PETITION TO LIST
The western glacier stonefly, *Zapada glacier* (Baumann & Gaufin, 1971)

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

Cataract Creek below Grinnell Glacier, the type locality for *Zapada glacier*.
Photograph by Lynn Lazenby, used with permission.

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Submitted by
The Xerces Society for Invertebrate Conservation
The Center for Biological Diversity
December 30, 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 for Invertebrate Conservation and the Center for Biological Diversity hereby formally petition the U.S. Fish and Wildlife Service to list the western glacier stonefly, *Zapada glacier*, as endangered pursuant to the Endangered Species Act, 16 U.S.C. §§ 1531 *et seq*. 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.

The Center for Biological Diversity is a non-profit, public interest environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has over 42,000 members throughout the United States. The Center and its members are concerned with the conservation of endangered species, including the western glacier stonefly, and the effective implementation of the ESA.

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I. EXECUTIVE SUMMARY

The western glacier stonefly (*Zapada glacier*) is a glacier meltwater-dependent stonefly known solely from a small area of Glacier National Park in Glacier County, Montana. Immature stoneflies, including the western glacier stonefly, have very narrow temperature requirements, making them especially vulnerable to extinction from increases in ambient water temperature. This narrowly endemic species is threatened by increases in water temperature and decreases in dissolved oxygen as a result of human-induced climate change in this region, specifically the loss of the glacial habitat on which this species depends. The glaciers within Glacier National Park are predicted to disappear by 2030. Loss of the glaciers, in combination with the species' limited range, limited dispersal ability, and the inherent instability of small populations, collectively threaten this rare species with extinction. *Zapada glacier* should be given immediate protection under the Endangered Species Act ("ESA").

II. CANDIDATE BACKGROUND, STATUS, AND LISTING HISTORY

Zapada glacier currently receives no federal protection. This species is rated by the Montana Natural Heritage Program (MNHP) as S1 (at high risk of range wide extinction or extirpation due to extremely limited and/or rapidly declining population numbers, range, and/or habitat) (MNHP, 2010). The NatureServe global ranking for this species has recently changed from G2 (Imperiled) to G1 (Critically Imperiled), based on the fact that climate change poses "an imminent and immediate threat [to this species], operationally occurring now and in the next couple years" (Stagliano, pers. comm., May 2010; Cordeiro, pers. comm., May 2010; Capuano, pers. comm., May 2010; NatureServe, 2009). To the best of our knowledge, this species has not been petitioned for listing in the past, nor does it have any federal status.

III. SPECIES DESCRIPTION

Stoneflies (order Plecoptera) are somewhat flattened, elongate, soft-bodied insects with filamentous antennae, large compound eyes, and two sensory tails (cerci) projecting from the end of the abdomen. Stonefly adults are generally characterized by having two pairs of membranous, heavily cross-veined wings, although adults (usually males) of a few species have wings that are reduced (brachypterous) or absent (apterous) (Stewart & Stark, 2008). Since stoneflies exhibit incomplete metamorphosis, the aquatic nymphs have many of the same features of the adult, including the paired cerci, and differ mainly in the lack of wings.

The western glacier stonefly is a member of the family Nemouridae, genus *Zapada*. Nymphs of the Nemouridae family are separated from other families by the small, stout body with numerous spines and the hairs on the dorsal surface and appendages (Baumann *et al.*, 1977). Adults are readily distinguished by the distinctive nemourid "X" in the adult forewing (Baumann, 1975; Baumann *et al.*, 1977). *Zapada* is a very distinctive genus in both the nymphal and adult stage (Baumann, 1975). *Zapada* nymphs are distinguished from other genera in the family by the very specialized whorls of large spines on all femora (Baumann, 1975). Adults of this genus have a single, simple gill on each side of the lateral cervical sclerites resulting in four single gills total, two on each side of the neck (Baumann, pers. comm., May 2010). Additionally, *Zapada* adults are characterized by large angular outer paraproctal lobes and a short, broad epiproct with the dorsal sclerite well developed (Baumann, 1975).

