PETITION TO LIST
The Gila mayfly, *Lachlania dencyanna* (Koss, 1970)

AS AN ENDANGERED SPECIES
UNDER THE U.S. ENDANGERED SPECIES ACT


Junction of Main and East forks of the Gila River, the type locality for *Lachlania dencyanna.*
Photograph by John Crossley, www.americansouthwest.net, used with permission.

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The Xerces Society for Invertebrate Conservation

Submitted by
The Xerces Society for Invertebrate Conservation, WildEarth Guardians and Dr. William Patrick McCafferty

September 21, 2010

The Honorable Ken Salazar
Secretary of the Interior
Office of the Secretary
Department of the Interior
1849 C Street N.W.
Washington D.C., 20240

Dear Mr. Salazar:

The Xerces Society, WildEarth Guardians and Dr. William Patrick McCafferty hereby formally petition the U.S. Fish and Wildlife Service to list the Gila mayfly, *Lachlania dencyanna*, as endangered pursuant to the Endangered Species Act, 16 U.S.C. §§ 1531 *et seq*. The Gila mayfly is known only from a small part of the Gila River drainage in southwestern New Mexico. This species is experiencing deteriorating ecological conditions as a result of increased sedimentation, nutrient loading, and pollution from recreational activities, agricultural operations, and cattle grazing; in addition to altered hydrological conditions and flow regimes from global climate change and increases in human water demand in an arid and increasingly populated region. In summary, the Gila mayfly is vulnerable to extinction from multiple anthropogenic threats and should be granted protection under the Endangered Species Act.

This petition is filed under 5 U.S.C. § 553(e) and 50 C.F.R. § 424.14 (1990), which grants interested parties the right to petition for issue of a rule from the Secretary of the Interior. Petitioners also request that critical habitat be designated concurrent with the listing, as required by 16 U.S.C. § 1533(b)(6)(C) and 50 C.F.R. § 424.12, and pursuant to the Administrative Procedure Act (5 U.S.C. § 553).

We are aware that this petition sets in motion a specific process placing definite response requirements on the U.S. Fish and Wildlife Service and very specific time constraints upon those responses. 16 U.S.C. § 1533(b). We will therefore expect a finding by the Service within 90 days, as to whether our petition contains substantial information to warrant a full status review. 16 U.S.C. § 1533(b)(3A).

Sincerely,

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The Xerces Society is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. Established in 1971, the Society is at the forefront of invertebrate protection worldwide, harnessing the knowledge of scientists and the enthusiasm of citizens to implement conservation programs.

WildEarth Guardians is a west-wide conservation group working to protect and restore wildlife, wild rivers, and wild places in the American West. The group has a long-standing campaign to safeguard the biodiversity and ecosystem health of the Greater Gila Bioregion.

Dr. William Patrick McCafferty is a professor at Purdue University, a North American mayfly expert, and the author of the widely used text *Aquatic Entomology: The Fisherman's and Ecologists' Illustrated Guide to Insects and their Relatives*.

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I. EXECUTIVE SUMMARY

Lachlania dencyanna is a highly unusual species of mayfly with rapid flight habits, atypical wing morphology, and a molting behavior that is unique among the Ephemeroptera (all mayflies) (Edmunds *et al.*, 1976, McCafferty *et al*., 1997). Known solely from a small area of the Gila River drainage system in Grant County, New Mexico, this narrowly endemic and sensitive species is in imminent danger of extinction (McCafferty *et al*., 1997). *Lachlania dencyanna* is threatened by numerous anthropogenic alterations to its habitat, including increased sedimentation, nutrient loading, as well as pollution resulting from recreational activities at Gila Cliff Dwellings National Monument and surrounding areas in the Gila National Forest. Cattle grazing is also increasing sediment and nutrients in this sensitive aquatic habitat. Additionally, this species is threatened by altered hydrological conditions and flow regimes, largely due to global climate change and increases in human water demand in an arid and increasingly populated region. These stressors, in combination with the species' limited range, limited dispersal ability, and the inherent instability of small populations, collectively threaten this rare and remarkable species with extinction. *Lachlania dencyanna* should be given immediate protection under the Endangered Species Act ("ESA").

II. CANDIDATE BACKGROUND, STATUS, AND LISTING HISTORY

Lachlania dencyanna currently receives no federal protection. This species is rated by NatureServe as G1 (Critically Imperiled; at high risk of range wide extinction or extirpation due to extreme rarity, rapidly declining numbers, or other factors) (NatureServe, 2009). This species was petitioned June 18, 2007 by WildEarth Guardians, as part of a multi-species petition based largely on NatureServe conservation rankings. The 90-day finding for this species reported that the petition did not present substantial information to indicate that listing of this species may be warranted (USFWS, 2009). This petition contains significantly more information demonstrating that *L. dencyanna* warrants ESA protection.

III. SPECIES DESCRIPTION

Mayflies (order Ephemeroptera) are elongate, soft-bodied insects with large compound eyes and typically three caudal filaments (two cerci and one terminal filament) projecting from the end of the abdomen, although some species (including *Lachlania dencyanna*) lack the terminal filament and have just two caudal filaments (Waltz & Burian, 2008). Since mayflies exhibit incomplete metamorphosis, the aquatic nymphs have many of the same features as the adult, differing mainly in the lack of wings. Mayfly adults generally have two pairs of wings: somewhat triangular forewings and much smaller hind wings (Waltz & Burian, 2008).

