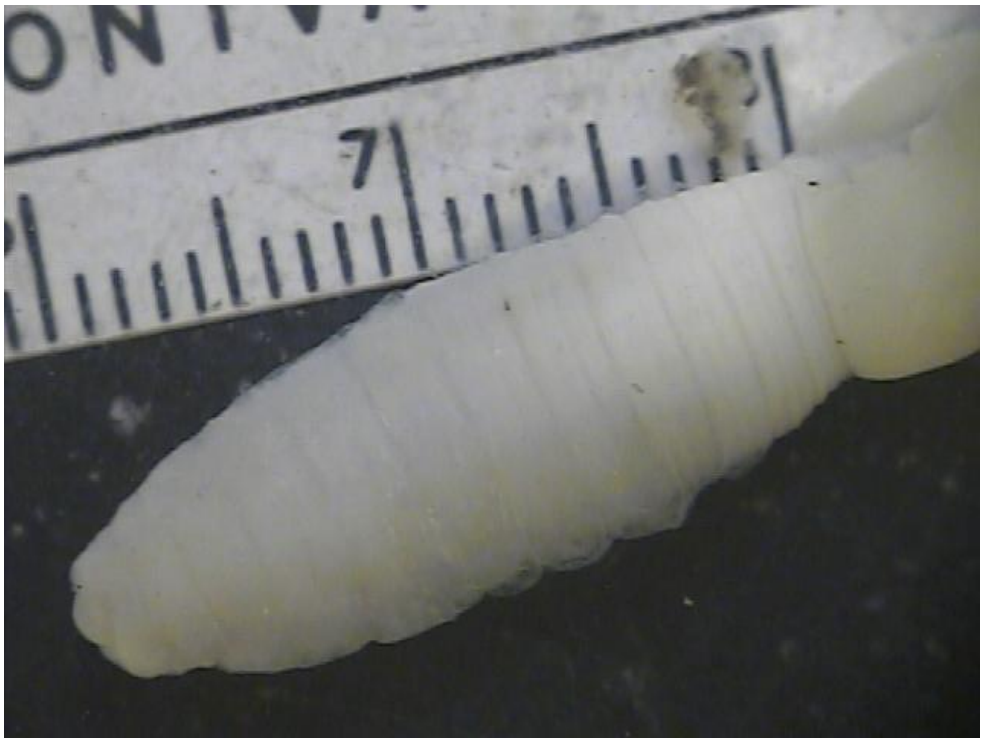

PETITION TO LIST

The Giant Palouse Earthworm (*Driloleirus americanus)*

AS A THREATENED OR ENDANGERED SPECIES
UNDER THE ENDANGERED SPECIES ACT

June 30, 2009

Friends of the Clearwater
Center for Biological Diversity
Palouse Audubon
Palouse Prairie Foundation
Palouse Group of the Sierra Club

June 30, 2009

Ken Salazar, Secretary of the Interior
U.S. Department of the Interior
1849 C Street N.W.
Washington, DC 20240

Robyn Thorson, Regional Director
U.S. Fish & Wildlife Service
Pacific Region
911 NE 11th Ave
Portland, Oregon

Dear Secretary Salazar,

Friends of the Clearwater, Center for Biological Diversity, Palouse Prairie Foundation, Palouse Audubon, Palouse Group of the Sierra Club and Steve Paulson formally petition to list the Giant Palouse Earthworm (*Driloleirus americanus*) as a threatened or endangered species pursuant to the Endangered Species Act (”ESA”), 16 U.S.C. §1531 et seq. This petition is filed under 5 U.S.C. 553(e) and 50 CFR 424.14 (1990), which grant interested parties the right to petition for issuance of a rule from the Secretary of Interior.

Petitioners also request that critical habitat be designated for the Giant Palouse Earthworm concurrent with the listing, pursuant to 50 CFR 424.12, and pursuant to the Administrative Procedures Act (5 U.S.C. 553).