A complete, illustrated description of *Zapada glacier* males and females is provided in Baumann and Gaufin (1971). The males are brown in general color with yellowish-brown legs, darkened at the tip of the femora and apex of the tibiae. The hyaline forewings have wide dark transverse bands at the cord and the hindwings have a dark area in the costal space beyond the cord. The male body length is 6.5-8.0 mm and the forewing length is 7-8 mm. In females, the body length is 8-10 mm and the forewing length is 9-11 mm. Both sexes are macropterous ("large-winged"), and the female body, appendages, and wings are similar to the males (Baumann & Gaufin, 1971). *Zapada glacier* nymphs have not been associated with the adults or distinguished from other nymphs in the *Z. oregonensis* group (Baumann & Gaufin, 1971; Baumann, pers. comm., May 2010). They can be recognized as belonging to the *Z. oregonensis* group by the simple cervical gills which are unbranched and not constricted past the base (Baumann & Gaufin, 1971; Stagliano *et al.*, 2007).

IV. TAXONOMY

This species was described by Richard Baumann and Arden Gaufin in 1971 based on collections (largely by Gaufin) from 1963 to 1969. The species was originally described as *Nemoura* (*Zapada*) *glacier* (Baumann & Gaufin, 1971) and later classified as *Zapada glacier* (Baumann, 1975). The taxonomic status of this species is currently accepted as valid and is uncontested.

V. POPULATION DISTRIBUTION AND STATUS

This species is restricted in distribution to a small area of Glacier National Park, Glacier County, northwest Montana. Of the 100 stonefly species documented from Glacier National Park, *Z. glacier* is one of just four species only found within the park on the east side of the Continental Divide (Newell *et al.*, 2006).

A. Historic Distribution

The range and abundance of *Z. glacier* is not known prior to 1963 when the first known specimen (one female) was collected from Wilbur Creek, a glacier-fed stream below Many Glacier (Baumann & Gaufin, 1971). Between 1964 and 1969 four additional localities for this species were found in the park: Cataract Creek, below Grinnell Lake; Grinnell Creek; Iceberg Creek, below Iceberg Lake; and Ptarmigan Creek (Bauman & Gaufin, 1971) (APPENDIX I: Table 1). The 1964 type locality is Cataract Creek, below Grinnell Lake. The majority of the records for this species are from Iceberg Creek, below Iceberg Lake. Although abundance estimates have not been conducted for this species, no more than four individuals have been collected at a single date/site combination, and twelve is the greatest number of individuals collected at a single site (Iceberg Creek) over multiple years.

B. Current Distribution

Zapada glacier is not known to have been observed or collected since 1979, although macroinvertebrate surveys haven't been conducted at the historic streams in recent years (Schweiger, pers. comm., May 2010), and the species is expected to be extant at most sites (Baumann, pers. comm., May 2010). Recent macroinvertebrate monitoring in Glacial National Park has documented several localities for the *Zapada oregonensis* group to which this species belongs, however, all collections were of the larval stage which makes further taxonomic resolution impossible, since only adults of this group can be positively identified (Schweiger, pers. comm., May 2010; Bollman, pers. comm., May 2010; Baumann, pers. comm., May 2010). According to Baumann (pers. comm., May 2010), the majority of these collections are thought to be *Z. haysi*, a very common species in the park and elsewhere. No localities other than those in the type series have been documented for *Z. glacier* adults (Stagliano *et al.*, 2007; Newell *et al.*, 2006; Baumann, pers. comm., May 2010; Newell, pers. comm., May 2010; Giersch, pers. comm., May 2010).