Lachlania dencyanna is a member of the family Oligoneuriidae, commonly known as the brush-legged mayflies. Both adults and nymphs in this family are among the most distinctive mayflies known, having diverged considerably from their nearest relatives (Edmunds *et al.*, 1976). Members of the Oligoneuriidae family are readily recognized from other families by the highly reduced wing venation (Triplehorn & Johnson, 2005). They are further separated from other mayfly families by having exposed anterior abdominal gills, un-fringed (as opposed to fringed) margins on gills of abdominal segments 2 – 7, and, most notably, a double row of long setae on the inner margins of the foreleg femora and tibiae (Waltz & Burian, 2008). The Oligoneuriidae family is primarily pantropical, with just two genera in North America: *Lachlania* and *Homoeoneuria* (Edmunds *et al.*, 1976). *Lachlania* nymphs are distinguished from *Homoeoneuria* and other Oligoneuriidae genera by several characteristics, including the flattened head with dorsal (as opposed to lateral) eyes; somewhat depressed (as opposed to stream-lined) body, claws present (as opposed to absent) on forelegs, and two (as opposed to three) caudal filaments (Edmunds *et al*., 1976, Waltz & Burian, 2008). *Lachlania* adults are distinguished from *Homoeoneuria* and other genera in the family by the forewing venation (presence of R_3 and IR_3) and male genitalia (presence of genital forceps) (Edmunds *et al*., 1976).

The presence of mid-dorsal abdominal tubercles is unique to *L. dencyanna* nymphs, and will readily distinguish this species from all other known nymphs of *Lachlania* (Koss & Edmunds, 1970). This species further differs from all other known *Lachlania* in the well-developed posterolateral projections of abdominal segment 9. *Lachlania dencyanna* is separated from *L. saskatchewanensis,* the only other *Lachlania* species in the United States, by the well-developed lateral projections of the thorax, the presence of lateral spines instead of hairs on the posterolateral abdominal projections, and the high density of short ventral abdominal spines (Koss & Edmunds, 1970). Mature nymphs of *L. dencyanna* are 15 to 17 mm in body length, with caudal filaments ranging from 10 to 12 mm in length. A complete, illustrated description of mature *L. dencyanna* nymphs is provided in Koss & Edmunds (1970).

Lachlania dencyanna adults are distinguished from other *Lachlania* species by wing venation. In particular, this species differs from *L. saskatchewanensis* by the greater number of crossveins in the forewing of *L. dencyanna* (Koss & Edmunds, 1970). *Lachlania saskatchewanensis* usually has a total of 3 crossveins in each forewing (5 is also possible, but less common, 25% or less), while *L. dencyanna* has a total of 5 to 14 crossveins in each forewing, with 8 to 14 being most common. *L. saskatchewanensis* has no more than 2 crossveins in the R1-R3 interspace, while *L. dencyanna* always has 3 or more crossveins in the R1-R3 interspace. The males of the two species are further distinguished as follows: the femur-tibia joints of the male meso- and metathoracic legs are pale in *L. dencyanna,* and brown in *L. saskatchewanensis*; the male sublateral abdominal sclerotized bars are poorly developed and visible dorsally in *L. dencyanna*, but well-developed and visible both laterally and dorsally in *L. saskatchewanensis.* The male genitalia are also distinctive for each species (Koss & Edmunds, 1970).

A complete, illustrated description of *Lachlania dencyanna* male and female imagoes (adults) is provided in Koss & Edmunds (1970). The body length of male *L. dencyanna* imagoes is 12-15 mm, the forewing length is 11-13 mm, and the caudal filaments are 38-43 mm. In females, the body length is 11 to 17 mm, the forewing length is 13 to 15 mm, and the caudal filaments are 8 to 11 mm in length (Koss & Edmunds, 1970).

IV. TAXONOMY

This species was described by Richard W. Koss and George F. Edmunds in 1970 based on collections by Koss in 1967. The original species epithet was *dencyanna*, although the ending was emended in 1997 to conform to the rules of zoological nomenclature: because it was based on the female name Dency Anne, it should have been given the appropriate *-ae* ending when Latinized by the original author (McCafferty *et al.*, 1997). The taxonomic status of this species is accepted as valid and is uncontested.

V. POPULATION DISTRIBUTION AND STATUS

Lachlania dencyanna is the only mayfly species endemic to New Mexico, where it is known from the upper Gila River drainage (McCafferty *et al.*, 1997). Although many other mayfly species occur in the Gila River drainage, *L. dencyanna* stands out as the only one restricted to the *upper* Gila River drainage, with a distribution that does not include the lower, Arizona portion of the drainage, or any other drainage (McCafferty *et al.*, 1997). In contrast, the only other *Lachlania* species in the United States (*L. saskatchewanensis*) is widespread, with a distribution stretching from Alberta and Saskatchewan south to Mexico, including Montana, Colorado, Nebraska, North Dakota, New Mexico, and Utah (Lugo-Ortiz & McCafferty, 1994; McCafferty *et al.* 1997; Guenther & McCafferty, 2005).

A. Historic Distribution

See Appendix I: Table 1 and Figures 1 and 2 for the historic distribution of this species. The range and abundance of *L. dencyanna* is not known prior to July, 1967 when the first known specimen (one nymph) was collected in Grant County, New Mexico, in a "tributary to the Gila River, one mile south of Cliff" (Koss & Edmunds, 1970). Two-hundred and twenty-one additional nymphs were collected over the next five days at a nearby locality, "East Fork of the Gila River at junction with Gila River, 40 miles north of Silver City, state highway 527." The first adult males (37) and females (29) were collected from this same locality that September, making this the type locality for the species. Additional specimens (two adult females and 10 larvae) were collected at the type locality in 1969.

B. Current Distribution

According to P. McCafferty, it is likely that this difficult-to-capture species still persists at the type locality at low numbers, although it has not been detected during the recent surveys (McCafferty, pers. comm., May 2010). The species is also thought to occur in the relatively pristine wilderness between the two known localities, although the number and abundance of populations are expected to have declined in recent years due to land use changes in the watershed and documented water-quality impairment in the streams (EPA, 2010).

