease area) of vegetation on private surface and subsurface would sustain moderate to major, adverse, direct impacts (i.e., removal, breakage, and burying of vegetation). Minor to major indirect impacts (e.g., influx of noxious and invasive species, disruption of seed bank, and plant community degradation) could occur over the long term. Because wells and roads would occur throughout the proposed lease area, both private and federal mineral estate lands could be adversely affected. Moderate increases in habitat fragmentation could occur, especially where invasive species increase adjacent to roads. Minor (access restricted by private landowners and fire starts remain similar to current levels) to major (access not restricted and fire starts increase substantially) wildfire impacts could degrade vegetation conditions increasing fragmentation over the long term. However, the extent (magnitude and scale) of impacts to vegetation would depend on land use designations and stipulations set forth in the FRMP.

Riparian Vegetation

Direct impacts (i.e., removal or damage) to riparian areas would not occur on federal mineral estate lands. Long-term indirect impacts on BLM surface and federal mineral estate riparian vegetation would be similar to Alternative A (Section 3.3.2.2) and depend on the proximity of the disturbance. The extent of indirect impacts could be greater than Alternative A because more development would require more access roads (0.5 versus 5.5 miles of new access roads).

Special Status Plants

No direct impacts to the Snake River goldenweed EO or other currently mapped special status plant EOs would occur. Long-term indirect impacts to SSPs on BLM surface and federal mineral estate could be minor to moderate, but would depend on the proximity of the disturbance. However, the degree of these impacts could be greater than Alternative A because development could occur within 0.2 miles of the EO. Increased fragmentation and wildfire potential would adversely affect the EO over the long term.

Noxious Weeds

The 5.5 miles of new roads (and upgrades of existing roads) accessing 22 wells would serve as minor to moderate noxious and invasive species corridors over the long term.

3.3.2.4 Alternative C

General Vegetation

The same area would be leased as Alternative B, but Cascade RMP stipulations and other lease notices for development would apply specific to riparian areas and SSPs. According to the RFDS, up to 87.5 acres (0.6% of the proposed lease area) would sustain moderate to major, adverse, direct impacts (i.e., removal, breakage, and burying of vegetation). Vegetation community degradation, increased invasive species, seed bank disruption, and wildfire impacts would be similar to those described in Alternative B (Section 3.3.2.3); however, federal mineral reserve lands (with minor exceptions associated with avoidance buffers) would be more likely to be affected because direct disturbances would occur on rather than adjacent to these lands.

Riparian Vegetation
Negligible indirect impacts could occur over the short and long term. Stipulations CSU-1 and CSU-2 (Section 2.3) would preclude direct impacts and limit indirect impacts.

Special Status Plants
Impacts (habitat degradation and fragmentation) would be similar to those described for Alternative B (Section 3.3.2.3); however, development could occur closer to EOs producing greater indirect impacts.

Noxious Weeds
The 6.25 miles of new access roads associated with 25 wells would increase the threat of noxious and invasive species spread slightly more than Alternative B (Section 3.3.2.3), but would remain in the minor to moderate range, overall. There are no stipulations or mitigation specific to noxious weeds under this scenario, but the Boise District BLM's annual weed control program could help mitigate noxious weed expansion.

3.3.3 Mitigation

Site specific mitigation would be addressed at the APD stage of exploration and development. If necessary, COAs could be applied including re-vegetation strategies using native and/or desirable non-native plant species, soil enhancement practices, modification of livestock grazing, and fencing of reclaimed areas. Noxious weed inventories and treatments may also be required.

Special Status Plants
Section 7 of the Endangered Species Act (ESA) requires BLM land managers to ensure that any action authorized, funded, or carried out by the BLM is not likely to jeopardize the continued existence of any threatened or endangered species and that it avoids any appreciable reduction in the likelihood of recovery of affected species. Consultation with the U. S. Fish and Wildlife Service (FWS) is required on any action proposed by the BLM or another federal agency that affects a listed species or that jeopardizes or modifies critical habitat.

The BLM's Special Status Species Policy outlined in BLM Manual 6840, Special Status Species Management, is to conserve listed species and the ecosystems on which they depend and to ensure that actions authorized or carried out by BLM are consistent with the conservation needs of special status species and do not contribute to the need to list any of these species. The BLM's policy is intended to ensure the survival of those plants that are rare or uncommon, either because they are restricted to specific uncommon habitat or because they may be in jeopardy due to human or other actions. The policy for federal candidate species and BLM sensitive species is to ensure that no action that requires federal approval should contribute to the need to list a species as threatened or endangered.

Prior to any exploration or development, the BLM would conduct site specific rare and sensitive plant surveys. If rare (threatened, endangered, proposed, or candidate species) or sensitive plants

(SSPs) are found, avoidance stipulations (e.g., disturbance buffers) would be applied. If listed species are found, BLM would consult with the USFWS during the analysis phase of processing an ADP.

3.3.4 Cumulative Impacts – Vegetation

Cumulative impacts to vegetation are based on the RFDS created for this document (Appendix 1), the Willow Field RFDS, and the actions described below.

3.3.4.1 Scope of Analysis

The CIAA for vegetation, consistent with the soils CIAA, encompasses the proposed lease area and the Willow field totaling plus a 0.5-mile buffer totaling approximately 32,460 acres (50 $miles^2$) (Map 4). This area was selected because it contains similar ecological sites and plant community components, conditions are similar, and oils and gas leasing and development is occurring (land uses are comparable).

3.3.4.2 Current Conditions, Effects of Past and Present Actions, and Reasonably Foreseeable Future Actions

Conditions across the CIAA are similar to conditions in the proposed lease sale perimeter: vegetation communities have been degraded and are largely dominated by non-native, weedy, annual species with small patches of remnant native shrubs and perennial grasses. There are no additional special status plants or noxious weeds mapped within the CIAA. Past, ongoing, and future land uses contributing to condition of vegetation include livestock grazing, agricultural development, rights-of-way, and oil and gas development. Wildfire has also been instrumental in shaping the vegetation community components and overall condition.

Livestock Grazing - Both BLM and private lands within CIAA, the proposed lease area in particular, encompass portions of the Sand Hollow, Rock Quarry Gulch, Dahnke, Hashegan, and Kaufman grazing allotments. Livestock grazing can damage and remove vegetation, especially where livestock tend to congregate. Historic and recent grazing management in these allotments have contributed to overall plant community condition. Livestock grazing would continue at current levels into the foreseeable future.

Agricultural Development - Conversion from shrub and grass communities to cultivated croplands on private land has occurred on approximately 28% (8,962 acres) of the CIAA. Future agricultural development is unlikely (or would be negligible) because water necessary for crop production is limited.

Roads and Rights-of-way (ROW) - Road or ROW (powerlines and pipelines) construction and subsequent ongoing maintenance (e.g., blading, grading, and/or spraying) along these features will continue to affect vegetation within and adjacent to maintained buffers. Blading and grading disturb soils and vegetation and often create conditions conducive to noxious and invasive species establishment. Spraying of these sites helps to keep weeds and weedy species relatively restricted to the maintained buffers or to a minimum (e.g., around powerline poles, which are kept relatively free of vegetation to prevent fire). As a result, upland vegetation is often sparse in these locations. Road construction and maintenance would continue to impact vegetation within maintained buffers. These effects are generally spatially restricted and occur over a continuous temporal scale.

Three short power line segments totaling approximately one mile are present in the CIAA. Power lines typically have two-track roads associated with them which disturb and impact vegetation. Approximately 9 miles of developed roads including the Little Willow Road (7.8 miles) and Big Willow Road (1.2 miles) run through the CIAA. Combined, these features have a disturbance footprint of approximately 40 acres; which has contributed to present plant community conditions. Additional roads are anticipated to access wells, well pads, and other infrastructure or facilities necessary to maintain oil and gas production.

Oil and Gas Development - Currently there are 11 wells and 1 well surface site in the CIAA. Vegetation on approximately 30-41 acres (depending on infrastructure) has been removed or disturbed to date due to oil and gas exploration and development. An additional 6 wells could be drilled in the Willow Field portion of the CIAA which would disturb approximately 21 acres of vegetation.

Wildfire - Several fires have burned across the CIAA, mainly in the 1980s. Approximately 51 % (16,655 acres) of the CIAA has burned at least one time. These fires have perpetuated increases of disturbance related plants, degrading overall vegetation community conditions. Disturbance related vegetation often equates to fine fuels which burn readily creating a negative feedback loop.

3.3.4.3 Alternative A – Cumulative Impacts

Disturbance from two wells and related infrastructure would produce negligible additive short- and long-term impacts to vegetation. In the Willow Field portion of the CIAA, an additional 6 wells would disturb vegetation on approximately 21 acres (<0.1% of the CIAA) combined with the 30-41 acres of existing disturbance would produce minor impacts over the short and long term. Ongoing livestock use in areas grazed each spring (before seed set) could perpetuate disturbance related plants. Sensitive plants could also be impacted directly via trampling by livestock. Rights-of-way construction and maintenance would produce overall minor impacts to vegetation including habitat degradation and fragmentation over the short and long term. Wildfires could produce minor to major direct and indirect impacts to vegetation depending on fire size and frequency. Further agricultural development is improbable, so no additional impacts to vegetation would take place.

3.3.4.4 Alternatives B and C – Cumulative Impacts

Development of 22 to 25 wells and related infrastructure totaling 77 to 87.5 acres of disturbance would produce minor short and long term additive impacts to vegetation in the CIAA. Cumulative impacts to vegetation from ongoing and future actions identified in section 3.3.3.2 (livestock grazing, agricultural development, roads and ROWs, oil and gas development, and wildfires) would be identical to those described for Alternative A.

3.4 Air Resources

Air resources include air quality, air quality related values (AQRVs), and climate change. As part of the planning and decision making process, the BLM considers and analyzes the potential effects of BLM and BLM-authorized activities on pollutant emissions and on air resources.

The Environmental Protection Agency (EPA) has the primary responsibility for regulating air quality, including seven criteria air pollutants subject to National Ambient Air Quality Standards (NAAQS). Pollutants regulated under NAAQS include carbon monoxide (CO), lead, nitrogen dioxide (NO2), ozone, particulate matter with a diameter less than or equal to 10 microns (PM10), particulate matter with a diameter less than or equal to 2.5 microns (PM2.5), and sulfur dioxide (SO2). Two additional pollutants, nitrogen oxides (NOx) and volatile organic compounds (VOCs) are regulated because they form ozone in the atmosphere. Air quality regulation is also delegated to the IDEQ. Air quality is determined by pollutant emissions and emission characteristics, atmospheric chemistry, dispersion meteorology, and terrain. The AQRVs include effects on soil and water such as sulfur and nitrogen deposition and lake acidification, and aesthetic effects such as visibility.

Climate is the composite of generally prevailing weather conditions of a particular region throughout the year, averaged over a series of years. Climate change includes both historic and predicted climate shifts that are beyond normal weather variations.

3.4.1 Affected Environment – Air Resources

Air Quality

Based on data from monitors located in Baker County Oregon (west and generally upwind of the lease area) and Ada and Canyon counties (southeast and generally downwind of the lease area), air quality in Payette County is believed to be much better than required by the NAAQS. The EPA air quality index (AQI) is an index used for reporting daily air quality (http://www.epa.gov/airdata/) to the public. The index tells how clean or polluted an area's air is and whether associated health effects might be a concern. The EPA calculates the AQI for five criteria air pollutants regulated by the Clean Air Act (CAA): ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established NAAQS to protect public health. An AQI value of 100 generally corresponds to the primary NAAQS for the pollutant. The following terms help interpret the AQI information:

- **Good** – The AQI value is between 0 and 50. Air quality is considered satisfactory and air pollution poses little or no risk.
- **Moderate** – The AQI is between 51 and 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- **Unhealthy for Sensitive Groups** – When AQI values are between 101 and 150, members of "sensitive groups" may experience health effects. These groups are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease

are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range.

- **Unhealthy** – The AQI is between 151 and 200. Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects.
- **Very Unhealthy** – The AQI is between 201 and 300. This index level would trigger a health alert signifying that everyone may experience more serious health effects.

AQI data show that there is little risk to the general public from air quality in the analysis area (Table 5). Based on available aggregate data for Baker, Ada, and Canyon counties (the nearest counties with monitoring data) for years 2011–2013, more than 84% of the days were rated "good" and the three-year median daily AQI was 19 to 32. Moderate or lower air quality days were typically associated with winter inversions or summer wildfire activity.

Table 5. Air Quality Index Report – Analysis Area Summary (2011-2013), Baker County Oregon and Ada Canyon Counties Idaho.

County[1]	# Days in Period	Median AQI	# Days rated Good	Percent of Days Rated Good	# Days Rated Moderate	# Days Rated Unhealthy for Sensitive Groups	# Days Rated Unhealthy	# Days Rated Very Unhealthy
Baker	1,084	28	915	84	167	2	0	0
Ada	1,088	32	917	84	157	11	2	1
Canyon	1,019	19	925	91	87	4	3	0

Source: EPA 2013a.

Emissions in Payette County are low, due to a small populations and little industrial activity. Based on 2011 emission inventory data available from the EPA National Emission Inventory, oxides of nitrogen, carbon monoxide, ≤10 micron particulate matter (PM_{10}), volatile organic compounds, and carbon dioxide were the most common non-biogenic emissions in Payette County (EPA 2014a). As described above, these emissions occur in an area with good air quality.

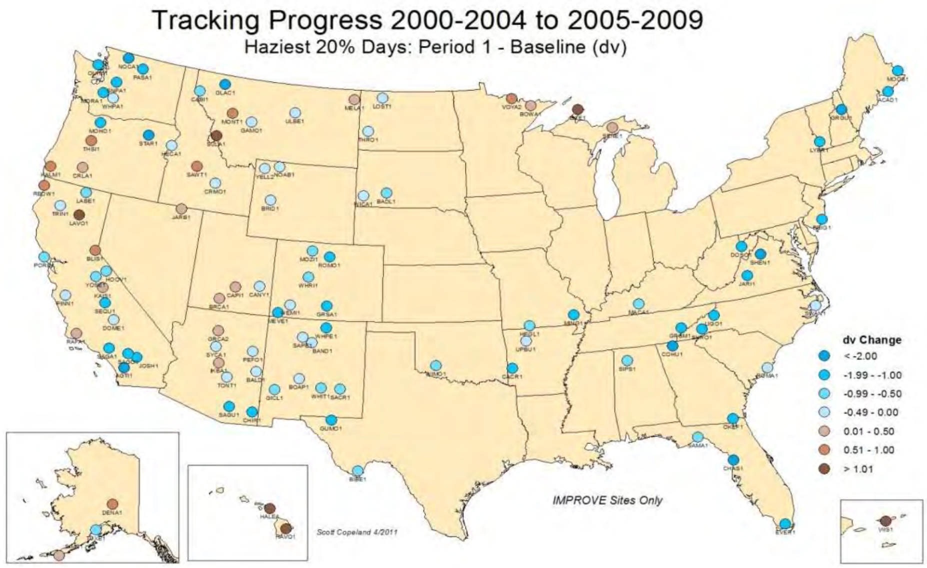
Table 6. Annual emissions (tons/year) of typical pollutants, typical annual emissions for a well (Upper Green River, Wyoming), and emissions for the reasonably foreseeable development scenario wells (Payette County) and cumulative impacts analysis area (Baker, Ada, Canyon, and Payette counties), Idaho and Oregon.

Pollutant	**Payette County**	**Cumulative Impacts Analysis Area**	**Per Well[1]**	**Alternative (%increase over Payette County values)**			**Hamilton and Willow Fields[(2)]**
				A	**B**	**C**	
NOx (Oxides of Nitrogen)	1,445.4	24,851.4	14.6	29.2 (2%)	321.2 (22.2%)	365 (25.3%)	774 (3.1%)
CO (Carbon Monoxide)	6,308.3	149,894.3	3.9	7.8 (0.1%)	85.8 (1.4%)	97.5 (1.6%)	207 (0.1%)
SO_2 (Sulfur Dioxide)	39.1	2,800.2	0.0004	0.0008 (<0.01%)	0.0088 (0.02%)	0.01 (0.03%)	0.02 (0.001%)
PM_{10} (Particulates	6,195.6	61,101.9	6.7	13.4	147.4	167.5	355.1

Pollutant	Payette County	Cumulative Impacts Analysis Area	Per Well[1]	Alternative (%increase over Payette County values)			Hamilton and Willow Fields[(2)]
				A	B	C	
with diameters ≤10 microns or ≤10 x 10^{-6} meters)				(0.2%)	(2.4%)	(2.7%)	(0.7%)
$PM_{2.5}$ (Particulates with diameters ≤ 2.5 microns or ≤2.5 x 10^{-6} meters)	828.4	12,815.4	0.8	1.6 (0.2%)	17.6 (2.1%)	20.0 (2.4%)	42.4 (0.3%)
VOCs (Volatile Organic Compounds)	1,123.1	28,539.1	5.2	10.4 (0.9%)	114.4 (10.2%)	130.0 (11.6%)	275.6 (1.0%)
HAPs (Hazardous Air Pollutants)							
Benzene	18.2	583.2	0.12	0.2 (1.3%)	2.6 (14.5%)	3.0 (16.5%)	6.4 (1.2%)
Toulene	67.4	1,509.5	0.22	0.4 (0.7%)	4.8 (7.2%)	5.5 (8.2%)	11.7 (0.8%)
Ethylbenezene	9.7	190.3	0.00003	0.00006 (<0.01%)	0.0007 (0.01%)	0.0008 (0.01%)	0.002 (0.001%)
Xylene	39	801.5	0.17	0.3 (0.9%)	3.7 (9.5%)	4.3 (10.9%)	9.0 (1.1%)
n-Hexane	23	615.1	0.20	0.4 (1.7%)	4.4 (19.1%)	5.0 (21.7%)	10.6 (1.7%)
Total HAPs	157.3	3,654.6	0.72	1.4 (0.9%)	15.8 (10.2%)	18.0 (11.4%)	38.2 (1.0%)
GHGs (Greenhouse Gases)							
CO_2 (Carbon Dioxide)	240,158	4,029,296	2,582.1	5,164.2 (2.2%)	56,806.2 (23.7%)	64,552.5 (26.9%)	136,851.3 (3.4%)
CH_4 (Methane)	28.6	1,478.8	14.1	28.2 (98.6%)	310.2 (1,085%)	352.5 (1,233%)	747.3 (50.5%)
N_xO (Nitrous Oxides)	8.4	169.0	0.05	0.1 (1.2%)	1.1 (13.1%)	1.3 (14.9%)	2.7 (1.6%)
CO_2 eq (Global Warming Potential)[3]	243,362	4,112,744	2,893.7	5,787.4 (2.4%)	63,661.4 (26.2%)	72,342.5 (29.7%)	153,366.1 (3.7%)

[1] Source: Kleinfelder (2014)
[2] %increase over CIAA
[3] GWP (Global Warming Potential/Carbon Dioxide Equivalent [CO_2eq]) for CO_2 =1, CH_4 = 21, and N_2O = 310.

Air resources also include visibility, which can be degraded by regional haze caused in part by sulfur, nitrogen, and particulate emissions. Based on trends identified during 2000-2009, visibility has improved slightly near the analysis area on the haziest and clearest days. Blue-shaded circles in Figure 3 indicate negative deciview (dv) changes, which mean that people can see more clearly at greater distances.



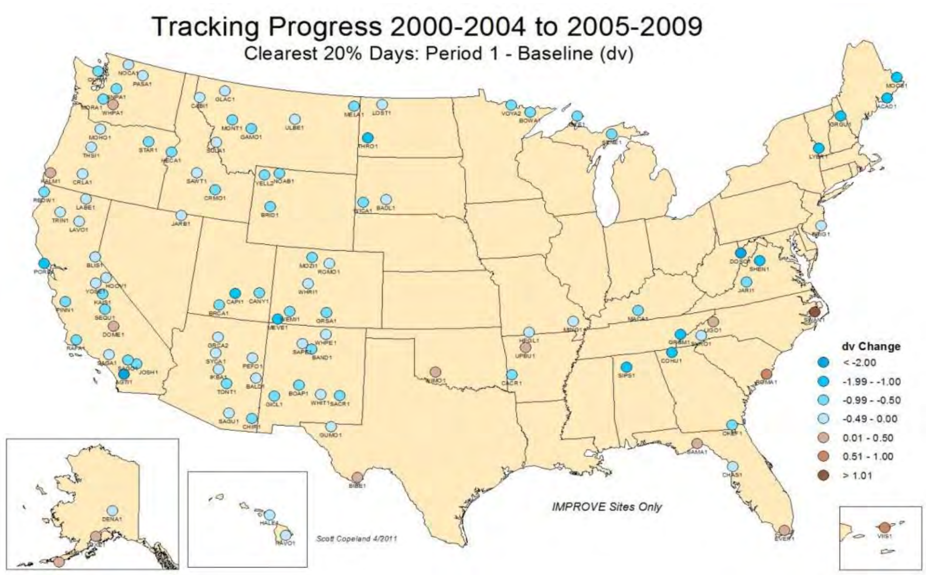


Figure 3. Visibility trends on haziest and clearest days, 2000-2009 (IMPROVE 2011).

Climate Change/Greenhouse Gasses

Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) as "a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and persist for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC 2007).

The Intergovernmental Panel on Climate Change (Climate Change SIR[D] 2010) states, "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Global average temperature has increased approximately 1.4°F since the early 20th century (Climate Change SIR 2010). Warming has occurred on land surfaces, oceans and other water bodies, and in the troposphere (lowest layer of earth's atmosphere, up to 4-12 miles above the earth). Other indications of global climate change described by the IPCC (Climate Change SIR 2010) include:

- Rates of surface warming increased in the mid-1970s and the global land surface has been warming at about double the rate of ocean surface warming since then;
- Eleven of the last 12 years rank among the 12 warmest years on record since 1850;
- Lower-tropospheric temperatures have slightly greater warming rates than the earth's surface from 1958-2005.

As discussed and summarized in the Climate Change SIR, earth has a natural greenhouse effect wherein naturally occurring gases such as water vapor, CO_2, methane, and N_2O absorb and retain heat. Without the natural greenhouse effect, earth would be approximately 60°F cooler (Climate Change SIR 2010). Current ongoing global climate change is caused, in part, by the atmospheric buildup of greenhouse gases (GHGs), which may persist for decades or even centuries. Each GHG has a global warming potential that accounts for the intensity of each GHG's heat trapping effect and its longevity in the atmosphere (Climate Change SIR 2010). Increased GHG emissions of CO_2, methane, N_2O, and halocarbons since the start of the industrial revolution have substantially increased atmospheric concentrations of these compounds compared to background levels. At such elevated concentrations, these compounds absorb more energy from the earth's surface and re-emit a larger portion of the earth's heat back to the earth rather than allowing the heat to escape into space than would be the case under more natural conditions of background GHG concentrations.

A number of activities contribute to the phenomenon of climate change, including emissions of GHGs (especially carbon dioxide and methane) from fossil fuel development, large wildfires, activities using combustion engines, changes to the natural carbon cycle, and changes to radiative forces and reflectivity (albedo) due to soot deposition and other surface changes. It is important to note that GHGs will have a sustained climatic impact over different temporal scales due to their differences in global warming potential (described above) and lifespans in the atmosphere. For example, CO_2 may last 50 to 200 years in the atmosphere while methane has an average atmospheric life time of 12 years (Climate Change SIR, 2010).

With regard to statewide GHG emissions, Idaho ranks in the lowest decile when compared to all states. The estimate of Idaho's 2011 GHG emissions of 28.5 million metric tons (MMt) of

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[D] Although the Climate Change SIR was developed for oil and gas leasing activities in Montana, North Dakota, and South Dakota, conclusions from broader scale analyses/findings are applicable in Idaho.

carbon dioxide equivalent (CO_2e) accounted for approximately 0.43% of the U.S. GHG emissions (WRI 2014).

Some information and projections of impacts beyond the project scale are becoming increasingly available. Chapter 3 of the Climate Change SIR describes impacts of climate change in detail at various scales, including the state scale when appropriate. The following summary characterizes potential changes identified by the EPA (EPA 2014a) that are expected to occur at the regional scale, where the Proposed Action and its alternatives could occur. The EPA identifies Idaho as part of the Northwest region (EPA 2014a):

- The region is expected to experience warmer temperatures with less snowfall.
- Temperatures are expected to increase more in winter than in summer, more at night than in the day, and more in the mountains than at lower elevations.
- Earlier snowmelt means that peak stream flow would be earlier, weeks before the peak needs of ranchers, farmers, recreationalists, and others. In late summer, rivers, lakes, and reservoirs would be drier.
- More frequent, more severe, and possibly longer-lasting droughts are expected to occur.

Other impacts could include:
- Increased particulate matter in the air as drier, less vegetated soils experience wind erosion.
- Shifts in vegetative communities which could threaten plant and wildlife species.
- Changes in the timing and quantity of snowmelt which could affect both aquatic species and agricultural needs.

Projected and documented broad-scale changes within ecosystems of the U.S. are summarized in the Climate Change SIR. Some key aspects include:
- Large-scale shifts have already occurred in the ranges of species and the timing of the seasons and animal migrations. These shifts are likely to continue. Climate changes include warming temperatures throughout the year and the arrival of spring an average of 10 days to two weeks earlier through much of the U.S. compared to 20 years ago. Multiple bird species now migrate north earlier in the year.
- Fires, insect epidemics, disease pathogens, and invasive weed species have increased and these trends are likely to continue. Changes in timing of precipitation and earlier runoff increase fire risks.
- Insect epidemics and the amount of damage that they may inflict have also been on the rise. The combination of higher temperatures and dry conditions have increases insect populations such as pine beetles, which have killed trees on millions of acres in western U.S. and Canada. Warmer winters allow beetles to survive the cold season, which would normally limit populations; while concurrently, drought weakens trees, making them more susceptible to mortality due to insect attack.

More specific to Idaho, additional projected changes associated with climate change described in Section 3.0 of the Climate Change SIR (2010) include:
- Temperature increases are predicted to be between 3 to 5°F at the mid-21st century.

- Precipitation may increase in winter by up to 25%, remain stable during the spring and fall, and decrease by up to 25% during the summer.
- Predicted annual runoff for 2041–2060 compared to 1901–1970 is expected to remain stable.
- Wildland fire risk is predicted to continue to increase due to climate change effects on temperature, precipitation, and wind. One study predicted an increase in median annual area burned by wildland fires in southern Idaho based on a 1°C global average temperature increase to be 111%.

While long-range regional changes might occur within this analysis area, it is impossible to predict precisely when they could occur. The following example summarizing climate data for the Idaho Southwestern Valleys illustrates this point at a regional scale. A potential regional effect of climate change is earlier snowmelt and associated runoff. This is directly related to spring-time temperatures. Over a 119-year record, temperatures increased 0.08 degrees per decade (Figure 4). This would suggest that runoff may be occurring earlier than in the past. However, data from 1994-2014 indicates a 0.5 degree per decade cooling trend (Figure 5). This example is not an anomaly, as several other 20-year windows can be selected to show either warming or cooling trends. Some of these year-to-year fluctuations in temperature are due to natural processes, such as the effects of El Niños, La Niñas, and the eruption of large volcanoes. This information illustrates the difficulty of predicting actual short-term regional or site-specific changes or conditions which may be due to climate change during any specific time frame.

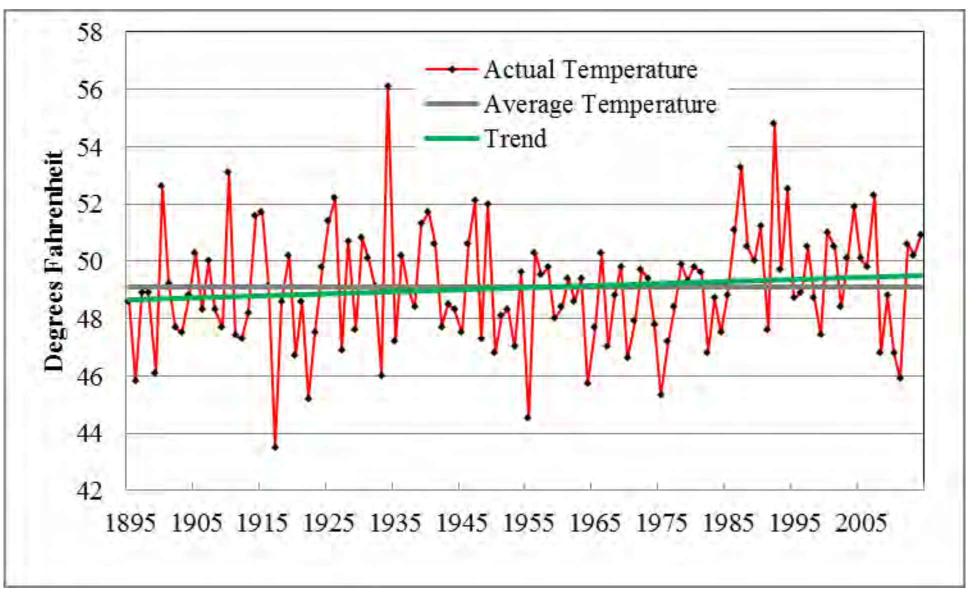


Figure 4. Regional climate summary of spring temperatures (March-May) for Idaho Southwestern Valleys, from 1895-2014. (Source: NOAA website http://www.ncdc.noaa.gov/oa/climate/research/cag3/wn.html)

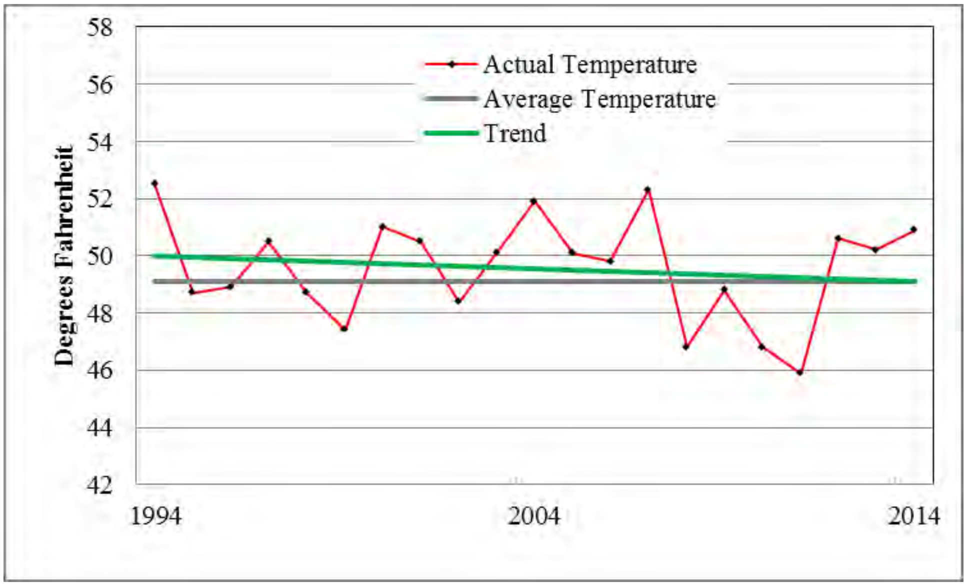


Figure 5. Regional climate summary of spring temperatures (March-May) for Idaho Southwestern Valleys, from 1994-2014. (Source: NOAA website http://www.ncdc.noaa.gov/oa/climate/research/cag3/wn.html)

3.4.2 Environmental Consequences – Air Resources

Impacts to air resources are based on the RFDS created for this document (Table 2, Appendix 1).

3.4.2.1 General Discussion of Impacts

Air Quality

Potential impacts of development could include increased airborne soil particles blown from new well pads or roads; exhaust emissions from drilling equipment, compressors, vehicles, and dehydration and separation facilities; as well as potential releases of GHGs and VOCs during drilling or production activities. The amount of increased emissions cannot be precisely quantified at this time since it is not known for certain how many wells might be drilled, the types of equipment needed if a well were to be completed successfully (e.g., compressor, separator, dehydrator), or what technologies may be employed by a given company for drilling any new wells. The degree of impact would also vary according to the characteristics of the geologic formations from which production occurs, as well as the scope of specific activities proposed in an APD. Oxides of nitrogen, carbon monoxide, volatile organic compounds, carbon dioxide, and methane are the most common emissions from a typical well (Green River, Wyoming; Table 6). The Kleinfelder report provides estimated pollutants for wells in three locations (San Juan, Uinta/Piceance, and Upper Green River basins). This analysis uses the Upper Green River values which represent the upper end of pollution production in the examples. The majority of pollution occurs during the production phase, where fugitive emissions (e.g., leaking pipes and valves) and dump valves (used to control the amount of fluid in the product) are the primary sources.

Climate Change/Greenhouse Gases

Sources of GHGs associated with development of lease parcels include construction activities, operations, and facility maintenance in the course of oil and gas exploration, development, and production. Estimated GHG emissions are discussed for these specific aspects of oil and gas activity because the BLM has direct involvement in these steps. Anticipated GHG emissions are based on emissions calculators developed by air quality specialists at the BLM National Operations Center in Denver, Colorado, based on a typical well in Green River Wyoming (Table 6).

3.4.2.2 Alternative A

Air Quality

Two new State lease wells and associated infrastructure would have minor adverse impacts on air quality over the long term. Small increases in nitrogen oxides (2%), carbon monoxide (0.1%), sulfur dioxide (<0.01%), and particulate matter (0.4%) would occur annually (Table 6). Good AQI values would likely predominate; however, well emissions could slightly increase the number of moderate AQI days especially during inversions. There would be negligible decreases in visibility, primarily within 1-2 miles of the wells.

Climate Change/Greenhouse Gases

Emissions from two new wells on State leases would increase Payette County's annual carbon dioxide equivalent production by 2.4% (Table 6).

3.4.2.3 Alternative B

Air Quality

Twenty-two new BLM lease wells and associated infrastructure would have moderate adverse impacts on air quality over the long term. Increases in nitrogen oxides (22%), carbon monoxide (1.4%), sulfur dioxide (0.02%), and particulate matter (4.5%) would occur annually (Table 6). The percent of days rated good AQI could decrease, especially during inversions. There would be minor decreases in visibility, primarily within 1-2 miles of the wells.

Climate Change/Greenhouse Gases

Twenty-two new wells on BLM leases would increase Payette County's annual carbon dioxide equivalent production by 26.2% (Table 6).

3.4.2.4 Alternative C

Air Quality

Twenty-five new BLM lease wells and associated infrastructure would have moderate adverse impacts on air quality over the long term. Controlled surface use stipulations could reduce some pollutants when or where they are in effect (e.g., the winter use restriction CSU-4 would reduce or eliminate some pollutants [e.g., PM_{10}] between December 1 and March 31; minimizing disturbance of fragile soils could reduce dust over the long term). Increases in nitrogen oxides (25%), carbon monoxide (1.6%), sulfur dioxide (0.03%), and particulate matter (5.1%) would occur annually (Table 6). The percent of days rated good AQI could decrease, especially during inversions. There would be minor decreases in visibility, primarily within 1-2 miles of the wells.

Climate Change/Greenhouse Gases
Twenty-five new wells on BLM leases would increase Payette County's annual carbon dioxide equivalent production by 29.7% (Table 6).

3.4.3 Mitigation

The BLM encourages industry to incorporate and implement BMPs to reduce impacts to air quality and climate change by reducing emissions, surface disturbances, and dust from field production and operations. Measures may also be required as COAs on permits by either the BLM or IDEQ. The BLM also manages venting and flaring of gas from federal wells as described in the provisions of Notice to Lessees (NTL) 4A, Royalty or Compensation for Oil and Gas Lost.

Some of the following measures could be imposed at the development stage:

- flare or incinerate hydrocarbon gases at high temperatures to reduce emissions of incomplete combustion;
- install emission control equipment of a minimum 95% efficiency on all condensate storage batteries;
- install emission control equipment of a minimum 95% efficiency on dehydration units, pneumatic pumps, produced water tanks;
- operate vapor recovery systems where petroleum liquids are stored;
- use Tier II or greater, natural gas or electric drill rig engines;
- operate secondary controls on drill rig engines;
- use no-bleed pneumatic controllers (most effective and cost effective technologies available for reducing volatile organic compounds (VOCs));
- operate gas or electric turbines rather than internal combustions engines for compressors;
- use nitrogen oxides (NO_x) emission controls for all new and replaced internal combustion oil and gas field engines;
- water dirt and gravel roads during periods of high use and control speed limits to reduce fugitive dust emissions;
- perform interim reclamation to re-vegetate areas of the pad not required for production facilities and to reduce the amount of dust from the pads.
- co-locate wells and production facilities to reduce new surface disturbance;
- use directional drilling and horizontal completion technologies whereby one well provides access to petroleum resources that would normally require the drilling of several vertical wellbores;
- operate gas-fired or electrified pump jack engines;
- install velocity tubing strings;
- use cleaner technologies on completion activities (i.e. green completions), and other ancillary sources;
- use centralized tank batteries and multi-phase gathering systems to reduce truck traffic;
- forward looking infrared (FLIR) technology to detect fugitive emissions; and
- perform air monitoring for NO_x and ozone (O_3).

Specifically with regard to reducing GHG emissions, Section 6.0 of the Climate Change SIR identifies and describes in detail commonly used technologies to reduce methane emissions from natural gas production operations. Technologies discussed in the Climate Change SIR and as summarized in Table 7 (reproduced from Table 6-2 in Climate Change SIR), display common methane emission technologies reported under the EPA Natural Gas STAR Program and associated emission reduction, cost, maintenance, and payback data.

Table 7. Selected methane emission reductions reported under the EPA Natural Gas STAR Program.

Source Type / Technology	Annual Methane Emission Reduction [1] (Mcf/yr)	Capital Cost Including Installation ($1,000)	Annual Operating and Maintenance Cost ($1,000)	Payback (Years or Months)	Payback Gas Price Basis ($/Mcf)
Wells					
Reduced emission (green) completion	7,000 [2]	$1 – $10	>$1	1 – 3 yr	$3
Plunger lift systems	630	$2.6 – $10	NR	2 – 14 mo	$7
Gas well smart automation system	1,000	$1.2	$0.1 – $1	1 – 3 yr	$3
Gas well foaming	2,520	>$10	$0.1 – $1	3 – 10 yr	NR
Tanks					
Vapor recovery units on crude oil tanks	4,900 – 96,000	$35 – $104	$7 – $17	3 – 19 mo	$7
Consolidate crude oil production and water storage tanks	4,200	>$10	<$0.1	1 – 3 yr	NR
Glycol Dehydrators					
Flash tank separators	237 – 10,643	$5 – $9.8	Negligible	4 – 51 mo	$7
Reducing glycol circulation rate	394 – 39,420	Negligible	Negligible	Immediate	$7
Zero-emission dehydrators	31,400	>$10	>$1	0 – 1 yr	NR
Pneumatic Devices and Controls					
Replace high-bleed devices with low-bleed devices					
End-of-life replacement	50 – 200	$0.2 – $0.3	Negligible	3 – 8 mo	$7
Early replacement	260	$1.9	Negligible	13 mo	$7
Retrofit	230	$0.7	Negligible	6 mo	$7
Maintenance	45 – 260	Negl. to $0.5	Negligible	0 – 4 mo	$7
Convert to instrument air	20,000 (per facility)	$60	Negligible	6 mo	$7
Convert to mechanical control systems	500	<$1	<$0.1	0 – 1 yr	NR
Valves					
Test and repair pressure safety valves	170	NR	$0.1 – $1	3 – 10 yr	NR
Inspect and repair compressor station blowdown valves	2,000	<$1	$0.1 – $1	0 – 1 yr	NR

Source Type / Technology	Annual Methane Emission Reduction [1] (Mcf/yr)	Capital Cost Including Installation ($1,000)	Annual Operating and Maintenance Cost ($1,000)	Payback (Years or Months)	Payback Gas Price Basis ($/Mcf)
Compressors					
Install electric compressors	40 – 16,000	>$10	>$1	>10 yr	NR
Replace centrifugal compressor wet seals with dry seals	45,120	$324	Negligible	10 mo	$7
Flare Installation	2,000	>$10	>$1	None	NR

Source: Multiple EPA Natural Gas STAR Program documents. Individual documents are referenced in Climate Change SIR (2010).

[1] Unless otherwise noted, emission reductions are given on a per-device basis (e.g., per well, per dehydrator, per valve, etc).

[2] Emission reduction (Mcf = thousand cubic feet of methane) is per completion, rather than per year.

NR = not reported

3.4.4 Cumulative Impacts – Air Resources

Cumulative impacts to air resources are based on the RFDS created for this document (Appendix 1), RFDS for Hamilton and Willow fields, and the actions discussed below.

3.4.4.1 Scope of Analysis

The CIAA includes the airshed associated with Ada, Baker, Canyon, and Payette counties. Because of prevailing wind patterns, changes in Baker County air quality would affect Payette County and impacts from Payette County air quality would dissipate at the eastern side of Ada County. The analysis period covers the 10-year lease period; however, pollutants are reported by their annual production levels.