The Giant Palouse Earthworm (*D. americanus*) is found only in the Columbia River Drainages of eastern Washington and Northern Idaho. Only four positive collections of this species have been made within the last 110 years, despite the fact that the earthworm was historically considered “very abundant” (Smith 1897). The four collections include one between Moscow, Idaho and Pullman, Washington, one near Moscow Mountain, Idaho, one at a prairie remnant called Smoot Hill and a fourth specimen near Ellensberg, Washington (Fender and McKey-Fender, 1990, James 2000, Sánchez de León and Johnson-Maynard, 2008). This represents the entire history of positively identified sightings for this animal in the last 110 years.

The U.S. Fish and Wildlife Service (FWS) denied a previous petition for listing in part because the collection near Ellensberg Washington was outside the Palouse Region and because the species is difficult to locate, concluding:

> We found little data provided by the petitioner or in our files to determine the extent of the historic or current range and distribution of the Giant Palouse Earthworm. At least one collection site is outside of the Palouse bioregion (Fender and McKey-Fender 1990, p. 358), suggesting that the species may not be endemic to the specific bioregion. We agree with the petitioners that the Palouse prairie has experienced a dramatic conversion of native habitat to agricultural practices; however, information linking the effect this may have had on the earthworm is currently nonexistent (FWS 2007).

Further research published since FWS made their finding demonstrates that although the Giant Palouse Earthworm may not be strictly limited to the Palouse bioregion, it is indeed highly rare and threatened by multiple factors, including habitat conversion and invasive earthworms. A

recent and comprehensive three year study of earthworms in eastern Washington and Idaho concluded that exotic earthworms dominate both Conservation Reserve Program (CRP) and prairie remnants, concluding:

> [The] results suggest that the combined effects of land-use change, habitat fragmentation and competitive interactions have resulted in the decimation of native earthworm populations and dominance of invasive earthworms in native and non-native grasslands of the Palouse region . . . . No information is available on pre-agricultural density or distribution of *D. americanus*; however, the description of the species as being abundant by Smith contrasts to the rarity of finding the earthworm today, suggesting a significant reduction in its population size. As mentioned previously, land use change from native vegetation to agriculture and habitat fragmentation in the Palouse region was extensive, resulting in a reduction of more than 99% of the Palouse prairie ecosystem. Extensive land use conversion to agriculture in the Palouse must have severely reduced available habitat for *D. americanus* and promoted undetected disturbance in the remaining prairie patches. In addition, the remaining prairie remnants could represent a low quality habitat for native earthworms. Remaining prairie remnants tend to have shallow and rocky soils in contrast to the deep, siltloam textured soil that characterizes the area (Lichthardt and Moseley 1997). Lower quality of the remaining habitat for native earthworms could represent an undetected, but ecologically significant change produced by habitat fragmentation in the Palouse region (Sánchez-de León and Johnson-Maynard 2008).

This new science clearly indicates that the Giant Palouse Earthworm warrants protection as a threatened or endangered species either because it is threatened in the entirety of its range or because the Palouse Region constitutes a significant portion of its range.

The most immediate threats to this species are habitat loss and fragmentation, competition with exotic earthworms, and the lack of existing regulatory mechanisms. Native habitats throughout all, and/or a significant portion, of the range for this species have suffered extreme destruction and modification. This habitat modification continues today with suburban and rural development, and road construction. Invasive species pose a threat in the remaining habitat. Current management of the species either does not exist or is inadequate at the federal, state and local levels, to protect the species and its habitat.

This information clearly indicates the Giant Palouse Earthworm warrants protection as a threatened or endangered species.

For the petitioners,

/s/
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Executive Summary

The Giant Palouse Earthworm (*Driloleirus americanus*) is a native species of the Columbia River basin of eastern Washington and northern Idaho.

In 2005, the last sighting of this animal was made in a small plot of native habitat. This collection represents the first sighting of this animal in 20 years, and only the fourth sighting in 110 years. In 1897, this animal was considered abundant.