In June of 1998 and 1999, benthic macroinvertebrate monitoring at the type locality revealed 29 different macroinvertebrate taxa, 11 of which were EPT (Ephemeroptera, Plecoptera, or Trichoptera), and four of which were mayfly species (Jacobi, 2000; NMED, 2002). Ten prior collections between 1987 and 1997 revealed at least twelve different mayfly species at this site (Guevara, pers. comm., May 2010). *Lachlania dencyanna*, however, was not observed in any of these collections, despite targeted collection of EPT and surveys which were conducted at the appropriate time of year for the nymphs of this species (Jacobi, 2000; NMED, 2002; Hogan, pers. comm., April 2010; Guevara, pers. comm., April 2010). Likewise, extensive benthic macroinvertebrate monitoring work in other portions of the watershed has not revealed this species (NMED, 2002; Hogan, pers. comm., April 2010; Guevara, pers. comm., April 2010). The Gila mayfly is not known to have been observed or collected since 1969 (McCafferty, pers. comm., April 2010), and appears to have declined at the type locality.

VI. HABITAT REQUIREMENTS

A. Overview

Mayflies are considered to be one of the most sensitive indicators of water quality in streams and are frequently used as sentinel organisms in biomonitoring, as they are among the first macroinvertebrates to disappear from systems impacted by physical habitat degradation and thermal and chemical pollution (Brittain, 1982; Menetrey *et al.*, 2008; Rosenberg & Resh, 1993; Barbour *et al.*, 1999). The larvae, in particular, have very narrow dissolved oxygen, pH, substrate, stream-size, and temperature requirements, making them especially vulnerable to eutrophication, sedimentation, nutrient loading, ambient water temperature changes, altered flow regimes, chemical pollutants, and other anthropogenic impacts on water quality (Brittain, 1982; Earl & Callaghan, 1998; Solimini *et al.*, 2006; Menetrey *et al.*, 2008; Bryce *et al.*, 2010).

By 1970, the type locality for this mayfly had already likely been severely impacted. The Gila mayfly type locality (East Fork of the Gila River at its junction with the Gila River) was described by Koss & Edmunds (1970) as a warm, turbid and rapid stream, mostly 6 in. to 2 ft. (~15.2 cm 0.61 m) in depth, 6 to 10 feet (~ 1.8 to 3 m) in width, and unshaded for most of the day (Koss & Edmunds, 1970). Nymphs that were kept overnight in a bucket of standing water perished (Koss & Edmunds, 1970), probably due to the species' requirements for fast-flowing water for adequate oxygen uptake. A detailed assessment of habitat-use by Koss & Edmunds (1970) found that the nymphs of this species utilize sticks and other vegetation caught in crevices among the rocks, unlike the closely related *Lachlania saskatchewanensis* nymphs, which were collected clinging to rocks. Jacobi (2000) describes the type locality as 5% boulder; 10% rubble; 10% gravel; and 75% sand/silt, and also notes that the substrate at this site was embedded in fine silt (Jacobi, 2000). These habitat changes may have resulted in the apparent decline or local extirpation of this species at this site.

B. Diet

Specific feeding behaviors of *L. dencyanna* nymphs have not been observed, but mayfly nymphs are mostly collectors or scrapers and feed on a variety of detritus and algae, as well as some macrophyte and animal material (Waltz & Burian, 2008). Mayfly feeding habits vary throughout the life cycle; newly hatched nymphs tend to feed primarily on fine particle detritus, and frequently shift to algae and eventually to animal material as they increase in size (Waltz & Burian, 2008). Adult mayflies have vestigial, nonfunctional mouthparts and do not feed (Waltz & Burian, 2008).

C. Life Cycle

Mayfly eggs are usually deposited at the surface of the water, either in large clusters or a few eggs at a time (Waltz & Burian, 2008). Although embryonic development usually takes just a few weeks, the eggs of most temperate species enter diapause, causing hatching to be delayed for approximately three to nine months. The majority of the mayfly life cycle is spent as an aquatic nymph. The length of the nymphal life stage varies greatly with temperature but is usually three to six months (Waltz & Burian, 2008). Specific information regarding the seasonality of this species was published by Koss & Edmunds (1970): during July, most nymphs appeared to be one to two weeks from emergence, although the observance of some individuals with darkened wing pads indicated that emergence was near or already occurring in a portion of the population. Mayfly nymphs actively feed and undergo numerous molts (ranging from ~12 to ~45) before emerging as a subimago (Waltz & Burian, 2008).

The subimago is a winged, terrestrial, pre-adult stage that resembles the adult (imago) in most features, but is sexually immature and undergoes one additional molt into the sexually mature imago stage. The metamorphosis of *Lachlania* is unique among all insects; this genus undergoes a peculiar process of subimaginal molting to adults in which the subimaginal cuticle is shed from the body but retained on the wings, resulting in the retention of microtrichia on the wings (Edmunds & McCafferty, 1988; McCafferty *et al.*, 1997). Although it has been hypothesized that the typical loss of wing microtrichia in the adult (as seen in other families of mayflies) is advantageous to flight due to reduced air friction, the *Lachlania* are among the fastest flying adult mayflies (*reviewed in* Edmunds & McCafferty, 1988), with flight speed rivaling that of a horsefly (McCafferty, pers. obs.). Adults fly upstream in a horizontal criss-crossing pattern, very atypical of mayflies (McCafferty, pers. obs.). Subimago behavior in the Gila mayfly is also highly unusual, even with regard to others in its genus, in that the subimago sheds the exoskeleton and molts into an adult without alighting, in contrast with typical mayfly subimagos which perch on shoreline vegetation during the molting process (McCafferty, pers. obs.).