3.4.4.2 Current Conditions and Effects of Past and Present Actions

Because of a large population base (615,335 people in 2013), Ada and Canyon counties contribute substantial amounts of nitrogen oxides (79%), PM_{10} (83%), volatile organic compounds (75%), hazardous air pollutants (87%), and GHG (80%) to the four-county total pollution (Table 6). Baker County, with a relatively small population (16,018 people in 2013) and large area (3,068 mi^2 compared with 2,047 mi^2 for the other three counties combined), accounts for 71% of methane production, while other pollutant contributions vary from 7-24% of totals. The majority of growth during the 10-year period is expected to occur in Ada and Canyon counties; therefore, pollutant contributions from growth-related activities (e.g., construction, vehicle emissions, dust, and manufacturing) in these counties would be expected remain similar or increase proportionately more than Baker and Payette counties.

3.4.4.3 Reasonably Foreseeable Future Actions

An estimated 53 wells could come into production in the Hamilton (33,400 acres) and Willow (7,000 acres outside the proposed lease area) fields (Map 1). These wells would contribute from<0.01-3.4% of most pollutants; however, they would cause a 51% increase in methane production annually. AM Idaho (Alta Mesa's Idaho subsidiary) is constructing a hydrocarbon liquid treatment (dehydrator) facility (4 miles south of New Plymouth, Idaho), an ancillary processing facility (1 mile east of New Plymouth), and associated pipelines from wells to the facilities. AM Idaho has applied for an IDEQ air quality permit for the facilities. Typical pollutants include NO_x, CO, particulate matter, HAP, and VOCs; however, the levels are unknown.

3.4.4.4 Alternative A – Cumulative Impacts

Two additional wells in the proposed lease area would have negligible additive impacts to air quality and GHG pollutants over the long term. Wells in the Hamilton and Willow fields and gas processing facilities would have minor (e.g., 3.7% CO2 eq increase in CIAA) to major (51% methane increase in CIAA) additive impacts (Table 6), whereas, with the exception of methane gas, growth-related activities would account for the majority of pollutant increases.

3.4.4.5 Alternative B– Cumulative Impacts

Twenty-two wells in the proposed lease area would have negligible additive impacts to air quality and most GHG pollutants over the long term and would account for a 1.5% increase in methane over current levels (Table 6). Pollutants from other sources would be as described in Alternative A (Section 3.4.4.4).

3.4.4.6 Alternatives C and D – Cumulative Impacts

Twenty-five wells in the proposed lease area would have negligible additive impacts to air quality and most GHG pollutants over the long term and would account for a 1.6% increase in methane over current levels (Table 6). Pollutants from other sources would be as described in Alternative A (Section 3.4.4.4).

3.5 Water Resources

3.5.1 Affected Environment – Water Resources

Surface Hydrology and Water Quality

Surface water quality in the planning area is variable due to the highly erratic discharge and moderately to highly erosive nature of the geologic parent material and soils. Perennial streams retain water year-round and have variable flow regimes. Big Willow (0.8 miles) and Little Willow (5 miles) creeks, perennial streams in the proposed lease area, are not a directly associated with proposed lease parcels. Intermittent streams flow during the part of the year when they receive sufficient water from springs, ground water, or surface sources such as snowmelt or storm events. Ephemeral streams flow only in direct response to precipitation and snowmelt. Ephemeral and intermittent streams (approximately 22 miles) occur in the proposed lease area with 8.2 miles directly associated with federal mineral estate. The Bolton and Patton irrigation canals parallel the north side of Little Willow Creek and the McIntyre and Nelson canals parallel on the south side. These canals remove the majority of water from Little Willow Creek during the irrigation season.

The National Wetland Inventory mapping identifies approximately 56 acres of wetland and riparian areas that are associated with perennial streams, canals, and ponds (Map 5). There are two springs and one seep associated with federal mineral estate. There are three ponds associated with federal mineral estate and seven other ponds in the proposed lease area. The ponds are fed by intermittent/ephemeral streams or irrigation runoff and are typically used as livestock water sources.

Big Willow Creek has an EPA approved temperature total maximum daily level (TMDL) that is not being met (IDEQ 2014). Little Willow Creek below Paddock Valley Reservoir was rated as Unassessed Waters (IDEQ 2014). In 2007, Little Willow Creek suspended sediment levels ranged from 10-165 mg/L. High levels (>30 mg/L) were associated with the irrigation season (May 1 – September 30) and IDEQ recommended a target of 22 mg/L during that period to support cold water aquatic beneficial uses.

There are 352 acres of 100-year floodplain associated with Little Willow and Big Willow creeks and an ephemeral drainage; however, only acre is associated with federal mineral estate.

The lease parcels are located within four hydrologic unit code (HUC) 6 watershed subbasins: Little Willow Creek (HUC 1705012208), Big Willow Creek (HUC 1705012207), Payette River-Snake River (HUC 1705012209), and Jacobsen Gulch – Snake River (HUC 1705011502) (Table 8). The acreage federal mineral reserve comprises between 0.06% (Payette River – Snake River) and 6.2% (Little Willow Creek) of each watershed.

Table 8. Acres and percentage of Level 6 HUC watersheds associated with federal mineral estate and Little Willow Creek lease area, Payette County, Idaho.

Watershed		**Federal Mineral Reserve**		**Total Lease Area**	
Name	**Acres**	**Acres**	**% Watershed**	**Acres**	**% Watershed**
Little Willow Creek	98,464	6,094	6.2	14,182	14.4
Big Willow Creek	98,919	84	0.08	694	0.7
Payette River – Snake River	177,466	106	0.06	629	0.4
Jacobsen Gulch – Snake River	91,054	67	0.07	139	0.2

<u>Ground Water</u>

The quality and availability of ground water varies greatly across Idaho. Residents in Payette County commonly get their ground water from aquifers consisting of unconsolidated, alluvial valley-fill materials, typically sand and gravel deposits. Alluvial aquifers occur in terrace deposits and within the floodplains, and along the channels of larger streams, tributaries, and rivers, and are important sources of ground water. Based on 41 wells in the lease area authorized by IDWR, typical domestic supply wells in the area are between 37-405 feet deep with standing water occurring at 5-330 feet and production occurring between 7-533 feet. Well water is typically used for domestic, livestock, and irrigation purposes.

Nitrate is present in shallow ground water beneath the Payette Valley at concentrations that occasionally exceed the drinking water standard of 10 milligrams per liter (mg/L; IDEQ 2012). Arsenic has been detected in exceedance of the drinking water standard of 0.010 mg/L. Fluoride has been detected occasionally at concentrations that exceed the drinking water standard of 4 mg/L, and dissolved iron and manganese have exceeded the secondary standards of 0.3 mg/L and 0.05 mg/L, respectively.

3.5.2 Environmental Consequences – Water Resources

Impacts to water resources are based on the RFDS created for this document (Table 2, Appendix 1).

3.5.2.1 General Discussion of Impacts

Surface Hydrology and Water Quality

The magnitude of the impacts to water resources would be dependent on the specific activity, season, proximity to waterbodies, location in the watershed, upland and riparian vegetation condition, effectiveness of mitigation, and the time until reclamation success. Surface disturbance effects typically are localized, short-term, and occur from implementation through vegetation reestablishment. As acres of surface-disturbance increase within a watershed, so could the effects on water resources.

Oil and gas exploration and development could cause the removal of vegetation, soil compaction, and soil disturbance in uplands within the watershed, 100-year floodplains of non-major streams, and non-riparian, ephemeral waterbodies. The potential effects from these activities could be accelerated erosion, increased overland flow, decreased infiltration, increased water temperature, channelization, and water quality degradation associated with increased sedimentation, turbidity, nutrients, metals, and other pollutants. Erosion potential can be further increased in the long term by soil compaction and low permeability surfacing (e.g. roads and well pads) which increases the energy and amount of overland flow and decreases infiltration, which in turn changes flow characteristics, reduces ground water recharge, and increases sedimentation and erosion.

Water withdrawals for drilling operations would lead to reduced aquifer water levels, reduced streamflow, and impacts to some water quality parameters associated with stream flow. These impacts to water quality may include increased water temperature, decreased concentrations of dissolved oxygen, and increases in other parameters such as salinity levels, sodium adsorption ratio, and introduction of drilling pollutants (e.g., organic acids, alkalis, diesel oil, crankcase oils, hydrochloric and hydrofluoric acids, chloride, sodium, calcium, magnesium, potassium, polycyclic aromatic hydrocarbons, lead, arsenic, barium, antimony, sulfur, zinc, and naturally occurring radioactive materials) (TEEIC 2014). Ground water removal would result in a depletion of flow in nearby streams and springs if the aquifer is hydraulically connected to such features. Typically produced water from conventional oil and gas wells is from a depth below useable aquifers.

Ground Water

Spills, drilling fluids, fracking fluids, or produced fluids could potentially impact surface and ground water resources over the long term. Drilling in the proposed lease area would most likely pass through useable ground water. Potential impacts to ground water resources could occur if proper cementing and casing programs are not followed. This could include loss of well integrity, failed cement, surface spills, and/or the loss of drilling, completion, and hydraulic fracturing fluids into groundwater. It is possible for chemical additives used in drilling activities to be introduced into ground water producing formations without proper casing and cementing of the well bore. Concentrations of these additives also vary considerably and are not always known because different mixtures can be used for different purposes in gas development and even in the same well bore. Changes in porosity or other properties of the rock being drilled can result in the loss of drilling fluids. When this occurs, drilling fluids can be introduced into ground water in the absence of proper cementing and casing. Site specific conditions and drilling practices determine the probability of this occurrence and determine the ground water resources that could be impacted. Some or all of the produced water from these leases is likely to be injected in wells for disposal. Improper construction and management of reserve and evaporation pits could degrade ground water quality through leakage and leaching.

The potential for adverse ground water impacts caused from hydraulic fracturing are currently being investigated by the EPA. Currently, water use to drill one well ranges between 1 and 6 million gallons. In fracturing a well, companies have estimated that generally they use a ratio of 0.5% hydraulic chemical fluid mix to 1.5 million gallons of water. That translates to a minimum of 5,000 gallons of chemicals into one well for every 1.5 million gallons of water used to fracture a well. In addition to changing the producing formations' physical properties by increasing the flow of water, gas, and/or oil around the well bore; hydraulic fracturing can also introduce chemical additives into the producing formations. Production zones generally do not contain fresh water. Types of chemical additives used in drilling activities may include acids, hydrocarbons, thickening agents, lubricants, and other additives that are operator and location specific. These additives are not always used in these drilling activities and some are likely to be benign such as bentonite clay and sand. Concentrations of these additives also vary considerably because different mixtures can be used for different purposes in oil and gas development and even in the same well bore. If contamination of aquifers from any source occurs, changes in ground water quality could impact springs and residential wells that are sourced from the affected aquifers.

If contamination of freshwater aquifers from oil and gas development occurs, changes in ground water quality could impact springs and residential wells if these springs and residential wells are sourced from the same aquifers that have been affected. Direct impacts to surface water would likely be greatest shortly after the start of construction activities and would likely decrease in time due to natural stabilization, and reclamation efforts. Ground water impacts would be less evident and occur on a longer time scale. Construction activities would occur over a relatively short period (commonly less than a month); however, natural stabilization of the soil can sometimes takes years to establish to the degree that would adequately prevent accelerated erosion caused by compaction and removal of vegetation. Spills or produced fluids (e.g., saltwater, oil, fracking chemicals, and/or condensate in the event of a breech, overflow, or spill from storage tanks) could result in contamination of the soil onsite, or offsite, and may potentially impact surface and ground water resources in the long term.

Not all wells resulting from an APD would employ fracturing, and water consumption would be temporary. Oil and gas wells are cased and cemented at a depth below all usable water zones; consequently impacts to water quality at springs and residential wells are not expected.

However, faulty cementing or well casing could result in methane migration to upper zones. Should hydrocarbon or associated chemicals for oil and gas development in excess of EPA/IDEQ standards for minimum concentration levels migrate into culinary water supply wells, springs, or systems, it could result in these water sources becoming non-potable.

For federal mineral estate wells, Onshore Order #2 requires that the proposed casing and cementing programs shall be conducted as approved to protect and/or isolate all usable water zones. For State-regulated wells, IDAPA 20.07.02 provides similar requirements from initial drilling to plugging. Authorization of exploration and production activities would require full compliance with local, state, and federal directives and stipulations that relate to surface and ground water protection.

3.5.2.2 Alternative A

Surface Hydrology and Water Quality

Not leasing 6,349 acres would limit surface disturbance in those areas. Vegetation and soil conditions would be maintained over the long term minimizing sediment input to waterbodies from 6% of the Little Willow Creek watershed and negligible (0.2%) portions of other watersheds (Table 8). Development of two wells and associated infrastructure (7 acres of disturbance) would have negligible (~0.001% of Little Willow Creek watershed) direct impacts to surface hydrology. Negligible (>0.25 miles from stream) to moderate (<200 feet from stream) short-term sediment inputs could occur to Little Willow Creek until vegetation reestablishment occurs. Produced water and pollutants carried by natural events would cause adverse water quality impacts where pollutants reach Little Willow Creek. The longevity and severity of the impacts would depend on the type of pollutant. Ground water depletion could adversely affect Little Willow Creek.

Ground Water

Direct development and production ground water impacts would not occur on 6,349 acres. Development of two wells could have negligible (well casings are effectively implemented) to major (well casings fail and persistent, toxic pollutants are introduced) adverse effects to ground water quality in the Little Willow Creek drainage. Up to 15 domestic and agricultural wells in the immediate vicinity and downstream could be affected.

3.5.2.3 Alternative B

Surface Hydrology and Water Quality

Leasing 6,349 acres with NSO and NSSO stipulations would limit surface disturbance in those areas. Vegetation and soil conditions would be maintained over the long term minimizing sediment input to waterbodies from 6% of the Little Willow Creek watershed and negligible (0.2%) portions of other watersheds (Table 8). Development of 22 wells and associated infrastructure (77 acres of disturbance) would have negligible to minor direct impacts to surface hydrology, primarily where roads collect and convey water rather than allowing infiltration. Impacts from sediment inputs would be similar to Alternative A (Section 3.5.2.2); however, four additional wells could be drilled near Little Willow and Big Willow creeks. Produced water and pollutant impacts could affect Little Willow and Big Willow creeks. Four additional wells would increase the probability of adverse water quality and ground water depletion impacts.

Ground Water

Direct development and production ground water impacts would not occur on 6,349 acres. Development of 22 wells could have negligible (well casings are effectively implemented) to major (persistent, toxic pollutants are introduced) adverse effects to ground water quality in the Little Willow and Big Willow drainages; however, the number of wells could increase the probability of a pollution event. Up to 54 domestic and agricultural wells in the immediate vicinity and downstream could be affected.

3.5.2.4 Alternative C

Surface Hydrology and Water Quality

Leasing 6,349 acres with CSU stipulations would limit surface disturbance in those areas. Vegetation and soil conditions would be maintained over the long term minimizing sediment input to waterbodies from 6% of the Little Willow Creek watershed and negligible (0.2%) portions of other watersheds (Table 8). Development of 25 wells and associated infrastructure (88 acres of disturbance) would have similar hydrology and sediment impacts to Alternative B (Section 3.5.2.3); however, 500 foot CSU buffers from waterbodies would help limit sediment inputs (Map 5). Fewer surface occupancy restrictions would allow wells to be placed further from streams relative to Alternative B. Produced water and pollutant impacts could affect Little Willow and Big Willow creeks; however, CSU buffers would reduce the probability of pollutants reaching waterbodies.

Ground Water

Direct development and production ground water impacts could occur on <6,162 acres. Development of 25 wells could have similar impacts to those described in Alternative B (Section 3.5.2.3); however, the probability of a pollution event could be slightly greater.

3.5.3 Mitigation

Mitigation measures that minimize the total area of disturbance, control wind and water erosion, reduce soil compaction, maintain vegetative cover, control nonnative species, and expedite rapid reclamation (including interim reclamation) would maintain surface hydrology processes and water quality. Methods to reduce erosion and sedimentation could include: reducing surface disturbance acres; installing and maintaining adequate erosion control; proper road design, road surfacing, and culvert design; road/infrastructure maintenance; use of low water crossings; and use of isolated or bore crossing methods for waterbodies and floodplains. In addition, applying mitigation to maintain adequate, undisturbed, vegetated buffer zones around waterbodies and floodplains could reduce sedimentation and maintain water quality. Lining ponds would minimize seepage of potentially toxic chemicals into ground water. Closing and rehabilitating ponds promptly, when no longer functional or needed, would exposure to toxic substances. Appropriate well completion, the use of Spill Prevention Plans, and Underground Injection Control (UIC) regulations would mitigate ground water impacts. Site-specific mitigation and reclamation measures would be described in the COAs.

Known water bearing zones in the lease area are protected by drilling requirements and, with proper practices, contamination of ground water resources would be unlikely (IOGCC 2013b; IDAPA 20.07.02). Casing along with cement would be extended well beyond fresh-water zones to insure that drilling fluids remain within the well bore and do not enter ground water. Potential impacts to ground water at site specific locations are analyzed through the NEPA review process at the development stage when the APD is submitted. This process includes geologic and engineering reviews and onsite oversight to ensure that cementing and casing programs are adequate to protect all downhole resources. All water used would have to comply with State water rights regulations and a source of water would need to be secured by industry that would not harm senior water rights holders.

3.5.4 Cumulative Impacts – Water Resources

Cumulative impacts to water resources are based on the RFDS created for this document (Appendix 1), RFDS for Hamilton and Willow fields, and the actions discussed below.

3.5.4.1 Scope of Analysis

The 65,700-acre CIAA includes portions of the Little Willow Creek, Big Willow Creek, and Payette River-Snake River (north of the Farmers Canal) Level 6 HUC watersheds downstream of the eastern boundary of the proposed lease area and the majority of the Payette Valley Flow System (Map 5). This represents an area that could potentially be affected by surface runoff and ground water pollutants. The analysis period covers the 10-year lease period; however, pollutants would be expected to travel at different rates in different systems. Surface pollutants could reach the downstream portion of the CIAA relatively quickly once they enter flowing waters. Conversely, ground water pollutants would likely take considerably longer to travel beyond the source.

3.5.4.2 Current Conditions and Effects of Past and Present Actions

Sagebrush and other shrubs (11,067 acres; 17% of CIAA), exotic annuals (13,716 acres; 21%), agriculture (35,404 acres; 54%), urban (2,271 acres; 3%), and perennial bunchgrass (2,452 acres; 4%) comprise the majority of cover types. Roads, ploughed fields and exotic annual cover provide the lowest degree of watershed protection. Watershed stability is at greatest risk where these cover types occur in moderate or highly erosive soils. Most agricultural lands are irrigated with surface (from canals) or ground water.

There are approximately 56.5 miles of perennial streams (Payette River, Little Willow and Big Willow creeks) and all are influenced by irrigation outtake and return flows. There are approximately 2,000 acres of wetland, riparian, and pond habitat. Stream and riparian conditions are similar to those described in Section 3.6.1. The 9,760 acres of floodway are primarily associated with the Payette River. There are 1,305 water wells, most occur south of the Payette River or northwest of the confluence of Little Willow Creek and the Payette River.

Potential pollutant sources include pesticides from agricultural and urban areas, chemicals from industrial and retail businesses, runoff from roadways, and 15 existing oil and gas wells. The amount of pollutants from these sources is unknown.

3.5.4.3 Reasonably Foreseeable Future Actions

At least 37 additional oil and gas wells could be drilled (1 well/640 acres in the portions of the Willow and Hamilton fields in the CIAA). Pollutants from development and production would be as described in Section 0. Wildfires, as described in other sections, would be expected to cause short-term increases in sediment inputs and watershed instability until vegetation cover is reestablished.

3.5.4.4 Alternative A – Cumulative Impacts

Surface Hydrology and Water Quality

Not leasing 6,349 acres (10% of the CIAA) would have negligible to minor additive benefits to surface hydrology and water quality. Wildfires, exotic annuals, and ploughed fields would potentially affect much larger areas. Rain events in these areas could result in minor to major sediment inputs to floodways and streams. Burned riparian areas would recover within five years, but upland areas would likely become dominated by exotic annuals and remain susceptible to erosion events. The extent of ground water withdrawal for irrigation is unknown. Irrigation water removal and return water pollutants (both agricultural and urban) would annually have moderate to major adverse water quality impacts to perennial streams. Development and production at up to 37 oil and gas wells would have negligible surface hydrology impacts, but could have negligible (no spills occur, spills are largely contained on site, or spills are non-pollutant materials) to major (spills affect domestic water supplies with toxic pollutants) adverse water quality impacts.

Ground Water

Not leasing 6,349 acres would have negligible additive ground water benefits. Agricultural activities (e.g., ground water pumping, pollution input from leaking wells) would have minor (seasonal reductions in water availability, pollution stays in immediate vicinity of well) to major (increased use of ground water during extended drought periods, pollutants migrate from well to domestic water supplies) adverse impacts to ground water availability and quality over the short and long term. Pollutants from industrial and urban sources could have minor to major short or long term adverse impact to ground water quality. Development and production at up to 37 oil and gas wells would have negligible (well casings are effectively implemented, ground water is not used to produce gas) to major (persistent, toxic pollutants are introduced; ground water is used to produce gas) adverse effects to ground water availability and quality.

3.5.4.5 Alternatives B and C – Cumulative Impacts

Surface Hydrology and Water Quality

Leasing 6,349 acres with some surface stipulations and development of 22-25 wells and associated infrastructure would have negligible to minor additive impacts to surface hydrology and increased sediment input. Minor to moderate additive water quality impacts from produced water and pollutants could occur. Impacts from other activities would be as described in Alternative A (Section 3.5.4.4).

Ground Water

Development and production at 22-25 wells would have negligible (well casings are effectively implemented) to major (persistent, toxic pollutants are introduced) adverse additive effects to ground water availability and quality. Impacts from other activities would be as described in Alternative A (Section 3.5.4.4).

3.6 Wildlife/Special Status Animals

3.6.1 Affected Environment – Wildlife/Special Status Animals

Habitats support a variety of special status wildlife including southern Idaho ground squirrel (SIDGS), a candidate species under the ESA, 14 other mammal species, 17 bird species, three amphibian species, and three reptile species (Appendix 4). Habitat conditions are described for representative groups of animals (migratory birds, southern Idaho ground squirrels, big game, and amphibians/fish).

Vegetation composition has been shaped by physical site characteristics such as aspect, soils, precipitation, and disturbances (primarily wildland fire, livestock grazing, and agricultural development). Fires and long-term spring grazing have reduced the diversity and abundance of native perennial forbs and grasses, favoring exotic annuals. The resulting conditions (Section 3.2.1) generally provide poor quality habitat for most species. Shrub-dominated communities comprise 32% of cover, annual and perennial grasslands and agriculture characterize the remainder. Although these disturbances have occurred on all aspects, native vegetation is less resilient on the hotter, drier southerly aspects than the cooler, moister northerly aspects; therefore, southerly aspects are dominated by exotic grasses and northerly aspects are dominated by native vegetation. This has resulted in major habitat fragmentation. The proposed lease area has approximately 36.6 miles of roads and trails (1.5 miles/mi^2). Access to many roads is restricted by private landowners; therefore, the majority of roads have minor fragmentation and disturbance impacts.

Migratory Birds and Raptors

The analysis area encompasses over 15,000 acres; therefore, bird habitat will be analyzed at a landscape scale, where birds are typically affected on a population level (Paige and Ritter 1999). Because the area lacks contiguous sagebrush habitat and suitable cover of native perennial bunchgrasses and forbs, it does not support stable populations of sagebrush-obligate species such as greater sage-grouse[E]. These sagebrush obligates require a large mosaic of big sagebrush cover

[E] Based on 2014 sage-grouse habitat maps developed by BLM and IDFG and lek monitoring data, the proposed lease area is approximately 1 mile from R2 (sagebrush with annual grass understory) habitat, 5 miles (isolated habitat) from key (sagebrush with perennial grass understory) and preliminary general habitat [areas outside of breeding habitat that support important seasonal (winter, summer, fall habitat, migration corridors) or year-round habitat for sage-grouse], and 6.5 miles (contiguous habitat) from key and preliminary priority [areas that have the highest conservation value (breeding, nesting, brood-rearing) to maintaining sage-grouse populations] sage-grouse habitats. The closest leks are 9.5 (active) or 10.5 (inactive) miles away.

types, inter-mixed with native bunchgrasses and forbs. Other sagebrush obligates including Brewer's sparrow, sage sparrow, and sage thrasher could be present during the spring and summer; however, these species are also sensitive to fragmented sagebrush habitats and they occur in low numbers.

Grassland associated species such as long-billed curlew, western meadowlark, vesper sparrow, and horned lark utilize short grassland habitat for nesting, breeding, and brood-rearing. Long-billed curlew populations have declined in nearby areas (i.e., Long-billed Curlew Habitat Area of Critical Environmental Concern 8-20 miles southeast of the lease area) primarily due to recreational activities and development. Between 1966 and 2012, vesper sparrow, western meadowlark, and horned lark populations in Idaho have also declined. Northern harrier, red-tailed hawk, ferruginous hawk, golden eagle, American kestrel, and turkey vulture are common birds of prey that hunt for insects, small mammals, birds, and carrion throughout the area, year-round or during annual migrations.

Riparian associated species including warblers, flycatchers, and sparrows utilize shrub and tree dominated habitat along Little Willow and Big Willow creeks for nesting, brood rearing, and foraging. Little Willow Creek provides marginal quality habitat that is substantially influenced by agricultural activities and is primarily characterized by herbaceous-dominated vegetation with scattered stands of cottonwood, willow, and Russian olive. Big Willow Creek provides good quality habitat that is characterized by a fairly contiguous cottonwood overstory with interspersed willow and herbaceous communities or understories.
Resident (e.g., golden eagle, red-tailed hawk, Cooper's hawk) and migratory (e.g., burrowing owl, short-eared owl, prairie falcon) birds use the area for nesting, brood rearing, foraging, and migration. Surveys for raptor nests have not occurred in or adjacent to the lease parcels. Although fires have degraded much of the habitat, it does provide suitable habitat for a variety of prey species including small mammals, song birds, reptiles, and insects.

Burrowing Mammals

Southern Idaho Ground Squirrel - Southern Idaho ground squirrels inhabit drainage bottoms and adjacent gradual slopes in small scattered populations, below approximately 3,200 feet elevation. Historically, SIDGS primarily occupied sandier soils that supported big sagebrush/bunchgrass/forb communities with antelope bitterbrush (Yensen 1991). In the absence of a reliable and nutritious diet provided by native grasses and forbs, SIDGS are subject to the highly variable productivity and nutritional value of exotic annuals. When annual precipitation is relatively low, poor productivity of exotic annuals may not provide enough nutritional sustenance to enable squirrels to store enough fat to survive their long over-wintering period (torpor). The availability of forbs plays a crucial role in the torpor persistence of juvenile male ground squirrels (Barrett 2005). Torpor begins in late June or early July when vegetation begins to dehydrate and desiccate, and lasts until late January or early February when squirrels emerge from their burrows.

Currently, SIDGS habitat is dominated by exotic annuals and provides limited sagebrush cover with perennial herbaceous understories needed to support a stable squirrel population; medusahead is common throughout the area, especially on south aspects, and is indigestible for

SIDGS due to its high silica content. The majority of known SIDGS colonies occur on adjacent private lands (IDFG 2013). There is a paucity of SIDGS monitoring data for the area, but it is likely that SIDGS utilize habitat on the northerly aspects of public land to some degree, as these areas tend to support more native vegetation.

Pygmy Rabbit - The pygmy rabbit is the smallest North American rabbit species (USFWS 2010). On September 30, 2010, the USFWS concluded that the pygmy rabbit does not currently warrant listing under the ESA (USFWS 2010). This species is typically found in areas of tall, dense sagebrush cover and are considered a sagebrush-obligate species because they are highly dependent on sagebrush to provide both food and shelter throughout the year (Green and Flinders 1980; Katzner and Parker 1997). Pygmy rabbits have been found from 2,900 feet to over 6,000 feet in elevation in southwestern Idaho. Although low sagebrush density and prevalence of cheatgrass provides marginal habitat, pygmy rabbits have been observed in the proposed lease area.

Big Game

The area provides limited winter habitat for antelope and mule deer as south slopes are typically dominated by annual grasses and do not support adequate shrub cover. Mule deer inhabiting the area are part of the Weiser-McCall Population Management Unit (IDFG 2010b). Deer winter range has been adversely impacted by wildfire, as fire has reduced the abundance of important shrub species such as bitterbrush and sagebrush that deer depend on for food and thermal cover during the winter. The spread of noxious weeds also poses a threat to mule deer winter range. The area may provide marginally better elk winter range because of their grass species dietary preferences even during winter. Elk inhabiting the area are part of the Weiser River Zone delineated by the Idaho Department of Fish and Game (IDFG). Threats to elk winter range habitat include noxious weed invasion such as yellow starthistle and whitetop (IDFG 2010a). Big game may avoid the area during late summer, fall, and winter due to lack of shrub cover on southerly slopes, reduced abundance of perennial grasses and forbs, and off-highway vehicle (OHV) activity. The proposed lease area occurs on the western edge of identified winter range and is characterized by regular human disturbance associated with low density rural residences and associated agricultural activities. Approximately 77% of the proposed lease area and 94% of lands associated with federal mineral reserves are considered big game winter range (Map 6).

Aquatic Species

Perennial and intermittent water sources provide breeding and brood-rearing habitat for a variety of amphibian, reptile, and fish species. Degraded water quality (e.g., increased temperature levels, sediment loads, and agricultural pollutants) and irrigation dewatering, especially in Little Willow Creek, may limit the suitability or productivity for some species. Adjacent uplands provide important foraging areas for amphibians and reptiles. Some species (e.g., western toad) may move up to 3.9 miles (1.2 miles on average) from breeding areas and occupy areas away from water sources (Bull 2006).

Bats

Up to 11 special status bat species could occur in the area. The species rely on natural (e.g., tress, cliffs, and caves) or manmade (e.g., buildings) structures for roosting and hibernating.

They are typically nocturnal insect foragers in a variety of habitats including forest, shrub, grass, or agriculture dominated areas. Little brown bats typically forage up to 0.6 miles from a roost area; however, ranges diminish to predominantly 0.1 miles in July when females are lactating and insect densities are high (Henry et. al. 2002).

3.6.2 Environmental Consequences – Wildlife/Special Status Animals

Impacts to wildlife are based on the RFDS created for this document (Table 2, Appendix 1).

3.6.2.1 General Discussion of Impacts

The use of standard lease terms and stipulations could minimize, but not preclude impacts to wildlife. Oil and gas development which results in surface disturbance could directly and indirectly impact aquatic and terrestrial wildlife species. The scale, location, and pace of development, combined with implementation of mitigation measures and the specific tolerance of the species to human disturbance all influence the severity of impacts to wildlife species and habitats.

Direct impacts would include disturbance or interruption of activities, vehicle collisions, powerline collisions and electrocutions, nest abandonment, habitat avoidance, displacement of wildlife species resulting from human presence and increased predation. Disturbances (e.g., natural gas development activities, OHV use) can adversely affect songbird habitat use (Ingelfinger 2001; Barton and Holmes 2007). The impacts were greatest within 330 feet of high traffic volume roads where ≤60% population reductions occurred even when traffic volumes were less than 12 vehicles/day. Noise and human activities can disrupt key activities such as breeding displays, brooding, and foraging. Road mortality can be influenced by travel speed, species abundance, species susceptibility, coincidence of vehicle and animal activity, and proximity to key habitats. Hawks and owls are more susceptible to electrocution especially where wingspans are wider than the line spacing, whereas quail, pheasants, ducks, and songbirds are more susceptible to collision hazards (Bevanger 1998).

Indirect impacts would include loss or reduction in suitability of habitat, improved habitat for undesirable (non-native) competitors, species or community shift to species or communities more tolerant of disturbances, barriers to species migration and dispersal, and habitat fragmentation. Increases in invasive and noxious weed species that displace native plant species would adversely affect habitat structure and quality, reducing habitat suitability for most species while favoring species that tolerate poor habitat quality.

Migratory Birds and Raptors

Construction and development activities can effect migratory bird's nesting season from as early as February 15; however, activity from March 15th through August 15th poses the greatest impact to migratory birds by disrupting breeding behavior and breeding success. Nest occupancy for some species (e.g., golden eagle and ferruginous hawk) may not be affected during the production phase (Wallace 2014). Response to disturbances during winter, when birds are stressed by environmental conditions could adversely affect survivability. During the winter, 97% of raptors flushed when humans on foot were within 385 feet and 38% flushed when vehicles were within 245 feet (Holmes et. al. 1993). Take of bald and golden eagles or any other migratory species would not be anticipated; however, take may occur indirectly as a result of vehicle collisions and other related actions associated with development.

Burrowing Mammals

Construction of well pads and roads could directly eliminate habitat. Vehicle traffic and increased raptor perch sites associated with powerlines and other infrastructure would increase mortality. Reduced habitat quality (e.g., increases in invasive annuals and noxious weeds) and increased fragmentation would adversely affect SIDGS annual body condition, survival rates, and population viability (Barrett 2005) and pygmy rabbit diet quality and cover (Larrucea and Brussard 2008).

Big Game

Well pad and road construction would reduce available habitat. Roads and associated disturbances would reduce suitability of adjacent habitat. Short and long-term responses to development and production activities vary by species and habitat type (Hebblewhite 2008). Mule deer avoided areas when development was initiated and did not become acclimated to activities as time passed; instead, avoidance distances increased as development progressed (Sawyer et. al. 2006). The distance animals were displaced increased from 1.7 to 2.3 miles away from well pads during the first three years of development. Mule deer densities decreased 46% in the developed area over a four year period. Animals forced to winter at higher elevations with increased snow levels would have reduced survival rates. Habitat loss and fragmentation were better predictors of antelope winter habitat use than distance to well pads and roads (Beckman et. al. 2008). In areas with relatively limited pre-development disturbance, major ungulate responses (e.g., avoidance or abandonment) could occur when oil and gas development of 0.3–1.3 wells/mi^2 and 0.3-1.6 linear road miles/mi^2 occurred (Hebblewhite 2008).

Aquatic Species

Noise and lights from development activities could disrupt breeding behavior annually. Road mortality would affect species that spend part of their life cycle in terrestrial habitats (Carr 2002). Pollutants discharged into aquatic systems could cause behavioral changes, mutations, or mortality at all life stages (Lefcort et. al. 1998).

Bats

Lights and noise associated with human activities could cause short-term disruptions in foraging behavior and success. Persistent disturbances near roost sites could cause avoidance or abandonment. Bat responses to disturbances vary by species, and some species (e.g., big brown bat) may be more tolerant than others (Duchamp et. al. 2004). Infrastructure (e.g., powerlines) could cause increased collision mortality. Actions that reduce insect productivity (e.g., reduced habitat quality, pollutants) would reduce available prey.

3.6.2.2 Alternative A

Migratory Birds and Raptors

Development of two wells and associated infrastructure would have minor adverse short- and long-term disturbance, mortality, and habitat quality reduction impacts. An additional 0.5 miles of roads would cause a negligible increase in fragmentation and disturbance. Low levels of localized disturbance would occur throughout the year over the long term. Up to 7 acres of habitat would be directly eliminated and use would be reduced on 70 acres because of disturbance.

Burrowing Mammals
Development of two wells and associated infrastructure would have minor adverse short- and long-term mortality and habitat quality reduction impacts. An additional 0.5 miles of roads and powerlines would cause a minor increase in SIDGS mortality. Up to 7 acres of habitat would be directly eliminated. Depending on the location of roads and well pads, impacts to pygmy rabbits could be negligible (development >0.35 miles from sagebrush) to major (development in an occupied sagebrush stand).

Big Game
Depending on their location and animal responses, development of two wells and associated infrastructure would have minor (wells adjacent to existing disturbances that animals have become habituated to) to major (at least one well on the east side of the lease area that effectively keeps animals from using the remainder of the lease area) disturbance impacts. Changes in habitat fragmentation (beyond the disturbance component) and habitat quality would have minor adverse long-term impacts. Animals habituated to low levels of disturbance could be displaced to adjacent agricultural areas over the short term when moderate or greater development disturbances occur during winter use periods.

Aquatic Species
Depending on their location, development of two wells and associated infrastructure would have negligible (>0.5 miles from wetland/riparian habitat with no possibility of pollution input) to moderate (<0.1 miles from wetland/riparian habitat with potential pollution input) disturbance and pollutant impacts.

Bats
Development of two wells and associated infrastructure would have negligible (located >0.75 miles from roost sites) to minor (located <0.5 miles from roost sites) adverse short- and long-term disturbance, mortality, and prey reduction impacts.

3.6.2.3 Alternative B

No direct habitat loss (77 acres of well pads and roads) would occur on the 6,349 acre federal mineral estate until the FRMP was implemented; however, loss could occur in adjacent areas that are developed prior to FRMP implementation. Stipulations derived from the FRMP could help mitigate impacts described below.

Migratory Birds and Raptors
Development of 22 wells and associated infrastructure would have moderate to major adverse short- and long-term disturbance, mortality, and habitat quality reduction impacts. An additional 5.5 miles of roads would cause a major increase in fragmentation and disturbance because regular activity would occur in most of the proposed lease area. Moderate levels of disturbance

would occur throughout the year and lease area over the long term. Up to 77 acres of habitat would be directly eliminated and use would be reduced on 770 acres because of disturbance.

Burrowing Mammals

Development of 22 wells and associated infrastructure would have moderate to major adverse short- and long-term mortality and habitat quality reduction impacts. An additional 5.5 miles of roads and powerlines would cause minor to moderate increases in SIDGS mortality. Up to 77 acres of habitat could be directly eliminated. Habitat quality changes would adversely affect both species; however, impacts to pygmy rabbits would be greater because of their year-round activity patterns. Depending on the location of roads and well pads, impacts to pygmy rabbits could be negligible (development >0.35 miles from sagebrush) to major (development in an occupied sagebrush stand).

Big Game

Development of 22 wells (1 well/mi^2) and associated infrastructure would have moderate to major adverse short- and long-term disturbance, habitat fragmentation, and habitat quality reduction impacts. Road densities would increase to 1.7 miles/mi^2, but vehicle traffic throughout the area would increase substantially, especially during the development phase. Existing unmaintained roads would be upgraded and become potentially more accessible throughout the year and to a greater number of users, increasing disturbance and fragmentation. Access restrictions by private landowner could limit disturbances to development and production activities. The activities would make the area unsuitable winter range for animals that do not become habituated to higher disturbance levels. Animals habituated to low levels of disturbance could be displaced to adjacent agricultural areas over the short and long (until development is completed) term when moderate or greater development disturbances occur during winter use periods. Increases in invasive and noxious weed species would further degrade habitat; however, improved access that helps fire suppression efforts could reduce fire size and associated habitat loss.

Aquatic Species

Development of 22 wells and associated roads would have minor to moderate adverse short- and long-term disturbance, mortality, and pollutant impacts. Ponds and streams downslope from well pads would be most susceptible to surface-flow pollutant impacts. Contaminated ground water that connects to streams could have negligible (short-term, non-toxic pollutants) to major (persistent toxicant introduced) adverse impacts on up to 5.8 miles of perennial streams in the proposed lease area and potentially downstream areas.

Bats

Development of 22 wells and associated infrastructure would have minor (disturbance located >0.75 miles from roost sites) to moderate (located <0.5 miles from roost sites) adverse short- and long-term disturbance, mortality, and prey reduction impacts. Disturbance tolerant species would be less affected than intolerant species. Reduced insect production associated with decreased habitat quality would adversely affect all species over the long term.

3.6.2.4 Alternative C

Migratory Birds and Raptors

Development of 25 wells and associated infrastructure would have similar disturbance, mortality, and habitat quality reduction impacts as described in Alternative B (Section 3.6.2.3). An additional 6.8 miles of roads would cause a major increase in fragmentation because roads would occur throughout the lease area. Up to 88 acres of habitat would be directly eliminated and use would be reduced on 875 acres because of disturbance. Winter and spring surface use restrictions would reduce or eliminate lessee-related disturbance and mortality impacts during critical periods; however, increased access by non-lessee users could offset those benefits. No surface occupancy within 0.5 miles of heron rookeries would minimize lessee-related disturbances and habitat impacts.

Burrowing Mammals

Development of 25 wells (1 well/mi^2) and associated infrastructure would have moderate adverse short- and long-term mortality and habitat quality reduction impacts. An additional 6.8 miles of roads and powerlines would cause minor to moderate increases in SIDGS mortality. Avoidance of burrow sites would eliminate direct impacts to those important areas, but up to 88 acres of foraging habitat could be eliminated and infrastructure that increases disturbance and raptor perch sites could adversely affect adjacent burrow sites. Habitat quality change impacts would be as described in Alternative B (Section 3.6.2.3). Controlled surface use restrictions would benefit burrowing mammals that occur in restricted areas by reducing (winter and spring restrictions that coincide with critical periods of pygmy rabbits) or eliminating (spring restrictions that coincide with SIDGS active periods) lessee-related disturbances.