Habitat for this species has suffered extreme destruction and modification. The currently available information suggests that, "… the combined effects of land-use change, habitat fragmentation and competitive interactions have resulted in the decimation of native earthworm populations and dominance of invasive earthworms in native and non-native grasslands of the Palouse region . . ." (Sánchez de León and Johnson-Maynard, 2008).

Current threats to this species' small and highly fragmented habitat exist in the form of highway and road expansion projects and road maintenance, rural and suburban development, competition with exotic species, lack of existing regulations to protect the species or its habitat, global climate change, and agricultural practices.

Without the protection of the Endangered Species Act, the Giant Palouse Earthworm faces an imminent threat to its continued existence. It is assured to be extinct in the immediate future without aggressive and timely protection measures.

Taxonomy

D. americanus is in the family Megascolecidae within the order Opisthophora of the Kingdom Animalia and the Subclass Oligochaeta.

Kingdom *Animalia*
Phylum *Annelida*
Subclass *Oligochaeta*
Order *Opisthophora*
Family *Megascolecidae*
Genus *Driloleirus*
Species *americanus*

Species Description

The Giant Palouse Earthworm, a large earthworm three feet or more in length and light pink in color was first described by Smith (1897) based on four specimens sent to him by Mr. R. W. Doane of the Washington Agricultural College and School of Science at Pullman, Washington, which he referred to as the genus *Megascolides*, believing that it was a close relative of the giant Australian earthworm *Megascolides australis*. Not actually closely related to its Australian cousin, the Giant Palouse Earthworm was renamed *Driloleirus*, which means "lily-like worm," because of its unique sweet fragrance (PBI 2004a).

Smith writes:

> Mr. Doane writes me that this species is very abundant in that region of country and that their burrows are sometimes seen extending to a depth of over fifteen feet, in cuts for new roads. I am also informed that much larger specimens than those sent me, are often found. (Smith 1897, p. 203)

Additionally, Smith writes that *M. americanus* is similar to three other native species of earthworms known to exist in the Pacific Northwest at that time. He notes, however, that *M. americanus* differs from the others by the presence of "numerous small nephridia in each somite instead of two large ones, in the extent of the clitellum and in several other characters." (p.204) Smith additionally published descriptions of *Megascolides macelfreshi*, *Megascolides cascadensis*, *Megascolides eiseni*, and *Megascolides michaelseni* in 1937 (Fender and McKey-Fender 1990, p. 372).

The taxonomic listing for this earthworm was eventually changed from *M. americanus* to reflect its present genus and species, *D. americanus*.

The Giant Palouse Earthworm was originally described by James (2000) as an anecic earthworm, one of three basic types, but based on further examination of a specimen, James (personal communication) now believes the species is an endogeic earthworm. Endogeic earthworms feed on organic matter in mineral soils and are larger, less pigmented and longer lived than epigeic worms (James 2000). Because they feed in the soil, they are rarely found on the surface (*Ibid.*)

Endogeic earthworms contribute to soil profile development by transferring organic and mineral materials within the soil and to soil carbon protection (*Ibid.*) The excreta of earthworms have higher levels of available macronutrients and cations than the organic food material (Lee 1985 in James 1995, p. 11).

Taxonomic identification of *D. americanus* is difficult. Within the family, Megascolecidae, specimens must be dissected in order to identify the genus. Identification to species requires an intimate knowledge of earthworm anatomy. Presently, there are very few people in the United States of America qualified to identify this genus to the species level, primarily due to the rarity of the species.

At the time of this petition, one other earthworm species native to the Columbia River basin is classified within the same genus, the rare *Driloleirus macelfreshi*.

No sub-species or varieties of *D. americanus* are known to exist.

Distribution

Of the four positively-identified collections of *D. americanus* in the last 110 years, three were collected from the Palouse River basin (in the general vicinity of Moscow, Idaho and Pullman, Washington) and a fourth was discovered at Ellensberg, Washington (Figure 1, does not show Smoot Hill). Several of these collection sites have since suffered significant ground disturbing activities, and subsequent attempts to re-locate this species at these specific sites have proven futile (Johnson-Maynard 2009).