Most adult mayflies live for two hours to three days (Waltz & Burian, 2008). Adults of this species were collected at the type locality on September 10th, but not observed during either of the July collecting trips (Koss & Edmunds, 1970). A detailed account of adult mating behavior is provided in Koss & Edmunds (1970), summarized as follows: adults first appeared around 11:30 A.M. and remained active until approximately 1:30 P.M. when the air temperature reached 82°F. The males flew a distance of 3 to 5 feet back and forth across the stream, facing upstream at approximately a 45° angle to the direction of the current, maintaining a height of 1 to 2 inches above the water, with "tails" (cerci) widespread. The males would occasionally dart up- or downstream a distance of 5 feet or more, or fly in one or more circles before continuing the back and forth flight pattern. Presumably exhausted males would occasionally alight on the water surface for one to two seconds and then resume the back and forth flight. Males were also observed "sitting and clambering about in the grass along the waters' edge" (Koss & Edmunds, 1970), a behavior which differs greatly from observations of *L. saskatchewanensis* adult males who did not alight or leave the air above the water at any time (Edmunds, 1951). *Lachlania dencyanna* females flew parallel to the current, either holding their position against the force of the wind, floating downwind (downstream), or shooting upwind (upstream). Quite frequently they were seen quickly flying downstream 20 feet or more, perhaps as an escape reaction following the perception of the observer's movements. Mated pairs of this species floated on the water when in tandem, the male on top of the female with his head posterior to hers (Koss & Edmunds, 1970), a position similar to that observed for *L. saskatchewanensis* (Edmunds, 1951).

VII. HABITAT STATUS AND CONDITION

A. Geographic, Hydrological, and Ecological Characteristics

The Gila River originates as three forks (East Fork, Middle Fork and West Fork) on the western slopes of the Continental Divide in the Black Range, an igneous mountain range running North-South through Grant and Sierra Counties in southwestern New Mexico. The river flows southwest through the Gila National Forest and the Gila Cliff Dwellings National Monument (near where this species occurs), then west and southwest over desert land into Arizona. It drains 58,000 square miles (150,000 sq. km) and flows 630 miles (1,014 km) before meeting its confluence with the Colorado River at Yuma, Arizona. Although the Gila River was historically a perennial stream carrying a large volume of water and navigable by boat from New Mexico to its mouth, numerous dams (including the Coolidge Dam) and water diversions for irrigation and municipal purposes have rendered the once navigable river dry and barren for most of its way across Arizona (McNamee, 1994). From below Phoenix to the confluence with the Colorado River, the Gila River is usually either a trickle or completely dry.

In contrast, stream flow in the upper Gila River is characterized by a snowmelt-dominated hydrograph (USFWS, 2003). Snowmelt runoff typically begins in February, peaks in March, gradually decreases through May, and returns to base flow conditions in June and into July. Mean monthly discharge characteristically increases in July through September, reflecting runoff patterns from convectional summer thunderstorms. In December and January, flows are often slightly elevated above base level due to sporadic periods of runoff from winter rains or mid-season snowmelt (USFWS, 2003). The climate in this region is mild, with average summer temperatures with lows of around 55º F and highs in the 90ºs F. Winter temperatures fall to the teens with highs in the 40ºs and 50ºs F (USDA Forest Service, n.d.).

The type locality for this species is located in the Gila Wilderness Area of the Gila National Forest (Wilderness Ranger District), a landscape comprised of steep mountains, rough deep canyons, flat mesas, large river channels, and flood plains (USDA Forest Service, n.d.). Higher elevations consist of a mixture of pine, spruce and other mixed conifers, while lower elevation vegetation is semi-desert shrub and grassland. Additionally, there are large tracts of ponderosa pine and areas with mixed pinyon-juniper-oak woodlands (USDA Forest Service, n.d.). This area of the Gila River system remains relatively intact compared to the vastly degraded lower reaches, although mining, logging, and cattle-grazing have resulted in habitat degradation, increased erosion and sedimentation, changes in water levels, increased water temperatures, and reduced bank cover (USFWS, 2003; Center for Biological Diversity, n.d. a,b). Other aquatic species in danger of extinction in the Upper Gila Watershed include the federally endangered Gila trout and Gila chub, and the threatened spikedace and loach minnow.

B. Land Ownership

The northwestern portion of the upper Gila River Basin is dominated by forested land, most of which is managed by the USDA Forest Service, although several private land parcels occur near the type locality of this species. Private ownership dominates the lower elevation drainages, including the Cliff locality for this species.

VIII. CURRENT AND POTENTIAL THREATS—SUMMARY OF FACTORS FOR CONSIDERATION

A. The Present or Threatened Modification, or Curtailment of its Habitat or Range

Like most mayflies, *L. dencyanna* requires a narrow set of environmental conditions to survive, including clean, rapidly flowing, well-oxygenated water and a substrate composed of rocks, leaves and other vegetation, and free of heavy siltation (Koss & Edmunds, 1970). Impaired water quality and habitat conditions have long been documented in many streams in the upper Gila River drainage, including the East Fork of the Gila River, the type locality for this species (EPA, 2010). This river has been on the Clean Water Act 303(d) list of impaired waters due to high levels of aluminum from 1996, when it was first assessed, to 2002, when an aluminum TMDL was completed (EPA, 2010; NMED, 2002). Both “chronic” (≥ 87 µg/L) and “acute” (≥750 µg/L) concentrations of aluminum have been recorded (NMED, 2002), and the most recent (2008) 305(b) report for this watershed continues to list the inability of this river to support high quality coldwater fishery due to high levels of aluminum (EPA, 2010). Aluminum in the water is highly toxic to aquatic insects at concentrations as low as 400 µg/L (Kegley *et al.*, 2009), and is known to alter the contents of structural lipids, deteriorate membrane structures, accumulate in tissues, decrease successful egg hatch, and increase adult mortality in mayflies and other aquatic insects (Tabak & Gibbs, 1991; Regerand *et al.*, 2005; Kegley *et al.*, 2009).