VI. HABITAT REQUIREMENTS

A. Overview

Stoneflies are considered to be one of the most sensitive indicators of water quality in streams and are frequently used as sentinel organisms in biological monitoring, as they are among the first macroinvertebrates to disappear from systems that are impacted by increases in water temperature (thermal pollution), as well as other forms of pollution and physical habitat degradation (Gaufin, 1973; Baumann, 1979, Rosenberg & Resh, 1993; Stark *et al.*, 1998; Barbour *et al.*, 1999). The larvae, which are entirely aquatic, have very narrow temperature requirements, making them especially vulnerable to the increases in ambient water temperature that are predicted to occur with global climate change. Stonefly larvae also have very specific dissolved oxygen, substrate, and stream-size requirements, which makes them vulnerable to sedimentation, nutrient loading, and other anthropogenic impacts on water quality. (Baumann 1979; Williams & Feltmate, 1992; Stewart & Stark, 2008).

Zapada glacier is exclusively known from steep, high elevation, glacier-fed alpine streams below glaciers or glacial lakes (Baumann & Gaufin, 1971; Baumann *et al.*, 1977; Newell *et al.*, 2006). Like other lakes in Glacier National Park, the lakes that feed the streams where this species lives are oligotrophic (low productivity and very clear) due to very cold temperatures, extreme depth, and unique mineral composition from the surrounding rock (NPS, 2008). The limiting habitat requirement for *Z. glacier* is cold, glacial melt-water, since the species is only found in glacier-fed streams despite hundreds of other streams in Glacier National Park with similar substrate and riparian vegetation characteristics (Baumann, pers. comm., May 2010). The Idaho Department of Environmental Quality defines the entire *Zapada oregonensis* group – to which *Z. glacier* belongs – as Cold Water Obligate Taxa with a temperature preference of 8.8°C (Grafe *et al.* 2002).

Baumann (pers. comm., May 2010) describes the streams where this species occurs as having a rocky (not sandy) substrate composed of variously sized cobble with some detritus. The stream microhabitat for *Zapada* larvae, in general, is described as leaf packs (accumulation of leaf litter and other coarse particulate detritus) and debris (*e.g.* logs, branches) in riffles (Stewart & Stark, 2008; Merritt *et al.*, 2008). This species is found just below the alpine tree-line, and the riparian vegetation generally consists of grasses, bushes, and conifers (Baumann, pers. comm., May 2010).

B. Diet

The specific feeding behaviors of *Z. glacier* nymphs have not been observed, but nymphs in this family are primary consumers and feed mostly on detritus (Baumann, 1975). The morphology of *Zapada glacier* mouthparts suggests that this species, like others in its genus, is well-suited for shredding plant tissue and coarse particulate organic matter (Stewart & Stark, 2008; Merritt *et al.*, 2008). Adult stoneflies generally hide on branches or vegetation during the day, and crawl about at night to feed (Hynes, 1976). Female stoneflies must eat to acquire nutrients for their eggs, but males in some families consume only water (Hynes, 1976). The adult feeding behavior of these species has not been documented, but nemourid adults are known to feed on epiphytic algae or the young leaves, buds, and pollen of riparian vegetation (Stewart & Stark, 2008).

C. Life Cycle

Species in the family Nemouridae have a one to two-year life cycle with diapause occurring in the egg stage in some species (Stewart & Stark, 2008). After a given period of active feeding and growth, mature nymphs climb out of the water onto rocks, leaf packs, or pieces of wood that extend above the water-line and emerge as adults. Most species in the genus *Zapada* emerge very early in the year and are collected along with the winter stoneflies (Capniidae), but the emergence period varies with species and elevation (Baumann, 1975; Stewart & Stark, 2002). *Zapada glacier* emerges relatively late compared to others in its genus, and adults have been collected from July 9th to 30th (Baumann & Gaufin, 1971). Male stoneflies attract females by drumming, *i.e.* tapping specialized structures on their terminal abdominal segments on the substrate (Hynes, 1976; Stark *et al.*, 1998; Sandberg & Stewart, 2006). The frequencies are transmitted through the substrate (not through the air), and females feel, rather than hear, the vibrations. Virgin females will drum in reply, followed by continued communication and migration towards each other until the two meet and mate. Shortly after mating, females extrude their egg mass over the stream surface or in the water (Hynes, 1976; Stark *et al.*, 1998). Although both males and females in this species are macropterous (fully-winged), stoneflies in general are weak fliers with limited airborne dispersal ranges, and rely primarily on stream corridor connections to colonize new habitats (Hynes, 1976; Stewart and Stark, 2002). Like other stoneflies, adults of this species are collected near streams, walking on rocks or streamside vegetation.