Big Game

Development of 25 wells and associated infrastructure would have moderate to major adverse short- and long-term disturbance, habitat fragmentation, and habitat quality reduction impacts. Road densities would increase to 1.8 miles/mi^2, but controlled surface use restrictions would reduce or eliminate lessee-related disturbances during the winter. If exceptions are granted to surface use restrictions, then disturbances from development and production activities could have minor (1-2 one-day exceptions during the course of a winter) to major (exceptions throughout the winter) short and long terms impacts similar to those described in Alternative B (Section 3.6.2.3). If exceptions are minimalized, animals would be less likely to move to adjacent agricultural lands (as described in Alternative B, Section 3.6.2.3). Other road-related and habitat quality impacts would be as described in Alternative B (Section 3.6.2.3). Overall winter range suitability could be similar to Alternative B or slightly improved depending on how animals respond to infrastructure and wells despite surface use restrictions.

Aquatic Species

Surface occupancy and pollutant restrictions would minimize or eliminate development and production related disturbance, mortality, and pollutant impacts to key aquatic habitat. Development of 25 wells and associated roads would have minor to moderate adverse short- and long-term disturbance and mortality impacts to species that utilize areas >500 feet from riparian habitats.

Bats
Development of 25 wells and associated infrastructure would have similar disturbance, mortality, and prey reduction impacts described in Alternative B (Section 3.6.2.3). Spring controlled surface use restrictions and riparian habitat buffers would benefit bats by reducing or eliminating activities in important foraging and roosting areas.

3.6.3 Mitigation

Measures would be taken to prevent, minimize, or mitigate impacts to terrestrial and aquatic species from exploration and development activities. Lease stipulations to mitigate impacts on wildlife would be placed on leases for crucial winter range (timing limitation), migratory birds and raptors (controlled surface use), burrowing mammals (lease notice), Endangered Species Act (Section 7 Consultation), and fragile soils (lease notice) stipulations which would protect additional habitat. Prior to authorization, activities would be evaluated on a case-by-case basis, and the project could be subject to additional mitigative COAs. Mitigation could include rapid revegetation, project relocation (<660 feet), or pre-disturbance wildlife species surveying. If oil and gas development is proposed in suitable habitat for threatened or endangered species, consultation with the USFWS would occur to determine if additional terms and conditions would need to be applied. Adherence to Avian Powerline Interaction Committee (APLIC) guidelines could help reduce or eliminate electrocution mortality.

The following operational measures would help reduce wildlife impacts. If drilling operations require evaporation ponds, cover ponds with nets to exclude migratory birds. Ponds should be checked frequently (daily) for trapped wildlife. Report trapped wildlife (live and dead) to BLM, FWS, and IDFG no later than 24 hours of initial discovery. Lighting at sites should be directed specifically to where needed to minimize potential impacts to wildlife and turned off when not in use. To minimize predators or nuisance wildlife at work sites, place an appropriately sized dumpster with lid at each site during construction activities and check/dump as needed. Prohibit workers from bringing dogs to well sites during drilling and site maintenance actions to avoid predation/harassment of wildlife. Enforce speed limits of 25 MPH on spur roads and well pads to reduce wildlife collision risk.

3.6.4 Cumulative Impacts - Wildlife/Special Status Animals

Cumulative impacts to wildlife are based on the RFDS created for this document (Appendix 1) and the actions discussed below.

3.6.4.1 Scope of Analysis

The 81,518-acre CIAA (13% BLM, 4% State, and 83% private) includes a 3-mile buffer around the proposed lease area and north of the Payette River (Map 6). This area was selected because it corresponds to typical foraging or dispersal movements or disturbance response distances for a variety of species. The lease period of 10 years will be used for the temporal analysis limit because most disturbance impacts are associated with lease activities and site reclamation would address some longer term impacts such as habitat quality and fragmentation.

3.6.4.2 Current Conditions and Effects of Past and Present Actions

The CIAA supports the same species described above. Migratory birds and raptors are common throughout the area. Pygmy rabbits are uncommon and SIDGS are present throughout most of the area. About 60% of the area, primarily in the north and east, is considered big game winter range. Approximately 36 miles of perennial streams and river provide marginal to suitable habitat for aquatic species.

Vegetative Cover and Habitat Conditions – Sagebrush and other shrubs (26,809 acres; 33% of CIAA), exotic annuals (29,807 acres; 37%), agriculture/urban (16,531 acres; 20%), and perennial bunchgrass (7,936 acres; 10%) comprise the majority of cover types. Sagebrush understory conditions vary by slope and aspect, with steeper and north facing slopes generally having a more intact native understory than gentler and south facing slopes. Approximately 79% of the area has burned one or more times, with most of the fires occurring during the 1980s. Where shrubs have become re-established in areas burned prior to 1990, exotic annuals are dominant or co-dominant in the understory. Conditions on the Little Willow (14 miles) and Big Willow (11.8 miles) creeks are similar to those described above. The Payette River (9.8 miles) is characterized by cottonwood and willow overstories with shrub and herbaceous understories.

Disturbance – The CIAA is characterized by low density rural development. Disturbance factors include agricultural activities, OHV use, hunting, and other recreational uses. Nonresident access is restricted in much of the CIAA by private landowners. Recreational use is greatest during the spring and fall.

Roads – There are approximately 197 miles of roads (1.5 miles/mi^2) including 9.3 miles of highway, 45 miles of maintained roads, and 142.7 miles of unmaintained roads. The majority of maintained roads are associated with developed areas on Little Willow and Big Willow creeks or the Payette River. There are 9 miles of designated trails east of the Big Willow and Stone Quarry roads junction. Within big game winter range, approximately 1,172 acres are designated as closed to motorized vehicles, 127 acres are designated as open, and the remainder are designated limited to existing roads.

Powerlines - The CIAA includes two transmission lines (26.5 miles) and numerous distribution lines (74.7 miles). Transmission lines are built to APLIC standards; however, most distribution lines are not. Therefore, both types represent collision hazards, but only the distribution lines represent electrocution hazards. The majority of distribution lines are within 0.3 miles of Little Willow and Big Willow creeks or the Payette River.

Livestock Grazing – The CIAA includes all or portions of 10 BLM-administered livestock grazing allotments (32,550 acres; 40% of CIAA). The allotments are used primarily during the spring, with some season long (e.g., Kauffman) or winter (e.g., Sand Hollow) use occurring. Undeveloped private lands outside BLM allotments and agricultural fields (fall-winter) are also used for grazing.

3.6.4.3 Reasonably Foreseeable Future Actions

Oil and Gas Lease Development and Production – There are 11 existing or planned wells (Map 1, IOGCC 2014). There are approximately 4,960 acres of State-managed mineral resources, some of which have been leased, but drilling has not been initiated. Exploration is currently being conducted in the eastern two-thirds of the CIAA. Approximately 15 wells could be drilled in the Willow Field between the Payette River and the proposed lease area.

Agricultural/Residential Development – Development causes a direct loss of wildlife habitat and activities associated with the developed areas can cause disturbance over the long term. Limited residential development would occur on the western boundary of the CIAA. Negligible increases in agricultural development would be expected because of limited water resources. If water resources decline, some fields could go fallow, creating marginal wildlife habitat. New development would require additional powerlines and other infrastructure.

Recreation Uses – Off-highway vehicle use would be expected to remain static (e.g., increased access restrictions imposed by private landowners) or increase (e.g., in response to increasing populations) over time. Approximately 384 acres along the Payette River are managed by the IDFG in the Payette River Wildlife Management Area to benefit wildlife and sportsmen.

Wildfire – Although not planned events, wildfires would be expected to periodically occur and may increase in size and frequency in response to climate change. Loss of shrubs and increased dominance of exotic annuals in burned areas would reduce habitat structure and quality over the short term. Adverse effects would persist over the long term where native perennials don't re-establish.

3.6.4.4 Alternative A – Cumulative Impacts

Two additional wells and associated infrastructure would have negligible additive disturbance, mortality, habitat quality reduction, and fragmentation impacts over the short and long term. Ongoing activities and existing roads and powerlines would cause minor (away from developed areas) to moderate (adjacent to developed areas along Little Willow and Big Willow creeks) disturbance and mortality impacts throughout the CIAA. Livestock grazing, especially in consistent spring use areas, would favor exotic annuals and early seral native and non-native species throughout undeveloped portions of the CIAA. Development and production activities of at least 26 wells would have moderate disturbance, mortality, and fragmentation impacts over the short and long term on approximately 20% of the CIAA. The majority of wells would be within 0.5 miles of perennial streams, but only nine wells would be within 1.5 miles of big game winter range. Additional agricultural and residential development would have minor disturbance, habitat loss, and fragmentation impacts over the long term. Depending on size, wildfires would have minor to major long-term adverse impacts on habitat quality and fragmentation.

3.6.4.5 Alternatives B and C – Cumulative Impacts

Development and production activities at 22 to 25 wells in the proposed lease area would have moderate additive disturbance, mortality, habitat quality reduction, and fragmentation impacts over the short and long term. Timing and other restrictions in Alternative C wells would help reduce spatial and temporal overlap with other disturbances (e.g., other oil and gas development, recreation use) and habitat quality and fragmentation impacts. Impacts from ongoing and foreseeable future actions would be as described in Alternative A (Section 3.6.4.4).

3.7 Cultural Resources

3.7.1 Affected Environment – Cultural Resources

The BLM is responsible for identifying, protecting, managing, and enhancing cultural resources which are located on public lands, or that may be affected by BLM undertakings on non-Federal lands, in accordance with the National Historic Preservation Act (NHPA) of 1966, as amended. The procedures for compliance with the NHPA are outlined in regulation under 36 CFR 800. Cultural resources include archaeological, historic, and architectural properties, as well as traditional life-way values and/or traditional cultural properties important to Native American groups.

Common prehistoric archaeological site types in Payette County include rock art, artifact scatters, burials, and tool manufacture. Common historic archaeological sites are the remains of farmsteads, homesteads, depressions, artifact scatters, foundations, cabins, sheepherder camps, and historic inscriptions.

A literature search (Level I or Class I) of Idaho State Historic Preservation Office records and a 2001 Class III survey (498 acres associated with Idaho Power right-of-way) identified 11 sites within a one-mile search radius. Records were reviewed to determine what types and numbers of known cultural resources are present within or adjacent to the lease area. Seven sites are prehistoric, three sites are historic, and one site includes prehistoric and historic artifacts. None of the sites were considered eligible for listing on the National Register of Historic Places (NRHP).

3.7.2 Environmental Consequences – Cultural Resources

Impacts to cultural resources are based on the RFDS created for this document (Table 2, Appendix 1).

3.7.2.1 General Discussion of Impacts

Ground disturbing activities could alter the characteristics of an eligible property by diminishing the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Other effects to cultural resources from surface disturbance activities include the destruction, damage, or alteration to all or part of the cultural resource and diminishing the property’s significant historic features as a result of the introduction of visual, atmospheric, or audible elements. Activities that adversely affect adjacent vegetation conditions and soil stability could increase erosion that would degrade or destroy site context.

3.7.2.2 Alternative A
Development of two wells and associated infrastructure could adversely affect cultural resources on private lands.

3.7.2.3 Alternative B
Leasing with a NSO stipulation would preclude ground disturbing impacts to cultural resources on 6,349 acres. Changes in vegetation condition and erosion could have negligible long-term impacts for eligible properties adjacent to ground disturbing activities.

3.7.2.4 Alternative C
Compliance with Cultural Resources S-2 would ensure that no sites would be disturbed or destroyed before they are inventoried and evaluated for eligibility for listing in the NRHP. Historic and archeological sites that are eligible for listing in the National Register of Historic Places or potentially eligible to be listed would either be avoided or have the information in the sites extracted through archeological data recovery prior to surface disturbance.

3.7.3 Mitigation
Specific mitigation measures including site avoidance, excavation, or data recovery would have to be determined when site-specific development proposals are received. Most surface-disturbing situations for cultural resources would be avoided by project redesign or relocation. Unavoidable, significant properties would be site-specifically mitigated with concurrence with the State Historic Preservation Office prior to implementation of a project.

3.7.4 Cumulative Impacts – Cultural Resources
Because the alternatives would cause none to negligible impacts to cultural resources, cumulative impacts will not be discussed.

3.8 Paleontological Resources

3.8.1 Affected Environment – Paleontological Resources
According to Section 6301 of the Paleontological Resource Protection Act of 2009 Omnibus Public Lands Bill, Subtitle D, SEC. 6301, paleontological resources are defined as “any fossilized remains, traces, or imprints of organisms, preserved in or on the earth’s crust, that are of paleontological interest and that provide information about the history of life on earth” (Paleontological Resource Protection Act of 2009 Omnibus Lands Bill, Subtitle D, SEC. 6301-3612 (P.L. 59-209; 34 Stat. 225; 16 U.S.C. 431-433). Significant fossils are defined by BLM policy as including all vertebrate fossil remains and those plant and invertebrate fossils determined to be scientifically unique, on a case-by-case basis. Paleontological resources do not include archaeological and cultural resources.

The proposed lease area includes Miocene (sedimentary rocks associated with flood basalts; 5-23 million years BP) and Pleistocene and Pliocene (older sediments and sedimentary rocks, gravel, sand, and silt deposited in fans; 11,700 to 5.3 million years BP) epochs, and Quaternary (alluvial gravel, sand, and silt deposits associated with Little and Big Willow creeks; 0-2.6 million years

BP) period deposits. Paleontological surveys have not been conducted in the proposed lease area; however, a diversity of fossiliferous resources could be expected to occur and fossilized remains of horse, beaver, camel, and elephant-like animals have been found in the Glenns Ferry Formation (Erasthem-Vanir 2009).

The BLM utilizes the Potential Fossil Yield Classification (PFYC) as a planning tool for identifying areas with high potential to yield significant fossils. The system consists of numbers ranging from 1-5 (low to high) assigned to geological units, with 1 being low potential and 5 being high potential to have significant fossil resources. The potential to yield significant fossil resources is never 0. It is anticipated that most significant fossil resources are located in those geologic units with a PFYC of 3 or greater. However, significant fossil resources could be discovered anywhere. Rock units not typically fossiliferous can in fact contain fossils in unique circumstances.

The BLM classified geologic formations that have a high Potential Fossil Yield Classification (PFYC) of 3 or higher should be specifically reviewed for paleontological resources. Much of the proposed lease area falls within the Glenns Ferry Formation which has a Class 5 PFYC and should be evaluated for fossil resources before and potentially during ground-disturbing activities.

3.8.2 Environmental Consequences – Paleontological Resources

Impacts to paleontological resources are based on the RFDS created for this document (Table 2, Appendix 1). The analysis assumes that surveys conducted prior to ground disturbing activities would identify paleontological resources on the surface (see CSU 12 and LN 7).

3.8.2.1 General Discussion of Impacts

Surface-disturbing activities could potentially alter the characteristics of paleontological resources through damage, fossil destruction, or disturbance of the stratigraphic context in which paleontological resources are located, resulting in the loss of important scientific data. Identified paleontological resources could be avoided by project redesign or relocation before project approval which would negate the need for the implementation of mitigation measures. Increased public access could result in vandalism or collection of paleontological resources. Conversely, surface-disturbing activities could potentially lead to the discovery of paleontological localities that would otherwise remain undiscovered due to burial or omission during review inventories. The scientific retrieval and study of these newly discovered resources would expand our understanding of past life and environments of Idaho.

3.8.2.2 Alternative A

Infrastructure development associated with two wells could directly impact paleontological resources on up to 7 acres on private lands. Increased public access could expose areas surrounding new roads to negligible to minor vandalism or collection impacts.

3.8.2.3 Alternative B

Infrastructure associated with 22 wells would not occur on 6,349 acres of BLM-administered and split estate lands; therefore, there would be no direct impacts to paleontological resources in these areas. Direct impacts could occur on up to 77 acres of private lands where development does occur. Increased access could have negligible (private landowners restrict public access) to moderate (access is not restricted) vandalism and collection impacts.

3.8.2.4 Alternative C

Infrastructure development associated with 25 wells could directly affect up to 88 acres; however, identification and avoidance or documentation/collection would minimize these impacts. Impacts from increased access would be as described in Alternative B (Section 3.8.2.3).

3.8.3 Mitigation

The application of lease terms, the paleontological conditional surface use stipulation (CSU 11), and the paleontological lease notice (LN 7) at leasing, provides protection to paleontological resources during development. The paleontological lease notice is applied to all lease parcels, requiring a field survey prior to surface disturbance. These survey requirements could result in the identification of paleontological resources. Avoidance of significant paleontological resources or implementation of mitigation prior to surface disturbance would protect paleontological resources.

However, the application of lease terms only allows the relocation of activities up to 200 meters, unless otherwise documented in the NEPA document, and cannot result in moving the activity off lease. Specific mitigation measures could include, but are not limited to, site avoidance or excavation. Avoidance of paleontological properties would be a best management practice. However, should a paleontological locality be unavoidable, significant fossil resources must be mitigated prior to implementation of a project. These mitigation measures and contingencies would be determined when site specific development proposals are received.

3.8.4 Cumulative Impacts – Paleontological Resources

Because paleontological resource impacts would be avoided or mitigated on BLM-administered and split estate lands, cumulative impacts will not be discussed.

3.9 Recreation

3.9.1 Affected Environment – Recreation

BLM only manages recreational opportunities and experiences on BLM-administered surface lands. Recreational activities enjoyed by the public on BLM lands in the proposed lease area include hunting, hiking, and OHV activities. Benefits and experiences enjoyed by recreational users include opportunities for solitude, spending time with families, enhancing leisure time, improving sports skills, enjoying nature, and enjoying physical exercise. The 997 acres of BLM-administered lands proposed for lease have limited legal public access (i.e., no public easements or rights-of-way across private property). The lack of public access limits use of the BLM parcels for recreational use by the general public. None of the BLM-administered lands occur in special recreation management areas (SRMAs) or recreation areas. Motorized use on BLM-administered lands is limited to existing roads and trails.

3.9.2 Environmental Consequences – Recreation

Impacts to recreation are based on the RFDS created for this document (Table 2, Appendix 1).

3.9.2.1 General Discussion of Impacts

Road construction that leads to or across BLM-administered lands would create or improve public access to those lands. However, access across private lands between public rights-of-way and public lands would still be at the discretion of the landowner. Noise and traffic associated with development and production could detract from the rural physical and social setting or disrupt some activities (e.g., hunting).

3.9.2.2 Alternative A

Infrastructure development associated with two wells would create none to negligible increases in BLM-administered land access. Public lands would be beyond the potential well sites; therefore, no new roads would be constructed to BLM-administered lands. Development and production activities would cause negligible adverse changes in user experiences.

3.9.2.3 Alternative B

Infrastructure associated with 22 wells would not occur on 6,349 acres of BLM-administered and split estate lands; therefore, there would be none to negligible increases in BLM-administered land access. Development and production activities would cause minor to moderate (e.g., activities adversely affect game species) adverse changes in user experiences.

3.9.2.4 Alternative C

Infrastructure development associated with 25 wells would create minor improvements in BLM-administered land access. Most BLM parcels have existing road access; therefore, upgrading those roads could allow better year-round access by a wider range of users. Development and production activities could cause minor to moderate (e.g., activities adversely affect game species) adverse changes in user experiences.

3.9.3 Mitigation

Because of the isolated nature of public lands in the area, no mitigation would be required.

3.9.4 Cumulative Impacts - Recreation

Because the alternatives would cause primarily none to minor impacts to recreation activities and experiences and public land access is at the discretion of private landowners, cumulative impacts will not be discussed.

3.10 Visual Resources Management

3.10.1 Affected Environment – Visual Resources Management

Visual Resource Management (VRM) is the system used to designate and manage the visual resources on public land. In the lease area, the CRMP designated 112 acres as Class III and 885 acres as Class IV (Map 7). A Class III VRM area classification means the level of change to the character of the landscape should be moderate. Changes caused by management activities should not dominate the view of the casual observer and should not detract from the existing landscape features. Any changes made should repeat the basic elements found in the natural landscape such as form, line, color and texture. A Class IV VRM area classification means that the characteristic landscape can provide for major modification of the landscape. The level of change in the basic landscape elements can be high. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements. An existing 230 kV line traverses Class III and IV lands in the northern portion of the proposed lease area. Human influences are relatively unnoticeable on the remainder of BLM-administered lands that are characterized by mixed vegetation communities, fencing, and unimproved two-track roads.

3.10.2 Environmental Consequences – Visual Resources Management

Impacts to visual resources are based on the RFDS created for this document (Table 2, Appendix 1).

3.10.2.1 General Discussion of Impacts

Disturbance of existing vegetation and creation of permanent linear (e.g., roads, powerlines) and point (e.g., well pads and structures) features would alter the form, line, color, and texture of the natural landscape.

3.10.2.2 Alternative A

Development of two wells on private lands would have no impact on VRM characteristics.

3.10.2.3 Alternative B

Development of 22 wells on private lands would have no impact on VRM characteristics.

3.10.2.4 Alternative C

Development of wells and associated infrastructure on BLM-administered lands could have negligible (Class IV) to minor (Class III) adverse impacts on visual resources. It would introduce more noticeable man-made structures to the natural environment.

3.10.3 Mitigation

All oil and gas development would implement, as appropriate for the site, BLM BMPs for VRM, regardless of the VRM class. This includes, but would not be limited to, proper site selection, reduction of visibility, minimizing disturbance, selecting color(s)/color schemes that blend with the background and reclaiming areas that are not in active use. Repetition of form, line, color and texture when designing projects would reduce contrasts between landscape and development. Wherever practical, no new development would be allowed on ridges. Overall, the goal would be to not reduce the scenic values that currently exist.

3.10.4 Cumulative Impacts – Visual Resources Management

Because the changes associated with the potential development would be in conformance with VRM guidance for Class III and IV lands, cumulative impacts will not be discussed.

3.11 Lands and Realty

3.11.1 Affected Environment – Lands and Realty

Lands and realty actions will only occur on BLM-administered surface lands. The affected environment consists of 997 acres of BLM-administered public lands (or 16% of the total acreage proposed for lease). Rights-of-way currently exist for an Idaho Power 230-kV powerline (IDI-13054; 0.53 miles long by 100 feet wide; 6.4 acres) and associated access roads (1.71 miles of roads 14 feet wide; 2.9 acres) and for the Little Willow Irrigation District's Nelson Canal (IDB-0019666; 0.12 miles) (Map 7).

3.11.2 Environmental Consequences – Lands and Realty

3.11.2.1 General Discussion of Impacts

Standard oil and gas lease terms recognize prior existing rights. Development activities could require rights-of-way that overlay and adversely affect existing rights-of-way. Rights-of-way applications would be analyzed through a NEPA process that would identify potential resource impacts which would likely be similar to impacts described in this document.

3.11.2.2 Alternative A

Development of two wells and associated infrastructure would not affect existing public lands or rights-of-way. The IDI-13054 right-of-way is >2 miles north of the proposed well sites.

3.11.2.3 Alternative B

Development of 22 wells and infrastructure outside BLM-administered mineral rights would not directly affect IDI-13054. Activity could occur within a 0.6-mile segment of the powerline corridor that occurs on private lands.

3.11.2.4 Alternative C

Development of 25 wells and associated infrastructure would have a negligible impact on IDI-13054. Roads associated with the right-of-way could be improved and used for oil and gas infrastructure which would improve access to the powerline. The powerline right-of-way occupies <1% of BLM-administered lands and occurs to the north of where infrastructure would likely occur; therefore, it could be readily avoided.

3.11.3 Mitigation

The split estate lease notice would require the lessee to attempt to work with the surface owner through execution of a Surface Use Agreement. A bond would be required, for the benefit of the surface owner, if no agreement was reached. Measures would be taken to avoid disturbance or impacts to existing rights-of-way, in the event of any oil and gas development activities. Any new "off-lease" or third party rights-of-way required across federal surface for exploration and/or development would be subject to lands and realty stipulations to protect other resources as determined by environmental analyses. In order to protect the existing rights-of-way it is recommended that LN-7 be applied to lease parcels associated with IDI-13054 and IDB-0019666.

3.11.4 Cumulative Impacts - Lands and Realty

Because the alternatives would cause no or negligible impacts to the existing rights-of-way, cumulative impacts will not be discussed.

3.12 Livestock Management

3.12.1 Affected Environment – Livestock Management

The proposed lease area includes portions of five BLM-administered grazing allotments (Map 8). The allotments are permitted for cattle and use periods are in the spring, spring through fall, or winter (Table 9). Total allotment sizes range from 1,488 acres (Danke Allotment) to 15,643 acres (Sand Hollow Allotment), with federal mineral estate affecting 306 acres (Sand Hollow Allotment) to 1,095 acres (Danke Allotment) (Table 10). The allotments have several range improvements including fences, stock ponds, wells, and roads (Map 8). Livestock grazing is not currently permitted on 184 acres of BLM-administered lands in the proposed lease area.

Table 9. Permit information for five allotments affected by proposed Little Willow Creek lease, Payette County, Idaho.

Allotment		Permittee	Livestock		Season of Use	Permitted AUMs
Name	Number		Kind	#		
Dannke	00084	Larry Dahnke	C	150	4/1 – 5/15	58
Hashagen	00248	Wolfe Ranches	C	112	3/16 – 4/15*	114
Kauffman	00163	Randall Kauffman	C	200	4/1 – 10/10**	25
Rock Quarry Gulch	20131		C	130	4/11-8/10	115
Sand Hollow	00254	Rocky Comfort Cattle Co.	C	1,302	10/26-3/15***	1,509

*Season and numbers are not restricted to those shown above provided overuse and deterioration do not occur to the federal range.
**Livestock numbers will be coordinated between BLM and the Lessee and may vary within the permitted use period, however, AUMs may not be exceeded. Any change to the scheduled use requires prior approval.
***Season and numbers of livestock are not restricted to those shown above provided overuse and deterioration does not occur to the public lands and the use is covered by the OX CRMP.

Table 10. Federal mineral reserve acres by allotment, amount of allotment in lease area, and total allotment size (acres) for five allotments affected by proposed Little Willow Creek lease, Payette County, Idaho.

Allotment	Federal Mineral Reserve		Lease Area		Allotment Total			
	BLM	Private	BLM	Private	BLM	State	Private	Total
Dannke	269	826	269	992	496	0	992	1,488
Hashagen	198	743	198	1,619	511	0	1,901	2,412
Kauffman	57	613	57	1,335	67	0	1,770	1,837
Rock Quarry Gulch	217	824	217	1,620	563	0	1,940	2,503
Sand Hollow	59	247	59	669	4,935	603	10,105	15,643

There are 23.1 miles of allotment boundary and 3.5 miles of pasture fencing in the five allotments. Natural or reservoir water sources occur in the Hashagen and Kaufman allotments.

3.12.2 Environmental Consequences – Livestock Management

Impacts to livestock management are based on the RFDS created for this document (Table 2, Appendix 1).

3.12.2.1 General Discussion of Impacts

Standard oil and gas lease terms recognize prior existing rights. Oil and gas development would result in a loss of vegetation for livestock grazing (e.g., direct removal, introduction of unpalatable plant species), decreased vegetation palatability due to fugitive dust, disrupted livestock management practices, increased vehicle collision injuries and mortalities, altered water quality and availability, and decreased grazing capacity (Fowler and Witte 1985). These impacts would vary from short-term impacts to long-term impacts depending on the development level, reclamation success, and the type of vegetation removed.

Oil and gas development activity would reduce BLM's ability to manage livestock grazing while meeting or progressing towards meeting the Idaho Standards of Rangeland Health (USDI 1997). Development and associated disturbances could reduce available forage or alter livestock distribution which could lead to overgrazing or other localized grazing impacts. Construction of roads, especially in areas of rough topography could improve livestock distribution.

3.12.2.2 Alternative A

Development of two wells and associated infrastructure would occur outside and, therefore, would not directly affect BLM-administered allotments. Negligible impacts from fugitive dust could occur.

3.12.2.3 Alternative B

Development of 22 wells and associated infrastructure on private lands would have negligible (Sand Hollow Allotment) to minor (Hashagen and Rock Quarry Gulch allotments) vegetation loss, palatability, collision, and capacity impacts over the short and long term. Approximately 32% of the development could occur in the allotments (2,982 acres of private lands with no split estate minerals in the allotments/9,292 acres in the proposed lease area); therefore, direct habitat loss would occur on approximately 25 acres (7 wells and 1.75 miles of roads). Changes in palatability and desirable species composition adjacent to roads would depend on the amount of dust generated and the distance it travelled. Roads that cross allotment or pasture boundaries could have moderate to major disruption impacts where animals are able to freely move between use areas. Changes in water availability and quality could occur in the Hashagen and Kaufman allotments. Minor adverse rangeland health impacts could occur on BLM-administered lands, primarily in the Danke, Hashagen, and Rock Quarry Gulch allotments where BLM-administered lands make up 21-25% of the allotment within the proposed lease area.

3.12.2.4 Alternative C

Development of 25 wells and associated infrastructure on private lands would have negligible (Sand Hollow Allotment; e.g., no direct impacts, possible dust and disturbance impacts) to moderate (Danke Allotment; e.g., reduced forage capacity caused by increased weeds) vegetation loss, palatability, collision, and capacity impacts over the short and long term. Based on allotment acreages and well spacing, none (Sand Hollow Allotment) to two wells (Danke, Hashagen, and Rock Quarry Gulch allotments) could be developed. Direct loss of vegetation would be ≤7 acres in a given allotment and 25 acres total in the five allotments. Impacts to livestock operations, water, and rangeland health would be as described in Alternative B (Section 3.12.2.3).

3.12.3 Mitigation

Measures would be taken to prevent, minimize, or mitigate impacts to livestock grazing from exploration and development activities. Prior to authorization, activities would be evaluated on a case-by-case basis, and the project would be subject to mitigation measures. Mitigation could potentially include controlling livestock movement by maintaining fence line integrity, fencing facilities, installing cattleguards, re-vegetation of disturbed sites, and fugitive dust control.

3.12.4 Cumulative Impacts - Livestock Management

Cumulative impacts to livestock management are based on the RFDS created for this document (Appendix 1) and the actions identified below.

3.12.4.1 Scope of Analysis

The 23,891-acre CIAA includes all lands associated with the five allotments associated with proposed lease (Table 10). Allotments represent an administrative boundary that addresses most components of an individual's livestock operation. Changes in vegetation conditions outside the allotments that could indirectly affect the allotments are discussed in Soils and Vegetation Cumulative Impacts (Section 3.2.4). The lease period of 10 years will be used for the temporal analysis limit because most impacts are associated with lease activities and site reclamation.

3.12.4.2 Current Conditions and Effects of Past and Present Actions

Vegetation Conditions – Major cover types include shrubs (10,793 acres; 45% of CIAA), exotic annuals (9,511 acres; 40%), and perennial grasses (3,512 acres; 15%). Exotic annuals are the dominant cover type in the Danke, Hashagen, and Rock Quarry Gulch (southern portion allotments. All of the Danke, Hashagen, and Rock Quarry Gulch and significant portions of the Sand Hollow and Kaufman allotments burned in the 1980s. Where shrubs have recovered, exotic annuals are dominant or co-dominant with perennial species in the understory. Species composition is the most important palatability influence, with areas dominated by medusahead providing the least palatable forage except during early spring green-up. Rangeland health assessments have not been conducted on the allotments. Consistent moderate or greater livestock use during the growing period would result in downward perennial grass trends and increased exotic annuals. Perennial grasses would be less affected by dormant season use and could be maintained in the absence of other disturbances (e.g., wildfire).

Disturbance – Disturbance impacts include leaving gates open, harassing livestock, and shooting livestock. There are approximately 46 miles of roads in the allotments, but almost all are unimproved 2-tracks that require access through private lands. Non-livestock related use occurs primarily during the spring and fall by OHV users and hunters. There are existing gas wells on the Hashagen (one well) and Kauffman (two wells) allotments. There are approximately 84 miles of allotment and pasture fences.

3.12.4.3 Reasonably Foreseeable Future Actions

Oil and Gas Lease Development and Production – There are approximately 765 acres of State-managed mineral resources (679 acres in Sand Hollow Allotment, 75 acres in Hashagen Allotment, and 5 acres in Dannke Allotment), some of which may have been leased, but drilling has not been initiated. An unknown amount of private land has also been leased. One additional well could be drilled in the Kaufman Allotment and up to seven wells could be drilled in the Sand Hollow Allotment that would not affect federal mineral estate.

Wildfire – Although not planned events, wildfires would be expected to periodically occur and may increase in size and frequency in response to climate change. Conversion of perennial grass understories to exotic annuals in burned areas would reduce forage quality and availability over the long term. Loss of shrub cover would reduce soil moisture and shorten growing periods. Burned public lands are typically rested one or more growing seasons until recovery objectives are met.

3.12.4.4 Alternative A – Cumulative Impacts

Not leasing federal mineral estate would have no additive impacts. Changes in vegetation conditions caused by livestock grazing and wildfires would have moderate to major adverse impacts to livestock forage where exotic annuals replace perennials and rangeland health standards would not be met over the long term. Larger wildfires would have moderate to major short-term adverse impacts to livestock operations where post-fire rest is implemented. Recreation, OHV, and development/production would cause negligible to moderate short-term disturbance impacts. An additional eight wells and associated infrastructure would cause negligible direct forage loss and decreased forage palatability, but could cause minor to moderate decreases in vegetation conditions where increased access and use increased exotic annuals and noxious weeds.

3.12.4.5 Alternatives B and C– Cumulative Impacts

Development and production activities at 7 to 10 wells in the proposed lease area would have minor to moderate additive vegetation condition and disturbance impacts over the short and long term. Impacts from ongoing and foreseeable future actions would be as described in Alternative A (Section 3.12.4.4).

3.13 Minerals (Fluid)

3.13.1 Affected Environment – Minerals (Fluid)

The proposed lease area occurs in the Payette River Valley, at an elevation of between 2,000 and 3,000 feet. It is on the northern edge of the western Snake River Plain, an approximately 40-mile wide, northwest-trending graben structure, filled with sediments of Plio-Pleistocene Lakes Idaho and Bruneau and intercalated basalts. These sediments are referred to as the Idaho Group (Pliocene) and Payette Formation (Miocene). While there is no type section for the Payette Formation, it is described as a thick body of fresh-water and continental sediments, generally made up of ash, clay, shale, and sandstone, with an occasional lignite bed (Buwalda 1923). The sediments are known to contain organic material, including petrified tree stumps, fresh-water shells and mammalian fossils, such as ancestral horses and camels. Strata seen at Payette extend westward across the Snake River for long distances into Oregon. The Payette Formation has been measured at over 4,000 feet in a deep well at Ontario, Oregon.

The Willow and Hamilton fields have been designated by the oil industry to delineate areas believed to have a natural gas reservoir large enough to sustain commercial development (Map 1). Developers describe the reservoir as being a sequence of fluvial sands, ranging from 500 to 800 feet thick, except where replaced/interrupted by volcanics (IOGCC 2013a). In the ML Investments #1-10 well, located in T. 8 N., R. 4 W., Section 10, the fluvial sand was found at 4,100 feet. Another sand layer is described at the 3,750 foot depth. The fluvial sands are porous and have consistent characteristics across the reservoir. They are overlain by 1,700 – 3,500 feet of lacustrine shale, which provides a regional topseal. Both sands are believed to be adequately drained by a well spacing of one well per 640 acres (IOGCC 2013a). The Western Idaho Basin is characterized primarily by conventional non-associated gas; however, conventional associated (with oil) and tight sand gasses may also be present, but shale-associated gas resources are not thought to be present (Johnson et. al. 2013). Conventional non-associated and associated gases typically can be extracted with smaller scale fracking (well-bore stimulation; Johnson et. al. 2013 pg. 8); however, tight sand and shale-associated gases likely would require fracking to extract.

Although BLM had numerous leases in the 1980's in the area, there are no current federal oil and gas leases in Payette County. In 2014, the Idaho Department of Lands (IDL) leased approximately 4,100 acres of State-owned minerals in Payette County. The remainder of the 20,288 acres of State-owned minerals in Payette County were leased between 2006 and 2013. The State currently has approximately 85,000 acres leased for oil and gas development statewide. There are no wells on federal mineral estates in Payette County; however, there is one producing well and 10 shut-in wells pending pipelines located on private lands (Table 11).

Table 11. Existing development activity on federal and State leases, Payette County, Idaho.

Well Type	Federal Estate	Private and State Leases
Drilling Well(s)	0	4
Producing Gas Well(s)	0	1
Shut-in Well(s) (pending pipeline)	0	10
Permitted, not Drilled Well(s)	0	2
Temporarily Abandoned Well(s)	0	1

3.13.2 Environmental Consequences – Minerals (Fluid)

Impacts to minerals are based on the RFDS created for this document (Table 2, Appendix 1).

3.13.2.1 General Discussion of Impacts

Issuing a lease provides the lessee with the exclusive right to explore for and develop oil and gas. Natural gas produced from federal mineral estate would enter the public markets. The production of oil and gas would result in the irreversible and irretrievable loss of these resources. Royalties and taxes would accrue to the federal and state treasuries from the lease parcel lands. There would be a reduction in the known amount of oil and gas resources. If the federal mineral estate is not leased, but is omitted by the Idaho Oil and Gas Conservation Commission (IOGCC), then they could be drained without compensation.

Stipulations applied to various areas with respect to occupancy, timing limitation, and control of surface use could affect oil and gas exploration and development, both on and off the federal parcel. Leases issued with major constraints (NSO stipulations) may decrease some lease values, increase operating costs, and require relocation of well sites, and modification of field development. Leases issued with moderate constraints (timing limitation and controlled surface use stipulations) may result in similar but reduced impacts, and delays in operations and uncertainty on the part of operators regarding restrictions.

3.13.2.2 Alternative A

The federal mineral estate could remain in place over the short and long terms if they were not leased. The two additional wells would occur in privately-owned mineral estate ≥0.5 miles from federal mineral estate. However, if the federal mineral estate were omitted by the IOGCC, then at least 493 acres of the federal mineral estate within 0.5 miles of existing wells (based on 1 well/640 acre spacing) could be drained.

Because of mineral ownership patterns, not leasing 6,349 acres of federal mineral estate could have moderate to major adverse effects on the ability to develop and produce State- and privately-owned fluid minerals. Lease values and operating costs could be adversely affected. Development of non-federal reserve minerals would not be adversely affected if the IOGCC omits the federal mineral estate.

3.13.2.3 Alternative B

The NSO and NSSO stipulations affecting 6,349 acres would cause minor to moderate decreased lease values and increased operating costs. Developing 22 wells on private lands would allow oil and gas production from the majority of federal mineral estate and State- and privately-owned minerals. Because of well spacing limitations, minerals from up to 1,920 acres of federal mineral estate would not be available because of NSO and NSSO stipulations. However, because of the interspersion of private lands in the proposed lease area, the amount of unavailable federal mineral estate would be expected to be much less.

3.13.2.4 Alternative C

Developing 25 wells would allow oil and gas production from almost all the federal mineral estate and State- and privately-owned minerals. Because of their proximity to federal mineral estate outside the lease area and current well spacing, some minerals at the periphery of the lease area might not be available for production. Applying lease stipulations would cause minor decreased lease values and minor to moderate increased operating costs, primarily during the development phase. The special status plant species and freshwater aquatic habitat stipulations would affect approximately 190 acres of federal mineral estate (Maps 4 and 5). The big game winter range stipulation would affect 4,800 acres (Map 6). Fragile soils are associated with approximately 2,600 acres of federal mineral estate and floodplains would affect <1 acre (Maps 3 and 5). Impacts from other resource stipulations and lease notices cannot be determined at this time because surveys have not been conducted for the resources; however, migratory birds, raptors, burrowing mammals, and bats likely are associated with most of the federal mineral estate.

3.13.3 Mitigation

Applying the drainage stipulation in Alternative C would ensure that the lessee of a parcel adequately addresses the issue of uncompensated drainage.

3.13.4 Cumulative Impacts – Minerals (Fluid)

Cumulative impacts to fluid minerals are based on the RFDS created for this document (Table 2, Appendix 1) and the actions described below.

3.13.4.1 Scope of Analysis

The CIAA is the 15,644-acre Little Willow Creek proposed oil and gas lease area because only federal minerals in the lease area would be available. Well spacing guidance should prevent uncompensated drainage from the federal mineral estate outside the proposed lease area. The lease period of 10 years will be used for the temporal analysis limit because the federal mineral estate would be available for production during that time period, but not necessarily beyond.

3.13.4.2 Current Conditions and Effects of Past and Present Actions

In addition to the 6,349 acres of federal mineral estate, the CIAA includes 493 acres of State-owned minerals and 8,799 acres of private-owned minerals. The lease status of the State and private minerals is unknown. Six wells (three drilled and pending pipelines and three in the process of being drilled) occur in (three wells) or within 0.5 miles (three wells) of the CIAA. The wells are associated with privately-owned minerals; however, one well is within 0.15 miles of State-owned minerals.

3.13.4.3 Reasonably Foreseeable Future Actions

Two wells on privately-owned minerals could be drilled. Wells associated with State-owned minerals could be subject to stipulations for unstable soils, wildlife, threatened and endangered species, and floodplains (Appendix 2). Private lessors could also incorporate stipulations in their lease agreements; however, their scope is unknown.