Since aluminum is a major constituent of both basalt and andesite (the main rock types which the East Fork Gila River runs through), it is not surprising that this metal is dissolved in the water column (NMED, 2002). However, even when metals are naturally present in rock or sediment, human activities which increase erosion can release these metals into surface waters at concentrations exceeding their background level. Grazing, off-road vehicles and other recreational and tourism activities have all been identified as probable sources contributing to the observed aluminum impairment in the East Fork Gila River (NMED, 2002; EPA, 2010, regarding 2008 listing cycle). Although aluminum is the only pollutant for which a TMDL has been developed, the East Fork Gila River has also suffered from additional impairments and was on 303(d) list in 1996 for habitat alteration (reduction of riparian vegetation), abnormal pH, and high levels of ammonia, nutrients, and total organic carbon (EPA, 2010, regarding 1996 listing cycle). High turbidity has also been recorded in this river (EPA, 2010, regarding 2002 listing cycle).

The primary threats to this species are identified as recreational activity and livestock grazing, both of which contribute to aluminum pollution in the water and lead to widespread habitat degradation that threatens the survival of this species. Dispersal limitations, the inherent vulnerability of small populations to stochastic events, and global climate change in this region pose additional threats to the continued existence of this species.

1. <u>Recreation</u>
The habitat conditions and water quality requirements of the Gila mayfly are threatened by intense recreational use at the type locality and surrounding area within the Gila National Forest (Wilderness Ranger District). The East Fork Gila River type locality for this species is located at Grapevine campground, a popular and very heavily used Forest Service dispersed campground with approximately 20 sites. The campground is free and open year round, and although usage data is not collected, federal employees who maintain the campground describe it as being "cram-packed" and "wall-to-wall with people," particularly on holidays, weekends, and in summer months (Carr, pers. comm., April 2010; Monzingo, pers. comm., April 2010). Vault toilets are present at the campground, but there are no fire-grates or picnic tables and the only water available to campers must come from the river (NPS, 2009). Common recreational activities at the campground and surrounding area include hiking, fishing, visiting hot-springs, swimming in the river, driving, horseback riding, and off road vehicle (ORV) use (Monzingo, pers. comm., April 2010). Rafting is popular when flows are high enough (March through May), and Grapevine Campground is a common put-in point for rafters (Allaboutrivers.com, 2010). In summertime, when flows are low, campers frequently swim in the river and have been observed re-arranging rocks and building dams in order to collect enough water to swim in (Monzingo, pers. comm., April 2010).

Recreational activities at this site may adversely affect *L. dencyanna* habitat in numerous ways, including increased erosion and sedimentation from foot, bike, car, and OHV traffic; runoff of pollutants from roads and ORV trails; introduction of bacteria and excess nutrients from dog and horse waste; manipulation and alteration of stream flow by swimmers; and the trampling of streamside riparian habitat by campers, hikers, rafters, and fishermen. Overall, intensified human activities in and around the Gila mayfly type locality is resulting in negative impacts on the aquatic and riparian habitat at this site.

The Gila Cliff Dwellings National Monument is a major attraction to this area, and although recreation at the monument may not directly impact this species, environmental damage associated with traffic to the monument is a threat. Located about five miles to the north of the campground, the monument is accessible only via the paved Hwy 15 which runs alongside the river and crosses it at numerous places including the type locality. Over the past 50 years, the monument has seen dramatic increases in visitation; in 1965 approximately 25,200 people visited the cliff dwellings, while in 2009, over 43,000 visitors were recorded (Deming, pers. comm., April 2010). Since usage data is only collected at the actual site of the cliff dwellings and doesn't include any other uses of the monument (*i.e.* hiking and horseback riding), the number of visitors to the area is actually much greater than the numbers represented in the annual reports (Deming, pers. comm., April 2010; NPS, 2010).

Visitor traffic on State Highway 15 and other roads criss-crossing the Gila River and draining into the watershed may negatively impact *L. dencyanna* habitat in several ways. As stated by Arnold & Gibbons

(1996), "as the natural landscape is paved over, a chain of events is initiated that typically ends in degraded water resources." Roads contribute substantially to sedimentation in aquatic systems; the increase in impervious surface area contributes to large quantities of overland flow, and both traffic and road maintenance activities generate large amounts of sediment (Anderson, 1996; Forman & Alexander, 1998; Jones *et al.*, 2000; Trombulak & Frissell, 2000; Gucinski *et al.*, 2001; Ziegler *et al.*, 2001; Grace, 2002), particularly in regions such as this, where the topography, soils, and climate make the watersheds very susceptible to erosion (NMED, 2002). In addition to increasing sedimentation, roads accumulate a variety of contaminants including brake dust, heavy metals, and organic pollutants, which are carried directly into streams by overland runoff (Forman & Alexander, 1998; Jones *et al.,* 2000; Trombulak & Frissell, 2000). Forest roads and smaller access roads often must receive periodic maintenance, including grading, which can increase the rate of erosion and deliver increased silt loads to streams (Gucinski *et al.*, 2001; Ziegler *et al.*, 2001; Grace, 2002). In addition to degrading habitat, road networks can also impose barriers to species dispersal, especially for insects such as adult mayflies, which are generally weak fliers and rely primarily on intact stream corridors for movement (Brittain, 1982).

2. <u>Grazing</u>

Livestock grazing is a common nonpoint source of pollution in this region, and both the East Fork Gila River type locality and the "Cliff locality" are threatened by grazing-related habitat impairment (Figures 1 and 2). The East Fork of the Gila has suffered extensively from grazing in the past, and although substantial recovery has been made on Forest Service land (e.g. Diamond Bank allotment), the river is still heavily impacted by grazing on private land, and many reaches are characterized by high sediment loads and eroding banks virtually devoid of woody vegetation (Hudak, pers. comm., April 2010; Brummett, pers. comm., April 2010). There are at least three private land parcels on the East Fork Gila River within 5 miles upstream of the type locality where cattle grazing is currently occurring or has occurred in the recent past (Figure 1; Monzingo, pers. comm., April 2010; Kramer, pers. comm., April 2010). Additionally, there are two active Forest Service grazing allotments on this river: Taylor Creek and Jordan Mesa allotments, both of which are permitted for year-round use (USDA Forest Service, 2009). Two-hundred cattle and 10 horses are permitted for the Jordan Mesa allotment, and 263 cattle and 7 horses are permitted for the Taylor Creek allotment (USDA Forest Service, 2009), although the actual number of cattle currently on these allotments is much fewer than that (Brummett, pers. comm., April 2010). Grazed private land surrounds both of these allotments (Brummett, pers. comm., April 2010). Regardless of land ownership, there are no exclosures in place in this area, and the cattle have complete access to the river and riparian zone, which is where they normally frequent (Brummett, pers. comm., April 2010).