VII. HABITAT STATUS AND CONDITION

A. Geographic, Hydrological, and Ecological Characteristics

Glacier National Park is located in the Lewis and Livingston ranges of the Rocky Mountains in northwest Montana. The Park preserves 1.4 million acres of glacial-carved peaks, valleys, forests, alpine meadows, and glacial-fed lakes and streams. Land cover in the park is categorized as roughly 33% moist coniferous forest, 29% barren or sparsely vegetated rock/snow/ice, 16% dry coniferous forest, 8% dry meadow and prairie, 6% deciduous forest (primarily aspen and black cottonwood), 5% wet meadow or fen, and 3% surface water (with aquatic plants occurring in the shallower zones) (NPS, 2008).

The continental divide bisects the park in a northwest-southeast direction. The area west of the continental divide drains into the Columbia River system and the area east of the continental divide drains into the Hudson Bay and the Missouri River systems (Newell *et al.*, 2006). Water originating in Glacier National Park—much of it from snow and ice-melt— can therefore be considered the headwaters of the continent. The total ice-covered area in the Lewis and Livingston ranges of Glacier National Park is about 40.5 km^2, and nine of the ten largest glaciers in the state are found here (Fountain, 2009). Since 1900, the mean annual temperature in Glacier National Park has increased 1.33°C, which is 1.8 times the mean global temperature increase (Pederson *et al.* 2010; USGS, 2010). Spring and summer minimum temperatures have also increased in the park (Pederson *et al.* 2010), and rain, rather than snow, has become the dominant form of increased annual precipitation (Selkowitz *et al.*, 2002). These changes have resulted in one of the most powerful and tangible examples of global climate change: the park's rapidly melting glaciers. Of the estimated 150 glaciers existing in the park in 1850, only 25 are currently remaining, and these are continuing to shrink (USGS, 2010). A recent model of carbon dioxide–induced global warming predicts complete loss of the park's glaciers as early as 2030 (Hall & Fagre, 2003; Fagre, 2005; USGS, 2010).

Two climate zones are separated by the Continental Divide, Pacific Maritime to the west and Prairie/Arctic to the east. The difference in rainfall is not extreme, but the colder, desiccating winds on the east side have made the plant communities very different. The timberline on the eastern side of the park is almost 800 feet

(244 m) lower than on the western side, and the dark, ancient cedar/hemlock forests of the west side are a stark contrast to the more open forests, glades and grasslands of the east side (NPS, 2008). Snowpacks at sites to the west of the Continental Divide tend to be larger than snowpacks at sites to the east of the Divide, probably due to periodic warm winds that race downslope on the east side of the Divide and may be responsible for rapid snowmelt at times when snowpacks to the west of the Divide remain stable (Selkowitz *et al.* 2002). In contrast to most of the park's stonefly species which are known from both sides of the Continental Divide, this species has been found only at glacier-fed streams draining glacial lakes on the east side of the Divide (Newell *et al.*, 2007).

Other aquatic species in danger of extinction in Glacier National Park include the federally threatened bull trout (*Salvelinus confluentus*), threatened primarily by introduced fishes, and the recently petitioned meltwater stonefly (*Lednia tumana*), threatened by glacial recession due to global climate change.