3.13.4.4 Alternative A – Cumulative Impacts

Not leasing 6,349 acres of federal mineral estate could have minor (if the federal mineral estate is omitted) to moderate (if not omitted) adverse additive impacts to the value of unleased State- and privately-owned minerals. Stipulations associated with State-owned minerals could have minor adverse impacts on lease values and operating costs.

3.13.4.5 Alternative B – Cumulative Impacts

Leasing 6,349 acres of federal mineral estate with NSO and NSSO stipulations could have minor (if stipulations have a limited effect on accessibility) to moderate (if stipulations affect accessibility) adverse additive impacts to the value of unleased State- and privately-owned minerals. Stipulations associated with State-owned minerals would be as described in Alternative A (Section 3.13.4.4).

3.13.4.6 Alternative C – Cumulative Impacts

Leasing 6,349 acres of federal mineral estate with stipulations and lease notices would have minor adverse additive impacts to the value of unleased State- and privately-owned minerals. Stipulations associated with State-owned minerals would be as described in Alternative A (Section 3.13.4.4).

3.14 Social and Economic

3.14.1 Affected Environment – Social and Economic

<u>Social and Environmental Justice</u>

The 2010 Payette County population was 22,623, an increase of 10% from 2000. In comparison, the state population increased 21% between 2000 and 2010, Ada and Canyon counties increased 30.4% and 43.7% respectively. The 2010 Payette County population density was 55 persons/mi^2, compared to 18.8 for Idaho as a whole and 370 and 313 for Ada and Canyon counties respectively. The areas in the vicinity of the proposed lease area are home to farms, ranches, and dispersed residences.

As defined in Executive Order 12898, minority, low income populations, and disadvantaged groups are present in Payette County. Between 2008 and 2012, 19.2% of Payette County's population lived below the poverty line compared to 15.1% of Idaho's total population (Payette County QuickFacts, USCB 2014). The County is not very ethnically or racially diverse. In 2010, 85% of residents identified themselves as being non-Hispanic or Latino ethnicity and 15% of residents reported having Hispanic ancestry (US Census Bureau 2010). Non-white races including African American, Asian, American Indian, Pacific Islander, and others accounted for 11% of the population. In 2010, American Indians accounted for 1.1% of Payette County's population compared to 1.4% for the state as a whole. Tribes in Idaho and elsewhere have an interest in lands in Payette County; however, BLM is unaware of potential interest involving the proposed lease area.

<u>Economics</u>

In 2011, Payette County supported 9,606 jobs and had a 9.1% unemployment rate (Table 12). Non-services related industries (e.g., farm, construction, and manufacturing) accounted for 2,868 jobs, while service related industries (e.g., wholesale, retail, transportation, finance, real estate, and health care) accounted for 5,330 jobs and government accounted for 1,146 jobs (U.S. Department of Commerce 2011). In 2012, labor earnings of $325 million included $100 million in non-services related, $153 million in services related, and $47 million in government related earnings. The 2011 per capita income was $29,475. Total personal income (TPI) in 2011 was estimated to be $667 million including a net residential inflow of $105 million (earnings gained from outside the county – earnings leaving the county). Total personal income includes labor and non-labor income, including money earned on investments (interest, dividends, and rents) and transfer payments relating to age (Medicare and Social Security payments) or poverty (Medicaid or welfare assistance). Idaho had 147 people employed in oil and gas extraction activities statewide in 2011 (IPAA 2012).

Table 12. Employment (2011) and personal income (2012) by industry, Payette County, Idaho.

Industry	**Employment (jobs)**	**Personal Income (Thousands of 2012 dollars)**	**Average Income/Job (Thousands of 2012 dollars)**
Farm	974	$28,255	$29
Forestry & Related Activities	na	na	na
Mining (incl. fossil fuels)[1]	na	na	na
Construction[1]	780	$25,285	$32.4
Manufacturing	1,114	$46,321	$41.6
Utilities	95	$10,480	$110.3
Wholesale Trade[1]	278	$9,247	$33.3
Retail Trade[1]	734	$13,380	$18.2
Transportation & Warehousing[1]	341	$13,446	$39.4
Information	111	$6,604	$59.5
Finance & Insurance[1]	381	$9,798	$25.7
Real Estate & Rental & Leasing[1]	426	$3,543	$8.3
Professional & Tech. Services[1]	313	$10,763	$34.4
Management of Companies[1]	90	$8,503	$94.5
Admin. & Waste Services[1]	526	$9,587	$18.2
Educational Services	90	$868	$9.6
Health Care & Social Assistance[1]	844	$35,832	$42.5
Arts, Entertainment, and Rec	94	$545	$5.8
Accommodation & Food Services[1]	294	$3,843	$13.1
Other Services[1]	713	$16,977	$23.8
Government[1]	1,146	$47,312	$41.3
Total	9,606	$325,048	$33.8

[1] Industries that typically add jobs to support oil and gas leasing, exploration, and production activities.

<u>Oil and Gas Leasing and Production</u>

Local economic effects of leasing federal minerals for oil and gas exploration, development, and production are influenced by the number of acres leased, the number of wells drilled, and the estimated levels of production. These activities influence local employment, income, and public revenues (indicators of economic impacts). There are no federal-administered leases in the area; however, in 2014, the IDL leased 4,006 acres of State owned lands and minerals in Payette County.

Leasing - Federal oil and gas leases generate a one-time lease bid as well as annual rents. Parcels containing federal minerals, which have been approved for leasing, are auctioned off periodically to interested parties starting at a minimum bid of $2.00 per acre. Many parcels leased at auction generate bonus bids in excess of the minimum bid. In 2014, bonus bids ranged from $50.24/acre (October) to $79.68/acre (January) for State leases; however, because no leases have been offered, figures for federal minerals are not available. Once federal minerals are leased, leases are subject to annual rent or royalty payments. Rent on leased minerals is $1.50 per acre per year for the first five years and $2.00 per acre per year thereafter. Typically, oil and gas leases expire after 10 years unless drilling activity on these parcels results in one or more producing wells.

Production – Idaho currently has one producing well on private land and none associated with federal mineral estate (IPAA 2012, IDL 2014). Of 18 Payette County gas wells currently permitted by IDL, one is in production, 10 have been drilled and are shut pending a pipeline (Table 11). Once production begins, federally leased minerals are considered to be held by production and lease holders are required to pay royalties on production instead of annual rent. The BLM also considers mineral leases to be held by production if they have been incorporated into fields or units working cooperatively to increase extraction capabilities.

Federal oil and gas production is subject to production taxes or royalties. On public domain lands, these federal oil and gas royalties generally equal 12.5% of the value of production (43 CFR 3103.3.1), of which 50% would be allocated to the State and 50% would be allocated to the U.S. Treasury. In Idaho, 90% of federal mineral royalty revenues that the state receives are distributed to the Public School Income Fund and 10% distributed to the general fund of the counties where the revenue was generated. For State leases, a 12.5% production royalty is distributed to the permanent fund of the appropriate beneficiary, other State agencies, and the General Fund. The 2.5% production tax goes to the producing county (11.2% of tax revenue), cities within the producing county (11.2%), public schools (11.2%), local economic development (6.4%), and an oil and gas conservation fund (60%).

Local Economic Contribution - Oil and gas development has the potential to stimulate economic activity in a number of sectors throughout the region. Exploration, development, and production activities create a multiplier effect in the local economy as money spent in the oil and gas related industries is spent and re-spent in other industries (Table 12).

3.14.2 Environmental Consequences – Social and Economic

Impacts to the social and economic environment are based on the RFDS created for this document (Table 2, Appendix 1).

3.14.2.1 General Discussion of Impacts

<u>Social and Environmental Justice</u>

Development of a lease may generate impacts to people living near or using the area in the vicinity of the lease. Oil and gas exploration, drilling, or production could create an inconvenience to these people due to increased traffic and traffic delays, noise, and visual impacts. This could be especially noticeable in areas where oil and gas development has been minimal. The amount of inconvenience would depend on the activity affected, traffic patterns within the area, noise levels, length of time, and season these activities occurred, etc. Creation of new access roads into an area could allow increased public access and exposure of private property to vandalism. For split estate leases, surface owner agreements, standard lease stipulations, and BMPs could address many of the concerns of private surface owners. Production and development activities could disproportionately affect disadvantaged groups where the activities are specifically targeted to their communities or properties to the benefit or avoidance of non-disadvantaged groups. They could also provide job opportunities for those groups.

Economics

Local and/or out-of-state workers could be hired or contracted to meet the direct and indirect needs of development and production. Individual income for workers typically associated with development and production activities would vary from $8,300 to $94,500 annually (Table 12). Mining-related jobs would likely pay above the median income ($32,400/year). Total new jobs created could be relatively low because some work would be short-term in nature. For each million dollars in gas production, 2.4 jobs could be created in the county of production (Weber 2012). Employees may shift to higher paying energy-related jobs creating a labor shortage for local employers. Sudden influxes of workers could reduce affordable housing availability. An influx of workers and equipment without commensurate financial support could adversely affect public and private sector infrastructure (schools, hospitals, law enforcement, fire protection, and other community needs), especially in rural communities. Tax, royalty, spending, and income revenues associated with leasing, development, and production would benefit local, county, State, and national economies. Stipulations that affect access to mineral resources could reduce economic return for lessors and lessees. Activities that increase access to mineral resources could benefit other mineral rights holders. Activities that adversely affect health, safety, or the environment could cause short- or long-term decreases in personal income and property values. Wildlife depredation on agricultural fields could adversely affect productivity of some crops (e.g., winter wheat, alfalfa).

Disclosure of the direct, indirect, and cumulative effects of GHG emissions provides information on the potential economic effects of climate change including effects that could be termed the "social cost of carbon" (SCC). The EPA and other federal agencies developed a method for estimating the SCC and a range of estimated values (EPA 2014). The SCC estimates damages associated with climate change impacts to net agricultural productivity, human health, property damage, and ecosystems. Using a 3% average discount rate and year 2020 values, the incremental SCC is estimated to be $51 per ton of annual CO_2eq increase.

3.14.2.2 Alternative A

Social and Environmental Justice

Not leasing the federal mineral estate in the project area would limit the development potential of the project area to only two wells, both located on private lands. Developing two wells and associated infrastructure would have minor short-term impacts from increased traffic and noise and long-term visual, public access, and vandalism impacts. Limited increases in access and worker influx would occur. There are disadvantaged groups in Payette County, but they do not appear to be disproportionately associated with the two wells or the proposed lease area.

Economics

By not leasing, federal, state, or local revenues would not be generated from leasing, rents, or royalties from federal mineral estate. If BLM does not lease the federal minerals, it is likely that the IOGCC would allow the federal mineral estate to be omitted from the drilling unit. Moderate (if 493 acres associated with existing wells are omitted) to major (if up to 6,349 acres throughout the lease area are omitted) resource and revenue losses would occur if the IOGCC omitted the federal mineral estate and productive wells are drilled on private lands in the same unit. Development and production of two wells would cause minor employment and income increases. Negligible to minor impacts to labor and housing availability and infrastructure would occur over the short term. Adjacent mineral rights holders would experience minor beneficial (omission allowed) or moderate adverse (omission not granted) financial impacts. Adverse water quality and availability (Section 3.5.2.2), safety, and environmental impacts would primarily affect individual landowners in the immediate vicinity of the wells. Negligible wildlife depredation losses could occur.

Based on the GHG emission estimate (Table 6), the annual SCC associated with two wells would be $295,137 (in 2011 dollars). Estimated SCC is not directly comparable to economic contributions reported above, which recognize certain economic contributions to the local area and governmental agencies, but do not include all contributions to private entities at the regional and national scale. Direct comparison of SCC to the economic contributions reported above is also not appropriate because costs associated with climate change are borne by many different entities.

3.14.2.3 Alternative B

Social and Environmental Justice

Developing 22 wells and associated infrastructure would have moderate to major short-term increased traffic and noise impacts and long-term visual impacts. Minor (access controlled by private landowners) to major (access not controlled by private landowners) access and vandalism impacts could occur over the long term. A moderate worker influx could adversely affect traditional lifestyles. Disadvantaged groups in Payette County would not be directly affected by the wells, but access to affordable housing and social services in nearby communities could be reduced during the short term.

Economics

Federal, state, or local revenues would be generated from leasing and rents ($9,528 to $12,704 annually) during the 10-year lease period. The NSO and NSSO stipulations could reduce the lease value and bonus bid amounts. Developing and maintaining 22 wells would have minor to moderate short-term and negligible long-term job increases. Royalty income would depend on how productive the wells are and cannot be estimated at this time. Minor to moderate impacts to labor and housing availability and infrastructure would occur over the short term. Adjacent mineral rights holders would experience moderate financial benefits where access to their minerals improved. Adverse water quality and availability (Section 3.5.2.3), safety, and environmental impacts could have negligible (wells remain intact and don't affect ground water) to major (surface and ground water adversely affected by multiple wells) to the adjacent landowners and downstream communities. Minor to moderate wildlife depredation losses could occur. Based on the GHG emission estimate (Table 6), the annual SCC associated with 22 wells would be $3,246,711 (in 2011 dollars).

3.14.2.4 Alternative C

Social and Environmental Justice

The impacts of developing 25 wells and associated infrastructure would be as described in Alternative B (Section 3.14.2.3).

Economics

Leasing 6,349 acres and associated development and production would have similar revenue, job, labor and housing availability, infrastructure, and adjacent mineral rights holder impacts as described in Alternative B (Section 3.14.2.3). The impact of CSU stipulations on lease value would be less than Alternative B and royalty income could be greater. Adverse water quality and availability (Section 3.5.2.4), safety, and environmental impacts would be similar to Alternative B; however, the freshwater aquatic habitat CSU stipulation could provide minor to moderate surface water protection. Minor wildlife depredation losses could occur. Based on the GHG emission estimate (Table 6), the annual SCC associated with 25 wells would be $3,689,442 (in 2011 dollars).

3.14.3 Mitigation

Measures that limit or control dust, noise, odors and protect visual impacts and water quality resources would help reduce social and economic impacts (Dahl et. al. 2010).

3.14.4 Cumulative Impacts – Social and Economic

Cumulative impacts to the social and economic environment are based on the RFDS created for this document (Table 2, Appendix 1), RFDS for the Willow and Hamilton fields, and the activities identified below.

3.14.4.1 Scope of Analysis

Payette County will serve as the CIAA. Although social and economic costs and benefits could occur at regional, state, national, and international levels, the majority would occur at the county level. The lease period of 10 years will be used for the temporal analysis limit because the federal mineral estate would be available for production during that time period, but not necessarily beyond.

3.14.4.2 Current Conditions and Effects of Past and Present Actions

Current Payette County social and economic conditions are described in Section 3.14.1. All State-owned minerals (Section 3.13.1) and an unknown acreage of privately-owned minerals have been leased in recent years. The State leases will expire between 2016 (14,181 acres) and 2024. The existing 17 oil and gas wells have been developed over several years, although the majority of work occurred since 2011. Exploration work is ongoing in the County. The effect of these activities on social and economic conditions, beyond State lease rental returns, is unknown.

3.14.4.3 Reasonably Foreseeable Future Actions

Oil and Gas Lease Development and Production – Development of wells and associated infrastructure would occur on private and State leases in the Willow and Hamilton (one new well proposed October 2014) fields. Current development is approximately two to four wells annually.

3.14.4.4 Alternative A – Cumulative Impacts

Social and Environmental Justice

Development of two wells and associated infrastructure would have negligible additive traffic, noise, visual, access, vandalism, and worker influx impacts. Development of up to 53 wells in the Hamilton and Willow fields would have minor impacts. The county's population base is large enough that changes associated with oil and gas development would be relatively unnoticeable.

Economics

Not leasing federal mineral estate would have negligible additive adverse revenue impacts. Development of two wells and associated infrastructure would have negligible additive employment, income, labor and housing availability, infrastructure, water quality and availability, and SCC impacts. Development of up to 53 wells in the Hamilton and Willow fields would have minor revenue, employment, income, labor and housing availability, infrastructure, safety, and environmental impacts. Development in the Hamilton and Willow fields could cause minor (water availability affected by increased use) to moderate (water quality adversely affected by persistent pollutants) water quality and availability and SCC ($7,660,302) impacts. The county's economic and employment base is large enough that changes associated with oil and gas development would be relatively unnoticeable.

3.14.4.5 Alternatives B and C – Cumulative Impacts

Social and Environmental Justice

Leasing federal mineral estate and the subsequent development of 22-25 wells and associated infrastructure would have minor additive traffic, noise, visual, access, vandalism, and worker influx impacts. Impacts from other oil and gas development would be as described in Alternative A (Section 3.14.4.4).

Economics

Leasing federal mineral estate and the subsequent development of 22-25 wells and associated infrastructure would have minor additive employment, income, labor and housing availability, and infrastructure impacts and minor to moderate additive water quality and availability and SCC impacts. Impacts from other oil and gas development would be as described in Alternative A (Section 3.14.4.4).

4.0 Consultation and Coordination

4.1 List of Preparers

Name	Position
Jonathan Beck	Planning and Environmental Coordinator, ID State Office and Boise District
Aimee Betts	Associate District Manager, Boise District
M.J. Byrne	Public Affairs, Boise District
Tate Fischer	Field Office Manager, Four Rivers
Sarah Garcia	Rangeland Management Specialist, Four Rivers
Lara Hannon	Natural Resource Specialist/Acting NEPA Specialist, Boise District
Valerie Lenhartzen	Geologist, Four Rivers
Matthew McCoy	Assistant Field Office Manager, Four Rivers
David Murphy	Branch Chief, Realty, ID State Office
Karen Porter	Geologist, ID State Office
Larry Ridenhour	Outdoor Recreation Planner, Four Rivers
Dean Shaw	Archaeologist, Four Rivers
Mark Steiger	Botanist, Four Rivers
Allen Tarter	Natural Resource Specialist (Riparian), Four Rivers

4.2 List of Agencies, Organizations, and Individuals Consulted

Affected Landowners and Permittees (84 individual or companies within 1 mile of proposed lease area)
Allen and Kirmse, Ltd
Alta Mesa Service, Inc., c/o F. David Murrell
Burns Paiute Tribe, Tribal Chairman
Canyon County Commissioners
Confederate Tribes of the Umatilla, Tribal Chairman
Congressman Raul Labrador
Energy West Corp.
Gem County Commissioners
Grazing Board Resource Area Representatives, Phil Soulen
Grazing Board Resource Area Representatives, Stan Boyd
Grazing Board Resource Area Representatives, Weldon Branch
Idaho Citizens Against Resource Extraction
Idaho Conservation League, John Robinson
Idaho Department of Agriculture
Idaho Department of Fish & Game c/o Rick Ward
Idaho Department of Lands c/o Grazing Program Manager
Idaho Governor, CL "Butch" Otter
Idaho Lieutenant Governor Brad Little
Idaho Office of Energy Resources, c/o John Chatburn

Larry Craig
Moffitt Thomas and Associates
Nez Perce Tribes, Tribal Chairman
SBS Associates, LLC
Senator Jim Risch
Senator Mike Crapo
Shoshone-Bannock Tribe, c/o Nathan Small
Shoshone-Paiute Tribe, c/o Ted Howard
Trendwell Energy Corp.
US Fish and Wildlife Service
Washington County Commissioners
Weiser-Brown Oil Co, c/o Richard Brown
Western Watersheds Project
WildLands Defense, Katie Fite

Native American Consultation

BLM is required to consult with Native American tribes to "help assure (1) that federally recognized tribal governments and Native American individuals, whose traditional uses of public land might be affected by a proposed action, will have sufficient opportunity to contribute to the decision, and (2) that the decision maker will give tribal concerns proper consideration" (U.S. Department of the Interior, *BLM Manual Handbook H-8120-1*). Tribal coordination and consultation responsibilities are implemented under laws and executive orders that are specific to cultural resources which are referred to as "cultural resource authorities," and under regulations that are not specific which are termed "general authorities." Cultural resource authorities include: the *National Historic Preservation Act of 1966*, as amended (NHPA); the *Archaeological Resources Protection Act of 1979*; and the *Native American Graves Protection and Repatriation Act of 1990, as amended*. General authorities include: the *American Indian Religious Freedom Act of 1979*; the NEPA; the FLPMA; and *Executive Order 13007-Indian Sacred Sites*. The proposed action is in compliance with the aforementioned authorities.

Southwest Idaho is the homeland of two culturally and linguistically related tribes: the Northern Shoshone and the Northern Paiute. In the latter half of the 19th century, a reservation was established at Duck Valley on the Nevada/Idaho border west of the Bruneau River. Today, the Shoshone-Paiute Tribes residing on the Duck Valley Reservation actively practice their culture and retain aboriginal rights and/or interests in this area. The Shoshone-Paiute Tribes assert aboriginal rights to their traditional homelands as their treaties with the United States, the Boise Valley Treaty of 1864 and the Bruneau Valley Treaty of 1866, which would have extinguished aboriginal title to the lands now federally administered, were never ratified.

Other tribes that have ties to southwest Idaho include the Bannock Tribe and the Nez Perce Tribe. Southeast Idaho is the homeland of the Northern Shoshone Tribe and the Bannock Tribe. In 1867 a reservation was established at Fort Hall in southeastern Idaho. The Fort Bridger Treaty of 1868 applies to BLM's relationship with the Shoshone-Bannock Tribes. The northern part of the BLM's Boise District was also inhabited by the Nez Perce Tribe. The Nez Perce signed treaties in 1855, 1863 and 1868. BLM considers off-reservation treaty-reserved fishing, hunting, gathering, and similar rights of access and resource use on the public lands for all tribes that may be affected by a proposed action.

The BLM initiated consultation with the Shoshone-Paiute Tribes during the June 19, 2014 Wings and Roots Program, Native American Campfire meeting. At that time, the Tribes were provided an information "early alert" with updated information from the June 12, 2014, field trip. The Shoshone-Paiute Tribes did not respond to a July 3, 2014 scoping letter, but will be consulted once again at the December 2014 Wings and Roots Program, Native American Campfire meeting.

4.3 Public Participation

The BLM received public scoping comments from the following individuals and entities (see Section 8.0 Comment Response for comments specific to the draft EA):

Alta Mesa Services, Inc.
Idaho Concerned Residents for the Environment (ICARE)
Idaho Office of Energy Resources
Idaho Petroleum Council
Idaho Residents Against Gas Extraction (IRAGE)
Jason Williams
JoAnn Higby
Lyndsey Winters Juel
Marilyn Richardson
Terry Paulus
William Fowkes and Alice Whitford
Western Watersheds Project (WWP)

5.0 Literature Cited

Barrett, J. 2005. Population viability of the southern Idaho ground squirrel (*Spermophilus brunneus endemicus*): effects of an altered landscape. M.S. Thesis, Boise State University, Boise, ID.

Barton, D. C. and A. L. Holmes. 2007. Off-highway vehicle trail impacts on breeding songbirds in northeastern California. J. Wildlife Manage. 71:1617-1620.

Beckman, J. P., K. M. Berger, J. K. Young, and J. Berger. 2008. Wildlife and energy development: pronghorn in the upper Green River Basin – year 3 summary. Wildlife Conservation Society, Bronx, NY. Available for download from http://www.wcs.org/yellowstone. 86 pp.

Bevanger, K. 1998. Biological and conservation aspects of bird mortality caused by electricity power lines: a review. Biol. Conserv. 86:67-76.

Bull, E. L. 2006. Sexual differences in the ecology and habitat selection of western toads (Bufo boreas) in northeastern Oregon. Herp. Conserv. Biol. 1:27-38.

Buwalda, J. P. 1923. A preliminary reconnaissance of the gas and oil possibilities of southwestern and south-central Idaho: Idaho Bur. Mines and Geology Pamph. 5. 10 pp.

Carr, L. W. and L. Fahrig. 2002. Effect of road density on two amphibian species of differing vagility. Conserv. Biol. 15: 1071-1078.

Climate Change SIR. 2010. Climate Change Supplementary Information Report for Montana, North Dakota, and South Dakota, Bureau of Land Management. Report on Greenhouse Gas Emissions and Climate Change for Montana, North Dakota, and South Dakota. Technical report prepared for the Montana/Dakotas Bureau of Land Management by URS Corporation. URS Project 22241790.

Dahl, G., C. Price, and D. Kalish. 2010. Oil and gas regulations: a guide for local governments. Colorado Dept of Local Affairs. 85 pp. http://www.springsgov.com/units/boardscomm/OilGas/DOLA%20O&G%20Guide%20for%20Local%20Governments.pdf Accessed November 23, 2014.

Duchamp, J. E., D. W. Sparks, and J. O. Whitaker, Jr. 2004. Foraging-habitat selection by bats at an urban-rural interface: comparison between a successful and a less successful species. Can. J. Zool. 82:1157=1164.

EPA. 2014a. The 2011 National Emissions Inventory [Website]. Version 1. U.S. Environmental Protection Agency. http://www.epa.gov/ttn/chief/net/2011inventory.html Accessed November 10, 2014.

EPA. 2014b. Climate impacts in the northwest. http://www.epa.gov/climatechange/impacts-adaptation/northwest.html. Accessed October 31, 2014.

Erathem-Vanir. 2009. Survey of Idaho fossil resources, G.F. Winterfeld and R. A. Rapp, eds. BLM Professional Services Contract DLP050083. Erathem-Vanir Geological Consultants, Pocatello, ID.

Fowler, J. M. and J. Witte. 1985. Oil and gas activity on ranch operations and rangelands. Rangelands 7:35-37.

Green, J.S., and J.T. Flinders. 1980. Habitat and dietary relationships of the pygmy rabbit. J. Range Manage. 33:136–142.

Hebblewhite, M. 2008. A literature review of the effects of energy development on ungulates: implications for central and eastern Montana. Report prepared for Montana Fish, Wildlife, and Parks, Miles City, MT. 125 pp.

Henry, M., D. W. Thomas, R. Vaudry, and M. Carrier. 2002. Foraging distances and home range of pregnant and lactating little brown bats (*Myotis lucifugus*). J. Mammal. 83:767-774.

Holmes, T. L., R. L. Knight, L. Stegall, and G. R. Craig. 1993. Responses of wintering grassland raptors to human disturbance. Wild. Soc. Bull. 21: 461-468.

IDAPA (Idaho Administrative Procedures Act) 20.07.02. 2014. Conservation of crude oil and natural gas in the State of Idaho. http://adminrules.idaho.gov/rules/current/20/0702.pdf. Accessed November 1, 2014.

IDEQ (Idaho Department of Environmental Quality). 2012. Payette County ground water quality improvement and drinking water source protection plan. IDEQ, Boise, Idaho. 77pp.

_____. 2014. Idaho's 2012 integrated report - final. IDEQ, Boise, Idaho. 847 pp. http://deq.idaho.gov/water-quality/surface-water/monitoring-assessment/integrated-report.aspx. Accessed November 1, 2014.

IDFG (Idaho Department of Fish Game). 2010a. Elk statewide progress report. Boise, ID.

_____. 2010b. Mule deer statewide progress report. Boise, ID.

_____. 2013. Idaho fish and wildlife information system. Idaho Department of Fish and Game, Boise, ID.

IMPROVE. 2011. Spatial and seasonal patterns and temporal variability of haze and its constituents in the United States, Report V. Interagency Monitoring of Protected Visual Environments (IMPROVE).

http://vista.cira.colostate.edu/improve/publications/Reports/2011/PDF/IMPROVE_V_FullReport.pdf. Accessed November 1, 2014.

Ingelfinger, F. 2001. The effects of natural gas development on sagebrush steppe passerines in Sublette County, Wyoming. M.S. Thesis. University of WY, Laramie, Wyoming.

IOGCC (Idaho Oil and Gas Conservation Commission). 2013. Final order in the matter of the petition by AM Idaho, LLC, requesting amendment to the spacing order for the Hamilton and Willow fields. http://www.idl.idaho.gov/oil-gas/commission/042413-am-idaho-final-spacing-order.pdf. Accessed November 29, 2014.

_____. 2013b. "Fracking" in Idaho and the potential impacts of oil and gas exploration. http://www.idl.idaho.gov/oil-gas/commission/2013-faq-fracking.pdf. Accessed December 6, 2014.

_____. 2014. Oil and gas drill permits. http://www.idl.idaho.gov/oil-gas/commission/well-permits/index.html. Accessed November 1, 2014.

IPAA (Independent Petroleum Association of America). 2012. The Oil and Gas Producing Industry in Your State 2011-2012. IPAA, Washington, DC. 140 pp.

IPCC. 2007. Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report: Climate Change 2007. http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html. Accessed November 7, 2014.

Johnson, Z., P. S. Cook, J. O'Lauglin, and K. Bird. 2013. Oil and gas resource exploration and development polixcies in Idaho. Report No. 33. Policy Analysis Group – College of Natural Resources, University of Idaho, Moscow. 77 pp.

Katzner, T. E. and K. L. Parker. 1997. Vegetative characteristics and size of home ranges used by pygmy rabbits (*Brachylagus idahoensis*) during winter. J. Mammal. 78:1063-1072.

Kleinfelder, Inc., and Environ International Corporation. 2014. Air emissions inventory for a representative oil and gas well in the western United States. Developed under contract with the Bureau of Land Management, updated March 21, Littleton, CO.

Larrucea, E. S. and P. F. Brussard. 2008. Habitat selection and current distribution of the pygmy rabbit in Nevada and California, USA. J. Mammal. 89:691-699.

Lefcort, H., R. A. Meguire, L. H. Wilson, and W. F. Ettinger. 1998. Heavy metals alter the survival, growth, metamorphosis, and antipredatory behavior of Columbia spotted frog (*Rana luteiventris*) tadpoles. Arch. Environ. Contamination Toxicology 35:447-456.

Leu, M. and S. E. Hanser. 2011. Influences of the human footprint on sagebrush landscape patterns-Implications for sage-grouse conservation. in Knick, S. T. and J. W. Connelly eds., Greater Sage-Grouse- Ecology and Conservation of a Landscape Species and Its Habitats, Studies in Avian Biology No. 38: Berkeley, CA, University of California Press, pp. 383-405.

Paige, C. and S. A. Ritter. 1999. Birds in a sagebrush ocean: managing sagebrush habitats for bird communities. Partners in Flight Western Working Group, Boise, ID. 52 pp.

Sawyer, H., R. M. Nielson, Lindzey, and L. L. McDonald. 2006. Winter habitat selection of mule deer before and during development of a natural gas field. J. Wildl. Manage. 70:396-403.

Sheley, R. L., Petroff, J. K., eds. 1999. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press. Pp. 85, 202, 217, 249, 261, 315, 350, 362, 401, and 408.

TEEIC (Tribal Energy and Environmental Information Clearinghouse). 2014. Oil and gas drilling/development impacts. http://teeic.indianaffairs.gov/er/oilgas/impact/drilldev/index.htm. Accessed November 23, 2014.

USCB (US Census Bureau). 2014. Various sites including Population Finder and QuickFacts. http://www.census.gov/en.html#. Accessed November 2, 2014.

USDA (US Department of Agriculture), Natural Resources Conservation Service (NRCS). 2014. Soil Survey Staff, Natural Resources Conservation Service, Soil Survey Geographic (SSURGO) Database for Soil survey of parts of Ada, Elmore, Owyhee, Boise, Canyon Gem and Payette County areas. http://soildatamart.nrcs.usda.gov. Accessed September 30, 2014.

USDA and USFS. 2006. Wildland Fire in Ecosystems: Effects of Fire on Soil and Water. General Technical Report RMRS-GTR-42-Volume 4. Pages 29-40.

USDI (US Department of the Interior). 1997. Idaho standards for rangeland health and guidelines for livestock grazing management. USDI, Bureau of Land Management, Boise, ID. 20 pp.

USFS (US Forest Service), Rocky Mountain Research Station (RMRS). 2014. SOLO. A Guide to Soil Quality Monitoring for Long Term Ecosystem Sustainability on Northern Regional National Forests. "The Effect of Fire on Soil Properties" report submitted by Leonard F. DeBano. Accessed November 19, 2014. http://forest.moscowfsl.wsu.edu/smp/solo/documents/GTRs/INT_280/DeBano_INT-280.php

USFWS (U. S. Fish and Wildlife Service). 2010. Endangered and threatened wildlife and plants; 12-month finding on a petition to list the pygmy rabbit as endangered or threatened. Federal Register 75:60516-60561.

Wallace, Z. 2014. Effects of oil and natural gas development on territory occupancy of ferruginous hawks and golden eagles in Wyoming, USA. M. S. Thesis, Oregon State University, Corvallis, OR. 137 pp.

Weber, J.G. 2012. The effects of a natural gas boom on employment and income in Colorado, Texas, and Wyoming. Energy Econ. 34:1580-1588.

WRI. 2012. Climate Analysis Indicators Tool (CAIT) 2.0. [Website]. World Resources Institute (WRI). http://cait.wri.org/ . Accessed October 31, 2014.

Yensen, E. 1991. Taxonomy and distribution of the Idaho ground squirrel, *Spermophilus brunneus*. J. Mammalogy 72:583-600.

6.0 Appendices

6.1 Appendix 1. Reasonably foreseeable development scenario for the proposed Little Willow Creek oil and gas lease area, Payette County, Idaho.

REASONABLY FORESEEABLE DEVELOPMENT SCENARIO

FOR

PROTECTIVE OIL AND GAS LEASING

IN PARTS OF
TOWNSHIP 8 NORTH, RANGE 4 WEST
TOWNSHIP 9 NORTH, RANGE 4 WEST, AND
TOWNSHIP 9 NORTH, RANGE 3 WEST
BOISE MERIDIAN

FOUR RIVERS FIELD OFFICE
IDAHO

Prepared by: ______________________________ Date: ____________
Karen Porter
BLM Idaho State Office Geologist

SUMMARY

The BLM's Four Rivers Field Office is currently analyzing the environmental effects of offering 6474.62 acres of federal mineral estate for competitive oil and gas leasing. This RFDS is being written in support of that analysis, to inform the public and the preparers of the environmental assessment of the disturbance that could occur as a result of leasing the lands, so that the environmental impacts can be determined and mitigation measures, in the form of lease stipulations, can be developed to minimize those impacts. The BLM plans to offer these lands in a lease sale in early 2015, in order to protect the federal mineral estate from potential drainage caused by the development of a natural gas field that is presently occurring on private lands, referred to by the developer as the Willow Field.

According to an April 16, 2013 order by the Idaho Oil and Gas Conservation Commission, well spacing in the area is one well per government section, or 640 acres. In the northern part of the field, lands with reserved federal mineral estate (also called split estate) are intermingled with some of the private lands, causing conflicts for the developer. Idaho BLM has been deferring leasing in the Four Rivers FO while the current land use plan, the CRMP, is being revised. The CRMP/EIS was completed in 1987, and, while it identified lands closed to leasing and identified some areas as No Surface Occupancy, the analysis does not meet current BLM standards for oil and gas leasing. One major component that is missing is an analysis based on a Reasonably Foreseeable Development Scenario, or RFDS. Therefore, this RFDS describes the likely disturbance that could occur if BLM were to select any of the alternatives being proposed.

This Reasonably Foreseeable Development Scenario (RFDS) indicates that the following impacts could occur, by alternative:

Alternative A (No Action) - If BLM does not lease in the project area, development drilling could occur in only 2 sections- T. 8 N., R. 4 W., section 2, and T. 9 N., R. 4 W., section 36. The lands in these sections are private and do not contain any federal mineral estate. Technically only two wells could be drilled in the project area. This would result in approximately 10 acres of disturbance.

Alternative B (Lease with NSO/NSSO) - Offering leases with NSO/NSSO would allow those sections that have lands with federal mineral estate to be drilled, however the drilling could not occur on the federal mineral estate. The only federal action would be to administer the leases and collect royalties. As there is only one section that has 100% federal minerals (T 9 N., R. 4 W., section 26) and there are 25 sections within the project boundary, technically Alt B could result in up to 24 wells. However, in looking at the topography of each section, it is noted that there are several sections where the private land is either inaccessible or is too steep to be suitable as a drill site. Two sections- T. 9 N., R. 4 W., section 13, and T. 9 N., R. 3 W., section 17- do not have favorable private land conditions for drilling. Therefore, if Alt B were selected, it is estimated that 22 wells would be drilled in the project area, resulting in 77 acres of disturbance.

Alts C (Lease with Cascade RMP stipulations and additional lease notices) - Generally all federal minerals would be available for development, resulting in the drilling of 25 wells (one per section), and 88 acres of disturbance.

It is anticipated that one geophysical exploration program would occur and that it would likely be conducted along existing roads or trails or by overland travel, thereby causing minor impacts to surface resources.

INTRODUCTION

This report describes the anticipated level of oil and gas exploration and development activity associated with issuing oil and gas leases in the project area. This projection is necessary so that the impacts to other natural resources can be analyzed in an environmental assessment, and to determine what if any stipulations, in addition to those on the standard lease form and those required by BLM policy, may be necessary to attach to the leases in order to mitigate those impacts.

ASSUMPTIONS AND DISCUSSION

- It is assumed that one well would be drilled per government section of approximately 640 acres. This is based on the state of Idaho's well spacing order.

- If a well is to be located on a federal lease, the lessee will be required to submit a drilling permit (APD) to BLM for approval prior to commencing operations. Site-specific NEPA would then be conducted, and additional site-specific requirements, termed Conditions of Approval, may be attached to the APD. If the well is to be located on fee lands, the lessee would seek approval for a drilling permit from the Idaho Department of Lands.

- If drilling is proposed on split estate lands, the lessee will be required to contact the surface owner and attempt to reach an agreement concerning surface access prior to submitting the APD. In accordance with BLM's Onshore Order Number One, upon submitting an APD, the lessee or its operator must certify to the BLM that: (1) It made a good faith effort to notify the private surface owner before entry; and (2) A Surface Access Agreement with the surface owner has been reached, or that a good faith effort to reach an agreement failed. The Surface Access Agreement may include terms or conditions of use, be a waiver, or an agreement for compensation. BLM is not a party to the surface agreement, however if no agreement is reached with the surface owner, the operator is required to submit an adequate bond (minimum of $1000) to the BLM for the benefit of the surface owner, in an amount sufficient to compensate for any loss of crops or damage to tangible improvements. This is a separate and distinct bond from the reclamation bond required under 43 CFR 3104.

- Based on the recent drilling that has occurred in the Willow Field, it is assumed that any well drilled would be a vertical hole, and that it would not require hydraulic fracturing. It is also assumed that the well would be a natural gas well.

- If the well is productive, it is assumed that it would be incorporated into the Willow Field unit development. If dry, the well would be plugged and abandoned, and the site would be reclaimed.

- Oil and gas leases are issued for an initial term of 10 years, subject to extension if there is drilling occurring or if there is a producing well on the lease.

ANTICIPATED SURFACE DISTURBANCE DUE TO OIL AND GAS ACTIVITIES

The following phases of oil and gas exploration/development are typical in searching for and developing an oil and gas resource:

1. Geophysical Exploration
2. Drilling Phase
3. Field Development and Production
4. Plugging and Abandonment

These phases are discussed in detail below.

Phase One: Geophysical Exploration

While a geophysical exploration program may have already been conducted, for the sake of this report it is anticipated that one geophysical exploration program may be conducted during the 10-year initial term of the leases. Geophysical techniques are often implemented to identify subsurface geologic structures and determine drilling targets. The BLM reviews and approves geophysical operations on a case by case basis, and a lease is not necessary for such work. Gravity, magnetics, and seismic reflection are the most common techniques used. Both gravity and magnetic surveys cause very little disturbance as the instruments used are small and easily transportable in light vehicles or OHVs. These surveys can cover large areas and take only weeks to conduct. It is preferable to use existing roads, yet some overland travel is sometimes necessary. In addition, both gravity and magnetic surveys can be completed from aircraft, virtually eliminating surface disturbance.