The Gila National Forest has a history of failing to monitor and protect the wildlife habitat from damage due to livestock grazing (Center for Biological Diversity, 2003; Earthjustice, 2000), and was sued in 2000 for ignoring the forest plan requirements on more than 90% of the forest's grazing allotments and for arbitrarily ignoring regional utilization limits and establishing its own limits, in some cases more than twice the permitted level (Earthjustice, 2000). Copetitioner WildEarth Guardians was the lead plaintiff in this law suit.

Livestock grazing can degrade water quality and negatively impact aquatic macroinvertebrate communities in several ways: trampling riparian vegetation; consuming streamside vegetation and downcutting the riparian buffer; defecating and urinating on stream banks or in the channel; and increasing sedimentation due to removal of riparian vegetation and direct damage to banks and channel from trampling and wallowing. In places where cattle are not excluded from the stream bed, eutrophication and erosion are especially significant threats. Intensive livestock grazing has been shown to result in loss of biodiversity, disruption of biological communities, and dramatic alteration of terrestrial and aquatic communities (Fleischner, 1994; Agouridis *et al.*, 2005). The negative effects of livestock grazing are frequently magnified in riparian ecosystems, as cattle tend to congregate in these areas for the abundant forage, shade, and water (Kennedy, 1977; Roath & Krueger, 1982; Gillen *et al.*, 1984; Chaney *et al.*, 1993; Belsky *et al.*, 1999). The preference of livestock to loiter near streams results in increased defecation and urination in or near the water source, which can degrade water quality and alter both nutrient levels and the trophic status of streams (Strand & Merritt, 1999). Nitrogen, phosphorus, and potassium levels have been shown to increase in close proximity to livestock forage and watering sites (Mathews *et al.*, 1994). High nutrient inputs can lead to excess algae growth (algal blooms), which cause oxygen depletion due to the growth and decomposition cycle of algae feeding on the nutrients and the biochemical oxygen demand as ammonia is transformed to nitrate-nitrogen. Reduction in dissolved oxygen levels is deleterious to mayflies and poses a significant threat to this species.

Additionally, livestock grazing creates greater erosion potential due to removal of riparian and upland vegetation, removal of soil litter, increased soil compaction via trampling, and increased area of bare ground (Schultz & Leininger, 1990; Fleishner, 1994). Increased erosion leads to higher sediment loads in nearby waters, degrading habitat and increasing water turbidity. These problems are exacerbated by the livestock removal of riparian vegetation, as a riparian buffer helps filter overland runoff, slow flooding, and stabilize stream banks. A four-year study of a western mountain stream found a dramatic decline in macroinvertebrate abundance when just ten cow-calf pairs were allowed to graze in units along the stream from July through September, including significant reductions in species richness and total abundance of the sensitive Ephemeroptera, Plecoptera, and Trichoptera taxa (mayflies, stoneflies, and caddisflies) in grazed units versus ungrazed controls (McIver & McInnis, 2007). Likewise, a variety of aquatic macroinvertebrate community attributes relating to taxa diversity, community balance, trophic status, and pollution tolerance were strongly negatively impacted by moderate or heavy grazing in small mountain streams in Virginia, compared to lightly grazed or ungrazed controls (Braccia & Voshell, 2007). Livestock grazing has been shown to remove riparian zone vegetation and disrupt riparian plant communities (Kennedy, 1977; Kovalchik & Elmore, 1992; Fleishner, 1994), which, in turn, reduces the shading canopy, leading to rising water temperatures and lower dissolved oxygen levels, as well as decreased emergence material (*e.g.* woody debris) and food supply (leaf detritus) for active foraging nymphs. All of these factors, combined with increased sediment loads discussed previously, further imperil the Gila mayfly's survival at the known sites.

3. <u>Barriers to Dispersal</u>
Mayfly dispersal to new habitat occurs primarily by means of larval drift downstream of an existing population. Upstream (aerial) dispersal by adults is also possible, although adult dispersal over long distances is limited by the short life span and fragile nature of the adult (Brittain, 1982; Hynes, 1970). Even in species which fly relatively well, such as the Gila mayfly, adults are often restricted in distribution to stream reaches within or adjacent to their stream of origin (Hynes, 1970; Brittain, 2008). The current, impaired habitat conditions in the Gila River downstream of the known range of this species, and the Middle Fork and East Fork of the River, upstream (EPA, 2010), may limit the Gila mayfly's ability to both inhabit these rivers and to use them as vehicles to colonize or re-colonize other apparently suitable tributaries. The Gila mayfly may thus be confined to a much smaller set of stream reaches than historically. Dispersal potential is of particular importance for this species, since dispersal is likely associated with the long-term persistence of freshwater taxa, and may be a predictor of a species' ability to withstand global climate change (*reviewed in* Bilton *et al.*, 2001).

B. Overutilization for Commercial Purposes
The Gila mayfly is not used commercially, nor is it at risk of over-collection.

C. Disease or Predation
Neither disease nor predation is known to threaten *L. dencyanna* at this time. However, little is known about the life history and ecology of this species, and threats from these influences have never been assessed. The occurrence of black fly (Simuliidae) and midge (Chironomidae) phoretic parasites has been reported on the nymphs of a Brazilian species of *Lachlania* (Pepinelli, *et al.*, 2009), although the effects of such parasitism on nymphal survival, longevity, movement, molting potential, vulnerability to predators, and feeding efficiency have not been examined. As discussed below, the rarity of the Gila mayfly and its confined range makes it more vulnerable to extinction as a result of normal population fluctuations resulting from predation or disease.