B. Land Ownership

All known records for this species are in Glacier National Park, managed by the National Park Service (NPS).

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

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

<u>1. Global climate change</u>

Human-induced climate change is one of the most pressing issues facing national parks, particularly in the Rocky Mountain West where warming temperatures and precipitation changes are well-documented and projected to be most severe (Intergovernmental Panel on Climate Change, 2007; Saunders *et al.*, 2008). Rapidly changing climate conditions are already hastening the extinction of many plants and animals in the western United States (*e.g.* McLaughlin *et al.*, 2002), and it has been predicted that 15–37% of species, globally, will be 'committed to extinction' by 2050 as a result of mid-range climate-warming scenarios (Thomas *et al.*, 2004).

Since its establishment as a park in 1910, Glacier National Park has lost over 80% of its glaciers and, since snowpack is not adequate to counteract the regional temperature changes, the remaining 25 glaciers are continuing to shrink (USGS, 2010). Without a supply of glacial melt water, summer water temperatures are increasing in the Park and are expected to cause the local extinction of temperature sensitive aquatic species (USGS, 2010), including *Zapada glacier* (Baumann, pers. comm., May 2010). *Zapada glacier* belongs to a group of cold water obligate species (the *Zapada oregonensis* group) that have a preferred temperature of 8.8°C (Grafe *et al.* 2002), and this habitat requirement makes *Z. glacier* unlikely to survive increasing water temperatures. Although winters still deposit snow in the mountains, this seasonal snow doesn't function the same as glacial ice. Snow melts early in the summer season, whereas glacial ice acts as a "bank" of water whose continual melt helps regulate stream temperatures and maintain streamflow during late summer and drought periods when other sources are depleted (USGS, 2010). Since *Z. glacier* has a known distribution entirely restricted to glacier-fed streams where it is adapted to very cold water temperatures and high dissolved oxygen concentrations, glacial disappearance is of enormous concern for this species. Simply put, "if the glaciers go, so does this species" (Baumann, pers. comm., May 2010).

The most likely negative impact of global climate change on this species is larval mortality due to thermal intolerance of lethally high temperatures and/or lethally low oxygen concentrations caused by elevated water temperatures (Baumann, pers. comm., May 2010). Additional impacts may be far more complex, including altered phenology, development, behavior, reproductive success, and dispersal (Sweeney *et al.*, 1990). For example, stonefly larvae have been reported to do "push-ups" in response to low dissolved oxygen conditions, an energetically costly behavioral change which could reduce time spent feeding and limit growth capacity (Sweeney *et al.*, 1990). Climate-induced changes in the streamside (riparian) plant communities at Glacier National Park could also affect the growth dynamics of this species, since riparian plants determine the type and abundance of leaves that fall into the streams, and the nutritional composition of leaves varies species-to-species. Consumption of different food species (*e.g.* basswood vs. hickory leaves) has been experimentally shown to significantly alter growth rates of aquatic insects (Sweeney *et al.*, 1990; Anderson and Cummins, 1979).

The adult stonefly stage is also expected to suffer as a result of warmer climate, due to both untimely emergences, which could occur at times that are not appropriate for mating and egg maturation (Lillehammer *et al.*, 1989), and impaired physiological conditions resulting in reduced fertility and fecundity. Species-specific temperature ranges for successful stonefly egg and nymph development have been documented (Lillehammer *et al.*, 1989), and gravid stonefly females have been shown to be unable to survive to lay eggs above certain temperature limits (Elliot, 1986). All of these factors suggest that intensifying climactic shifts in this region pose serious threats to *Z. glacier*, largely via reductions in the availability and suitability of its thermal habitat.