Fender and McKey-Fender (1990) describe the geographical area as:

> "*D. americanus* is found in the area around Pullman, Washington, and Moscow, Idaho, and in the hills west of Ellensburg, Washington, but is not known from the arid land between." (p. 367)

This suggests the earthworm may have historically occurred in two disjunct populations—one centered on the Palouse Region and a second in the hills near Ellensburg. Further support for the fact that the Giant Palouse Earthworm does not occur in the intervening areas between the species' two locations is provided by the fact that earthworms in general are limited to areas with moist soils and areas between the two population centers are considerably more arid (James 2000). Indeed, Fender and McKey-Fender (1990) observed that:

> The lower limit of precipitation tolerated by argilophine species appears to be about 15 in. (38 cm) annual precipitation. This is about the edge of moist forests in our area, although the range of *D. americanus* extends into treeless areas.

Given that three of four collections of the species were in the Palouse Region and this is the area where the species was considered historically abundant, but now is quite rare, this area clearly qualifies as a significant portion of its range. Regardless, both areas where the species has been recorded have suffered extensive habitat modification.

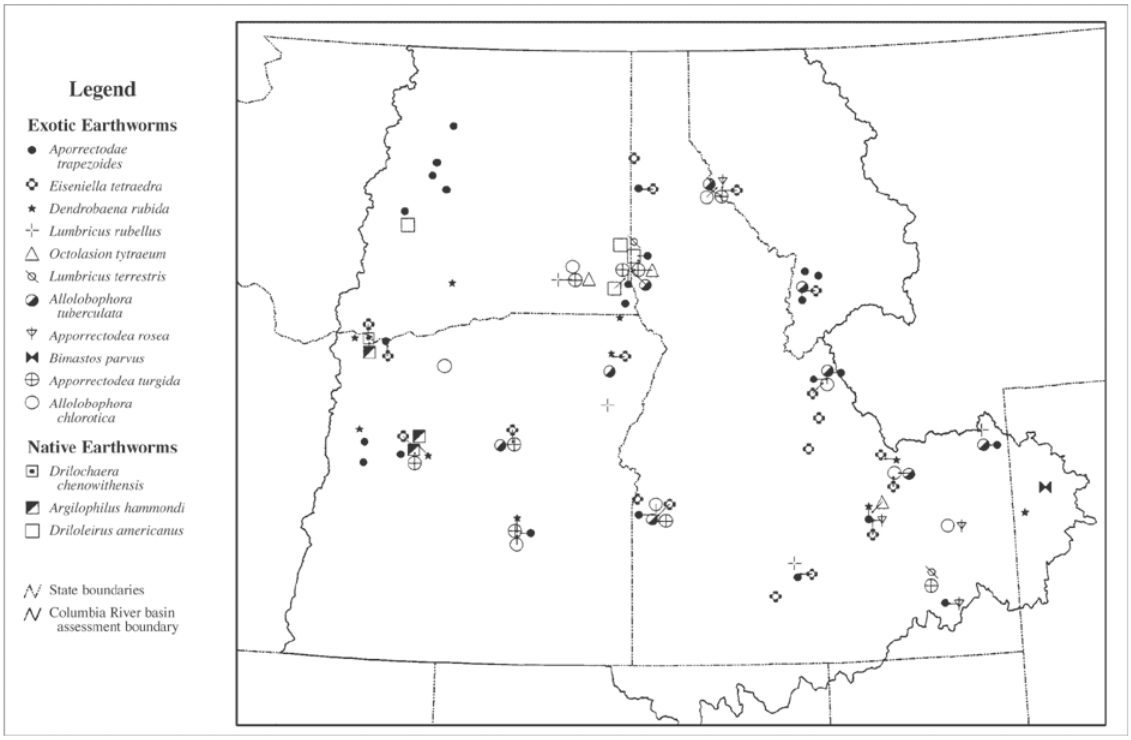


Figure 1: Collection points for native and exotic earthworms in the Columbia River Basin (James 2000, p. 4).