D. The Inadequacy of Existing Regulatory Mechanisms
Despite being the only endemic mayfly to New Mexico, the Gila mayfly is not ranked by Natural Heritage New Mexico (NHNM) (NatureServe, 2009), and currently receives no recognition or protection under federal or state law. The New Mexico Wildlife Conservation Act does not extend to insects (NMDGF, 2008). It is recognized as a Species of Greatest Conservation Need by the New Mexico Department of Game and Fish (NMDGF, 2006), and as Globally Imperiled (G1) by NatureServe (2009), but these designations do not provide any protection for the species or its habitat.

E. Other natural or manmade factors affecting its continued existence
1. Small population size and stochastic events

The population size(s) of the Gila mayfly are unknown but presumably small, as recent macroinvertebrate monitoring at the type locality has not revealed this species, despite prior collections of 221 nymphs at this locality over a period of just 5 days (Koss & Edmunds, 1970). Small and fragmented populations are generally at a greater risk of extinction from normal population fluctuations due to predation, disease, and changing food supply, as well as from natural disasters such as floods or droughts (*reviewed in* Shaffer, 1981). Small populations are also threatened with extinction from a loss of genetic variability and reduced fitness due to the unavoidable inbreeding that occurs in such small populations (*reviewed in* Shaffer, 1981). Specific vulnerability of mayflies to stochastic events and small population size has been documented, including the difficulty for fertile adults to locate each other in small mayfly populations, resulting in continued population declines or die-off (*reviewed in* Brittain, 2008).

2. Global climate change

a. Temperature and precipitation changes

Assessment of global climate change trends in North America has already revealed substantial changes in temperature and precipitation patterns, particularly in the American Southwest, where spring and summer snow cover is decreasing, periods of drought are more frequent and intense, and warming trends exceed global averages by about 50% (D'Antonio, 2006; Intergovernmental Panel on Climate Change, 2007; Saunders *et al.*, 2008; US Global Change Research Program, 2009). In New Mexico, wintertime average temperatures have increased by nearly 1.5°F since the 1960s (D'Antonio, 2006), and statewide climate models project substantial changes in New Mexico's climate over the next fifty to one hundred years, including:

- air temperatures warmer by 6-12°F on average
- increased episodes of extreme heat, fewer episodes of extreme cold; more severe droughts
- a longer frost-free season
- more intense storm events, flash floods, and torrential rains
- winter precipitation falling more often as rain, less often as snow

(*reviewed in* Agency Technical Work Group, 2005).

Since water supply and stream flow in the upper Gila River drainage are regulated largely by snow-pack (USFWS, 2003), increases in temperature will have important consequences for the hydrological cycle in this drainage. Less winter precipitation falling as snow and the melting of winter snow earlier in the spring will shift peak river runoff toward winter and early spring, and away from summer and autumn when the demand for water is highest (Barnett *et al.*, 2005; Agency Technical Work Group, 2005). In addition to drastic reductions in stream flow, climate change models also predict winter and spring flooding due to earlier, more rapid snowmelts, and summertime flash flooding due to intense summer storms (Agency Technical Work Group, 2005).

Survival of the Gila mayfly will thus require tolerance of both severe hydrological changes (*e.g.* lower minimum flows and longer periods of extremely low flow) and the physical and chemical habitat disturbance imposed by the predicted flooding scenarios, including substrate disturbance, sedimentation, scouring of stream channels, and increased levels of contaminated runoff, such as from roads, grazing lands, and agricultural parcels in the watershed (Agency Technical Work Group, 2005). Given the rare and isolated status of this species (McCafferty *et al*., 1997), its sensitivity to flow patterns, substrate conditions, and water pollution (Koss & Edmunds, 1970; Brittain, 1982; McCafferty *et al*., 1997), and the already impaired water quality in its habitat (EPA, 2010); even slight climate-induced changes of the above nature are of serious concern (Brittain, 2008).

Physiological changes to the Gila mayfly are also expected as a result of climate change, as temperature is known to regulate physiological processes within each stage of the mayfly life-cycle (Brittain, 2008). Egg hatching in many mayflies is temperature dependent, requiring a combination of specific cool periods to break diapause and specific warm temperatures to stimulate hatching (Waltz & Burian, 2008). Additionally, there is a clear relationship between water temperature and the length of egg development, and distinct temperature limits for successful egg development have been reported (Elliott & Humpesch 1980 *in* Brittain, 2008). Various properties of the nymphal and subimago stages are also thermally regulated (Waltz & Burian, 2008). Adult body size, for example, depends largely on thermal conditions during nymphal development. Suboptimal temperatures result in smaller adults, which in turn have lower fecundity, since mayfly fecundity is closely correlated with adult size (*reviewed in* Brittain 1980). The timing of subimago emergence from the nymphal stage is highly correlated with water temperature (Brittain 1980; Harper & Peckarsky, 2006) and experimental studies have demonstrated that earlier mayfly emergence is likely in a warmer climate (Harper & Peckarsky, 2006). Likewise, subimago transformation to sexually mature adults appears to be tightly linked to climatic conditions, with more rapid transformations and shorter subimago stages in warm climates (e.g. Waltz & Burian, 2008). Since male and female nymphal and subimago transformations are generally asychronized (*e.g.* males emerging from the nymphal stage several hours before the females, but both sexes transforming into adults around the same time), climatic alterations could disrupt highly complicated patterns of emergence and pre-mating behavior (Waltz & Burian, 2008). All of these factors suggest that intensifying climatic shifts in this region could cause significant changes in mayfly egg viability, timing of metamorphosis, duration of life cycle stages, adult body size and fecundity, and mating success (Brittain, 2008), resulting in further threats to the successful reproduction and maintenance of existing populations of the Gila mayfly.