<u>2. Barriers to Dispersal</u>

Zapada glacier is a narrowly endemic species, probably due to both its narrow habitat tolerance, which restricts it to very cold glacier-fed streams, and its poor flight capacity, which limits its airborne dispersal range (Stewart & Stark, 2008; Baumann & Gaufin, 1971). Stonefly dispersal from inhabited tributaries into new catchments is thought to occur primarily by means of larval drift down-stream to a confluence, followed by upstream migration of adults into the adjacent headwater (Griffith *et al.*, 1998). Aerial dispersal to new tributaries by adults is also possible, although adult dispersal over long distances is limited by the relatively short life span and poor flight capacity of the adult.

Dispersal potential is of particular importance for this species, since dispersal is likely associated with the long-term persistence of freshwater taxa, and may present the only option for a species to avoid extinction in a changing climate (*reviewed in* Bilton *et al.*, 2001). Many species are expected to tolerate climate-driven habitat change by shifting their distribution to a similar habitat elsewhere – for example, insects displaced from previously forested streams in southern regions may avoid extinction by colonizing newly forested streams where tundra streams once existed (Sweeney *et al.*, 1990). The future of glacier dependent species, however, is not so bright, for even under optimal dispersal scenarios (*e.g.* unlimited dispersal potential and unfragmented landscape), these species have nowhere to disperse *to*, as their habitat itself is going extinct.

B. Overutilization for Commercial Purposes

Zapada glacier is not used commercially, nor is it at risk of over-collection.

C. Disease or Predation

Neither disease nor predation is known to threaten *Z. glacier* 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. As discussed below, the rarity of this species 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 in danger of range-wide extinction due to climate change, *Z. glacier* currently receives no recognition or protection under federal or state law. The climate change regulations that currently exist are inadequate to protect *Z. glacier* from range-wide extinction.

1. Existing Regulatory Mechanisms are Inadequate to Protect *Z. glacier*

Zapada glacier faces formidable threats which could be ameliorated or eliminated by regulatory actions. To date, few of these regulatory actions have been implemented with regard to *Z. glacier*, despite the existence of regulatory authority by various agencies. To protect *Z. glacier*'s habitat, the reduction of greenhouse gas pollution is essential. This will slow global warming and ultimately stabilize the climate system, protecting the cold water habitat in Glacier National Park that *Z. glacier* depends upon.

2. Regulatory Mechanisms Addressing Greenhouse Gas Pollution and Global Warming are Inadequate

Existing international and U.S. regulatory mechanisms to reduce global greenhouse gas emissions are clearly inadequate to safeguard *Z. glacier* against extinction resulting from climate change.

National and international emissions reductions are needed to protect Z. glacier

The best-available science indicates that the atmospheric concentration of CO_2 must be reduced from the current level of ~390 ppm to at most 350 ppm to protect species and ecosystems from anthropogenic climate change. Numerous scientific studies indicate that climate change resulting from greenhouse gases currently in the atmosphere already constitutes "dangerous anthropogenic interference" (DAI) with regard to species and ecosystems (Warren 2006, Hansen *et al*. 2008, Lenton *et al*. 2008, Jones *et al*. 2009, Smith *et al*. 2009). Climatic changes experienced so far, including the ~0.7°C temperature rise and 30% increase in ocean acidity since the pre-industrial era, have resulted in significant changes in distribution, phenology, physiology, demographic rates, and genetics across taxa and regions, which have lead to population declines and species extinctions (Walther *et al*. 2002, Parmesan and Yohe 2003, Root *et al*. 2003, Parmesan 2006, Warren 2006, Walther 2010). Moreover, the impacts to biodiversity from the greenhouse gases currently in the atmosphere have not been fully realized. Due to thermal inertia in the climate system, there is a time lag between the emission of greenhouse gases and the full physical climate response to those emissions. The delayed effects from existing emissions are known as the "climate commitment." Based on the greenhouse gases already emitted, the Earth is committed to additional warming estimated at 0.6°C to 1.6°C within this century (Meehl *et al*. 2007, Ramanathan and Feng 2008), which commits species and ecosystems to further impacts.