Habitat

Given the paucity of collections of the Giant Palouse Earthworm, there have not been detailed studies of its habitat requirements. Earthworms in general require moist soils, neutral pH, moderate temperatures at least seasonally and sufficient organic matter for forage (James 2000). As an endogeic species, the Giant Palouse Earthworm requires sufficient organic matter in the soil for forage and is highly sensitive to soil disturbance (James personal communication).

Habitat of the Giant Palouse Earthworm has been broadly characterized as sites with fine-textured, compact, deep, naturally-occurring soil characteristics and native grassland and shrubsteppe vegetation (James 1995 and 2000, Niwa et al. 2001, Fauci and Bezdicek 2002, Sánchez de León and Johnson-Maynard, 2008).

Providing new information concerning the habitat of the Giant Palouse Earthworm, Sánchez de León and Johnson-Maynard (2008) searched four prairie remnant sites and adjacent agricultural areas now managed under the conservation reserve program and found the species only in one prairie remnant. Likewise, the other three known locations were found in areas with native vegetation and relatively undisturbed soils (James 2000). Combined with information showing that earthworms in general occur in reduced numbers in agricultural areas and are closely tied to the quality and quantity of vegetation litter for forage, the lack of collections in agricultural areas provides strong indication that the Giant Palouse Earthworm cannot occur in disturbed areas

(Ibid.) In addition, Sánchez de León and Johnson-Maynard (2008) observed that many remnant prairie patches in the range of the Giant Palouse Earthworm occur in areas that are not suitable for tillage, typically meaning they are steep, rocky or otherwise have shallow soils and further observe that such areas may not have the deep soils required by the species. In other words, there are very few areas that are likely to support the earthworm.

The small and highly fragmented acreages that remain in a natural state are few and far between. A preliminary list of remaining potential habitat for this species follows: The Rose Creek Preserve, maintained by The Nature Conservancy; Kamiak Butte county park and nearby private land; Steptoe Butte, north of Colfax, WA; Farr Cemetery, Pullman; Wawawai County Park, Snake River; Klemgard Park, a Whitman County park; Washington State University's Roundtop Area, adjacent to the expanding Palouse Ridge Golf Course; and Magpie Forest, a hawthorn prairie remnant on the outskirts of Pullman. These are a few examples of the small patches of native communities that are still wholly or partially intact (Cook and Hufford Online). Also, Paradise Ridge, Tomer Butte, Smoot Hill, and Bald Butte contain small acreages of native soils and plant communities (Sánchez-de León and Johnson-Maynard, 2008).

Population Status

Since being first described and observed to be abundant in 1897, the Giant Palouse Earthworm has been observed only four times. Several Giant Palouse Earthworms were collected by Fender near Pullman, Washington and Moscow Idaho in 1978 (Fender 1995). A specimen was discovered near Ellensberg, Washington sometime before 1990 and positively identified to be *D. americanus* (Fender and McKey-Fender, 1990). The species was collected in 1988, by J. B. Johnson and P. Johnson, who observed several of these worms in a forest clearing near Moscow, Idaho. The two specimens that they collected were sent to Fender-Westwind, and were positively confirmed to be *D. americanus* (Mullins 2006). Finally, University of Idaho graduate student Yaniria Sánchez-de León was the first person in nearly two decades to report a sighting of this earthworm (University of Idaho 2006). She was conducting her graduate research at a site near Pullman, Washington on May 27, 2005 (Sánchez-de León and Johnson-Maynard, 2008), when she accidentally killed and collected a specimen of this species. Since that time, her preserved specimen has been confirmed to be *D. americanus* by two professional entities. Independent confirmation of the specimen was made by northwest earthworm expert William M. Fender-Westwind and by earthworm experts gathered for a workshop in Puerto Rico in November, 2005 (Mullins 2006). Prior to this collection, the species was considered by many authorities to be extinct. There have been two more recent collections of earthworms suspected to be *D. americanus* —one near Moscow, Idaho and one near Leavenworth, Washington. Neither, however, was able to be positively identified as *D. americanus* (University of Idaho 2008).