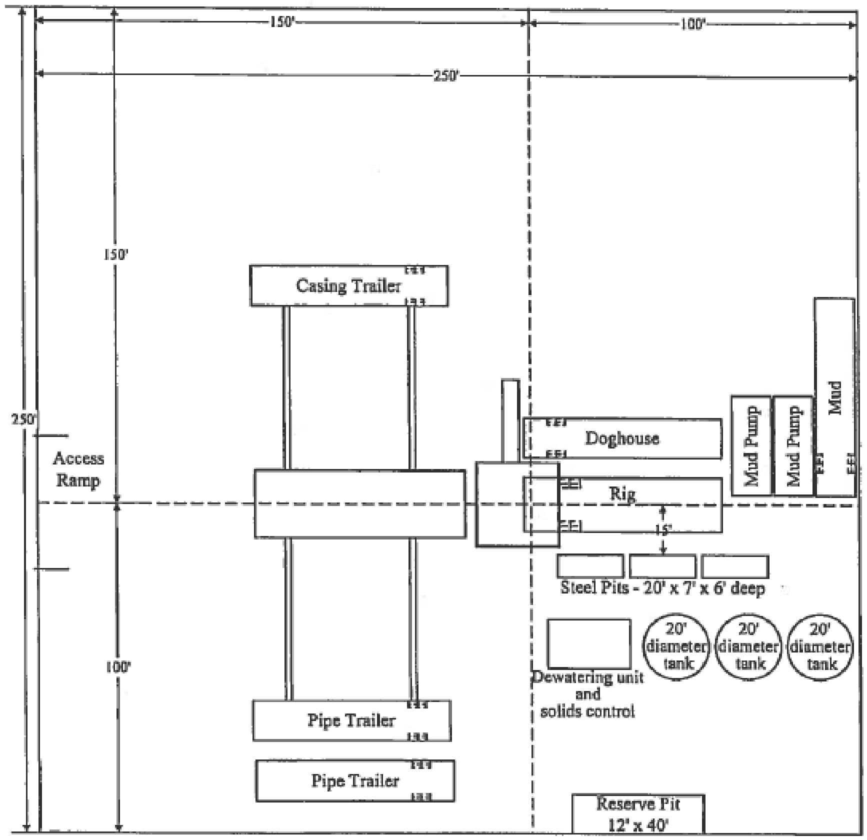
Seismic reflection surveys- either 2D or 3D- are the most commonly used geophysical tool. They require a seismic energy source and an array of receptors that are laid down in rows on the ground surface. Shock waves are created by vibrating or thumping the ground. Reflected seismic waves are recorded by a series of surface equipment along a 3- to 5-mile line. The general principle of seismic reflection is to send elastic waves (using an energy source such as dynamite explosion or Vibroseis) into the Earth, where each layer within the Earth reflects a portion of the wave’s energy back and allows the rest to refract through. These reflected energy waves are recorded over a predetermined time period by receivers that detect the motion of the ground in which they are placed. On land, the typical receiver used is a small, portable instrument known as a geophone, which converts ground motion into an analogue electrical signal. In preparation for gathering the seismic data, the survey crew establishes a grid, with source lines running one direction and receiver lines running a different direction. The source lines mark the points where either explosives or vibroseis vehicles will be placed. The receiver lines mark points where geophones (small devices inserted into the ground that pick up reflected vibrations) are placed to take readings when either a small explosion is set off or, more commonly, the vibroseis vehicles are used. Either method is used to send vibrations underground that are reflected back to the surface where readings are taken by geophones on the receiver lines and transferred to a data recorder vehicle. A crew of 10 to 15 people with five to seven vehicles is used, and several square miles can be surveyed in a single day. The geophones are then retrieved from the ground, and moved to the next survey area.

Phase Two: Drilling Phase

Given Idaho's well spacing requirements, it is assumed that a single well would be drilled in each section. If the proposed well is located on lands with federal minerals (i.e. on a federal lease), the lessee is required to submit an APD to BLM. If the proposed well is located on lands with private or state minerals, the lessee would submit a drilling permit application to the Idaho Department of Lands. Drilling on federal mineral estate would be analyzed by BLM in a site-specific NEPA document, and would involve coordination with the surface owner. Conditions of Approval, specific to the proposed activity and site, would be developed and attached to the drilling permit. These conditions, as well as the lease contract itself and any additional stipulations, would need to be complied with. A reclamation bond is required, and if necessary, a surface owner bond would be held by BLM on the surface owner's behalf.

Vehicle access to each drill pad would be required, to transport the drill rig, personnel, and other heavy equipment to the drill site. Existing roads may be used, however may require upgrading. Most of the individual parcels can be accessed off of the Little Willow Creek road, which is paved. Two-track and gravel roads that branch off of Little Willow Creek may require upgrading. Typically, roads are constructed with a 20-foot wide graveled running surface with adjacent ditches and berms, for a total disturbance width of about 40 feet. It may be necessary to haul in gravel to obtain a good road base, as well as a base for the well pad. In the area of the subject parcels, there are several good gravel roads that provide access to some part of the section that would be an appropriate drilling site. It is unlikely that the lessee would need access to the top of the bluffs on which many of the parcels lie. Given the existing road density in the area, it is assumed that an average of 1/4 of a mile of new road construction would be required to access the drill sites. Surface disturbance from the construction of 1/4 mile of road equals approximately one acre.

A drill pad is required to accommodate the rig and equipment. Previous drill pads in the Willow Field have been approximately 1.5 acres in size, however this report assumes a larger pad of 2.5 acres (300' x 350'). Topsoil and existing vegetation is scraped from the well pad site and stored on site for reclamation. The drill pad must be level, possibly requiring some cut-and-fill of the site. In addition to the drill rig, the well pad may house a reserve pit for storage or disposal of water, drill mud, and cuttings; several mud pits and pumps, drill pipe racks, a fuel tank, a water tank, a generator and several compressors, equipment storage, and several trailers for temporary lab and office quarters. To date, reserve pits associated with developing the Willow Field have all been lined with a 12-mil synthetic liner. Below is a schematic diagram of an actual well pad (from Bridge Energy Resources' drilling permit application to IDL):



Getting the rig and ancillary equipment to the site may require 15 to 20 trips by full-sized tractor-trailers, with a similar amount for de-mobilizing the rig. There would be 10 to 40 daily trips for commuting and hauling in equipment. Drilling operations would likely occur 24 hours a day and seven days a week. It takes approximately one month to drill one well. A drilling operation generally has from 10 to 15 people on-site at all times, with more people coming and going periodically with equipment and supplies.

Well drilling also requires water. As much water as possible is recycled on site, yet about 5,000 to 15,000 gallons of water may be needed each day depending on well conditions. Initially, water would need to be provided, either by wells or trucked in, to meet demands. Many oil or gas wells encounter water at depth when drilling for oil and/or gas, as it may be part of the oil and gas reservoir, and can be utilized when production is ongoing.

Production wells drilled in the Willow Field to-date have been 24 inches in diameter at the surface, gradually narrowing (telescoping) to 8¾ inches at the bottom of the well. In order to drill these deep, large-diameter holes, a large drilling rig is utilized. The top of the drill rig derrick could be as much as 155 feet above the ground surface, and the rig floor could be at least 25 feet above the ground surface. These rigs are typically equipped with diesel engines, fuel and drilling mud storage tanks, mud pumps, and other ancillary equipment. Once drilling commences, drilling fluid or mud is continuously circulated down the drill pipe and back to the surface equipment. The purpose of the drilling mud is to balance underground hydrostatic pressure, cool the drill bit, and flush out rock cuttings.

The risk of an uncontrolled flow from the reservoir to the surface (occasionally caused by encountering a pressurized thermal pocket) is greatly reduced by using a blowout preventer—a series of hydraulically-actuated steel rams that can close quickly around the drill string or casing to seal off a well. The BOP is pressure-tested after installation to ensure proper operation. Steel casing is run into completed sections of the borehole and cemented into place. The casing provides structural support to maintain the integrity of the borehole and isolates underground formations.

Exploration holes drilled to-date in the Willow Field have ranged in depth from 2500 to 6900 feet. At the conclusion of well testing, if paying quantities of oil and gas are not discovered, the operator is required to plug and abandon the well according to State standards. Cement plugs are placed above and below water-bearing units with drilling mud placed in the space between plugs. When abandonment is complete, the site is reclaimed, which includes pad and road recontouring, topsoil replacement, and seeding with approved mixtures. Erosion control measures would be incorporated into the reclamation design as needed.

The drilling site could be active for approximately one year, from the start of drill pad and access road construction; through drilling and well testing; to completion of plugging the hole and reclamation.

Phase Three: Field Development and Production

Where oil and gas flow to the surface naturally, control valves and collection pipes are attached to the well head. Otherwise a pump may be installed. Oil is typically produced along with water and gas. Once the raw hydrocarbon reaches the surface, it would be routed through a pipeline to a central production facility, which gathers and separates the produced fluids (oil, gas and water). A production facility is currently being constructed on private lands on the east side of the town of New Plymouth, and dehydration plant has been constructed on Highway 30, immediately north of Interstate 84. The production facility processes the hydrocarbon fluids and separates oil, gas and water. The oil must usually be free of dissolved gas before export. Similarly, the gas must be stabilized and free of liquids and unwanted components such as hydrogen sulphide and carbon dioxide. Any water produced would be treated at these facilities before disposal. Produced water at the well site is disposed of either through surface discharge, evaporation ponds or re-injection into the producing formation.

The producing life span of an oil or gas field varies depending on field characteristics. A field may produce for a few years to many decades. Commodity price, recovery technique, and the political environment also affect the life of a field. Abandonment of wells may begin as soon as they are depleted or wells may be rested for a period of time or drilled to a different horizon, and put back into production.

Phase Four: Abandonment

If paying quantities of oil and gas are not discovered, or at the end of the producing life span of a producing well or field, the operator is required to plug and abandon the well according to Federal and State standards and reclaim the disturbed areas. To plug a well, cement plugs are placed above and below water-bearing units with drilling mud placed in the space between plugs. When well abandonment is complete, equipment and surface facilities are removed, and the site is reclaimed. In a producing field, underground pipelines are often plugged and left in place in order to avoid re-disturbing these areas. Site reclamation includes pad and road obliteration and recontouring, topsoil replacement, and seeding with approved mixtures. Erosion control measures would be incorporated into the reclamation design as needed.

CONCLUSION

Surface disturbance associated with the anticipated leasing of the federal mineral estate in the project area would be approximately 5 acres per well. One well can be drilled per section according to the State of Idaho's well spacing order. Therefore, depending on which alternative is selected, between 10 acres and 125 acres could be disturbed. Pad and access road construction, drilling and well testing, and reclamation would take an estimated 4-6 months, depending on well depth and drilling conditions encountered. It is reasonably likely that well testing would be favorable for production, in which case a pipeline would likely be installed to transport the hydrocarbons to a central production facility located off-lease, located on private land several miles to the south. It is anticipated that one geophysical survey program would be completed during the life of the lease. This disturbance would be temporary, on the order of weeks, and would result in minor to negligible surface impacts.

This RFDS meets the requirements of BLM's Manual Section 1624-2 in describing potential surface impacts that could occur as a result of leasing the federal mineral estate in the project area.

6.2 Appendix 2. State lease stipulations in the vicinity of the proposed Little Willow Creek lease area, Payette County, Idaho.

1. Construction Notification. Lessee shall notify and obtain approval from Idaho Department of Lands (IDL) prior to constructing well pads, roads, power lines, and related facilities that may require surface disturbance on the tract. Lessee shall submit a surface use plan of operations to IDL and obtain approval before beginning surface disturbance activities. Lessee shall comply with any mitigation measures stipulated in IDL's approval.
2. Surface Owner Notification. If the State does not own the surface, the Lessee must contact the owner of the surface in writing at least 30 days prior to any surface activity. A copy of the correspondence shall be sent to IDL.
3. Unstable Soils. Due to unstable soil conditions on this tract and/or topography that is rough and/or steep, surface use may be restricted or denied. Seismic activity may be restricted to surface shots.
4. Metalliferous/Gem Lease. This lease is issued subject to a prior existing State of Idaho metalliferous/gem lease. Lessee's rights to search, develop, and produce oil and gas may be restricted by such prior existing lease rights.
5. Wildlife Concerns. Potential wildlife conflicts have been identified for this tract. The applicant must contact the Idaho Department of Fish and Game (IDFG) in the area for advice on alleviating any possible conflicts caused by the Lessee's proposed activities. Documentation that IDFG requirements have been satisfied unless otherwise authorized by IDL is required. Additional mitigation measures may also be required.
6. Threatened and Endangered Plant Species. Plant species of concern have been identified on or near this tract. A vegetation survey in areas of proposed activity will be required prior to disturbance. Identified rare plant species will be avoided, unless otherwise authorized by the IDL.
7. Threatened and Endangered Animal Species. Animal species of concern have been identified on or near this tract. A survey in areas of proposed activity will be required prior to disturbance. Identified habitat of threatened and endangered species will be avoided, unless otherwise authorized by the IDL.
8. Navigable Waters and Infrastructure. Unless otherwise approved by IDL in writing, wells and related surface infrastructure, including new road construction, are prohibited within 1/4 mile of the mean high water mark of a navigable river, lake or reservoir, including direct tributary streams of navigable waterways, on or adjacent to this tract. No surface occupancy is allowed within the bed of a river, stream, lake or reservoir, islands and accretions or abandoned channels.
9. Floodplain. Due to the floodplain/wetlands area(s), surface use may be restricted or denied.
10. Surveys. If the lessee completes a successful oil and/or gas well, and if land title is disputed, the lessee shall fund professional land surveys as needed to determine the location and acreage encompassed by the spacing and/or pooling unit and the state lease acreage within that unit. Surveys shall be conducted by a licensed land surveyor acceptable to IDL, and shall be prepared pursuant to survey requirements provide by the IDL.
11. Public Trust Lands. This tract contains navigable riverbeds. No surface occupancy is allowed within the bed of the navigable river, abandoned channels, or on islands and

accretions. In addition, upon completion of a successful well, where river title is disputed, the Lessee will file an interpleader action under Rule 22 of Idaho Rules of Civil Procedure in the local District Court, or other court having jurisdiction, in which the leased lands are located for all acreage within the lease in which the title is disputed. The Lessee shall name all potential royalty claimants as defendants.

12. Existing Surface Uses. Due to existing surface uses (such as center pivots, wheel lines, etc.) development on this tract may be restricted.
13. Activity restrictions. No activity shall be allowed within 100 feet of any perennial or seasonal stream, pond, lake, wetland, spring, reservoir, well, aqueduct, irrigation ditch, canal, or related facilities without prior approval of the IDL.
14. Sage Grouse. Active sage-grouse lek(s) have been identified on or adjacent to this tract. No activities shall occur on the tract until the proposed action has been approved in writing by the Director of the Department. If surface activity is proposed on the tract, the Department will consult with the Director of Idaho Department of Fish and Game (IDFG) for their comments, concerns and recommendations. Additional mitigation measures may be required, including no-surface-occupancy buffers and/or timing restrictions, which may encompass part or the entire tract.
15. No Surface Occupancy. No Surface Occupancy shall be allowed on this tract.

6.3 Appendix 3. Legal description of lease parcels and applicability of Alternative C stipulations and lease notices.

Legal description of lease parcels.

Parcel	Legal Description			Acres
	Township/Range	**Section**	**Quartersection/Lot**	
A	T. 08 N R. 04 W	01	Lots 1-4; S½NE¼; S½NW¼; N½SE¼	364.78
		03	Lots 3 and 4; SW1/4NW1/4; W½SW1/4	185.11
		04	Lots 1 and 2; S½NE¼; SE¼NW¼; SE¼; E½SW¼	426.53
		05	Lots 1-3; SE¼NW¼; E½SW¼	223.22
		08	E½NW¼	79.39
		12	NW¼; SW¼	312.44
		13	N½SE¼; SE¼SW¼	117.49
		24	NE¼NW¼	39.32
	Total			**1,748.29**
B	T. 09 N R. 04 W	28	N½NE¼; SW¼NE¼; NW¼; W½SE¼; N½SW¼	430.33
		32	SW¼NW¼	38.88
		33	NE¼NW¼; NW¼SE¼	80.03
	Total			**549.25**
C	T. 09 N R. 04 W	26	All	628.28
		27	E½NE¼; SW¼NE¼; W½NW¼; N½SE¼; SE¼SE¼	312.27
		34	NE¼; NE¼SE¼; S½SE¼	276.04
		35	N½NW¼; SW¼NW¼; SW¼SW¼	157.90
	Total			**1,374.49**
D	T. 09 N R. 03 W	18	Lots 2-4	125.56
		19	Lots 1 and 4; NE¼NW¼	123.06
	T. 09 N R. 04 W	13	S½NE¼; E½NW¼; S½	469.41
		24	N½NE¼; SW¼NE¼; S½SE¼; NW¼SE¼; W½	551.35
		25	W½	316.36
	Total			**1,585.74**
E	T. 09 N R. 03 W	17	S½NE¼; SE¼; W½	544.94
		18	NE¼; N½SE¼; SE¼SE¼	273.15
		20	NW¼NE¼; N½NW¼; SW¼NW¼	155.79
		29	N½NE¼; NE¼NW¼	117.55
	Total			**1,091.43**
Total				**6,349.20**

Applicability of stipulations and lease notices by parcel.

Stipulation/Lease Notice	Parcel[1]				
	A	**B**	**C**	**D**	**E**
Freshwater Aquatic Habitat CSU-1: 500' buffer from surface waters	Y	N	N	Y	Y
Freshwater Aquatic Habitat CSU-2: 100' buffer from surface waters	Y	N	N	Y	Y
Special Status Plants CSU -3: Types 1-4	P	Y	P	P	P
Big Game Range CSU-4: No surface use December 1 – March 31 any species; May 1 – June 30 antelope	Y	Y	Y	Y	Y
Sensitive Wildlife Species CSU-5: No surface use ≤0.75 miles of ferruginous and Swainson's hawk nests March 15 – June 30	P	P	P	P	P
Sensitive Wildlife Species CSU-6: No surface use ≤0.75 miles of osprey nests April 15 – August 31	P	P	P	P	P

Stipulation/Lease Notice	Parcel[1]				
	A	B	C	D	E
Sensitive Wildlife Species CSU-7: No surface use ≤0.25 miles of burrowing owl nests March 15 – June 30	P	P	P	P	P
Wildlife Species of Concern CSU-8: No surface use ≤0.75 miles of golden eagle nests February 1 – June 30	P	P	P	P	P
Wildlife Species of Concern CSU-9: No surface use ≤0.75 miles of prairie falcon nests March 15 – June 30	P	P	P	P	P
Wildlife Species of Concern CSU -10: No surface use ≤0. 5 miles of heron rookery	P	P	P	P	P
Fragile Soils LN-1: Minimize adverse impacts to fragile soils	Y	Y	Y	Y	Y
Floodplain Management LN-2: Minimize adverse impacts to 100-year floodplain	Y	Y	N	N	N
Endangered Species S-1: Consultation and mitigation to protect listed species and critical habitat.	Y	Y	Y	Y	Y
Special Status Mammals LN-3: Minimize adverse impacts to SIDGS and pygmy rabbits.	P	P	P	P	P
Migratory Birds and Raptors LN-4: Compliance with MBTA by minimizing adverse impacts to migratory birds.	P	P	P	P	P
Migratory Birds and Raptors CSU-11: No surface use ≤1 mile of active bald eagle or peregrine falcon nest. No surface use December 1 – March 31 where wintering bald eagles or peregrine falcons are present.	P	P	P	P	P
Water Quality LN-5: Reduce impacts on water quality and quantity.	Y	Y	Y	Y	Y
Cultural Resources S-2: Comply with applicable statutes and executive orders.	Y	Y	Y	Y	Y
Cultural Resources LN-6: Cultural resource survey.	Y	Y	Y	Y	Y
Lands and Realty LN-7: Existing authorizations.	Y	Y	Y	Y	Y
Drainage LN-A: Wells on adjacent private lands.	Y	Y	Y	Y	Y
Split Estate LN-B: Surface use agreement required on split-estate.	Y	Y	Y	Y	Y
Paleontological Resources CSU-12: No surface use on identified resources.	Y	Y	Y	Y	Y
Paleontological Resources LN-7: Paleontological resource survey.	Y	Y	Y	Y	Y

[1] Y – applies to at least a portion of the parcel. P – potentially applies based on subsequent survey work. N – would not apply to that parcel.

6.4 Appendix 4. Idaho BLM special status animal species known to, or potentially occurring, in the Little Willow Creek lease area, Payette County, Idaho.

Type 1. Federally Listed Species and Critical Habitat: Includes species that are listed under the Endangered Species Act as Threatened (T) or Endangered (E) and designated critical habitats.

Type 2. BLM Special Status Species: Includes FWS Candidate (C), Delisted within 5-years (D), Proposed (P), Experimental Population (XN), and Proposed Critical Habitat (PCH); and BLM Sensitive Species.

The proposed lease area does not currently provide habitat for any Type 1 species. The proposed lease area is outside the range or typical habitat of the following special status animal species that occur in the Four Rivers Field Office, so they will not be considered further: Idaho giant salamander, Cassin's finch, Columbian sharp-tailed grouse, flammulated owl, harlequin duck, Lewis' woodpecker, mountain quail, bull trout, redband trout, white sturgeon, ashy pebblesnail, California floater, bighorn sheep, coast mole, fisher, grizzly bear, northern Idaho ground squirrel, Piute ground squirrel, and wolverine.

Note* NI=No impacts due to leasing and associated activities
DI=direct impacts due to leasing and associated activities
ID=indirect impacts due to leasing and associated activities

Common Name	Scientific Name	Habitat	Management Considerations
Amphibians			
Northern Leopard Frog	*Rana pipiens*	Wetlands, riparian areas, and adjacent uplands	DI – Adverse water quality impacts could cause mortality or affect breeding, etc. Discussed in Section 3.6.2 (Aquatic Species).
Western Toad	*Bufo boreas*	Ponds, streams, and adjacent uplands.	DI – Adverse water quality impacts could cause mortality or affect breeding, etc. Discussed in Section 3.6.2 (Aquatic Species).
Woodhouse's Toad	*Bufo woodhousii*	Grasslands, shrublands, agricultural areas, and ponds.	DI – Adverse water quality impacts could cause mortality or affect breeding, etc. Discussed in Section 3.6.2 (Aquatic Species).
Birds			
Bald Eagle	*Haliaeetus leucocephalus*	Winter migrant to lease area. Habitat includes lakes, reservoirs, streams, and uplands.	NI - No known nesting pairs are present. ID – Could occur for wintering birds where activities affect big game presence and winterkill. Discussed in Section 3.6.2 (Migratory Birds and Raptors).

Common Name	Scientific Name	Habitat	Management Considerations
Black Tern	*Chlidonias niger*	Open water lakes (>10 acres), ditches, and emergent wetlands.	ID – Activities could disturb migrating birds, but lease area doesn't provide nesting habitat.
Black-throated Sparrow	*Amphispiza bilineata*	Breeds in barren and grassy hillsides with scattered sagebrush and rabbitbrush.	DI/ID – Activities could reduce nesting foraging habitat, but lease area is on northern edge of species range.
Brewer's Sparrow	*Spizella breweri*	Sagebrush-steppe, nests in shrubs.	ID – Extensive sagebrush stands are not present; however, activities could affect species during migration.
Burrowing Owl	*Athene cunicularia*	Gently-sloping areas of shrubsteppe.	DI – Ground disturbing activities could destroy nests. ID - Activities could disturb or reduce prey species. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Ferruginous Hawk	*Buteo regalis*	Open country, nests on ground or rock outcrops, forages in shrubsteppe and grassland habitats.	ID – Activities could disturb or reduce prey species. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Golden Eagle	*Aquila chrysaetos*	Open country, nests on cliffs and artificial structures, forages in shrubsteppe and grassland habitats.	ID – Activities could disturb or reduce prey species. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Grasshopper Sparrow	*Ammodramus savannarum*	Shrubsteppe grasslands	DI/ID – Activities could reduce nesting and foraging habitat. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Greater Sage-grouse (C)	*Centrocercus urophasianus*	Sagebrush obligate.	NI - Outside currently delineated ranges, area lacks key habitat component.
Green-tailed Towhee	*Pipilo chlorurus*	Shrubsteppe in areas with high diversity of shrub species.	ID – Shrub stands are limited; however, activities could affect species during migration.
Loggerhead Shrike	*Lanius ludovicianus*	Shrubsteppe, open woodlands. Nests in tall shrubs and small trees.	ID – Activities could disturb or reduce nesting habitat and prey species. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Long-billed Curlew	*Numenius americanus*	Short-grass or mixed-prairie with flat rolling topography.	DI/ID – Activities could disrupt breeding, reduce nesting and foraging habitat. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Northern Goshawk	*Accipiter gentilis*	Aspen stands and conifer forests	NI – Habitat not present, occasional migrants could be affected by activities.
Olive-sided Flycatcher	*Contopus cooperi*	Montane or coniferous forests and riparian areas.	ID – Disturbance of birds using riparian areas during migration.
Sage Sparrow	*Amphispiza belli*	Sagebrush-steppe, nests in shrubs.	ID – Extensive sagebrush stands are not present; however, activities could affect species during migration.

Common Name	Scientific Name	Habitat	Management Considerations
Sage Thrasher	*Oreoscoptes montanus*	Sagebrush obligate	ID – Extensive sagebrush stands are not present; however, activities could affect species during migration.
Short-eared Owl	*Asio flammeus*	Large expanses of shrubsteppe and grasslands.	DI/ID – Activities could disrupt breeding, reduce nesting and foraging habitat. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Willow Flycatcher	*Empidonax trailii*	Dense willow riparian areas.	ID – Pollution could reduce prey species. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Yellow-billed Cuckoo (T)	*Coccyzus americanus*	Thick, wide riparian corridors, primarily dominated by cottonwoods. Known only as rare erratic breeder in the Snake River corridor mainly in southeast Idaho. Limited potential habitat occurs in area.	NI - Outside currently delineated ranges, area lacks key habitat component.
Mammals			
Big Brown Bat	*Eptesicus fuscus*	Rural areas and fields.	ID – Activities could reduce foraging success and prey habitat. Discussed in Section 3.6.2 (Bats).
Canyon Bat (formerly Western pipistrelle)	*Parastrellus hesperus*	Canyons and deserts in rock crevices, under rocks, and burrows	DI/ID – Activities could eliminate burrows, reduce foraging success and decrease prey habitat. Discussed in Section 3.6.2 (Bats).
Fringed Myotis	*Myotis thysanoides*	Caves, rock crevices, and open areas.	ID – Activities could reduce foraging success and prey habitat. Northeastern edge of range. Discussed in Section 3.6.2 (Bats).
Grey wolf	*Canus lupus*	Generalist habitat species. Follows big game herds.	ID - Could occur where activities affect big game presence.
Hoary Bat	*Lasiurus cinereus*	Trees, cavities, and open areas.	ID – Activities could reduce foraging success and prey habitat. Discussed in Section 3.6.2 (Bats).
Little Brown Bat	*Myotis lucifugus*	Forested lands near water, caves, and drier open areas.	ID – Activities could reduce foraging success and prey habitat. Discussed in Section 3.6.2 (Bats).
Long-eared Myotis	*Myotis evotis*	Coniferous forest and associated with forest-woodland riparian areas	ID – Insect prey base could be adversely affected by habitat alterations. Discussed in Section 3.6.2 (Bats).
Long-legged Myotis	*Myotis volans*	Coniferous forest and deserts; may change habitat seasonally	ID – Insect prey base could be adversely affected by habitat alterations. . Discussed in Section 3.6.2 (Bats).
Pallid Bat	*Antrozous pallidus*	Arid, semi-arid uplands, sparsely vegetated grasslands, buildings, and caves.	ID – Activities could reduce foraging success and prey habitat. Discussed in Section 3.6.2 (Bats).

Common Name	Scientific Name	Habitat	Management Considerations
Pygmy Rabbit	*Brachylagus idahoensis*	Thick big sagebrush with deep soils.	DI/ID – Burrow destruction, vehicle mortality, foraging habitat. Discussed in Section 3.6.2 (Burrowing Mammals).
Silver-haired Bat	*Lasionycteris noctivagans*	Riparian areas, ponds, and streams.	ID – Activities could reduce foraging success. Pollution could reduce prey species. Discussed in Section 3.6.2 (Bats).
Southern Idaho Ground Squirrel (C)	*Spermophilus brunneus endemicus*	Sagebrush and grasslands	DI/ID – Burrow destruction, vehicle mortality, foraging habitat. Discussed in Section 3.6.2 (Burrowing Mammals).
Spotted Bat	*Euderma maculatum*	Rocky canyons and cliffs, forages over sagebrush.	ID – Insect prey base could be adversely affected by habitat alterations. Discussed in Section 3.6.2 (Bats).
Townsend's Big-eared Bat	*Plecotus townsendii*	Winter in stable-climate caves, forage over sagebrush.	ID – Insect prey base could be adversely affected by habitat alterations. Discussed in Section 3.6.2 (Bats).
Western Small-footed Myotis	*Myotis ciliolabrum*	Winters in lava tube caves and rock crevices, under boulders, and beneath loose bark in summer	ID – Insect prey base could be adversely affected by habitat alterations. Discussed in Section 3.6.2 (Bats).
Yuma Myotis	*Myotis yumanensis*	Wide elevation range including riparian, desert scrub and mesic woodland and forested areas.	ID – Insect prey base could be adversely affected by habitat alterations. Discussed in Section 3.6.2 (Bats).
Reptiles			
Great basin Black-collared Lizard	*Crotaphytus bicinctores*	Deserts, presence of rocks and boulders.	DI/ID – Vehicle mortality, loss of habitat and prey. Discussed in Section 3.6.2
Longnose Snake	*Rhinocheilus lecontei*	Deserts, grasslands, and rocky canyons.	DI/ID – Vehicle mortality, loss of habitat and prey. Discussed in Section 3.6.2
Western Ground Snake	*Sonora semiannulata*	Deserts with loose or sandy soils.	DI/ID – Vehicle mortality, loss of habitat and prey. Discussed in Section 3.6.2

7.0 Maps

If you are viewing this via the following link on the NEPA Register:
https://www.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=39064&dctmId=0b0003e8806d22d8
Please find the maps in the home page's sidebar under Maps. Select "Map Package to accompany Little Willow Creek Protective Leasing EA".

8.0 Comment Responses

A Draft EA was made available to the public with a 30-day comment period (December 22, 2014 to January 21, 2015). Comments were received from the Idaho Conservation League (ICL); Randy and Thana Kauffman (K); the State of Idaho (SoI) including Office of Energy Resources, Department of Fish and Game, Office of Species Conservation, and Department of Environmental Quality; WildLands Defense (WLD); and WildEarth Guardians (WEG). Responses to summarized comments are provided below (organized by major topic) and the EA was modified as necessary to address some comments.

Land Use Plan

ICL-1: *The CRMP is outdated*.
WLD-7: *The CRMP is outdated and inadequate*.
WEG-7: *Leasing should be deferred until a new RMP is completed.*
Under normal circumstances, BLM offers lands nominated by the public for leasing, that have been identified in a land use plan as eligible and available for leasing. However, BLM regulations state that lands which are subject to drainage should be leased, even if they are otherwise unavailable for leasing (43 CFR 3120.1-1(d)). BLM has determined that the lands currently being considered for lease are or soon will be threatened by drainage of federally-owned oil and gas.

BLM IM 2010-117, Oil and Gas Leasing Reform Land Use Planning and Lease Parcel Reviews states: "There are other considerations that should be taken into account when determining the availability of parcels for lease." Field offices should consider whether… "There is a risk of drainage to Federal mineral resources due to development of nearby non-Federal parcels if the parcel is not leased (based upon a determination made by a Petroleum Engineer or Petroleum Geologist)."

The1988 CRMP provided a variety of stipulations related to issues and resources identified during that process (Section 2.3); however, BLM guidance allows for additional requirements to address changing resource concerns. According to IM 2010-117, "If a proposed modification to the terms of a stipulation changes the extent, but does not result in a new planning decision (e.g., the timing limitation protective radius increases from 2 miles to 3 miles, but the stipulation remains a moderate constraint), no plan amendment is required. The site-specific NEPA compliance documentation for the lease, however, may need to analyze the proposed stipulation modification if this analysis has not already been conducted in the NEPA documentation associated with the land use plan." Lease notices are included in Alternative C to address additional resource concerns.

WLD-13 and WEG-6: *The CRMP does not support oil and gas leasing.*
The CRMP Final EIS analyzed the effects of designating areas open to gas leasing. This EA analyzes several alternatives, including Alternative C, which includes stipulations based on management direction from the CRMP. If post-lease actions are proposed (exploration and/or development), additional NEPA will be conducted to analyze site-specific effects of the proposed actions.

NEPA Adequacy

WLD-1: *An EIS is needed to address the impacts*.

The act of leasing (Alternatives B and C) would not constitute a major federal action that would significantly affect the quality of the human environment; therefore, an Environmental Impact Statement is not required. The BLM will determine the level of NEPA analysis needed when/if an APD is received. See also WLD-13 and WEG-6.

WLD-2: *The cumulative effects areas are not adequate*.

See cumulative effects sections in the EA. The CIAAs were selected based on BLM's knowledge of current oil and gas leasing in the area and the RFDS developed for this EA. It is difficult to speculate what will be nominated for oil and gas leasing in the future, as well as how much exploration and development will result. The RFDS created for this EA is BLM's best estimate and was analyzed in relative detail in the Environmental Consequences and Cumulative Impacts sections (Section 3.0).

WLD-5: *Adequate baseline information for a variety of resources was not provided or considered; therefore, none of the alternatives can be adequately analyzed*.

The interdisciplinary team used the best available resource data to create the baselines for analyzing alternatives (e.g., data from BLM, USDA/NRCS, IDFG/IFWIS, IDEQ, IDWR, EPA, US Census Bureau, etc.). The affected environment sections provide summaries of baseline data.

WLD-9: *The BLM must consider a broad range of alternatives and mitigation actions to protect air, water, and natural resources and human health. The proposed protection measures are inadequate*.

The alternatives analyzed provide a range of protection measures to federal mineral reserves and associated lands and resources. Direct impacts to resources associated with federal mineral reserve lands would not occur in Alternative A and indirect impacts would be limited. Direct impacts to resources associated with federal mineral reserve lands would also not occur in Alternative B; however, indirect impacts would occur. Direct and indirect impacts to resources associated with federal mineral reserve lands would occur in Alternative C; however, a variety of protective measures would help limit their degree. This EA begins to identify potential mitigation measures; however, APDs and associated NEPA analyses would help guide development of the most appropriate measures.

WLD-11: *The proposed lease and associated EA represents a piecemeal approach and does not adequately address all alternatives*.

The BLM is following its national guidance on the NEPA approach for leasing and subsequent, if any, drilling. Leasing and post-lease activities are not analyzed in the same NEPA document, since nationally, only about 10% of oil and gas leases ever get drilled. It is impossible to speculate precisely where, how, and what post-lease activities will occur, since a lease can be for up to 2,560 acres in size. BLM has taken a hard look at the impacts of leasing in this area with three alternatives and over 100 pages of analysis in this EA.

If an APD is proposed once a lease is issued, BLM will conduct a thorough and in-depth analysis that is site- and activity-specific. Mitigation measures in the form of enforceable Conditions of Approval would be attached to each APD. The BLM lease terms and stipulations, onshore orders, and regulations must be followed, and a performance bond must be accepted by BLM before any surface disturbing activities can occur. The BLM will monitor and inspect operations to ensure that the lessee is in compliance with BLM's requirements for both surface as well as down-hole resources.

WEG-1: *Leasing the BLM parcels may enable expanded drilling on State and/or private lands.* The range of alternatives clearly indicates that leasing would likely increase drilling opportunities on State and/or private lands. Existing (2) and proposed wells (2) occur on non-federal leases in the proposed lease area (Map 1). The RFDS and associated analyses recognize how many wells could be drilled within the lease area without (Alternative A – 2 new wells) or with (Alternatives B and C – 22 or 25 new wells, respectively) a federal lease. The current State well spacing of 1 well/640 acres was one of the factors used to determine the number of wells that could be drilled by alternative. The EA also recognizes that if federal minerals are omitted, then up to 25 new wells could potentially be drilled. With few exceptions (e.g., visual resource management and realty rights-of-way designations that do not apply to non-federal lands), potential impacts were described irrespective of land ownership.

WLD-12: *The drainage explanation and current status of leases in the area are unclear*.
WEG-5: *Drainage is not a compelling reason for leasing.*
Based on a current State of Idaho well spacing of 1 well/640 acres the BLM assumes that a well could drain mineral reserves in a 640 acre area regardless of ownership. Four existing wells and two proposed wells are within 0.5 miles of federal mineral resources. The existing wells are classified as "shut in pending a pipeline" indicating that they are producing wells. In a September 4, 2014 IOGCC hearing, the commission voted 4-1 to reconsider a request by Alta Mesa to omit federal mineral resources. If federal minerals are omitted from a drilling unit, BLM would be unable to collect the royalties it is due for its proportionate share of the drilling unit; therefore, the BLM considers these resources threatened by uncompensated drainage.

While 43 CFR 3162.2-2 offers several protective measures that BLM may take to avoid uncompensated drainage on unleased lands, they all require the cooperation of the owner-of-interest in the producing well, except for leasing. The BLM has offered several times to enter into a communitization or compensatory royalty agreement with Alta Mesa; however, Alta Mesa has rejected those offers. Existing and proposed wells provide some indication of non-BLM lease activity; however, the BLM does not have specific knowledge of existing leases in the proposed lease area.

WLD-14: *The proposed action violates the laws and policies described in Section 1.6*.
The BLM disagrees and finds that impacts to sensitive resources can be mitigated by application of stipulations, lease terms and conditions, onshore orders, and regulations for leasing.

Alternatives
K-1: *Parcel A should be split into two parcels along the Little Willow Road*.

The BLM will consider this comment prior to releasing the Notice of Lease Sale. The environmental impacts would be the same.

Vegetation
WLD-21: *Site specific surveys are lacking and impact magnitudes are discounted because of current conditions*.
The IDFG report information specific to the EOs in the proposed leasing area and CIAAs was added (Section 3.3.1). This information supports the current conditions and conclusions presented in the EA.

Air Resources
Table 6 in the Draft EA incorrectly used oxides of nitrogen values rather than nitrous oxides values for calculating greenhouse gas production. The nitrous oxides and consequently CO_2 eq values have been adjusted accordingly.

WLD-22: *The referenced air quality report is biased and inadequate*.
WLD-19: *Potential impacts to climate change are not adequately addressed*.
ICL-2: *Substantial increases in carbon dioxide equivalent emissions need to be mitigated*.
The BLM contracted the Kleinfelder Report to evaluate air quality impacts associated with oil and gas development activities for the Four Rivers RMP. The report provides detailed emission estimates of criteria pollutants, greenhouse gases (GHG), and key hazardous air pollutants (HAPs) anticipated to be released during each phase of oil and gas development for a representative oil and gas well in the western United States. The report acknowledges that defining a "representative" oil and gas well for the entire western U.S. is extremely challenging as there are numerous variables that can materially affect the emissions. Such variables include oil and gas composition, difficulty drilling the geologic formation, oil and gas production rate, equipment at the well site, emission controls, and the amount of produced water that may be associated with oil and gas production, among many others. Five well types (three natural gas wells and two oil wells), representative of different oil and gas basins in the western U.S., were evaluated.

The three types of natural gas wells were summarized as:

1. Uinta/Piceance Basin represents deep (15,000 feet) wells which may be drilled into shale with dry gas. These wells produce a moderate amount of condensate (420 gal/day) and 168,000 gal/yr of produced water. Methane emissions are estimated at 12.2 tons/yr (Table 13) and the Global Warming Potential (GWP) is estimated at 2,825 tons of CO_2 eq/yr.

2. San Juan Basin represents shallow (2,500-7,000 feet) wells with dry gas. These wells produce little to no condensate (210 gal/day) and 33,600 gal/yr of produced water. Other equipment included in the emissions inventory includes a pumpjack engine (to remove water) and a condensate tank. Average gas production per well, over the life of the well is estimated to be 27.8 MMscf/day (million cubic feet/day). Methane emissions

estimated at 6.1 tons per year. GWP is estimated at 791 tons of CO_2 equivalent.

3. Upper Green River Basin represents deep wells drilled into non-shale formations with wet gas, and higher condensate production (1,260 gal/day) and 126,000 gal/yr of produced water. More water vapor is present in the gas at this well, so each well site contains a dehydrator, separator, and line heater. The wells are drilled at relatively high density. Average gas production per well, over the life of the well is estimated to be 4.0 MMscf/day. Methane emissions estimated at 14.1 tons per year (Table 13). GWP is estimated at 3,194 tons of CO_2 equivalent.

Table 13. Total GHG emissions (tons/year) for two wells, Kleinfelder Report.

	Upper Green River Basin			**San Juan Basin**		
	CO_2	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
Construction Phase	33.84	0.001	0.0003	33.84	0.001	0.0003
Development Phase	1900.27	1.11	0.0498	561.61	1.05	0.0389
Operation Phase	947.96	12.99	0.0018	56.44	4.99	0.0004
Total	2882.07	14.10	0.0519	651.89	6.05	0.0396

For the Upper Green River Basin well, the following methane emissions (tons/year) are estimated, broken out by the development stage of the well:

Construction Phase 0.001 tons/yr
Sources: tailpipe of construction equipment, trucks

Development Phase (i.e. drilling and well treatment)

Sources:	Drill rig engine	0.03	(18 days, 24 hrs)
	Well frac engine	0.04	(7 days, 24 hrs)
	Frac flowback venting	0.94	(100 hrs)
	Workover venting	0.094	(once, 5000 Scf)
	TOTAL	1.104 tons methane/yr	

Operational Phase (i.e. Production activities)

Sources:	Fugitive emissions	3.16	
	(97 valves, 348 connectors, 12 OE lines, 6 PR valves)		
	Process heaters	0.0178	
	Wellsite tank flashing	0.552	
	Pneumatic devices:		
	Dump valves	8.896	four (4) valves, intermittent bleed
	Pneumatic controller	0.229	(low bleed)
	Pneumatic pumps	0.131	(chemical sandpiper, glycol)
	TOTAL	12.99 tons methane/yr	

The construction and development (drilling) phases of oil and gas development are not major sources of methane emissions; however, methane releases during the development phase can occur, resulting mainly from actuation of gas-operated valves during well operations and from fugitive gas leaks along the infrastructure required for the production and transmission of gas.