Continuing greenhouse gas emissions, which are occurring at a rapid rate tracking the most fossil-fuel intensive emissions scenario of the Intergovernmental Panel on Climate Change (IPCC) (Raupach *et al*. 2007, Richardson *et al*. 2009), further jeopardize species and ecosystems. The IPCC has warned that 20 to 30% of plant and animal species will face an increased risk of extinction if global average temperature rise exceeds 1.5 to 2.5°C (relative to 1980-1999), with an increased risk of extinction for up to 70% of species worldwide if global average temperature rise exceeds 3.5°C relative to 1980-1999 (IPCC 2007). Thomas *et al*. (2004) projected that 15-37% of species will be committed to extinction by 2050 under a mid-level emissions scenario, which the world has been exceeding.

Hansen *et al*. (2008) presented evidence that the safe upper limit for atmospheric CO_2 needed to avoid "dangerous climate change" and "maintain the climate to which humanity, wildlife, and the rest of the biosphere are adapted" is at most 350 ppm. Hansen *et al*. (2008) found that our current CO_2 level has committed us to a dangerous warming commitment of ~2°C temperature rise still to come and is already resulting in dangerous changes: the rapid loss of Arctic sea-ice cover, 4° poleward latitudinal shift in subtropical regions leading to increased aridity in many regions of the earth; the near-global retreat of alpine glaciers affecting water supply during the summer; accelerating mass loss from the Greenland and west Antarctic ice sheets; and increasing stress to coral reefs from rising temperatures and ocean acidification. Hansen *et al*. (2008) concluded that the overall target of at most 350 ppm CO_2 must be pursued on a timescale of decades since paleoclimatic evidence and ongoing changes suggest that it would be dangerous to allow emissions to overshoot this target for an extended period of time:

> If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current 385 ppm to at most 350 ppm, but likely less than that. (Hansen *et al*. 2008:217).

In order to reach a 350 ppm CO_2 target or below, numerous studies indicate that global CO_2 emissions must peak before 2020 followed by rapid annual reductions bringing emissions to or very close to net zero by 2050. The IPCC found that to reach a 450 ppm CO_2eq target, the emissions of the United States and other developed countries should be reduced by 25 to 40% below 1990 levels by 2020 and by 80-95% below 1990 levels by 2050 (Gupta *et al*. 2007); thus reductions to reach a 350 ppm CO_2 target must be more stringent. Baer and Athanasiou (2009) outlined a trajectory to reach 350 ppm CO_2 target by 2100 that requires 2020 global emissions to reach 42% below 1990 levels, with emissions reaching zero in 2050. Negative emissions options make such a pathway more feasible. Baer and Athanasiou (2009) concluded that Annex I (developed country) emissions must be more than 50% below 1990 levels by 2020 and reach zero emissions in 2050 (Baer and Athanasiou 2009).

With atmospheric carbon dioxide at ~390 ppm and worldwide emissions continuing to increase by more than 2 ppm each year, rapid and substantial reductions are clearly needed immediately to protect *Z. glacier* and prevent dangerous levels of climate change.

United States Climate Initiatives are Ineffective

The United States is responsible for approximately 20% of worldwide annual carbon dioxide emissions (U.S. Energy Information Administration 2010, http://www.eia.gov), yet does not currently have adequate regulations to reduce greenhouse gas emissions. This was acknowledged by the Department of Interior in the final listing rule for the polar bear, which concluded that regulatory mechanisms in the United States are inadequate to effectively address climate change (73 Fed. Reg. 28287-28288). While existing laws including the Clean Air Act, Energy Policy and Conservation Act, Clean Water Act, Endangered Species Act, and others provide authority to executive branch agencies to require greenhouse gas emissions reductions from virtually all major sources in the U.S., these agencies are either failing to implement or only partially implementing these laws for greenhouse gases. For example, the EPA has recently issued a rulemaking regulating greenhouse gas emissions from automobiles (75 Fed. Reg. 25324, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule), but has to date failed to implement the majority of other Clean Air Act programs, such as the new source review, the new source pollution standards, or the criteria air pollutant/national ambient air quality standards programs, to address the climate crisis (See, e.g. 75 Fed. Reg. 17004, Reconsideration of Interpretation of Regulations That Determine Pollutants Covered by Clean Air Act Permitting Programs). While full implementation of these flagship environmental laws, particularly the Clean Air Act, would provide an effective and comprehensive greenhouse gas reduction strategy, due to their non-implementation, existing regulatory mechanisms must be considered inadequate to protect the *Z. glacier* from climate change.