Many of these historic collection sites have been resurveyed by earthworm experts in the time period following the 2005 collection and the original petition to list this species in 2006. All of these follow up searches have been unable to locate native worms and many of the original collection sites have undergone major ground disturbing activities since the original collections were made (Johnson-Maynard 2009). For instance, one of the sites surveyed by Fender in 1978 at Pullman, Washington is now a parking lot and another near the Moscow-Pullman Highway is now "very disturbed with graveling" (*Ibid*). The site near Moscow, Idaho was resurveyed by

Johnson and Johnson in 1988, but the species was not located perhaps because of disturbance by logging (*Ibid*)

Living underground in deep burrows, the Giant Palouse Earthworm is obviously a cryptic species. That said, there is little reason to believe that there are large undiscovered populations on the landscape. Recent extensive surveys in both Prairie remnants and agricultural lands failed to find the Giant Palouse Earthworm (Fauci and Bezdicek 2002, Sánchez-de León and Johnson-Maynard 2008). Fauci and Bezdicek (2002) sampled 46 agricultural and remnant prairie sites in the Palouse Region for earthworms and failed to find any *D. americanus*. Similarly, Sánchez-de León and Johnson-Maynard (2008) extensively searched four areas with both remnant prairie patches and agricultural lands currently being managed under the conservation reserve program and found one Giant Palouse Earthworm on a prairie remnant. This was the first sighting of the species in more than 20 years. These extensive searches strongly indicate the species is very rare and not simply going undetected.

In their negative finding, FWS (2007) argued that because Giant Palouse Earthworms "generally form permanent burrows at least 14.7 feet (4.5 meters) deep and can move very rapidly to escape a shovel" and that "there have been very limited formal studies of native earthworms in the bioregion" that may explain "the fact that there have been only a few recorded sightings of the giant Palouse earthworm in the past 107 years." Although it is correct that the earthworm does form deep burrows, it is likely that were the species common, that it would have been detected by the above studies. First, the burrows are deep, but they also lead to the surface, meaning the burrows would have been observed by the above studies. Indeed, Fauci and Bezdicek (2002) specifically looked for large, vertical burrows typically made by the Giant Palouse Earthworm, and where found, carefully searched for *D. americanus*, but instead found in every case the introduced night crawler, *Lumbicus terrestris*, which also forms deep, vertical burrows and has a similar diameter. It is also noteworthy that Sánchez-de León and Johnson-Maynard (2008) did in fact find one Giant Palouse Earthworm, meaning that their survey methods were able to detect *D. americanus*. Given the complete absence of any information to suggest that the species is common or widespread combined with the few number of times the species has been seen despite extensive surveys and the scale of habitat conversion in the species range, the best available information clearly indicates that the Giant Palouse Earthworm is a rare and severely endangered species.

In fact, all of the scientific literature indicates that this species is rare and imperiled (Fender and McKey-Fender 1990, Fender 1995, James 1995, Noss et al. 1995, Lichthardt and Moseley 1997, James 2000, Niwa et al. 2001, Fauci and Bezdicek 2002, Hendrix and Bohlen 2002, NatureServe 2008, Sánchez-de León and Johnson-Maynard 2008, IUCN 2009, Johnson-Maynard 2009, WDFW 2009). James (2000), for example, concluded that the Giant Palouse Earthworm should be of "special concern" and that "current information suggests that it may be a narrow endemic using a threatened habitat." The IUCN classifies the species as vulnerable because it is "characterized by an acute restriction in its area of occupancy or in the number of locations (typically less than five)" and "would thus be prone to the effects of human activities (or stochastic events whose impact is increased by human activities) within a very short period of time in an unforeseeable future, and is thus capable of becoming Critically Endangered or even Extinct in a very short period." Likewise, NatureServe (2008) classifies the Giant Palouse