Several pneumatic devices are used at the wellhead to control the amount of fluid in the product. Raw natural gas must be free of oil and water before it is piped to a processing plant. This liquid removal takes place in a vessel called a separator, located at or near the wellhead. A pneumatic controller regulates the fluid level in the separator. When the fluid reaches a certain level, the controller's pilot directs gas to a diaphragm valve, which opens and dumps the liquid into a storage tank. Liquid separators at most older well sites have pneumatic controllers with dump valves that vent natural gas continuously. Newer valves (intermittent) vent only when fluid levels are actively being controlled, and emit only so much gas as is needed to open the dump valve so it can close again at the end of the dump cycle (from Devon Energy Corp. website "Tiny Valve- Big Difference").

The number of pneumatic devices used on a well is presumably determined by the amount of condensate (oil) and water produced. Since this information is not known, it is difficult to determine which gas well in the Kleinfelder Report is representative of conditions in the Little Willow Field. Because many of the input parameters for drilling and operations on the Little Willow Creek wells are unknown, BLM used the pollutant values for the Upper Green River Basin well in Table 6 of the EA. This represents a worst-case scenario for emissions at a natural gas well. A review of emissions inventories that have been conducted by other BLM offices in areas with more densely spaced wells than in Idaho (where spacing is limited to one well per 640 acres) reveals that the Kleinfelder Report used by BLM for this EA is conservative. It is likely that actual emissions at a Willow Field well head would be lower than the Upper Green River well (i.e., other inventories reported lower emissions values for GHG than what was used in this EA).

Implementation of mitigation measures (Section 3.4.3) at the APD processing stage could markedly reduce these emission values. The potential increases are substantial for Payette County, which currently produces limited amounts of Greenhouse Gases; however, when considered at larger scales [e.g., the four-county CIAA where they could account for a 1.7% increase over current levels or 0.001% of the 2012 US CO_2 eq production of 7,195 million tons (EPA: http://www.epa.gov/climatechange/ghgemissions/gases.html)], they represent negligible to minor increases. At the time an APD is submitted, additional NEPA analysis would be conducted, and a Condition of Approval can be attached to the APD that requires methane emissions not exceed a certain threshold, based on the best available information and analysis at that time.

The BLM is currently working at the national level to adopt new standards regarding venting and flaring to reduce natural gas waste and methane pollution. According to a DOI news release dated January 23, 2015, the new draft standards are scheduled to be put out for public comment this spring. According to the standard lease terms, the Willow Creek leases would be subject to those new standards, even if the leases are issued prior to adoption of the new standards.

SoI-3: *The BLM needs to consider air and water quality impacts and appropriate stipulations to maintain them if leasing occurs*.
Air and water quality impacts are discussed in Sections 3.4.2 and 3.5.2, respectively. While there would be no impacts associated with issuing leases, post-lease activities could be proposed that would result in impacts as discussed in those sections. Potential mitigation measures are identified in Sections 3.4.3 and 3.5.3. For air quality, these measures would be further refined based on site- and project-specific circumstances and would be imposed as APD Conditions of Approval, described in Section 3.4.3, as appropriate.

Section 2.3 of the EA provides lease stipulations and notices designed to protect water resources under Alternative C. For example, Freshwater Aquatic Habitat stipulations (CSU 1 and CSU 2) protect surface water quality in sensitive areas. Lease notices to inform the lessee that protective measures may be required if post-lease activities are proposed to minimize impacts within the 100-year floodplain (LN-2) and to minimize impacts to water quality and quantity (LN-5). Additionally, BLM is currently working at the national level to adopt new regulations regarding hydraulic fracturing. A final rule is anticipated in spring 2015. According to the standard lease terms, the Willow Creek leases would be subject to those new standards, even if the leases are issued prior to adoption of the new standards.

WLD-4: *The pollution emission zone and local and regional airsheds have not been mapped or adequately analyzed*.
WLD-23: *The air quality cumulative effects analysis is inadequate*.
The analysis areas include Payette County for localized impacts and a four county area (Ada, Baker, Canyon, and Payette) for CIAA. The analyses were conducted at county levels because the EPA provides information at that scale. These counties largely address the area you expressed concerns about (Treasure Valley) and the likely area pollutants would spread from the proposed lease. They include parts of two airsheds identified in Idaho; however, the EPA does not provide data by airsheds. The proposed lease area is 65 (Eagle Cap Wilderness), 67 (Hells Canyon Wilderness), or 72 (Sawtooth Wilderness) miles from the nearest Class 1 airshed areas. With the exception of GHG, which would affect resources at a much larger scale, pollutants from the development and production phase would typically not travel that far. North Ada County is a nonattainment zone for CO and PM_{10}. Maintenance plans are in place to address these issues (EPA 2015, Idaho nonattainment area plans, http://yosemite.epa.gov/r10/airpage.nsf/283d45bd5bb068e68825650f0064cdc2/e2ab2cc6df433b8688256b2f00800ff8?OpenDocument). Ada and Canyon counties are also considered areas of concern for $PM_{2.5}$ and O_3. There are no nonattainment areas in eastern Oregon, but La Grande has a PM_{10} maintenance plan in place. Without mitigation measures, the maximum RFDS of 25 wells add 0.1% and 0.7% respectively to CO and PM_{10} pollutants in the CIAA.

Water Resources
WLD-3: *Water depletion, quality, and protection issues were not adequately addressed*.
WLD-24: *Current water quality conditions need to be clarified*.
The EA provides what is publicly known about water quality in the area (Section 3.5.1). The BLM is not aware of any further pesticide or other chemical testing of ground or surface waters

in the area. Water quality in Little Willow Creek especially is variable because of agricultural influences (dewatering for irrigation and potential pollutants in return flows). Until more specific information at the APD phase is available, the current analysis can only provide a broad range of impacts (Sections 3.5.2 and 3.5.4).

WLD-15: *Aquifer and geological strata should be used to inform analyses on aquatic habitat impacts*.
Information, primarily from IDWR and IDEQ, and analyses concerning aquifers are presented in Water Resources (Section 3.5) under the heading "Ground Water." Aquatic habitat impacts are discussed Section 3.6.2. Stipulations concerning freshwater aquatic habitat are included as part of Alternative C.

WLD-4: *The pollution emission zone has not been mapped*.
The BLM is not clear what you mean by pollution emission zone. The identified CIAA (Section 3.5.4.1) is large enough to consider horizontal pollutant spread through the 10-year analysis period.

WLD-8: *The EA does not adequately address fracking*.
WEG-9: *Impacts of hydraulic fracturing were not adequately addressed.*
While BLM does not anticipate that hydraulic fracturing will be utilized in the Willow Field area, impacts are discussed in Water Resources (Section 3.5.2). If hydraulic fracturing is proposed on a well that has been drilled under an approved APD, it would be analyzed in much greater depth in a subsequent NEPA document. The Idaho Department of Lands has proposed a new rule currently pending the approval of the legislature, which has new requirements including water quality monitoring, should hydraulic fracturing be proposed. Additionally, BLM is currently working at the national level to adopt new regulations regarding hydraulic fracturing. A final rule is anticipated to be released in spring 2015. According to the standard lease terms, the Willow Creek leases would be subject to those new standards, even if leases are issued prior to adoption of the new standards.

Wildlife/Special Status Species

<u>General</u>

WLD-10: *The variety of impacts was not adequately addressed*.
Section 3.6.2.1 describes most of the impacts you identify including disturbance, mortality, changes in habitat quality, fragmentation, and pollution (including erosion and runoff) for the groups of animals they would likely affect. During the APD phase, when the types of development are more clearly identified, impacts would be more readily identified.

<u>Special Status Species</u>

WLD-20: *Inventory requirements for special status species are inadequate*.
SoI-1: *The BLM needs to consider the presence of SIDGS and other special status species and take appropriate measures to inventory and protect them*.
The BLM used the field visits, 2014 Idaho Fish and Wildlife Information System (which includes the referenced SIDGS data), and other data sources to determine presence of special status species in the proposed lease area. Impacts from the proposed actions are discussed in

Section 3.6.2. Sections 2.2, 2.3, 2.4, and 3.6.3 describe measures that would be taken to reduce or avoid impacts. Section 6 of the Lease Terms on the Offer to Lease and Lease for Oil and Gas (Form 3100-11) provide for requiring inventories of resources prior to ground disturbing activities. Lease specific stipulations (S1) and notices (LN-3 and LN-4) also provide for inventory and subsequent mitigation measures. The inventories would occur before and during the APD process and potential impacts would be analyzed in a subsequent EA.

WLD-6: *Leasing would preclude conservation, enhancement, and restoration of sage-grouse and other special status species habitats*.
The proposed lease area is outside any sage-grouse habitat designation; therefore, it would not be a restoration priority for that species. SIDGS are the most prevalent special status species in the proposed lease area. Although development and production activities could degrade habitat, they would not preclude habitat restoration activities once disturbance factors have been stabilized and restoration could be a requirement during the abandonment phase. Efforts to maintain or enhance SIDGS habitat would likely benefit most other special status species.

WLD-16: *The migratory bird and raptor provisions are outdated and scientifically indefensible*.
The winter range avoidance period (November 15 to May 15), which affects 94% of the federal mineral reserve lands, would provide more widespread protections during early breeding and nesting periods for periods not addressed by migratory bird and raptor nesting protections.

WEG-2: *Greater sage-grouse were not adequately addressed*.
The CRMP did not provide leasing stipulations for sage-grouse. Because of historic wildfires and human activities (e.g., livestock grazing), the proposed lease area does not provide suitable sage-grouse habitat. The distances to identified sage-grouse habitat (5-6.5 miles to sagebrush/perennial grass dominated communities [Key, Preliminary General, and Preliminary Priority habitats]) and active leks (9.5 miles)[E] are substantially greater than the 3 mile buffer recommended by Dr. Braun. The proposed lease would not affect sage-grouse in the area; therefore, it would not affect listing decisions.

WEG-4: *Impacts to other sensitive species, especially sagebrush obligates were not adequately addressed.*
Impacts to representative special status species, including SIDGS and sagebrush obligates, are discussed in Sections 3.3.2 and 3.6.2 and Appendix 4. The proposed lease area would affect approximately 4% of the current distribution of SIDGS (based on minimum convex polygon of current and historic locations, assuming 66% of the polygon is suitable habitat). Shrub-dominated communities occur on up to 25% of the lease area, but typically occur in isolated stands (see Figure 1 and Figure 2).

<u>Big Game</u>
SoI-2: *The BLM needs to clarify where big game winter range stipulations would apply, consider impacts to private lands that development would have, and provide adequate measures to avoid disturbance*.
The CRMP used the term crucial; therefore, it was carried forward into this document. The BLM used IDFG data (Map 6) to delineate current big game winter range, combining mule deer,

elk, and pronghorn ranges into one polygon. For Alternative C, the winter timing restriction would apply to all federal mineral estate in winter range (approximately 6,053 acres or 94% of leased lands). Wildlife depredation is discussed in Sections 3.6.2 and 3.14.2. The winter timing restriction was expanded to November 15 to May 15. This expansion is within the 60-day flexibility allowed by BLM policy.

WEG-3: *Impacts to pronghorn winter range were not adequately addressed.*
The EA (Section 3.6.1, Map 6) describe winter ranges for pronghorn, mule deer, and elk. A combination of all three was used for analysis purposes. The CRMP recognized that winter range delineations could change through time[B]; therefore, the winter ranges used in this analysis were developed in cooperation with IDFG using current monitoring information and represent a larger area than was identified in the CRMP. The analyses indicate moderate to major adverse impacts could occur from the proposed levels of development in Alternatives B and C (Sections 3.6.2.3 and 3.6.2.4). The cumulative impacts of changes in habitat conditions from oil and gas production and development and other activities are addressed in Section 3.6.4.

The no surface use limitation (CSU-4) would apply to the exploration, drilling, development and production, and abandonment phases and would cover all activities (e.g., surface disturbing and disruptive). Your concern about exceptions is addressed in Section 3.6.2.4. The proposed lease area is on the periphery of winter range; therefore, it would not affect migration corridors.

Recreation
WLD-17: *Impacts to and by recreationists were not adequately addressed*.
Access to the isolated parcels of BLM-administered lands occurs through private lands. They are near agricultural lands and provide little opportunity for those seeking solitude. Impacts from increased access were addressed in Sections 3.6, 3.7, 3.8, 3.9, and 3.14.

Visual Resources Management
WLD-4: *The visual analysis is inadequate*.
The BLM only manages visual resources on BLM-administered lands. Impacts to visual resources on BLM-administered lands have been analyzed in Section 3.10.

Social and Economic
ICL-3: *Social and economic impacts to landowners were not adequately addressed*.
Social and economic impacts, including land values and use, are addressed in Sections 3.5, 3.13, and 3.14. Private landowners in and adjacent to the proposed lease area have been involved in this process. The concerns raised during the July 20144 scoping period were addressed in the EA. One landowner commented on the EA regarding how parcels were delineated. Analyses during the APD phase will provide more in-depth assessment of these issues.

WLD-4: *The noise zone has not been mapped*.
Noise impacts to wildlife and humans are discussed in Sections 3.6.2 and 3.14, respectively. Noise is an impact that is more appropriately analyzed in the NEPA for an APD, and can be mitigated by applying a Condition of Approval requiring noise reduction measures, if needed.

WEG-8: *The social cost of carbon needs to be addressed.*
The social cost of carbon is addressed in Air Resources and Social and Economic sections 3.4.2 and 3.14.2, respectively.

Other Resources
WLD-18: *Paleontological resources are ignored*.
A paleontological resource stipulation (CSU-12) was added to Alternative C (Section 2.3) and the affected environment and environmental consequences were described (Section 3.8).

Exhibit 10

nature climate change

LETTERS

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Temperature impacts on economic growth warrant stringent mitigation policy

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Integrated assessment models compare the costs of greenhouse gas mitigation with damages from climate change to evaluate the social welfare implications of climate policy proposals and inform optimal emissions reduction trajectories. However, these models have been criticized for lacking a strong empirical basis for their damage functions, which do little to alter assumptions of sustained gross domestic product (GDP) growth, even under extreme temperature scenarios[1–3]. We implement empirical estimates of temperature effects on GDP growth rates in the DICE model through two pathways, total factor productivity growth and capital depreciation[4,5]. This damage specification, even under optimistic adaptation assumptions, substantially slows GDP growth in poor regions but has more modest effects in rich countries. Optimal climate policy in this model stabilizes global temperature change below 2 °C by eliminating emissions in the near future and implies a social cost of carbon several times larger than previous estimates[6]. A sensitivity analysis shows that the magnitude of climate change impacts on economic growth, the rate of adaptation, and the dynamic interaction between damages and GDP are three critical uncertainties requiring further research. In particular, optimal mitigation rates are much lower if countries become less sensitive to climate change impacts as they develop, making this a major source of uncertainty and an important subject for future research.

Integrated assessment models (IAMs) have traditionally captured the negative impacts of climate change with a damage function that relates global temperature change to a loss of current economic output. This formulation captures the transient effects of climate on the economy such as lost agricultural output, increased cooling demand, or lower worker productivity due to hotter temperatures[7–9]. Factors of production, namely labour and capital, and their total factor productivity (TFP) are not directly impacted, meaning that climate change has no effect, or only a very weak effect, on GDP growth. Two IAMs recently used for the US government social cost of carbon (SCC) estimate, FUND and PAGE, assume that GDP growth is entirely exogenous[10,11]. In the DICE model, labour and TFP are specified exogenously and capital formation is determined through endogenous investment decisions[5]; temperature shocks can therefore alter economic growth through capital stock reductions, but this effect is small and indirect[12].

Damages from climate change that directly affect growth rates have the potential to markedly increase the SCC because each temperature shock has a persistent effect that permanently lowers GDP below what it would otherwise be (Supplementary Fig. 1). Continued warming therefore has a compounding effect over time, so that even very small growth effects result in much larger impacts than the traditional damage formulation[12]. Examples of pathways by which temperature could affect the growth rate of GDP include damage to capital stocks from extreme events, reductions in TFP because of a change in the environment that investments were originally designed for, or slower growth in TFP because of the diversion of resources away from research and development and towards climate threats[1]. Empirical evidence that these impacts exist is mounting. Two studies have found a reduced-form relationship between temperature shocks and GDP growth[4,13], and other studies have demonstrated plausible pathways including increasing conflict risk[14] and changes in labour supply[15]. Previous work has demonstrated that DICE results are sensitive to the inclusion of growth impacts[12,16], but no previous studies have calibrated these damages using empirically grounded results from the econometrics literature. Given the potentially first-order impacts of these growth effects, understanding their implications for climate policy is of critical importance.

Table 1 | Parameters used to calibrate the gro-DICE damage functions, reported in Dell *et al.* Table 3, column 4 (ref. 4).

	Effect 1 °C temp increase on GDP growth rates (γ_0)	Effect 1 °C temp increase on economic output (β_0)
Poor	−1.171 pp	−0.426%
Rich	−0.152 pp	0.371%

This specification includes 10 temperature lags and no precipitation controls. A brief summary of the estimation strategy used in ref. 4 is given in the Supplementary Information. pp: percentage point.

Here we examine alternative formulations of the DICE damage function based on empirical estimates of the impact of inter-annual temperature variability on national economic output and growth rates by Dell and colleagues[4]. They find large, statistically significant negative effects of hot temperatures on growth rates in poor countries, smaller effects in rich countries, and mixed effects on output (Table 1). To implement these parameters in an IAM, we develop a two-region version of DICE (ref. 17; DICE-2R). We then modify the damage pathway so that warming affects either TFP growth or capital depreciation as per results in ref. 4 (gro-DICE) and investigate sensitivities to the parameters used by Dell *et al.*[4] (Methods). We present results of the TFP pathway here, but the capital pathway gives quantitatively similar results and is discussed further in the Methods and Supplementary Information.

As Dell *et al.*[4] use transient and largely unanticipated weather shocks in their estimation, the growth-rate sensitivities (reduction

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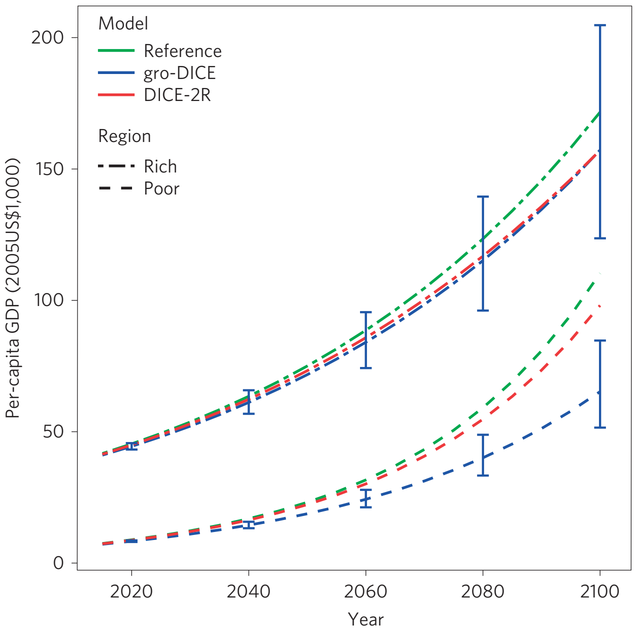

Figure 1 | Per-capita GDP for rich and poor regions for the reference (no damages) run and DICE-2R and gro-DICE models under business-as-usual. Temperature in the reference reaches 5 °C above pre-industrial by 2100. The error bars show results using ± one standard error (68% confidence interval) around the growth-rate damages reported in ref. 4 (Table 1).

in growth rate from 1 °C of warming) shown in Table 1 are the short-run impacts of higher temperatures. Long-run impacts of the permanent warming associated with climate change could be either larger (owing to intensification) or smaller (owing to adaptation) than this short-run effect[9], although several studies show evidence for some adaptation[18–20]. We adopt optimistic adaptation assumptions in gro-DICE by assuming that the long-run effect of temperature on GDP growth is zero and that the short-run impacts decay exponentially at a constant adaptation rate (Methods). As there is a very limited empirical basis for the rate of adaptation, we assume a value of 10% per year and examine sensitivity to this parameter (Supplementary Fig. 2).

Figure 1 shows the trajectory of per-capita GDP under business-as-usual for the reference (no climate damages), DICE-2R and gro-DICE models. Temperatures exceed 4.5 °C by 2100, causing economic losses in both models with damages. Impacts in DICE-2R are modest because impacts are transient and offset by sustained growth in TFP, labour and capital: the difference from reference GDP is less than 12% in both poor and rich regions by 2100. In contrast, the growth effects in gro-DICE compound over the century, leading to much larger impacts. The average annual growth rate in poor regions is cut from 3.2% to 2.6%, which means that by 2100 per-capita GDP is 40% below reference. The much smaller growth effects in rich countries, combined with the fact that warming slightly improves economic output, means the gro-DICE and DICE-2R timepaths are very similar in the rich region. Figure 1 also shows the effect of increasing and decreasing the growth-rate sensitivity parameter by one standard error. The large negative impact in poor countries is robust, but uncertainty around the magnitude of growth impacts in rich regions means that they could benefit from warming.

Figure 2 shows results if mitigation levels are chosen to maximize global discounted social welfare. Optimal climate policy in DICE-2R demonstrates a classic 'policy-ramp' in which mitigation efforts increase gradually over the century, with emissions peaking in 2060 and warming of over 3.5 °C by 2100. In contrast, optimal mitigation in gro-DICE consists of eliminating emissions in the very near future to stabilize global temperatures below 2 °C above pre-industrial. Even optimistic assumptions about temperature effects on GDP growth (the upper bound on the error bars in Fig. 2) lead to more stringent near-term mitigation than DICE-2R and elimination of emissions by 2070. The findings of near-term decarbonization and global temperature stabilization below 2 °C are robust to changes in the adaptation rate, which we vary between 0 and 20% per year (Supplementary Fig. 3). A variant of gro-DICE in which temperatures affect the depreciation of capital rather than TFP growth also gives quantitatively similar results (Supplementary Fig. 4).

The motivation for rapid decarbonization can be illustrated with the high SCC in gro-DICE (Fig. 2). One additional ton of CO_2 emitted in 2015 reduces net social welfare by US$33 in DICE-2R but by US$220 in gro-DICE. This value is higher both because climate damages are larger in gro-DICE and because slower economic growth leads to a lower discount rate[5]. The trajectory of the SCC over time has an inverted U-shape determined by relative changes in the marginal utility of emissions and the marginal utility of consumption over time (Supplementary Fig. 5). The additional mitigation undertaken in the gro-DICE optimal run does reduce damages compared to business-as-usual, but poor countries still suffer substantial impacts, with per-capita GDP in 2100 still 20% lower than the reference.

Our results thus far assume a static damage function, but the relationship between economic growth and temperature is likely to change over time. Dell *et al.*[4] find much higher sensitivity of GDP growth rates to warming in poor countries than in rich (Table 1), which could result from two possible mechanisms. One is that high sensitivity may result from biophysical temperature thresholds, beyond which warming becomes particularly damaging[8,21]. As poor countries are, on average, hotter than rich countries, they are exposed more frequently to damaging temperatures and therefore show higher sensitivity to temperature. Under this mechanism, the sensitivity of rich countries would increase as they warm. Alternatively, higher temperatures may be more damaging in poor countries because their economies are reliant on climate-exposed sectors such as agriculture and natural resource extraction, or because risk management options such as insurance or air conditioning are not as widely available. In this case we would expect the sensitivity of poor regions to warming to decrease as per-capita GDP increases. We call these two mechanisms the 'temperature' and 'resilience' mechanism respectively and implement each separately in gro-DICE by making the growth-rate damage parameters a function of either temperature change or per-capita GDP (Methods).

Although both the temperature and resilience mechanisms could explain the different sensitivities of rich and poor countries to higher temperatures observed today, they have contrasting implications for how damages might evolve over time and for optimal climate policy (Fig. 3). As mitigation is already so high in the standard gro-DICE model, adding the temperature mechanism has little additional effect. However, the resilience mechanism results in a very different mitigation trajectory. Early mitigation serves to slow the rate of climate change but is later relaxed because of the benefits of economic growth in poor regions in terms of reduced sensitivity to warming (Supplementary Fig. 6). Once sensitivity in poor regions stabilizes in 2070 at the level observed at present in rich countries, mitigation gradually increases so that emissions peak in 2120 and are eliminated by 2150, stabilizing global temperatures at 6 °C above pre-industrial. The evolution of the damage function over time therefore has important policy implications for balancing the dual priorities of increasing resilience through economic growth and decarbonization.

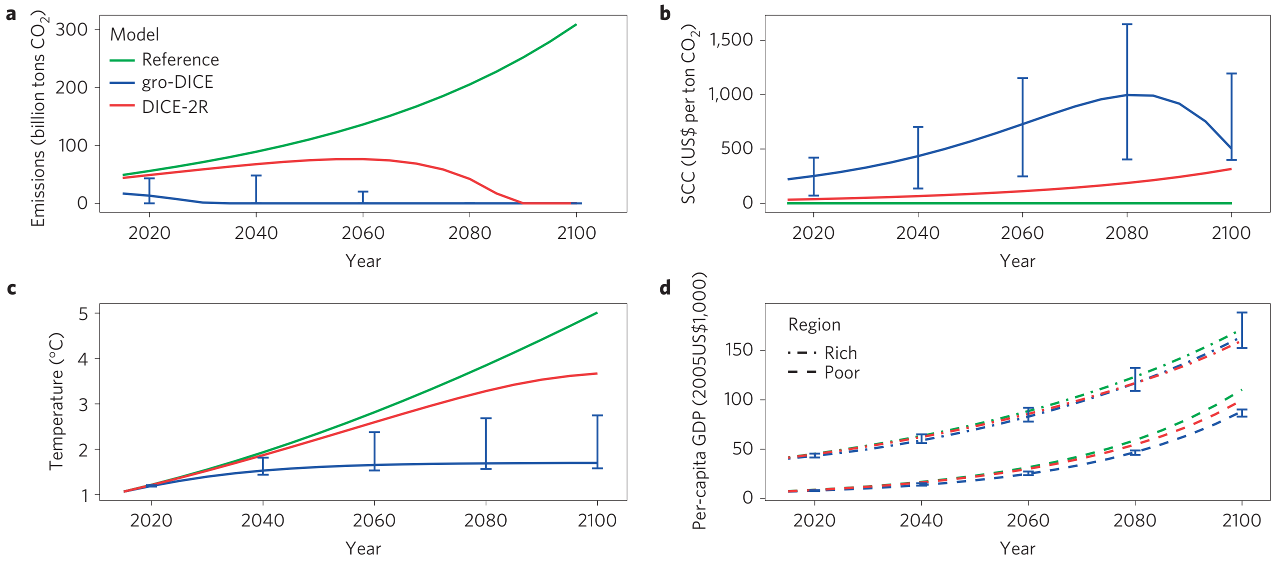

Figure 2 | Results of Pareto optimal runs of DICE-2R and gro-DICE. a–d, Annual global emissions (**a**), SCC (**b**), global temperature (**c**) and regional per-capita GDP (**d**). The error bars show results from Pareto optimal runs of gro-DICE using ± one standard error (68% confidence interval) around the growth-rate sensitivity reported in ref. 4. The reference is defined as a model run with no climate damages and therefore has zero SCC by definition.

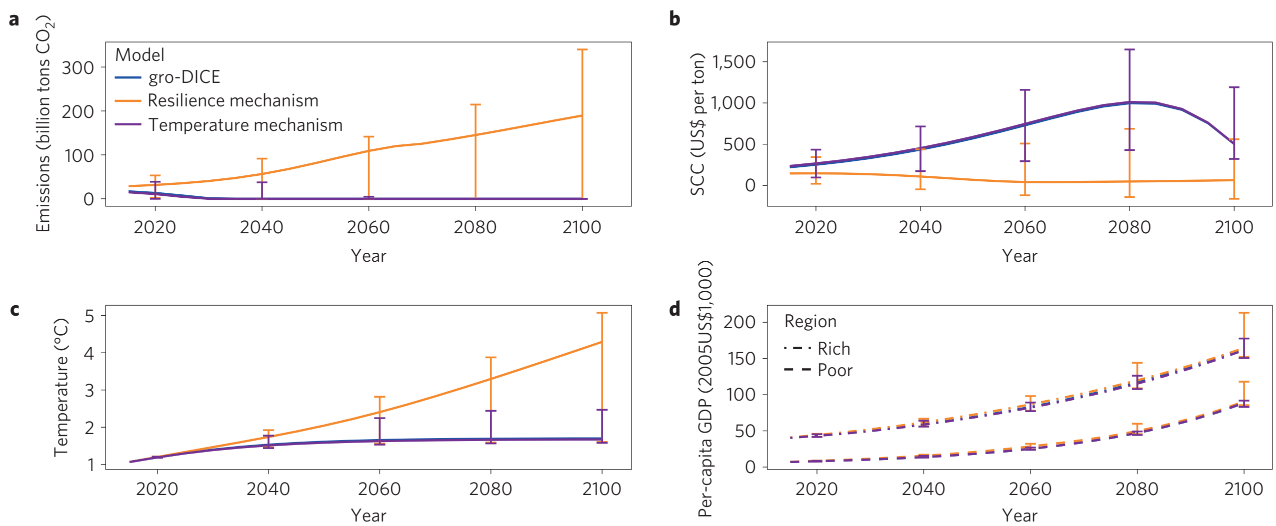

Figure 3 | Results of Pareto optimal runs of gro-DICE, and versions of gro-DICE that include dynamic damage functions based on either the temperature or resilience mechanisms (Methods). a–d, Annual global emissions (**a**), SCC (**b**), global temperature (**c**) and regional per-capita GDP (**d**). The gro-DICE and temperature mechanism lines are indistinguishable. The error bars show Pareto optimal runs using ± one standard error (68% confidence interval) around the growth-rate sensitivity reported in ref. 4.

One limitation of the DICE model is the simplicity of the reduced-form mitigation function[5,22]. First, the mitigation level can fluctuate freely, with no expansion constraint from period to period. This fails to capture real-world inertia, represented in other energy system IAMs, which limits the rate of decarbonization owing to delayed availability of low-emitting technologies, construction lead times, stranded assets, or other capital turnover factors[23,24]. Second, the simple mitigation cost function constitutes a claim on current output without affecting the factors of production or TFP. Mitigation at the rate implied by gro-DICE could well impose its own persistent impacts on economic growth, as suggested by some previous research[25]. Although gro-DICE was designed to investigate the effects of temperature on growth, it does not include the converse effect of mitigation, something beyond the scope of this paper but a priority for future research. For both these reasons, the results regarding very rapid, near-term mitigation should not be over-interpreted as evidence that such a policy would necessarily be economically optimal. Nevertheless, the findings that temperature effects on growth rates imply much larger climate damages and, correspondingly, more stringent mitigation than is justified by transient impacts on economic output are probably robust to more realistic modelling of mitigation costs.

Historically, attention has narrowly focused on climate sensitivity and the discount rate in driving uncertainty in IAM results[26,27]. We compare these two uncertainties with the new factors introduced in this paper. Figure 4 shows that the magnitude of GDP growth-rate sensitivity, the rate of adaptation, and how sensitivity to warming changes with per-capita GDP are at least as important as climate sensitivity and the pure rate of time preference in determining optimal climate policy over the next century.

This paper has shown that allowing climate change to directly affect economic growth through impacts to TFP or capital can

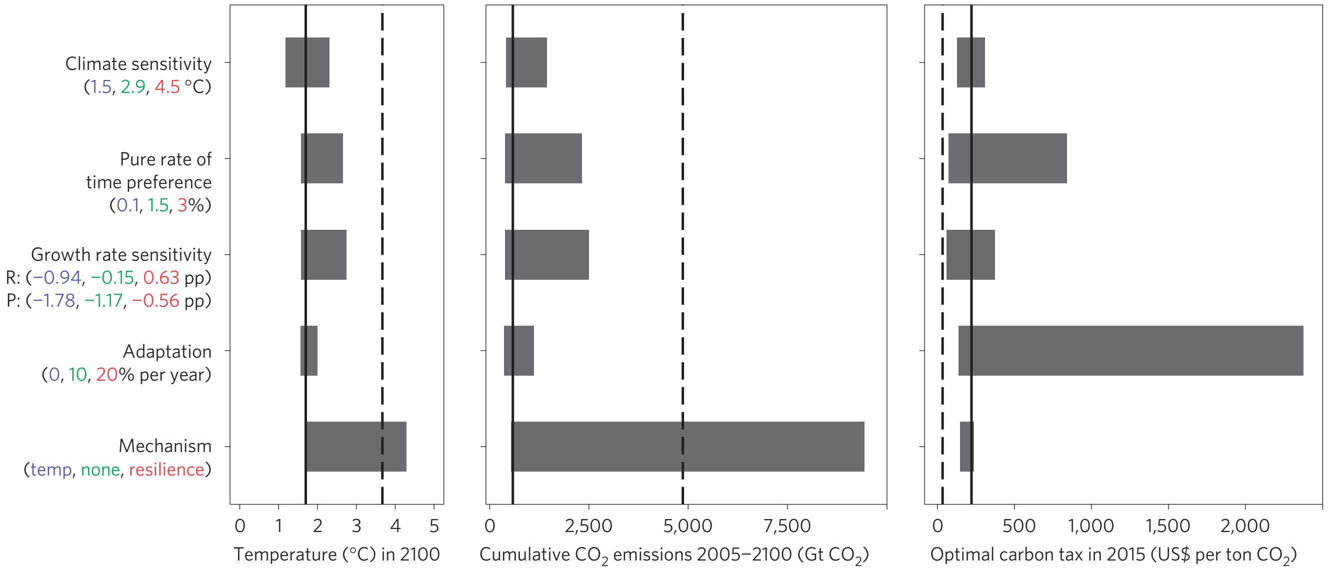

Figure 4 | Sensitivity of three key indicators of twenty-first century climate policy to climate sensitivity, the pure rate of time preference (PRTP), the sensitivity of economic growth rates to temperature, adaptation rate, and the temperature or resilience mechanisms. The lower, main and upper values of the parameter range are labelled in blue, green and red, respectively. The climate sensitivity range is derived from the 66% confidence (likely) interval given by the Intergovernmental Panel on Climate Change Fifth Assessment Report[30]. The values for the pure rate of time preference do not correspond to a confidence interval, but to noted low and high values from the literature. The growth-rate sensitivities are based on ± one standard error (68% confidence interval) as reported in ref. 4. Results for the gro-DICE model (solid line) and DICE-2R model (dashed line) are shown for comparison.

significantly increase the SCC and the optimal rate of near-term mitigation. This finding holds for empirically derived estimates of the magnitude of temperature effects on growth rates using optimistic adaptation assumptions, and is robust to uncertainty in the sensitivity parameter and the rate of adaptation, but not to the mechanism driving different growth-rate impacts in rich and poor regions. Although the simplified representation of mitigation in DICE means the optimal level of near-term mitigation may be overestimated here, the higher marginal damage of CO_2 emissions should be robust to higher mitigation costs. The sensitive dependence of model results on the magnitude of growth-rate impacts, the adaptation rate, and the interaction of temperature sensitivity with per-capita GDP indicate that these topics should be a priority for future empirical work. If further studies confirm that climate change has the potential to adversely affect TFP, capital stocks or labour supply then aggressive, near-term mitigation could well be warranted.

Methods

To study the growth effects as presented in Dell *et al.*[4] (DJO in this section) we created a two-region version of DICE (DICE-2R). The rich and poor regions are parameterized on the basis of output-weighted regional values from the 2010 RICE model[5,17] (Supplementary Table 1). DICE-2R chooses mitigation and savings so as to maximize the discounted sum of utility in both regions, weighted by regional Negishi weights[28]. We also altered DICE by fixing emissions in 2005 and 2010, making 2015 the first year when mitigation is possible. As the parameterization of the rich and poor regions in DICE-2R, although consistent with RICE2010, differs from the DICE-2013R aggregate, DICE-2R does not exactly reproduce the most recent DICE results[5]. Specifically, the slightly faster TFP growth in DICE-2R means that incomes and emissions are higher in DICE-2R than in DICE-2013R in the second half of the twenty-first century.

We investigate two alternative pathways by which warming could affect economic growth: slowing the growth of TFP or accelerating depreciation of the capital stock. For the first pathway, climate damages impact the growth rate of TFP, reflecting the fact that climate change could affect the productivity of the research sector or existing investments[12]:

$$A_{j,t} = (1 + j_{\mathrm{TFP}_{j,t}} - r_{\mathrm{DJO}_{j,t}})^{\Delta t} A_{j,t-1}$$

$$j_{\mathrm{DJO}_{j,t}} = \tilde{\gamma}_{0_j} T_t \qquad (1)$$

where $A_{j,t}$ is TFP in region j in time period t, j_{TFP} is the exogenous annual TFP growth rate, T is the global temperature change from pre-industrial, Δt is the model time step, and $\tilde{\gamma}_{0_j}$ is the regional growth-rate sensitivity to temperature, calibrated to reproduce the DJO result (Table 1). Calibration is necessary because economic growth is not completely exogenous in DICE but is partly determined by an endogenous capital stock, meaning that reductions in TFP affect economic growth both through lower productivity and through lower capital. Details on the calibration are given in the Supplementary Information. The gro-DICE model also includes transient impacts of temperature on regional output estimated by DJO ($\beta_{0_j} T_t$, Table 1), but this effect is small compared with the growth-rate damages.

The second pathway assumes climate damages fall on the capital depreciation rate. This simulates the impact of climate change on physical infrastructure through more frequent or larger extreme events or on institutional capital through, for example, increased risk of civil conflict[14]. We calibrate the relationship between temperature change and depreciation rate for the DJO results for values of capital stock, investment, TFP and labour in the reference run for a range of temperatures up to 6 °C (calibration details in Supplementary Information and Supplementary Fig. 9). This gives a concave, quadratic function relating warming and depreciation rate (Supplementary Fig. 10). We find comparable implications for climate policy along both the TFP and depreciation pathways. In reality, both impact pathways (as well as others) are likely to be important in determining climate change damages, but we present them separately here for clarity and because of the lack of empirical studies on their relative roles.

We model adaptation in gro-DICE using an exponential decay curve in which the initial impact of a change in temperature (determined by parameters calibrated to the DJO results) declines over time at the rate of adaptation. We introduce a new variable, the effective temperature, which is the sum of all residual temperature shocks:

$$\mathrm{ET}_t = \sum_{i=1850}^{t} (T_i - T_{i-1}) \mathrm{e}^{-a(t-i)}$$

where ET_t is the effective temperature at time t, T_i is the temperature in year i, and a is the rate of adaptation. For runs with a positive adaptation rate, ET_t replaces T_t in the calculation of damages (equation (1)). As there is a very limited empirical basis for the rate of adaptation, we use a value of 10% per year and vary it between 0 and 20% per year in a robustness check. Ten per cent per year is equivalent to a 95% reduction in the impact of a temperature shock after a 30-year adjustment period (Supplementary Fig. 2). The contribution to effective temperature of temperature change before the start of the model time horizon is based on the global surface temperature record since 1850 (ref. 29). The effective temperature rather than absolute temperature is then used to define damages on output and TFP or capital. This formulation means that impacts depend both on the magnitude and the rate of temperature change because faster warming results in larger disequilibrium and therefore higher adjustment costs.

The temperature and resilience mechanisms are implemented such that the growth-rate damage parameters $\tilde{\gamma}_{0_j}$ are a function of either temperature or per-capita GDP, respectively. In the temperature mechanism, sensitivity in poor regions remains constant but increases with warming in rich regions, not exceeding the sensitivity observed at present in poor regions (Supplementary Fig. 11). The resilience mechanism causes sensitivity in poor regions to decrease until they reach the per-capita GDP of rich regions today, reducing damages from warming over time as poor regions develop (Supplementary Fig. 12).

The effect of parametric uncertainty in five factors is investigated by independently varying each parameter from its reference value to a high or low value using one-at-a-time sensitivity analysis (Fig. 4). The uncertainties captured and not captured by this approach are discussed more fully in the Supplementary Information.