International Climate Initiatives are Ineffective
The primary international regulatory mechanisms addressing greenhouse gas emissions are the United Nations Framework Convention on Climate Change and the Kyoto Protocol. As acknowledged by the Department of Interior in the final listing rule for the polar bear, these international initiatives are inadequate to effectively address climate change (73 Fed. Reg. 28287-28288). The Kyoto Protocol's first commitment period only sets targets for action through 2012. Importantly, there is still no binding international agreement governing greenhouse gas emissions in the years beyond 2012. While the 2009 U.N. Climate Change Conference in Copenhagen called on countries to hold the increase in global temperature below 2°C (an inadequate target for avoiding dangerous climate change), the *non-binding* "Copenhagen Accord" that emerged from the conference failed to enact binding regulations that limit emissions to reach this goal. Even if countries did meet their pledges, analyses of the Accord found that collective national pledges to cut greenhouse gas emissions are inadequate to achieve the 2°C, and instead suggest emission scenarios leading to a 3 to 3.9°C warming (Pew 2010, Rogelj *et al*. 2010). Thus international regulatory mechanisms must be considered inadequate to protect the *Z. glacier* from climate change.

E. Other natural or manmade factors affecting its continued existence

1. Small population size and stochastic events
The population sizes of *Z. glacier* are unknown but presumably small, as no more than four individuals have been reported from a single site on any given date, and no more than 12 individuals have been recorded at any site over time (Baumann & Gaufin, 1971). Stagliano *et al.* (2007) consider the species to be relatively rare and in low abundance in all of its occupied reaches. Small and fragmented populations are generally at 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).

IX. CRITICAL HABITAT

Petitioners request the designation of critical habitat for *Zapada glacier* concurrent with its listing. 16 U.S.C. § 1533(b)(6)(C) and 50 C.F.R. § 424.12. Critical habitat should include all five streams where this species currently and/or historically occurred.

X. CONCLUSION

For the above reasons, *Zapada glacier* 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 serious 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 formally petition the U.S. Fish and Wildlife Service list the western glacial stonefly (*Zapada glacier*) as an 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 stonefly.

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APPENDIX I. Table of collection localities for *Zapada glacier*, all from glacier-fed streams in Glacier County, Montana. Additional information (*e.g.* collector, repository) is available from the Xerces Society. M = male; F = female. Cataract Creek is the type locality for this species.

Locality	Date	Number of Specimens
Cataract Creek	9 July 1966	1 M, 3 F
Cataract Creek, below Grinnell Lake	11 July 1964	2 M, 2 F (including holotype, allotype, and paratypes)
Grinnell Creek	9 July 1966	3 F
Iceberg Creek, below Iceberg Lake	28 July 1964	3 F
Iceberg Creek, below Iceberg Lake	27 July 1965	1 F
Iceberg Creek, below Iceberg Lake	30 July 1965	2 F
Iceberg Creek, below Iceberg Lake	19 July 1966	3 F
Iceberg Creek, below Iceberg Lake	27 July 1969	2 F
Iceberg Creek, below Iceberg Lake	21 August 1979	1 M
Ptarmigan Creek	28 July 1964	1 F
Wilbur Creek, Many Glacier	13 July 1963	1 F