b. Climate-driven changes in availability of water to meet human demand

Projected climatic changes in this region will likely have a significant impact on the availability of and demand for New Mexico's water during the next century (D'Antonio, 2006). Limitations imposed on water supply by temperature increases are likely to be made worse by predicted reductions in rain and snowfall in the spring months, when precipitation is most needed to fill reservoirs to meet summer demand (US Global Change Research Program, 2009). Despite the already limited water supply and substantial pressures on water resources in this arid region, the human population is rapidly increasing in New Mexico, Arizona, and across the southwestern United States, creating an even greater water demand (D'Antonio, 2006). In the Gila River drainage, in particular, water supplies are notoriously limited, and the availability of water has become a serious concern for many cities, communities, and rural areas, particularly in the lower portions of the drainage where numerous dams and water diversions for irrigation and municipal purposes have rendered the once navigable river dry and barren for most of its way across Arizona (McNamee, 1994).

The upper Gila River Drainage where the Gila mayfly occurs is the last remaining undammed stretch of the Gila River, and although highly valued for its wildlife habitat and recreational uses, current water limitations in Arizona and New Mexico are causing officials to look toward this area as an important water resource (McNamee, 1994). The Central Arizona Project (CAP) is a multipurpose water resource development project authorized in 1968 for management of irrigation, municipal, and industrial water in Arizona and parts of New Mexico (USDI Bureau of Reclamation, 2009). A subject of much local controversy, the plan includes the construction of Hooker Dam and Reservoir on the upper Gila River, designed to provide 18,000 acre-feet water storage, flood and sediment control, and recreation opportunities. The 1986 listing of two fish species (the spike dace and the loach minnow) as threatened under the Endangered Species Act has done little to hinder this project, and a report issued by the Bureau of Reclamation in 1987 stated that part or all of the 18,000 acre-feet at issue might be developed in a way consistent with protecting endangered fish species of the Gila River (NM Office of the State Engineer, 1999). The report's economic analysis, however, suggested that the project be delayed until available groundwater supplies are no longer adequate to meet Grant County municipal and industrial water needs, which was expected to occur around the year 2010 (NM Office of the State Engineer, 1999). Although these facilities have not yet been built and are currently in deferred status due to "cost considerations, a lack of demand for the water, lack of repayment capability by the users, and environmental constraint," the structures are still authorized, and the Bureau of Reclamation is continuing to evaluate information to assist the state in determining whether to pursue this construction project or some other water supply alternative in the Upper Gila Basin (USDI Bureau of Reclamation, 2009). Inarguably, the construction of Hooker Dam and Reservoir would do irreparable harm to the relative integrity of the upper Gila River drainage, potentially devastating the riverine environment and its suitability to mayflies in this area (*e.g.* Malmgvist & Englund 1996) and posing even further threats to the continued survival of *L. dencyanna.*

IX. CRITICAL HABITAT

Petitioners request the designation of critical habitat for the Gila mayfly concurrent with its listing. Critical habitat should include areas of the Gila River, at sites where this species currently and/or historically occurred.

X. CONCLUSION

For the above reasons, the Gila mayfly meets three criteria under the Endangered Species Act for consideration as an endangered species: 16 U.S.C. § 1533 (a)(1)(A,D,E) (Section 4) including: (A) The present or threatened destruction, modification, or curtailment of its habitat or range, (D) The inadequacy of existing regulatory mechanisms, and (E) Other natural or manmade factors affecting its continued existence.

Due to the multiple different threats faced by this species, its small population size, restricted distribution, isolation, and the likelihood that it will be driven to extinction, the Xerces Society for Invertebrate Conservation, WildEarth Guardians and Dr. William Patrick McCafferty formally petition the U.S. Fish and Wildlife Service to list the Gila mayfly (*Lachlania dencyanna*) as endangered species. Furthermore, we request the Service use its authority to establish Critical Habitat based on the facts presented to prevent the extinction of this rare and vulnerable mayfly.

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XII. PERSONAL COMMUNICATIONS

Tawnya Brummett, Gila National Forest, Wilderness Ranger District
Mike Carr, Gila Cliff Dwellings National Monument
Anita Deming, Gila Cliff Dwellings National Monument
Mike Hudak, Author and activist
James Hogan, New Mexico Environment Department: Surface Water Quality Bureau
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Lynette Guevara, New Mexico Environment Department: Surface Water Quality Bureau
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Virginia McLemore, New Mexico Bureau of Geology and Mineral Resources
Jerry Monzingo, Gila National Forest

APPENDIX I. Table and Maps of the Gila mayfly collection localities.

Table 1. Known records of *Lachlania dencyanna*, Grant County, New Mexico. Additional information (*e.g.* collector, determiner, repository) is available from the Xerces Society. M = male; F = female; H = holotype; A = allotype; P = paratypes.

Locality	**Date**	**Number of Specimens**
East Fork of the Gila River at junction with Gila River	10 Sept 1967	1 M imago (H), 1 F imago (A), 36 M imagoes (P), 27 F imagoes (P), 2 nymphs (P).
East Fork of the Gila River at junction with Gila River	15-19 July 1967	221 nymphs
Tributary to Gila River, 1 mile south of Cliff	14 July 1967	1 nymph
East Fork of the Gila River at junction with Gila River	1969	2 F, 10 nymphs

Figure 1. Google Earth satellite image of the type locality (A) on the East Fork Gila River where it meets the main stem Gila River. Note the adjacent Grapevine Campground (B), and one of the larger parcels of

private, grazed land (C), one river mile upstream (northeast) of the type locality.

Figure 2. Google Earth satellite image of the Cliff locality (A) ("tributary to Gila River, one mile south of Cliff"). Cattle ranching is the dominant land-use in this area (Brummett, pers. comm., April 2010).