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References

1. Pindyck, R. S. Uncertain outcomes and climate change policy. *J. Environ. Econ. Manage.* **63,** 289–303 (2012).
2. Stern, N. The structure of economic modeling of the potential impacts of climate change: Grafting gross underestimation of risk onto already narrow science models. *J. Econ. Lit.* **51,** 838–859 (2013).
3. Revesz, R. L. *et al.* Global warming: Improve economic models of climate change. *Nature* **508,** 173–175 (2014).
4. Dell, M., Jones, B. F. & Olken, B. A. Temperature shocks and economic growth: Evidence from the last half century. *Am. Econ. J. Macroecon.* **4,** 66–95 (2012).
5. Nordhaus, W. D. & Sztorc, P. *DICE 2013R: Introduction and User's Manual* 1–102 (2013); http://www.econ.yale.edu/~nordhaus/homepage/documents/DICE_Manual_103113r2.pdf.
6. IAWG, U. *Technical support document: Technical update of the social cost of carbon for regulatory impact analysis under executive order 12866.* 1–22 (US government, 2013).
7. Deschênes, O. & Greenstone, M. Climate change, mortality, and adaptation: Evidence from annual fluctuations in weather in the US. *Am. Econ. J. Appl. Econ.* **3,** 152–185 (2011).
8. Schlenker, W. & Roberts, D. L. Nonlinear temperature effects indicate severe damages to US corn yields under climate change. *Proc. Natl Acad. Sci.* **106,** 15594–15598 (2009).
9. Dell, M., Jones, B. F. & Olken, B. A. What do we learn from the weather? The new climate-economy literature. *J. Econ. Lit.* **52,** 740–798 (2014).
10. Hope, C. W. The marginal impact of CO_2 from PAGE2002: An integrated assessment model incorporating the IPCC's five reasons for concern. *Integr. Assess. J.* **6,** 19–56 (2006).
11. Anthoff, D. & Tol, R. S. J. *The Climate Framework for Uncertainty, Negotiation and Distribution (FUND), Technical Description, Version 3.6.* (2012); http://www.fund-model.org/versions
12. Moyer, E., Woolley, M. M., Matteson, N. J., Glotter, M. M. & Weisbach, D. Drivers of uncertainty in the Social Cost of Carbon. *J. Leg. Stud.* **43,** 401–425 (2014).
13. Bansal, R. & Ochoa, M. *Temperature, Aggregate Risk, and Expected Returns* (National Bureau for Economic Research, 2011).
14. Hsiang, S. M., Burke, M. & Miguel, E. Quantifying the influence of climate on human conflict. *Science* **341,** 1235367 (2013).
15. Graff Zivin, J. & Neidell, M. Temperature and the allocation of time: Implications for climate change. *J. Labor Econ.* **32,** 1–26 (2014).
16. Dietz, S. & Stern, N. *Endogenous Growth, Convexity of Damages and Climate Risk: How Nordhaus' Framework Supports Deep Cuts in Carbon Emissions* (Center for Climate Change Economics and Policy, 2014).
17. Nordhaus, W. D. Economic aspects of global warming in a post-Copenhagen environment. *Proc. Natl Acad. Sci. USA* **107,** 11721–11726 (2010).
18. Moore, F. C. & Lobell, D. B. The adaptation potential of European agriculture in response to climate change. *Nature Clim. Change* **4,** 610–614 (2014).
19. Hornbeck, R. The enduring impact of the American dust bowl: Short and long-run adjustments to environmental catastrophe. *Am. Econ. Rev.* **102,** 1477–1507 (2012).
20. Hsiang, S. M. & Narita, D. Adaptation to cyclone risk: Evidence from the global cross-section. *Clim. Change Econ.* **03** (2012).
21. Lobell, D. B., Banziger, M., Magorokosho, C. & Vivek, B. Nonlinear heat effects on African maize as evidenced by historical yield trials. *Nature Clim. Change* **1,** 42–45 (2011).
22. Keller, K., McInerney, D. & Bradford, D. F. Carbon dioxide sequestration: How much and when? *Climatic Change* **88,** 267–291 (2008).
23. Ha-Duong, M., Grubb, M. & Hourcade, J. Influence of socioeconomic inertia and uncertainty on optimal CO_2-emission abatement. *Nature* **390,** 270–273 (1997).
24. Richels, R. G. & Blanford, G. J. The value of technological advance in decarbonizing the US economy. *Energy Econ.* **30,** 2930–2946 (2008).
25. Hogan, W. W. & Jorgenson, D. W. Productivity trends and the cost of reducing CO_2 emissions. *Energy J.* **12,** 67–85 (1991).
26. Weitzman, M. L. GHG targets as insurance against catastrophic climate damages. *J. Public Econ. Theory* **14,** 221–244 (2012).
27. Stern, N. & Taylor, C. Climate change: Risk, ethics, and the Stern review. *Science* **317,** 203–204 (2007).
28. Stanton, E. A. Negishi welfare weights in integrated assessment models: The mathematics of global inequality. *Clim. Change* **107,** 417–432 (2010).
29. NASA GISS Surface Temperature Analysis (GISTEMP) (Goddard Institute for Space Studies, 2014); http://data.giss.nasa.gov/gistemp/graphs_v3/Fig.A2.txt
30. IPCC *Summary for Policymakers in Climate Change 2013: The Physical Science Basis* (eds Stocker, T. F. *et al.*) (Cambridge Univ. Press, 2013).

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Author contributions

F.C.M. and D.B.D. designed the analysis. D.B.D. performed the analysis. F.C.M. and D.B.D. analysed results and wrote the paper.

Additional information

Supplementary information is available in the online version of the paper. Reprints and permissions information is available online at www.nature.com/reprints. Correspondence and requests for materials should be addressed to F.C.M.

Competing financial interests

The authors declare no competing financial interests.

Exhibit 11

THE COST OF DELAYING ACTION TO STEM CLIMATE CHANGE

July 2014

Executive Summary

The signs of climate change are all around us. The average temperature in the United States during the past decade was 0.8° Celsius (1.5° Fahrenheit) warmer than the 1901-1960 average, and the last decade was the warmest on record both in the United States and globally. Global sea levels are currently rising at approximately 1.25 inches per decade, and the rate of increase appears to be accelerating. Climate change is having different impacts across regions within the United States. In the West, heat waves have become more frequent and more intense, while heavy downpours are increasing throughout the lower 48 States and Alaska, especially in the Midwest and Northeast.[1] The scientific consensus is that these changes, and many others, are largely consequences of anthropogenic emissions of greenhouse gases.[2]

The emission of greenhouse gases such as carbon dioxide (CO_2) harms others in a way that is not reflected in the price of carbon-based energy, that is, CO_2 emissions create a negative externality. Because the price of carbon-based energy does not reflect the full costs, or economic damages, of CO_2 emissions, market forces result in a level of CO_2 emissions that is too high. Because of this market failure, public policies are needed to reduce CO_2 emissions and thereby to limit the damage to economies and the natural world from further climate change.

There is a vigorous public debate over whether to act now to stem climate change or instead to delay implementing mitigation policies until a future date. This report examines the economic consequences of delaying implementing such policies and reaches two main conclusions, both of which point to the benefits of implementing mitigation policies now and to the net costs of delaying taking such actions.

First, although delaying action can reduce costs in the short run, on net, delaying action to limit the effects of climate change is costly. Because CO_2 accumulates in the atmosphere, delaying action increases CO_2 concentrations. Thus, if a policy delay leads to higher ultimate CO_2 concentrations, that delay produces persistent economic damages that arise from higher temperatures and higher CO_2 concentrations. Alternatively, if a delayed policy still aims to hit a given climate target, such as limiting CO_2 concentration to given level, then that delay means that the policy, when implemented, must be more stringent and thus more costly in subsequent years. In either case, delay is costly.

These costs will take the form of either greater damages from climate change or higher costs associated with implementing more rapid reductions in greenhouse gas emissions. In practice, delay could result in both types of costs. These costs can be large:

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[1] For a fuller treatment of the current and projected consequences of climate change for U.S. regions and sectors, see the Third National Climate Assessment (United States Global Change Research Program (USGCRP) 2014).
[2] See for example the Summary for Policymakers in Working Group I contribution to the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC WG I AR5 2013).

- Based on a leading aggregate damage estimate in the climate economics literature, a delay that results in warming of 3° Celsius above preindustrial levels, instead of 2°, could increase economic damages by approximately 0.9 percent of global output. To put this percentage in perspective, 0.9 percent of estimated 2014 U.S. Gross Domestic Product (GDP) is approximately $150 billion. The incremental cost of an additional degree of warming beyond 3° Celsius would be even greater. Moreover, these costs are not one-time, but are rather incurred year after year because of the permanent damage caused by increased climate change resulting from the delay.

- An analysis of research on the cost of delay for hitting a specified climate target (typically, a given concentration of greenhouse gases) suggests that net mitigation costs increase, on average, by approximately 40 percent for each decade of delay. These costs are higher for more aggressive climate goals: each year of delay means more CO_2 emissions, so it becomes increasingly difficult, or even infeasible, to hit a climate target that is likely to yield only moderate temperature increases.

Second, climate policy can be thought of as "climate insurance" taken out against the most severe and irreversible potential consequences of climate change. Events such as the rapid melting of ice sheets and the consequent increase of global sea levels, or temperature increases on the higher end of the range of scientific uncertainty, could pose such severe economic consequences as reasonably to be thought of as climate catastrophes. Confronting the possibility of climate catastrophes means taking prudent steps now to reduce the future chances of the most severe consequences of climate change. The longer that action is postponed, the greater will be the concentration of CO_2 in the atmosphere and the greater is the risk. Just as businesses and individuals guard against severe financial risks by purchasing various forms of insurance, policymakers can take actions now that reduce the chances of triggering the most severe climate events. And, unlike conventional insurance policies, climate policy that serves as climate insurance is an investment that also leads to cleaner air, energy security, and benefits that are difficult to monetize like biological diversity.

I. Introduction

The changing climate and increasing atmospheric greenhouse gas (GHG) concentrations are projected to accelerate multiple threats, including more severe storms, droughts, and heat waves, further sea level rise, more frequent and severe storm surge damage, and acidification of the oceans (USGCRP 2014). Beyond the sorts of gradual changes we have already experienced, global warming raises additional threats of large-scale changes, either changes to the global climate system, such as the disappearance of late-summer Arctic sea ice and the melting of large glacial ice sheets, or ecosystem impacts of climate change, such as critical endangerment or extinction of a large number of species.

Emissions of GHGs such as carbon dioxide (CO_2) generate a cost that is borne by present and future generations, that is, by people other than those generating the emissions. These costs, or economic damages, include costs to health, costs from sea level rise, and damage from increasingly severe storms, droughts, and wildfires. These costs are not reflected in the price of those emissions. In economists' jargon, emitting CO_2 generates a negative externality and thus a market failure. Because the price of CO_2 emissions does not reflect its true costs, market forces alone are not able to solve the problem of climate change. As a result, without policy action, there will be more emissions and less investment in emissions-reducing technology than there would be if the price of emissions reflected their true costs.

This report examines the cost of delaying policy actions to stem climate change, and reaches two main conclusions. First, delaying action is costly. If a policy delay leads to higher ultimate CO_2 concentrations, then that delay produces persistent additional economic damages caused by higher temperatures, more acidic oceans, and other consequences of higher CO_2 concentrations. Moreover, if delay means that the policy, when implemented, must be more stringent to meet a given target, then it will be more costly.

Second, uncertainty about the most severe, irreversible consequences of climate change adds urgency to implementing climate policies *now* that reduce GHG emissions. In fact, climate policy can be seen as climate insurance taken out against the most damaging potential consequences of climate change—consequences so severe that these events are sometimes referred to as climate catastrophes. The possibility of climate catastrophes leads to taking prudent steps now to sharply reduce the chances that they occur.

The costs of inaction underscore the importance of taking meaningful steps today towards reducing carbon emissions. An example of such a step is the Environmental Protection Agency's (EPA) proposed rule (2014) to regulate carbon pollution from existing power plants. By adopting economically efficient mechanisms to reduce emissions over the coming years, this proposed rule would generate large positive net benefits, which EPA estimates to be in the range of $27 - 50 billion annually in 2020 and $49 - 84 billion in 2030. These benefits include benefits to health from reducing particulate emissions as well as benefits from reducing CO_2 emissions.

Delaying Climate Policies Increases Costs

Delaying climate policies avoids or reduces expenditures on new pollution control technologies in the near term. But this short-term advantage must be set against the disadvantages, which are the costs of delay. The costs of delay are driven by fundamental elements of climate science and economics. Because the lifetime of CO_2 in the atmosphere is very long, if a mitigation policy is delayed, it must take as its starting point a higher atmospheric concentration of CO_2. As a result, delayed mitigation can result in two types of cost, which we would experience in different proportions depending on subsequent policy choices.

First, if delay means an increase in the ultimate end-point concentration of CO_2, then delay will result in additional warming and additional economic damages resulting from climate change. As is discussed in Section II, economists who have studied the costs of climate change find that temperature increases of 2° Celsius above preindustrial levels or less are likely to result in aggregate economic damages that are a small fraction of GDP. This small net effect masks important differences in which some regions could benefit somewhat from this warming while other regions could experience net costs. But global temperatures have *already* risen nearly 1° above preindustrial levels, and it will require concerted effort to hold temperature increases to within the narrow range consistent with small costs.[3] For temperature increases of 3° Celsius or more above preindustrial levels, the aggregate economic damages from climate change are expected to increase sharply.

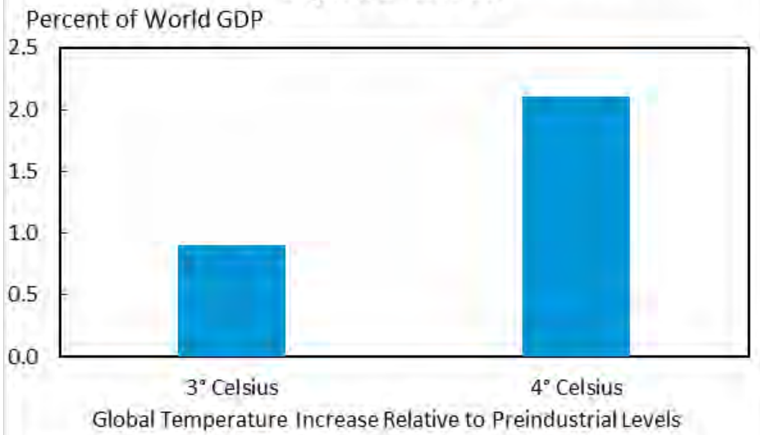
Delay that causes a climate target to be missed creates large estimated economic damages. For example, a calculation in Section II of this report, based on a leading climate model (the DICE model as reported in Nordhaus 2013), shows that if a delay causes the mean global temperature increase to stabilize at 3° Celsius above preindustrial levels, instead of 2°, that delay will induce annual additional damages of approximately 0.9 percent of global output, as shown in Figure 1.[4] To put this percentage in perspective, 0.9 percent of estimated 2014 U.S. GDP is approximately $150 billion.[5] The next degree increase, from 3° to 4°, would incur greater *additional* annual costs of approximately 1.2 percent of global output. These costs are not one-time: they are incurred year after year because of the permanent damage caused by additional climate change resulting from the delay.

[3] The Working Group III contribution to the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC WG III AR5 2014) does not analyze scenarios producing temperatures in 2100 less than 1.5 Celsius above preindustrial, because this is considered so difficult to achieve.

[4] Nordhaus (2013) stresses that these estimates "are subject to large uncertainties…because of the difficulty of estimating impacts in areas such as the value of lost species and damage to ecosystems." (pp. 139-140).

[5] These percentages apply to gross world output and the application of them to U.S. GDP is illustrative.

Figure 1: Economic Damage from Temperature Increase Beyond 2° Celsius



Source: Nordhaus (2013) and CEA calculations

The second type of cost of delay is the increased cost of reducing emissions more sharply if, instead, the delayed policy is to achieve the same climate target as the non-delayed policy. Taking meaningful steps now sends a signal to the market that reduces long-run costs of meeting the target. Part of this signal is that new carbon-intensive polluting facilities will be seen as bad investments; this reduces the amount of locked-in high-carbon infrastructure that is expensive to replace. Second, taking steps now to reduce CO_2 emissions signals the value of developing new low- and zero-emissions technologies, so additional steps towards a zero-carbon future can be taken as policy action incentivizes the development of new technologies. For both reasons, the least-cost mitigation path to achieve a given concentration target typically starts with a relatively low price of carbon to send these signals to the market, and subsequently increases as new low-carbon technology becomes available.[6]

The research discussed in Section II of this report shows that any short run gains from delay tend to be outweighed by the additional costs arising from the need to adopt a more abrupt and stringent policy later.[7] An analysis of the collective results from that research, described in more detail in Section II, suggests that the cost of hitting a specific climate target increases, on average, by approximately 40 percent for each decade of delay. These costs are higher for more aggressive climate goals: the longer the delay, the more difficult it becomes to hit a climate target. Furthermore, the research also finds that delay substantially decreases the chances that even concerted efforts in the future will hit the most aggressive climate targets.

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[6] The 2010 National Research Council, *Limiting the Magnitude of Future Climate Change*, also stressed the importance of acting now to implement mitigation policies as a way to reduce costs. The NRC emphasized the importance of technology development in holding down costs, including by providing clear signals to the private sector through predictable policies that support development of and investment in low-carbon technologies.

[7] The IPCC WG III AR5 (2014) includes an extensive discussion of mitigation, including sectoral detail, potential for technological progress, and the timing of mitigation policies.

Although global action is essential to meet climate targets, unilateral steps both encourage broader action and benefit the United States. Climate change is a global problem, and it will require strong international leadership to secure cooperation among both developed and developing countries to solve it. America must help forge a truly global solution to this global challenge by galvanizing international action to significantly reduce emissions. By taking credible steps toward mitigation, the United States will also reap the benefits of early action, such as investing in low-carbon infrastructure now that will reduce the costs of reaching climate targets in the future.

Climate Policy as Climate Insurance

Individuals and businesses routinely purchase insurance to guard against various forms of risk such as fire, theft, or other loss. This logic of self-protection also applies to climate change. Much is known about the basic science of climate change: there is a scientific consensus that, because of anthropogenic emissions of CO_2 and other GHGs, global temperatures are increasing, sea levels are rising, and the world's oceans are becoming more acidic. These and other climate changes are expected to be harmful, on balance, to the world's natural and economic systems. Nevertheless, uncertainty remains about the magnitude and timing of these and other aspects of climate change, even if we assume that future climate policies are known in advance. For example, the Working Group I contribution to the IPCC's Fifth Assessment Report (IPCC WG I AR5 2013) provides a likely range of 1.5° to 4.5° Celsius for the equilibrium climate sensitivity, which is the long-run increase in global mean surface temperature that is caused by a sustained doubling of atmospheric CO_2 concentrations. The upper end of that range would imply severe climate impacts under current emissions trajectories, and current scientific knowledge indicates that values in excess of this range are also possible.[8]

An additional, related source of climate uncertainty is the possibility of irreversible, large-scale changes that have wide-ranging and severe consequences. These are sometimes called abrupt changes because they could occur extremely rapidly as measured in geologic time, and are also sometimes called climate catastrophes. We are already witnessing one of these events—the rapid trend towards disappearance of late-summer Arctic sea ice. A recent study from the National Research Council (NRC 2013) found that this strong trend toward decreasing sea-ice cover could have large effects on a variety of components of the Arctic ecosystem and could potentially alter large-scale atmospheric circulation and its variability. The NRC also found that another large-scale change has been occurring, which is the critical endangerment or loss of a significant percentage of marine and terrestrial species. Other events judged by the NRC to be likely in the more distant future (after 2100) include, for example, the possible rapid melting of the Western Antarctic ice and Greenland ice sheets and the potential thawing of Arctic permafrost and the consequent release of the potent GHG methane, which would accelerate global warming. These and other potential large-scale changes are irreversible on relevant time

[8] It is important to note that, as a global average, the equilibrium climate sensitivity masks the expectation that temperature change will be higher over land than the oceans, and that there will be substantial regional variations in temperature increases. The equilibrium climate sensitivity describes a long-term effect and is only one component of determining near term warming due to the buildup of GHGs in the atmosphere.

scales—if an ice sheet melts, it cannot be reconstituted—and they could potentially have massive global consequences and costs. For many of these events, there is thought to be a "tipping point," for example a temperature threshold, beyond which the transition to the new state becomes inevitable, but the values or locations of these tipping points are typically unknown.

Section III of this report examines the implications of these possible climate-related catastrophes for climate policy. Research on the economic and policy implications of such threats is relatively recent. As detailed in Section III, a conclusion that clearly emerges from this young but active literature is that the threat of a climate catastrophe, potentially triggered by crossing an unknown tipping point, implies erring on the side of prudence today. Accordingly, in a phrase used by Weitzman (2009, 2012), Pindyck (2011), and others, climate policy can be thought of as "climate insurance." The logic here is that of risk management, in which one acts now to reduce the chances of worst-case outcomes in the future. Here, too, there is a cost to delay: the longer emission reductions are postponed, the greater are atmospheric concentrations of GHGs, and the greater is the risk arising from delay.

Other Costs of Delay and Benefits of Acting Now

An additional benefit of adopting meaningful mitigation policies now is that doing so sends a strong signal to the market to spur the investments that will reduce mitigation costs in the future. An argument sometimes made is that mitigation policies should be postponed until new low-carbon technologies become available. Indeed, ongoing technological progress has dramatically improved productivity and welfare in the United States because of vast inventions and process improvements in the private sector (see for example CEA 2014, Chapter 6). The private sector invests in research and development, and especially in process improvements, because those technological advances reap private rewards. But low-carbon technologies, and environmental technologies more generally, face a unique barrier: their benefits – the reduction in global impacts of climate change – accrue to everyone and not just to the developer or adopter of such technologies.[9] Thus private sector investment in low-carbon technologies requires confidence that those investments, if successful, will pay off, that is, the private sector needs to have confidence that there will be a market for low-carbon technologies now and in the future. Public policies that set out a clear and ongoing mitigation path provide that confidence. Simply waiting for a technological solution, but not providing any reason for the private sector to create that solution, is not an effective policy. Although public financing of basic research is warranted because many of the benefits of basic research cannot be privately appropriated, many of the productivity improvements and cost reductions seen in new technologies come from incremental advances and process improvements that only arise through private-sector experience producing the product and learning-by-doing. These advances are protected through the patent system and as trade secrets, but those advances will only transpire if it is clear that they will have current and

[9] Popp, Newell, and Jaffe (2010) provide a thorough review of the literature regarding technological change and the environment.

future value. In other words, policy action induces technological change.[10] Although a full treatment of the literature on technological change is beyond the scope of this report, providing the private sector with the certainty needed to invest in low-carbon technologies and produce such technological change is a benefit of adopting meaningful mitigation policies now.

Finally, because this report examines the economic costs of delay, it focuses on actions or consequences that have a market price. But the total costs of climate change include much that does not trade in the market and to which it is difficult to assign a monetary value, such as the loss of habitat preservation, decreased value of ecosystem goods and services, and mass extinctions. Although some studies have attempted to quantify these costs, including all relevant climate impacts is infeasible. Accordingly, the monetized economic costs of delay analyzed in this report understate the true total cost of delaying action to mitigate climate change.

[10] For example, Popp (2003) provides empirical evidence that Title IV of the 1990 Clean Air Act Amendments (CAAA) led to innovations that reduced the cost of the environmental technologies that reduced SO_2 emissions from coal-fired power plants. Other literature shows evidence linking environmental regulation more broadly to innovation (e.g., Popp 2006, Jaffe and Palmer 1997, Lanjouw and Mody 1996).

II. Costs from Delaying Policy Action

Delaying action on climate change can increase economic costs in two ways. First, if the delayed policy is no more stringent, it will miss the climate target of the original, non-delayed policy, resulting in atmospheric GHG concentrations that are permanently higher, thereby increasing the economic damages from climate change. Second, suppose a delayed policy alternatively strove to achieve the original climate target; if so, it would require a more stringent path to achieve that target. But this delayed, more stringent policy typically will result in additional mitigation costs by requiring more rapid adjustment later. In reality, delay might result in a mix of these two types of costs. The estimates of the costs of delay in this section draw on large bodies of research on these two types of costs. We first examine the economic damages from higher temperatures, then turn to the increased mitigation costs arising from delay.

Our focus here is on targets that limit GHG concentrations, both because this is what most of the "delay" literature considers and because concentration limits have been the focus of other assessments. These concentration targets are typically expressed as concentrations of CO_2-equivalent (CO_2e) GHGs, so they incorporate not just CO_2 concentrations but also methane and other GHGs. The CO_2e targets translate roughly into ranges of temperature changes as estimated by climate models and into the cumulative GHG emissions budgets discussed in some other climate literature. More stringent concentration targets decrease the odds that global average temperature exceeds 2°C above preindustrial levels by 2100. According to the IPCC WG III AR5 (2014), meeting a concentration target of 450 parts per million (ppm) CO_2e makes it "likely" (probability between 66 and 100 percent) that the temperature increase will be at most 2°C, relative to preindustrial levels, whereas stabilizing at a concentration level of 550 ppm CO_2e makes it "more unlikely than likely" (less than a 50 percent probability) that the temperature increase by 2100 will be limited to 2°C (IPCC WG III AR5 2014).[11]

Increasing Damages if Delay Means Missing Climate Targets

If delay means that a climate target slips, then the ultimate GHG concentrations, temperatures, and other changes in global climate would be greater than without the delay.[12]

A growing body of work examines the costs that climate change imposes on specific aspects of economic activity. The IPCC WG II AR5 (2014) surveys this growing literature and summarizes the impacts of projected climate change by sector. Impacts include decreased agricultural production; coastal flooding, erosion, and submergence; increases in heat-related illness and other stresses due to extreme weather events; reduction in water availability and quality;

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[11] IPCC WG III AR5 (2014, ch. 6) provides a further refinement of these probabilities, associating a concentration target of 450 ppm of CO_2e with an approximate 70-85 percent probability of maintaining temperature change below 2°C, and a concentration level of 550 CO_2e with an approximate 30-45 percent probability of maintaining temperature change below 2°C.

[12] For information on the impacts of climate change at various levels of warming see *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia* (NRC 2011).

displacement of people and increased risk of violent conflict; and species extinction and biodiversity loss. Although these impacts vary by region, and some impacts are not well-understood, evidence of these impacts has grown in recent years.[13]

A new class of empirical studies draw similar conclusions. Dell, Jones, and Olken (2013) review academic research that draws on historical variation in weather patterns to infer the effects of climate change on productivity, health, crime, political instability, and other social and economic outcomes. This approach complements physical science research by estimating the economic impacts of historical weather events that can be used to extrapolate to those expected in the future climate. The research finds evidence of economically meaningful impacts of climate change on a variety of outcomes. For example, when the temperature is greater than 100° Fahrenheit in the United States, labor supply in outdoor industries declines up to one hour per day relative to temperatures in the 76°-80° Fahrenheit range (Graff Zivin and Neidell 2014). Also in the United States, each additional day of extreme heat (exceeding 90° Fahrenheit) relative to a moderate day (50° to 59° Fahrenheit) increases the annual age-adjusted mortality rate by roughly 0.11 percent (Deschênes and Greenstone 2011).

These studies provide insights into the response of specific sectors or aspects of the economy to climate change. But because they focus on specific aspects of climate change, use different data sources, and use a variety of outcome measures, they do not provide direct estimates of the aggregate, or total, cost of climate change. Because estimating the total cost of climate change requires specifying future baseline economic and population trajectories, efforts to estimate the total cost of climate change typically rely on integrated assessment models (IAMs). IAMs are a class of economic and climate models that incorporate both climate and economic dynamics so that the climate responds to anthropogenic emissions and economic activity responds to the climate. In addition to projecting future climate variables and other economic variables, the IAMs estimate the total economic damages (and, in some cases, benefits) of climate change which includes impacts on agriculture, health, ecosystems services, productivity, heating and cooling demand, sea level rise, and adaptation.

Overall costs of climate change are substantial, according to IAMs. Nordhaus (2013) estimates global costs that increase with the rise in global average temperature, and Tol (2009, 2014) surveys various estimates. Two themes are common among these damage estimates. First, damage estimates remain uncertain, especially for large temperature increases. Second, the costs of climate change increase nonlinearly with the temperature change. Based on Nordhaus's (2013, Figure 22) net damage estimates, a 3° Celsius temperature increase above preindustrial levels, instead of 2°, results in additional damages of 0.9 percent of global output.[14] To put this

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[13] The EPA's Climate Change Impacts and Risk Analysis project collects new research that estimates the potential damages of inaction and the benefits of GHG mitigation at national and regional scales for many important sectors, including human health, infrastructure, water resources, electricity demand and supply, ecosystems, agriculture, and forestry (Waldhoff et al. 2014).

[14] Some studies estimate that small temperature increases have a net economic *benefit*, for instance due to increased agricultural production in regions with colder climates. However, projected temperature increases even

percentage in perspective, 0.9 percent of estimated 2014 U.S. GDP is approximately $150 billion. The next degree increase, from 3° to 4°, would incur additional costs of 1.2 percent of global output. Moreover, these costs are not one-time, rather they recur year after year because of the permanent damage caused by increased climate change resulting from the delay. It should be stressed that these illustrative estimates are based on a single (albeit leading) model, and there is uncertainty associated with the aggregate monetized damage estimates from climate change; see for example the discussion in IPCC WG II AR5 (2014).

Increased Mitigation Costs from Delay

The second type of cost of delay arises if policy is delayed but still hits the climate target, for example stabilizing CO_2e concentrations at 550 ppm. Because a delay results in additional near-term accumulation of GHGs in the atmosphere, delay means that the policy, when implemented, must be more stringent to achieve the given long-term climate target. This additional stringency increases mitigation costs, relative to those that would be incurred under the least-cost path starting today.

This section reviews the recent literature on the additional mitigation costs of delay, under the assumption that both the original and delayed policy achieve a given climate target. We review 16 studies that compare 106 pairs of policy simulations based on integrated climate mitigation models (the studies are listed and briefly described in the Appendix). The simulations comprising each pair implement similar policies that lead to the same climate target (typically a concentration target but in some cases a temperature target) but differ in the timing of the policy implementation, nuanced in some cases by variation in when different countries adopt the policy. Because the climate target is the same for each scenario in the pair, the environmental and economic damages from climate change are approximately the same for each scenario. The additional cost of delaying implementation thus equals the difference in the mitigation costs in the two scenarios in each paired comparison. The studies reflect a broad array of climate targets, delayed timing scenarios, and modeling assumptions as discussed below. We focus on studies published in 2007 or later, including recent unpublished manuscripts.

In each case, a model computes the path of cost-effective mitigation policies, mitigation costs, and climate outcomes over time, constraining the emissions path so that the climate target is hit. Each path weighs technological progress in mitigation technology and other factors that encourage starting out slowly against the costs that arise if mitigation, delayed too long, must be undertaken rapidly. Because the models typically compute the policy in terms of a carbon price, the carbon price path computed by the model starts out relatively low and increases over the course of the policy. Thus a policy started today typically has a steadily increasing carbon price, whereas a delayed policy typically has a carbon price of zero until the start date, at which point it jumps to a higher initial level then increases more rapidly than the optimal immediate policy.

under immediate action fall in a range with a strong consensus that the costs of climate change exceed such benefits. The cost estimates presented here are net of any benefits expected to accrue.

The higher carbon prices after a delay typically lead to higher total costs than a policy that would impose the carbon price today.[15]

The IPCC WG III AR5 (2014) includes an overview of the literature on the cost of delayed action on climate change. They cite simulation studies showing that delay is costly, both when all countries delay action and when there is partial delay, with some countries delaying acting alone until there is a more coordinated international effort. The present report expands on that overview by further analyzing the findings of the studies considered by the IPCC report as well as additional studies. Like the IPCC report, we find broad agreement across the scenario pairs examined that delayed policy action is more costly compared to immediate action conditional on a particular climate target. This finding is consistent across a range of climate targets, policy participants, and modeling assumptions. The vast majority of studies estimate that delayed action incurs greater mitigation costs compared to immediate action. Furthermore, some models used in the research predict that the most stringent climate targets are feasible only if immediate action is taken under full participation. One implication is that considering only comparisons with numerical cost estimates may understate the true costs of delay, as failing to reach a climate target means incurring the costs from the associated climate change.

The costs of delay in these studies depend on a number of factors, including the length of delay, the climate target, modeling assumptions, future baseline emissions, future mitigation technology, delay scenarios, the participants implementing the policy, and geographic location. More aggressive targets are more costly to achieve, and meeting them is predicted to be particularly costly, if not infeasible, if action is delayed. Similarly, international coordination in policy action reduces mitigation costs, and the cost of delay depends on which countries participate in the policy, as well as the length of delay.

[15] Some models explicitly identify the carbon price path that minimizes total social costs. These optimization models always find equal or greater costs for scenarios with a delay constraint. Other models forecast carbon prices that result in the climate target but do not demand that the path results in minimal cost. These latter models can predict that delay reduces costs, and a small number of comparisons we review report negative delay costs.

THE ROLE OF TECHNOLOGICAL PROGRESS IN COST ESTIMATES

Assumptions about energy technology play an important role in estimating mitigation costs. For example, many models assume that carbon capture and storage (CCS) will enable point sources of emission to capture the bulk of carbon emissions and store them with minimal leakage into the atmosphere over a long period. Some comparisons also assume that CCS will combine with large-scale bio-energy ("bio-CCS"), effectively generating "negative emissions" since biological fuels extract atmospheric carbon during growth. Such technology could facilitate reaching a long-term atmospheric concentration target despite relatively modest near-term mitigation efforts. However, the IPCC warns that "There is only limited evidence on the potential for large-scale deployment of [bio-CCS], large-scale afforestation, and other [CO_2 removal] technologies and methods" (IPCC WG III AR5 2014). In addition, models must also specify the cost and timing of availability of such technology, potentially creating further variation in mitigation cost estimates.

The potential importance of technology, especially bio-CCS, is manifested in differences across models. Clarke et al. (2009) present delay cost estimates for 10 models simulating a 550 ppm CO_2 equivalent target by 2100 allowing for overshoot. The three models that assume bio-CCS availability estimate global present values of the cost of delay ranging from $1.4 trillion to $4.7 trillion. Among the seven models without bio-CCS, four predict higher delay costs, one predicts that the concentration target was infeasible under a delay, and two predict lower delay costs. The importance of bio-CCS is even clearer with a more stringent target. For example, two of the three models with bio-CCS find that a 450 ppm CO_2 equivalent target is feasible under a delay scenario, while none of the seven models without bio-CCS find the stringent target to be feasible.

The Department of Energy sponsors ongoing research on CCS for coal-fired power plants. As part of its nearly $6 billion commitment to clean coal technology, the Administration, partnered with industry, has already invested in four commercial-scale and 24 industrial-scale CCS projects that together will store more than 15 million metric tons of CO_2 per year.

An important determinant of costs is the role of technological progress and the availability of mitigation technologies (see the box). The models typically assume technological progress in mitigation technology, which means that the cost of reducing emissions declines over time as energy technologies improve. As a result, it is cost-effective to start with a relatively less stringent policy, then increase stringency over time, and the models typically build in this cost-effective tradeoff. However, most models still find that immediate initiation of a less stringent policy followed by increasing stringency incurs lower costs than delaying policy entirely and then increasing stringency more rapidly.

We begin by characterizing the primary findings in the literature broadly, discussing the estimates of delay costs and how the costs vary based on key parameters of the policy scenarios; additional details can be found in the Appendix. We then turn to a statistical analysis of all the available delay cost estimates that we could gather in a standardized form, that is, we conduct a meta-analysis of the literature on delay cost estimates.

Effect on Costs of Climate Targets, Length of Delay, and International Coordination

Climate Targets

Researchers estimate a range of climate and economic impacts from a given concentration of GHGs and find that delaying action is much costlier for more stringent targets. Two recent major modeling simulation projects conducted by the Energy Modeling Forum (Clarke et al. 2009) and by AMPERE (Riahi et al. 2014) consider the economic costs of delaying policies to reach a range of CO_2e concentration targets from 450 to 650 ppm in 2100. In the Energy Modeling Forum simulations in Clarke et al. (2009), the median additional cost (global present value) for a 20-year delay is estimated to be $0.7 trillion for 650 ppm CO_2e but a substantially greater $4.7 trillion for 550 ppm CO_2e. Many of the models in these studies suggest that delay causes a target of 450 ppm CO_2e to be much more costly to achieve, or possibly even infeasible.

Length of Delay

The longer the delay, the greater the cumulative emissions before action begins and the shorter the available time to meet a given target. Several recent studies examine the cost implications of delayed climate action and find that even a short delay can add substantial costs to meeting a stringent concentration target, or even make the target impossible to meet. For example, Luderer et al. (2012) find that delay from 2010 to 2020 to stabilize CO_2 concentration levels at 450 ppm by 2100 raises mitigation cost by 50 to 700 percent.[16] Furthermore, Luderer et al. find that delay until 2030 renders the 450 ppm target infeasible. Edmonds et al. (2008) find that additional mitigation costs of delay by newly developed and developing countries are substantial. In fact, they find that stabilizing CO_2 concentrations at 450 ppm even for a relatively short delay from 2012 to 2020 increases costs by 28 percent over the idealized case, and a delay to 2035 increased costs by more than 250 percent.

International Coordination

Meeting stringent climate targets with action from only one country or a small group of countries is difficult or impossible, making international coordination of policies essential. Recent research shows, however, that even if a delay in international mitigation efforts occurs, unilateral or fragmented action reduces the costs of delay: although immediate coordinated international action is the least costly approach, unilateral action is less costly than doing nothing.[17] More specifically, Jakob et al. (2012) consider a 10-year delay of mitigation efforts to reach a 450 ppm CO_2 target by 2100 and find that global mitigation costs increase by 43 to 700 percent if all countries begin mitigation efforts in 2020 rather than 2010. However, early action in 2010 by more developed countries reduces this increase to 29 to 300 percent. In a similar scenario,

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[16] We present a range of cost estimates which comes from the three IAMs – ReMIND-R, WITCH and IMACLIM-R – used by Luderer et al. (2012). These scenarios also allow temporary overshoot of the target.

[17] Waldhoff and Fawcett (2011) find that early mitigation action by industrialized economies significantly reduces the likelihood of large temperature changes in 2100 while also increasing the likelihood of lower temperature changes, relative to a no policy scenario.

Luderer et al. (2012) find that costs increase by 50 to 700 percent with global delay from 2010 to 2020, however if the industrialized countries begin mitigation efforts unilaterally in 2010 (and are joined by all countries in 2020), the estimated cost increases range from zero to about 200 percent. Luderer et al. (2013) and Riahi et al. (2014) find that costs of delay are smaller when fewer countries delay mitigation efforts, or when short-term actions during the delay are more aggressive.

Jakob et al. (2012) find it is in the best interest of the European Union to begin climate action in 2010 rather than delaying action with all other countries until 2020. They also estimate that the cost increase to the United States from delaying climate action with all other countries until 2020 is from 28 to 225 percent, relative to acting early along with other industrialized economies.[18] McKibbin, Morris, and Wilcoxen (2014) consider the impact that a delay in imposing a unilateral price of carbon would have on economic outcomes in the United States including GDP, investment, consumption and employment. They find that although unilateral mitigation efforts do incur costs, delay is costlier.

Summary: Quantifying Patterns across the Studies

We now turn to a quantitative summary and assessment, or meta-analysis, of the studies discussed above.[19] The data set for this analysis consists of the results on all available numerical estimates of the average or total cost of delayed action from our literature search. Each estimate is a paired comparison of a delay scenario and its companion scenario without delay. To make results comparable across studies, we convert the delay cost estimates (presented in the original studies variously as present values of dollars, percent of consumption, or percent of GDP) to percent change in costs as a result of delay.[20] We capture variation across study and experimental designs using variables that encode the length of the delay in years; the target CO_2e concentration; whether only the relatively more-developed countries act immediately (partial delay); the discount rate used to calculate costs; and the model used for the simulation.[21] All comparisons consider policies and outcomes measured approximately through the end of the century. To reduce the effect of outliers, the primary regression analysis only uses results with less than a 400 percent increase in costs (alternative methods of handling the outliers are

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[18] Note that the IMACLIM model finds that U.S. mitigation declines to the point in which they are slightly negative (i.e. net gains compared to business-as-usual).

[19] A study of the results of other studies is referred to as a meta-analysis, and there is a rich body of statistical tools for meta-analysis, see for example Borenstein et al. (2009).

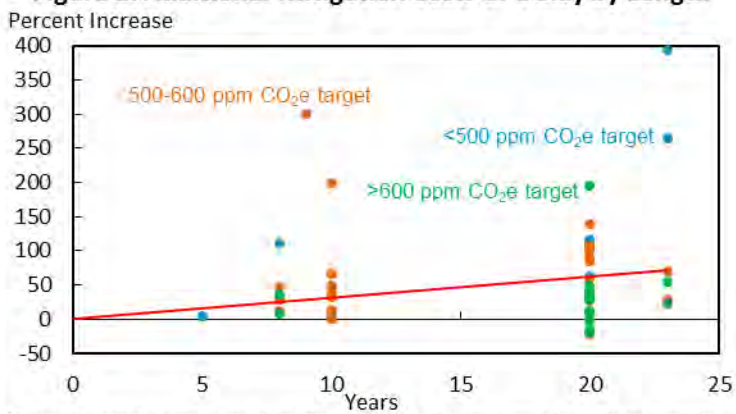
[20] For example, if in some paired comparison delay increased mitigation costs from 0.20 percent of GDP to 0.30 percent of GDP, the cost increase would be 50 percent. Comparisons for which the studies provided insufficient information to calculate the percentage increase in costs (including all comparisons from Riahi et al. 2014) are excluded. Also excluded are comparisons that report only the market price of carbon emissions at the end of the simulation, which is not necessarily proportional to total mitigation costs.

[21] When measuring delay length for policies with multiple stages of implementation, we count the delay as ending at the start of any new participation in mitigation by any party after the start of the simulation. We also exclude scenarios with delays exceeding 30 years. When other climate targets were provided (e.g., CO_2 concentration or global average temperature increase), the corresponding CO_2e concentration levels are estimated using conversions from IPCC WG III AR5 (2014).

discussed below as sensitivity checks), and only includes paired comparisons for which both the primary and delayed policies are feasible (i.e. the model was able to solve for both cases).[22] The dataset contains a total of 106 observations (paired comparisons), with 58 included in the primary analysis. All observations in the data set are weighted equally.

Analysis of these data suggests two main conclusions, both consistent with findings from specific papers in the underlying literature. The first is that, looking across studies, costs increase with the length of the delay. Figure 2 shows the delay costs as a function of the delay time. Although there is considerable variability in costs for a given delay length because of variations across models and experiments, there is an overall pattern of costs increasing with delay.

Figure 2: Additional Mitigation Costs of Delay by Length



Notes: Data points are percentage increase in mitigation costs from delay and the associated length of delay for a given paired simulation. The scatterplot presents a total of 58 paired delay simulations. The solid line is the regression fit to these data, restricted to pass through the origin.
Source: CEA calculations.

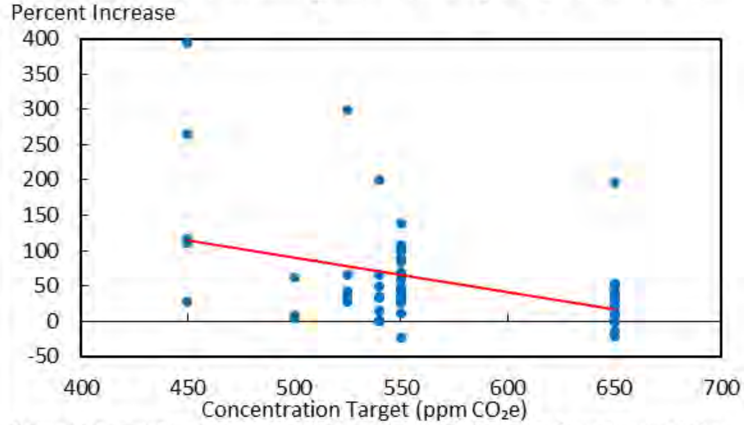
For example, of the 14 paired simulations with 10 years of delay (these are represented by the points in Figure 2 with 10 years of delay), the average delay cost is 39 percent. The regression line shown in Figure 2 estimates an average cost of delay per year using all 58 paired experiments under the assumption of a constant increasing delay cost per year (and, by definition, no cost if there is no delay), and this estimate is 37 percent per decade. This analysis ignores possible confounding factors, such as longer delays being associated with less stringent targets, and the multiple regression analysis presented below controls for such confounding factors.

The second conclusion is that the more ambitious the climate target, the greater are the costs of delay. This can be seen in Figure 3, in which the lowest (most stringent) concentration targets tend to have the highest cost estimates. In fact, close inspection of Figure 2 reveals a related pattern: the relationship between delay length and additional costs is steeper for the points representing CO_2e targets of 500 ppm or less than for those in the other two ranges. That is, costs

[22] In the event that a model estimates a cost for a first-best scenario but determines the corresponding delay scenario to be infeasible, the comparison is coded as having costs exceeding 400 percent. In addition, one comparison from Clarke et al. (2009) is excluded because a negative baseline cost precludes the calculation of a percent increase.

of delay are particularly high for scenarios with the most stringent target and the longest delay lengths.

Figure 3: Additional Mitigation Costs by CO_2 Concentration



Notes: Data points are percentage increase in mitigation costs from delay and the associated CO_2 concetration target for a given paired simulation. The scatterplot presents a total of 58 paired delay simulations. The solid line is the regression line fit to these data.

Table 1 presents the results of multiple regression analysis that summarizes how various factors affect predictions from the included studies, holding constant the other variables included in the regression. The dependent variable is the cost of delay, measured as the percentage increase relative to the comparable no-delay scenario, and the length of delay is measured in decades. Specifications (1) and (2) correspond to Figures 2 and 3, respectively. Each subsequent specification includes the length of the delay in years, an indicator variable for a partial delay scenario, and the target CO_2e concentration. In addition to the coefficients shown, specification (4) includes model fixed effects, which control for systematic differences across models, and each specification other than column (1) includes an intercept.

The results in Table 1 quantify the two main findings mentioned above. The coefficients in column (3) indicate that, looking across these studies, a one decade increase in delay length is on average associated with a 41 percent increase in mitigation cost relative to the no-delay scenario. This regression does not control for possible differences in baseline costs across the different models, however, so column (4) reports a variant that includes an additional set of binary variables indicating the model used ("model fixed effects"). Including model fixed effects increases the delay cost to 56 percent per decade. When the cost of a delay is estimated separately for different concentration target bins (column (5)), delay is more costly the more ambitious is the concentration target. But even for the least ambitious target – a CO_2e concentration exceeding 600 ppm – delay is estimated to increase costs by approximately 24 percent per decade. Because of the relatively small number of cases (58 paired comparisons), which are further reduced when delay is estimated within target bins, the standard errors are large, especially for the least ambitious scenarios, so for an overall estimate of the delay cost we do not differentiate between the different targets. While the regression in column (4) desirably controls for differences across models, other (unreported) specifications that handle the outliers in different ways and include other control variables give per-decade delay estimates both larger and smaller than the regression in column (3).[23] We therefore adopt the estimate in regression (3) of 41 percent per decade as the overall annual estimate of delay costs.

One caveat concerning this analysis is that it only considers cases in which model solutions exist. The omitted, infeasible cases tend to be ones with ambitious targets that cannot be met when there is long delay, given the model's technology assumptions. For this reason, omitting these cases arguably understates the costs of delay reported in Table 1.[24] Additionally, we note that estimates of the effect of a partial delay (when some developed nations act now and other nations delay action) are imprecisely estimated, perhaps reflecting the heterogeneity of partial delay scenarios examined in the studies.

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[23] The results in Table 1 are generally robust to using a variety of other specifications and regression methods, including: using the percent decrease from the delay case, instead of the percent increase from the no-delay case, as the dependent variable as an alternative way to handle outliers; using median regression, also as an alternative way to handle outliers; and including the discount factor as additional explanation of variation in the cost of delay, but this coefficient is never statistically significant. These regressions use linear compounding, not exponential, because the focus is on the per-decade delay cost not the annual delay cost. An alternative approach is to specify the dependent variable in logarithms (although this eliminates the negative estimates), and doing so yields generally similar results after compounding to those in Table 1.

[24] An alternative approach to omitting the infeasible-solution observations is to treat their values as censored at some level. Accordingly, the regressions in Table 1 were re-estimated using tobit regression, for which values exceeding 400 percent (including the non-solution cases) are treated as censored. As expected, the estimated costs of delay per year estimated by tobit regression exceed the ordinary least squares estimates. A linear probability model (not shown) indicates that scenarios with longer delay and more stringent targets are more likely to have delay cost increases exceeding 400 percent (including non-solution cases). The assumption of bio-CCS technology has no statistically significant correlation with delay cost increase in a censored regression but is associated with a significantly lower probability of delay cost increases exceeding 400 percent.

Table 1: Increased Mitigation Costs Resulting from a Delay, Given a Specified Climate Target: Regression Results

	(1)	(2)	(3)	(4)	(5)
Delay (decades)	37.3*** (5.9)		41.1** (17.0)	56.3*** (18.2)	
Delay (decades) x ppm CO_2e≤500					66.7** (27.1)
Delay (decades) x 500<ppm CO_2e≤600					24.9 (18.5)
Delay (decades) x ppm CO_2e>600					24.1 (33.9)
Partial delay			8.3 (26.0)	-20.0 (27.8)	14.8 (25.7)
Target CO_2e concentration		-0.49*** (0.16)	-0.61*** (0.16)	-0.61*** (0.15)	-0.30 (0.49)
Model fixed effects?	No	No	No	Yes	No
Observations	58	58	58	58	58
R-squared	0.41	0.15	0.24	0.53	0.30

Notes: The table presents ordinary least squares regression coefficients, with each column representing a different regression. For each, the dependent variable is the percent increase in cost from a scenario involving no delay to a scenario involving a delay. Each observation is a comparison of a pair of scenarios with the same climate target, for a total of 58 observations. The regressors represent some of the variables that characterize each paired comparison: the simulated delay, the delay interacted with the concentration target (binned), whether only some countries delayed (partial delay), and the target concentration. The appendix lists all studies from which the data were drawn. The specification in column (1) does not include a constant.
Significant at the: *10% **5% ***1% significance level.
Source: CEA calculations on results from studies listed in appendix.

III. Climate Policy as Climate Insurance

As discussed in the 2013 NRC report, *Abrupt Impacts of Climate Change: Anticipating Surprises*, the Earth's climate history suggests the existence of "tipping points," that is, thresholds beyond which major changes occur that may be self-reinforcing and are likely to be irreversible over relevant time scales. Some of these changes, such as the rapid decline in late-summer Arctic sea ice, are already under way. Others represent potential events for which a tipping point likely exists, but cannot at the present be located. For example, there is new evidence that we might already have crossed a previously unrecognized tipping point concerning the destabilization of the West Antarctic Ice Sheet (Joughin, Smith, and Medley 2014 and Rignot et. al. 2014). A tipping point that is unknown, but thought unlikely to be reached in this century, is the release of methane from thawing Arctic permafrost, which could reinforce the greenhouse effect and spur additional warming and exacerbate climate change. Tipping points can also be crossed by slower climate changes that exceed a threshold at which there is a large-scale change in a biological system, such as the rapid extinction of species. Such impacts could pose such severe consequences for societies and economies that they are sometimes called potential climate catastrophes.

This section examines the implications of these potentially severe outcomes for climate policy, a topic that has been the focus of considerable recent research in the economics literature. The main conclusion emerging from this growing body of work is that the potential of these events to have large-scale impacts has important implications for climate policy. Because the probability of a climate catastrophe increases as GHG emissions rise, missing climate targets because of postponed policies increases risks. Uncertainty about the likelihood and consequences of potential climate catastrophes adds further urgency to implementing policies now to reduce GHG emissions.

Tail Risk Uncertainty and Possible Large-Scale Changes

Were some of these large-scale events to occur, they would have severe consequences and would effectively be irreversible. Because these events are thought to be relatively unlikely, at least in the near term – that is, they occur in the "tail" of the distribution – but would have severe consequences, they are sometimes referred to as "tail risk" events. Because these tail risk events are outside the range of modern human experience, uncertainty surrounds both the science of their dynamics and the economics of their consequences.

Because many of these events are triggered by warming, their likelihood depends in part on the equilibrium climate sensitivity. The IPCC WG I AR5 (2013) provides a likely range of 1.5° to 4.5° Celsius for the equilibrium climate sensitivity. However, considerably larger values cannot be ruled out and are more likely than lower values (i.e. the probability distribution is skewed towards higher values). Combinations of high climate sensitivity and high GHG emissions can result in extremely large end-of-century temperature changes. For example, the IPCC WG III AR5 (2014) cites a high-end projected warming of 7.8° Celsius by 2100, relative to 1900-1950.

A second way to express this risk is to focus on specific large-scale changes in Earth or biological systems that could be triggered and locked in by GHG concentrations rising beyond a certain point. At higher climate sensitivities, the larger temperature response to atmospheric GHG concentrations would make it even more likely that we would cross temperature-related tipping points in the climate system. The potential for additional releases of methane, a potent GHG, from thawing permafrost, thus creating a positive feedback to further increase temperatures, is an example of such a tail risk event. Higher carbon dioxide concentrations in the atmosphere, by increasing the acidity of the oceans, could also trigger and lock in permanent changes to ocean ecosystems, such as diminished coral reef-building, which decreases biodiversity supported on reefs and decreases the breakwater effects that protect shorelines. The probability of significant negative effects from ocean acidification can be increased by other stressors such as higher temperatures and overfishing.

The box summarizes some of these potential large-scale events, which are sometimes also referred to as “abrupt” because they occur in a very brief period of geological time. These events are sufficiently large-scale they have the potential for severely disrupting ecosystems and human societies, and thus are sometimes referred to as catastrophic outcomes.

Abrupt Impacts of Climate Change: Anticipating Surprises

The National Research Council's 2013 report, *Abrupt Impacts of Climate Change: Anticipating Surprises*, discusses a number of abrupt climate changes with potentially severe consequences. These events include:

- **Late-summer Arctic sea ice disappearance:** Strong trends of accelerating late-summer sea ice loss have been observed in the Arctic. The melting of Arctic sea ice comprises a positive feedback loop, as less ice means more sunlight will be absorbed into the dark ocean, causing further warming.
- **Sea level rise (SLR) from destabilization of West Antarctic ice sheets (WAIS):** The WAIS represents a potential SLR of 3-4 meters as well as coastal inundation and stronger storm surges. Much remains unknown of the physical processes at the ice-ocean frontier. However, two recent studies (Joughin, Smith, and Medley 2014, Rignot et. al. 2014) report evidence that irreversible WAIS destabilization has already started.
- **Sea level rise from other ice sheets melting:** Losing all other ice sheets, including Greenland, may cause SLR of up to 60 meters as well as coastal inundation and stronger storm surges. Melting of the Greenland ice sheet alone may induce SLR of 7m, but it is not expected to destabilize rapidly within this century.
- **Disruption to Atlantic Meridional Overturning Circulation (AMOC):** Potential disruptions to the AMOC may disrupt local marine ecosystems and shift tropical rain belts southward. Although current models do not indicate that an abrupt shift in the AMOC is likely within the century, the deep ocean remains understudied with respect to measures necessary for AMOC calculations.
- **Decrease in ocean oxygen:** As the solubility of gases decrease with rising temperature, a warming of the ocean will decrease the oxygen content in the surface ocean and expand existing Oxygen Minimum Zones. This will pose a threat to aerobic marine life as well as release nitrous oxide—a potent GHG—as a byproduct of microbial processes. The NRC study assesses a moderate likelihood of an abrupt increase in oxygen minimum zones in this century.
- **Increasing release of carbon stores in soils and permafrost:** Northern permafrost contains enough carbon to trigger a positive feedback response to warming temperatures. With an estimated stock of 1700-1800 Gt, the permafrost carbon stock could amplify considerably human-induced climate change. Small trends in soil carbon releases have been already observed.
- **Increasing release of methane from ocean methane hydrates:** This is a particularly potent long-term risk due to hydrate deposits through changes in ocean water temperature; the likely timescale for the physical processes involved spans centuries, however, and there is low risk this century.

- **Rapid state changes in ecosystems, species range shifts, and species boundary changes:** Research shows that climate change is an important component of abrupt ecosystem state-changes, with a prominent example being the Sahel region of Africa. Such state-changes from forests to savanna, from savanna to grassland, et cetera, will cause extensive habitat loss to animal species and threaten food and water supplies. The NRC study assesses moderate risk during this century and high risk afterwards.
- **Increases in extinctions of marine and terrestrial species:** Abrupt climate impacts include extensive extinctions of marine and terrestrial species; examples such as the destruction of coral reef ecosystems are already underway. Numerous land mammal, bird, and amphibian species are expected to become extinct with a high probability within the next one or two centuries.

Implications of Tail Risk

An implication of the theory of decision-making under uncertainty is that the risks posed by irreversible catastrophic events can be substantial enough to influence or even dominate decisions.

Weitzman's Dismal Theorem

Over the past few years, economists have examined the implications of decision-making under uncertainty for climate change policy. In a particularly influential treatment, Weitzman (2009) proposes his so-called "Dismal Theorem," which provides a set of assumptions under which the current generation would be willing to bear very large (in fact, arbitrarily large) costs to avoid a future event with widespread, large-scale costs. The intuition behind Weitzman's mathematical result rests with the basic insight that because individuals are risk-averse, they prefer to buy health, home, and auto insurance than to take their chances of a major financial loss. Similarly, if major climate events have the potential to reduce aggregate consumption by a large amount, society will be better off if it can take out "climate insurance" by paying mitigation costs now that will reduce the odds of a large-scale—in Weitzman's (2009) word, catastrophic—drop in consumption later.[25]

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[25] This logic has its basis in expected utility theory. Because individuals are risk averse, each additional dollar of consumption provides less value, or utility, to individuals than the previous dollar. To avoid this major loss, an individual will buy home insurance. That insurance is provided by the market because an insurance company can offer home insurance to many homeowners in different regions of the country, and through diversification the company will on average have many homeowners paying premiums and a few collecting insurance, so diversification allows the company to run a relatively low-risk business. But risks from severe climate change are not diversifiable because their enormous costs would impact the global economy. Consequently, as long as there is a non-negligible probability of a large drop in consumption, and therefore a very large drop in utility, arising from a large-scale loss in consumption, society today should be willing to pay a substantial amount if doing so would avoid that loss.

Weitzman's (2009) dismal theorem has spurred a substantial amount of research on the economics of what this literature often refers to as climate catastrophes. A number of authors (e.g. Newbold and Daigneault 2009, Ackerman et al. 2010, Pindyck 2011, 2013, Nordhaus 2011, 2012, Litterman 2013, Millner 2013), including Weitzman (2011, 2014), stress that although the strong version of Weitzman's (2009) result—that society would be willing to pay an arbitrarily large amount to avoid future large-scale economic losses—depends on specific mathematical assumptions, the general principle of taking action to prevent such events does not. The basic insight is that, just as the sufficiently high threat of a fire justifies purchasing homeowners insurance, the threat of large-scale losses from climate change justifies purchasing "climate insurance" in the form of mitigation policies now (Pindyck 2011), and that taking actions today could help to avoid worst-case outcomes (Hwang, Tol, and Hofkes 2013). According to this line of thinking, the difficulty of assessing the probabilities of such large-scale losses or the location of tipping points does not change the basic conclusion that, because their potential costs are so overwhelming, the threat of very large losses due to climate change warrants implementing mitigation policies now.

Several recent studies have started down the road of quantifying the implications of the precautionary motive for climate policy. One approach is to build the effects of large-scale changes into IAMs, either by modeling the different risks explicitly or by simulation using heavy-tailed distributions for key parameters such as the equilibrium climate sensitivity or parameters of the economic damage function. Research along these lines includes Ackerman, Stanton, and Bueno (2013), Pycroft et al. (2011), Dietz (2011), Ceronsky et al. (2011), and Link and Tol (2011). Another approach is to focus on valuation of the extreme risks themselves outside an IAM, for example as examined by Pindyck (2012) and van der Ploeg and de Zeeuw (2013). Kopits, Marten, and Wolverton (2013) review some of the tail risk literature and literature on large-scale Earth system changes, and suggest steps forward for incorporating such events in IAMs, identifying ways in which the modeling could be improved even within current IAM frameworks and where additional work is needed. One of the challenges in assessing these large-scale events is that some of the most extreme events could occur in the distant future, and valuing consumption losses beyond this century raises additional uncertainty about intervening economic growth rates and questions about how to discount the distant future.[26] The literature is robust in showing that the potential for such events could have important climate policy implications, however, the scientific community has yet to derive robust quantitative policy recommendations based on a detailed analyses of the link between possible large-scale Earth system changes and their economic consequences.

Implications of Uncertainty about Tipping Points

Although research that embeds tipping points into climate models is young, one qualitative conclusion is that the prospect of a potential tipping point with unknown location enhances the precautionary motive for climate policy (Baranzini, Chesney, and Morisset 2003, Brozovic and Schlenker 2011, Cai, Judd, and Lontzek 2013, Lemoine and Traeger 2012, Barro 2013, van der

[26] For various perspectives on the challenges of evaluating long-term climate risks, see Dasgupta (2008), Barro (2013), Ackerman, Stanton, and Bueno (2013), Roe and Bauman (2013), and Weitzman (2013).

Ploeg 2014). To develop the intuition, first suppose that the tipping point is a known temperature increase, say 3° Celsius above preindustrial levels, and that the economic consequences of crossing the tipping point are severe, and temporarily put aside other reasons for reducing carbon emissions. Under these assumptions climate policy would allow temperature to rise, stopping just short of the 3° increase. In contrast, now suppose that the tipping point is unknown and that its estimated mean is 3°, but that it could be less or more with equal probability. In this case, the policy that stops just short of 3° warming runs a large risk of crossing the true tipping point. Because that mistake would be very costly, the uncertainty about the tipping point generally leads to a policy that is more stringent today than it would be absent uncertainty. To the extent that delayed implementation means higher long-run CO_2 concentrations, then the risks of hitting a tipping point increase with delay.

As a simplification, the above description assumes away other costs of climate change that increase smoothly with temperature, as well as the reality that important tipping points in biological systems could be crossed by small gradual changes in temperatures, so as to focus on the consequences of uncertainty about large-scale temperature changes. When the two sets of costs are combined, the presence of potential large-scale changes increases the benefits of mitigation policies, and the presence of uncertainty about tipping points that would produce abrupt changes increases those benefits further.[27] Cai, Judd, and Lontzek (2013) use a dynamic stochastic general equilibrium version of DICE model that is modified to include multiple tipping points with unknown (random) locations. To avoid the Weitzman "infinities" problem, they focus on tipping events with economic consequences that are large (5 or 10 percent of global GDP) but fall short of global economic collapses. They conclude that the possibility of future tipping points increases the optimal carbon price today: in their benchmark case, the optimal pre-tipping carbon price more than doubles, relative to having no tipping point dynamics. Similarly, Lemoine and Traeger (2012) embed unknown tipping points in the DICE model and estimate that the optimal carbon price increases by 45 percent as a result. In complementary work, Barro (2013) considers a simplified model in which the only benefits of reducing carbon emissions come from reducing the probability of potential climate catastrophes, and finds that this channel alone can justify investment in reducing GHG pollution of one percent of GDP or more, beyond what would normally occur in the market absent climate policy.

[27] Cai, Judd, and Lontzek (2013) provide a stark example of this dynamic. Their analysis, which is undertaken using a modified version of Nordhaus's (2008) DICE-2007 model, includes both the usual reasons for emissions mitigation (damages that increase smoothly with temperature) and the possibility of a tipping point at an uncertain future temperature which results in a jump in damages.

References

Ackerman, Frank, Stephen J. DeCanio, Richard B. Howarth, and Kristen Sheeran. 2010. "The Need for a Fresh Approach to Climate Change Economics." In *Assessing the Benefits of Avoided Climate Change: Cost-Benefit Analysis and Beyond:* 159-181.

Ackerman, Frank, Elizabeth A. Stanton, and Ramón Bueno. 2013. "Epstein-Zin Utility in DICE: Is Risk Aversion Irrelevant to Climate Policy?" *Environmental Resource Economics* 56, 1: 73-84.

Barranzani, Andrea, Marc Chesney, and Jacques Morisset. 2003. "The Impact of Possible Climate Catastrophes on Global Warming Policy." *Energy Policy* 31, 8: 691-701.

Barro, Robert J. 2013. "Environmental Protection, Rare Disasters, and Discount Rates." *NBER Working Paper* 19258.

Blanford, Geoffrey J., Richard G. Richels, and Thomas F. Rutherford. 2009. "Feasible Climate Targets: The Roles of Economic Growth, Coalition Development and Expectations." *Energy Economics* 31, supplement 2: S82-S93.

Borenstein, Michael, Larry V. Hedges, Julian P.T. Higgins, and Hannah Rothstein. 2009. *Introduction to Meta-Analysis*. Chichester, U.K.: Wiley.

Bosetti, Valentina, Carlo Carraro, and Massimo Tavoni. 2009. "Climate Change Mitigation Strategies in Fast-Growing Countries: the Benefits of Early Action." *Energy Economics* 31, supplement 2: S14-S151.

Bosetti, Valentina, Carlo Carraro, Alessandra Sgobbi, and Massimo Tavoni. 2009. "Delayed Action and Uncertain Stabilisation Targets. How Much Will the Delay Cost?" *Climatic Change* 96, 3: 299-312.

Brozovic, N. and W. Schlenker. 2011. "Optimal Management of an Ecosystem with an Unknown Threshold." *Ecological Economics* 70, 4: 627-640.

Cai, Yonyang, Kenneth L. Judd, and Thomas S. Lontzek. 2013. "The Social Cost of Stochastic and Irreversible Climate Change." *NBER Working Paper* 18704.

Calvin, Katherine, James Edmonds, Ben Bond-Lamberty, Leon Clarke, Son H. Kim, Page Kyle, Steven J. Smith, Allison Thomson, and Marshall Wise. 2009a. "Limiting Climate Change to 450 ppm CO2 Equivalent in the 21st Century." *Energy Economics* 31, supplement 2: S107-S120.

Calvin, Katherine, Pralit Patel, Allen Fawcett, Leon Clarke, Karen Fisher-Vanden, Jae Edmonds, Son H. Kim, Ron Sands, and Marshall Wise. 2009b. "The Distribution and Magnitude of Emissions Mitigation Costs in Climate Stabilization under Less Than Perfect International Cooperation: SGM Results." *Energy Economics* 31, supplement 2: S187-S197.

Ceronsky, Megan, David Anthoff, Cameron Hepburn, and Richard S.J. Tol. 2011. "Checking the Price Tag on Catastrophe: The Social Cost of Carbon under Non-Linear Climate Response." *ESRI Working Paper* 392.

Clarke, Leon, Jae Edmonds, Volker Krey, Richard Richels, Steven Rose, and Massimo Tavoni. 2009. "International Climate Policy Architectures: Overview of the EMF 22 International Scenarios." *Energy Economics* 31, supplement 2: S64-S81.

Council of Economic Advisers. 2014. *Economic Report of the President, 2014*.

Dasgupta, Partha. 2008. "Discounting Climate Change." *Journal of Risk and Uncertainty* 37, 2/3: 141-169.

Dell, Melissa, Benjamin F. Jones, Benjamin A. Olken. 2013. "What Do We Learn from the Weather? The New Climate-Economy Literature." *Journal of Economic Literature*, forthcoming.

Deschênes, Olivier and Michael Greenstone. 2011. "Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the US." *American Economic Journal: Applied Economics* 3, 4: 152-185.

Dietz, Simon. 2011. "High Impact, Low Probability? An Empirical Analysis of Risk in the Economics of Climate Change." *Climatic Change* 108, 3: 519-541.

Edmonds, Jae, Leon Clarke, John Lurz, and J. Macgregor Wise. 2008. "Stabilizing CO_2 Concentrations with Incomplete International Cooperation." *Climate Policy* 8, 4: 355-376.

Graff Zivin, Joshua and Matthew Neidell. 2014. "Temperature and the Allocation of Time: Implications for Climate Change." *Journal of Labor Economics* 32, 1: 1-26.

Gurney, Andrew, Helal Ahammad, and Melanie Ford. 2009. "The Economics of Greenhouse Gas Mitigation: Insights from Illustrative Global Abatement Scenarios Modelling." *Energy Economics* 31, supplement 2: S174-S186.

Hwang, In Chang, Richard S.J. Tol, and Marjan W. Hofkes. 2013. "Tail-Effect and the Role of Greenhouse Gas Emissions Control." *University of Sussex Working Paper* Series 6613.

Intergovernmental Panel on Climate Change, Working Group I contribution to the Fifth Assessment Report (IPCC WG I AR5). 2013. *Climate Change 2013: The Physical Science Basis*.

Intergovernmental Panel on Climate Change, Working Group II contribution to the Fifth Assessment Report (IPCC WG II AR5). 2014. *Climate Change 2014: Impacts, Adaptation and Vulnerability*.

Intergovernmental Panel on Climate Change, Working Group III contribution to the Fifth Assessment Report (IPCC WG III AR5). 2014. *Climate Change 2014: Mitigation of Climate Change*.

Jaffe, Adam and Karen Palmer. 1997. "Environmental Regulation and Innovation: A Panel Data Study." *Review of Economics and Statistics* 79, 4: 610-619.

Jakob, Michael, Gunnar Luderer, Jan Steckel, Massimo Tavoni, and Stephanie Monjon. 2012. "Time to Act Now? Assessing the Costs of Delaying Climate Measures and Benefits of Early Action." *Climatic Change* 114, 1: 79-99.

Joughin, Ian, Benjamin E. Smith, and Brooke Medley. 2014. "Marine Ice Sheet Collapse Potentially Underway for the Thwaites Glacier Basin, West Antarctica." *Science* 344, 6185: 735-738.

Kopits, Elizabeth, Alex Marten, and Ann Wolverton. 2013. "Incorporating 'Catastrophic' Climate Change into Policy Analysis." *Climate Policy* ahead-of-print: 1-28.

Krey, Volker and Keywan Riahi. 2009. "Implications of Delayed Participation and Technology Failure for the Feasibility, Costs, and Likelihood of Staying Below Temperature Targets—Greenhouse Gas Mitigation Scenarios for the 21st Century." *Energy Economics* 31, supplement 2: S94-S106.

Lanjouw, Jean and Ashoka Mody. 1996. "Innovation and the International Diffusion of Environmentally Responsive Technology." *Research Policy* 25, 4: 549-571.

Lemoine, Derek and Christian Traeger. 2012. “Tipping Points and Ambiguity in the Economics of Climate Change.” *NBER Working Paper* 18230.

Link, P. Michael and Richard S.J. Tol. 2011. “Estimation of the Economic Impact of Temperature Changes Induced by a Shutdown of the Thermohaline Circulation: An Application of FUND.” *Climactic Change* 104, 2: 287-304.

Litterman, Bob. 2013. “What is the Right Price for Carbon Emissions?” *Regulation* 36, 2: 38-51.

Loulou, Richard, Maryse Labriet, and Amit Kanudia. 2009. “Deterministic and Stochastic Analysis of Alternative Climate Targets under Differentiated Cooperation Regimes.” *Energy Economics* 31, supplement 2: S131-S143.

Luderer, Gunnar, Valentina Bosetti, Michael Jakob, Marian Leimbach, Jan Steckel, Henri Waisman, and Ottmar Edenhofer. 2012. “The Economics of Decarbonizing the Energy System – Results and Insights from the RECIPE Model Intercomparison.” *Climatic Change* 114, 1: 9-37.

Luderer, Gunnar, Robert C. Pietzcker, Christoph Bertram, Elmar Kriegler, Malte Meinshausen, and Ottmar Edenhofer. 2013. “Economic Mitigation Challenges: How Further Delay Closes the Door for Achieving Climate Targets.” *Environmental Research Letters* 8, 3.

McKibbin, Warwick J., Adele C. Morris, and Peter J. Wilcoxen. 2014. “The Economic Consequences of Delay in U.S. Climate Policy.” Brookings: The Climate and Energy Economics Project.

Millner, Antony. 2013. “On Welfare Frameworks and Catastrophic Climate Risks.” *Journal of Environmental Economics and Management* 65, 2: 310-325.

National Research Council. 2010. *Limiting the Magnitude of Future Climate Change*. Washington, D.C.: The National Academies Press

National Research Council. 2011. *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia*. Washington D.C.: The National Academies Press.

National Research Council. 2013. *Abrupt Impacts of Climate Change: Anticipating Surprises.* Washington D.C.: The National Academies Press.

Newbold, Stephen and Adam Daigneault. 2009. “Climate Response Uncertainty and the Benefits of Greenhouse Gas Emissions Reductions.” *Environmental and Resource Economics* 44, 3: 351-377.

Nordhaus, William D. 2008. *A Question of Balance: Weighing the Options on Global Warming Policies*. New Haven: Yale University Press.

Nordhaus, William D. 2011. “The Economics of Tail Events with an Application to Climate Change.” *Review of Environmental Economics and Policy* 5, 2: 240-257.

Nordhaus, William D. 2012. “Economic Policy in the Face of Severe Tail Events.” *Journal of Public Economic Theory* 14, 2: 197-219.

Nordhaus, William D. 2013. *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World*. New Haven: Yale University Press.

Pindyck, Robert S. 2011. “Fat Tails, Thin Tails, and Climate Change Policy.” *Review of Environmental Economics and Policy* 5, 2: 258-274.

Pindyck, Robert S. 2012. “Uncertain Outcomes and Climate Change Policy.” *Journal of Environmental Economics and Management* 63, 3: 289-303.

Pindyck, Robert S. 2013. “Climate Change Policy: What do the Models tell us?” *Journal of Economic Literature* 51, 3: 860-872.

Popp, David. 2003. "Pollution Control Innovations and the Clean Air Act of 1990." *Journal of Policy Analysis and Management* 22, 4: 641-660.

Popp, David. 2006. "International Innovation and Diffusion of Air Pollution Control Technologies: The effects of NO_X and SO_2 Regulation in the U.S., Japan, and Germany." *Journal of Environmental Economics and Management* 51, 1: 46-71.

Popp, David, Richard G. Newell, and Adam B. Jaffe. 2010. "Energy, the Environment, and Technological Change." In *Handbook of the Economics of Innovation* 2: 873-937.

Pycroft, Jonathan, Lucia Vergano, Chris Hope, Daniele Paci, and Juano Carlos Ciscar. 2011. "A Tale of Tails: Uncertainty and the Social Cost of Carbon Dioxide." *Economics* 5, 22: 1-29.

Riahi, Keywan, Elmar Kriegler, Nils Johnson, Christoph Bertram, Michel den Elzen, Jiyong Eom, Michiel Schaeffer, Jae Edmonds, Morna Isaac, Volker Krey, Thomas Longden, Gunnar Luderer, Aurélie Méjean, David L. McCollum, Silvana Mimai, Hal Turton, Detlef P. van Vuuren, Kenichi Wada, Valentina Bosetti, Pantelis Caprosm, Patrick Criqui, Meriem Hamdi-Cherif, Mikiko Kainuma, and Ottmar Edenhofer. 2014. "Locked into Copenhagen Pledges—Implications of Short-Term Emission Targets for the Cost and Feasibility of Long-Term Climate Goals." *Technological Forecasting and Social Change*. In Press.

Richels, Richard G., Thomas F. Rutherford, Geoffrey J. Blanford, and Leon Clarke. 2007. "Managing the Transition to Climate Stabilization." *Climatic Policy* 7, 5: 409-428.

Rignot, Eric, Jeremie Mouginot, Mathieu Morlighem, Helene Seroussi, and Bernd Scheuchl. 2014. "Widespread, Rapid Grounding Line Retreat of Pine Island, Thwaites, Smith, and Kohler Glaciers, West Antarctica, from 1992 to 2011." *Geophysical Research Letters* 41, 10: 3502-3509.

Roe, Gerard H. and Yoram Bauman. 2013. "Climate Sensitivity: Should the Climate Tail Wag the Policy Dog?" *Climatic Change* 117, 4: 647-662.

Russ, Peter and Tom van Ierland. 2009. "Insights on Different Participation Schemes to Meet Climate Goals." *Energy Economics* 31, supplement 2: S163-S173.

Tol, Richard S.J. 2009. "The Feasibility of Low Concentration Targets: An Application of FUND." *Energy Economics* 31, supplement 2: S121-S130.

Tol, Richard S.J. 2014. "Correction and Update: The Economic Effects of Climate Change." *Journal of Economic Perspectives* 28, 2: 221-226.

United States Environmental Protection Agency. 2014. "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units." https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating

(USGCRP) U.S. Global Change Research Program. 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment.*

van der Ploeg, Frederick. 2014. "Abrupt Positive Feedback and the Social Cost of Carbon." *European Economic Review* 67: 28-41.

van der Ploeg, Frederick and Aart de Zeeuw. 2013. "Climate Policy and Catastrophic Change: Be Prepared and Avert Risk." *OxCarre Working Papers* 118, Oxford Centre for the Analysis of Resource Rich Economies, University of Oxford.

van Vliet, Jasper, Michael G.J. den Elzen, and Detlef P. van Vuuren. 2009. "Meeting Radiative Forcing Targets under Delayed Participation." *Energy Economics* 31, supplement 2: S152-S162.

Waldhoff, Stephanie A. and Allen A. Fawcett. 2011. “Can Developed Economies Combat Dangerous Anthropogenic Climate Change Without Near-Term Reductions from Developing Economies?” *Climatic Change* 107, 3/4: 635–641.

Waldhoff, Stephanie, Jeremy Martinich, Marcus Sarofim, Ben DeAngelo, James McFarland, Lesley Jantarasami, Kate Shouse, Allison Crimmins, Sara Ohrel, and Jia Li. 2014. “Overview of the Special Issue: A multi-model framework to achieve consistent evaluation of climate change impacts in the United States.” *Climatic Change*, forthcoming.

Weitzman, Martin. 2009. “On Modeling and Interpreting the Economics of Catastrophic Climate Change.” *The Review of Economics and Statistics* 91, 1: 1-19.

Weitzman, Martin. 2011. “Fat-Tailed Uncertainty in the Economics of Catastrophic Climate Change.” *Review of Environmental Issues and Policy* 5, 2: 275-292.

Weitzman, Martin. 2012. “GHG Targets as Insurance against Catastrophic Climate Damages.” *Journal of Public Economic Theory* 14, 2: 221-244.

Weitzman, Martin. 2013. “Tail-Hedge Discounting and the Social Cost of Carbon.” *Journal of Economic Literature* 51, 3: 873-882.

Weitzman, Martin. 2014. “Fat Tails and the Social Cost of Carbon*.” American Economic Review: Papers & Proceedings* 104, 5: 544-546.

Appendix: Literature on Delay Costs

This appendix lists the studies reviewed Section II and used in the meta-analysis, and briefly describes the scenarios they analyzed.

The EMF22 project engaged ten leading integrated assessment models to analyze the climate and economic consequences of delay scenarios. The EMF22 studies consist of Loulou, Labriet, and Kanudia (2009), Tol (2009), Gurney, Ahammad, and Ford (2009), van Vliet, den Elzen, and van Vuuren (2009), Blanford, Richels, and Rutherford (2009), Krey and Riahi (2009), Calvin et al. (2009a, 2009b), Russ and van Ierland (2009), and Bosetti, Carraro, and Tavoni (2009), with Clarke et al. (2009) providing an overview of the project.[28] Among other objectives, each study estimates the mitigation costs associated with five climate targets under both an immediate action scenario and a harmonized delay scenario. The targets are 450, 550, and 650 ppm CO_2e in 2100, and the models consider the first two targets alternatively allowing or prohibiting an overshoot before 2100.[29] In the delay scenario, only more developed countries (minus Russia) begin mitigation immediately in 2012 in a coordinated fashion (i.e., with the same carbon pricing), with some countries delaying action until 2030, and remaining countries delay action until 2050. These scenarios enable calculating the additional mitigation costs associated with delay for each concentration target.

The AMPERE project engaged nine modeling teams to analyze the climate and economic consequences of global emissions following the proposed policy stringency of the national pledges from the Copenhagen Accord and Cancún Agreements to 2030. (The AMPERE scenarios were not included in the meta-analysis in Section II because Riahi et al. (2014) did not provide sufficient information to calculate the percent increase in mitigation costs for each delay scenario.) One of the questions addressed by this project is the economic costs of delaying policies to reach CO2e concentration targets of 450 and 550 ppm in 2100 (Riahi et al. 2014). Eight models simulate pairs of policy scenarios reaching each target. One simulation in each pair assumes that all countries act immediately in a coordinated fashion (i.e., with the same carbon pricing), while the other simulation assumes that all countries follow the less stringent emissions commitments made during the Copenhagen Accord and Cancun Agreements until 2030, when coordinated international action begins.

The meta-analysis includes the following studies not associated with either AMPERE or EMF22: Jakob et al. (2012); Luderer et al. (2012, 2013); Edmonds et al. (2008); Richels et al. (2007), and Bosetti et al. (2009). Jakob et al. (2012) consider a 10-year delay of mitigation efforts to reach a 450 ppm CO_2 target by 2100, including variations where more developed countries implement mitigation immediately. Luderer et al. (2012) consider a similar 10-year delay and the same 450 ppm CO_2 target by 2100, with a scenario where Europe and all other industrialized countries

[28] Russ and van Ierland (2009) did not present estimates of total delay costs, so this paper is not included in the meta-analysis in Section II.

[29] We included three additional scenarios in van Vliet, den Elzen, and van Vuuren (2009) with alternate targets and models that were not reported in Clarke et al. (2009).

begin mitigation efforts in 2010. Luderer et al. (2013) analyze a scenario where countries implement fragmented policies before coordinating efforts in 2015, 2020, or 2030 to meet a target of 2°C above preindustrial levels by 2100, allowing for overshooting. Edmonds et al. (2008) consider targets of 450, 550, and 660 ppm CO_2, with newly developed and developing countries delaying climate action from a start date of 2012 to 2020, 2035 and 2050. Richels et al. (2007) estimate the additional cost of delay by newly developing countries until 2050 for a 450 and 550 ppm CO_2 target. Finally, Bosetti et al. (2009) estimate the additional cost when all countries delay climate action for 20 years with a goal of reaching a 550 ppm and 650 ppm CO_2e target by 2100.