Earthworm as critically imperiled, observing that: "the population appears to be very low" and "one individual has been found in the past 20 years," and Niwa et al. (2001) concluded: "the currently available information suggests it may be a narrow endemic utilizing a threatened habitat (grassland sites with good soil)." The Washington Department of Fish and Wildlife (WDFW) also lists the Giant Palouse Earthworm as a candidate for listing, which is limited to species where there is "sufficient evidence suggest[ing] that its status may meet the listing criteria defined for State Endangered, Threatened, or Sensitive" (WDFW 2009).

Most recently and since FWS (2007), Sánchez-de León and Johnson-Maynard (2008) published significant new information concerning the status of *D. Americanus*. Based on their surveys of both prairie remnants and CRP lands, which with one exception found exotic earthworms, they concluded: "our results suggest that the combined effects of land-use change, habitat fragmentation and competitive interactions have resulted in the decimation of native earthworm populations and dominance of invasive earthworms in native and non-native grasslands of the Palouse region," adding that "no information is available on pre-agricultural density or distribution of D. americanus; however, the description of the species as being abundant by Smith (1897) contrasts to the rarity of finding the earthworm today, suggesting a significant reduction in its population size."

In sum, all of the available information shows that the Giant Palouse Earthworm is exceedingly rare and at risk of extinction. It is also severely threatened by agricultural and urban sprawl and exotic earthworms. As such, the Giant Palouse Earthworm clearly warrants protection as a threatened or endangered species.

Summary of Factors for Consideration

The Giant Palouse Earthworm meets all five criteria under the Endangered Species Act for consideration as an endangered species: 16 U.S.C. §1533 (a)(1)(A,B,C,D,E) (Section 4). In evaluating a species, the Service must evaluate whether a species is threatened or endangered under the five listing factors set forth in ESA section 4(a)(1). Any one of these factors is sufficient to support a listing:

> (A) Present or threatened destruction, modification, or curtailment of [the species'] habitat or range;
> (B) Over utilization for commercial, recreational, scientific, or educational purposes;
> (C) Disease or predation;
> (D) Inadequacy of existing regulatory mechanisms; or
> (E) Other natural or manmade factors affecting [the species'] continued existence.
> (16 U.S.C. § 1533(a)(1)).

Additionally, the Service is required to make listing determinations "…**solely on the basis of the best scientific and commercial data available** to [it] after conducting a review of the status of the species and after taking into account…" existing efforts to protect the species**.** 16 U.S.C. § 1533(b)(1)(A); see also 50 C.F.R. §§ 424.11(b), (f).

1: Present or threatened destruction, modification, or curtailment of its habitat or range

The Giant Palouse Earthworm and the habitat upon which it depends is threatened by the nearly total conversion of its native habitat to agricultural production, livestock grazing, suburban development, and road building and maintenance (James 2000, Sánchez-de León and Johnson-Maynard 2008). We discuss each of these threats in detail.

Agriculture. During the past 125 years, the native habitat of the region has experienced a dramatic conversion of native vegetation and habitat to agricultural development (see Fig's. 2 and 3). Conversion of this productive landscape for agriculture began in the 1870s and rapidly the land was converted to cereal and cool-season legume production. Agriculture remains a dominant economic, social, and biological force in the region (Donovan, et al. 2009). Gilmore (2004), for example, concluded:

> Where once native grasslands and shrub lands stretched unbroken for thousands of square miles, there exists only fragments of native habitats in a matrix of agricultural lands. This breakup of formerly contiguous habitats has had detrimental effects on both plant and wildlife species occurrence."

The expansion of agriculture has resulted in the destruction of 99% of the native habitat of the Palouse Prairie, which represents a significant portion of the range for the earthworm, making it among the most endangered ecosystems in the United States (Noss et al. 1995).

Like the Palouse Region, areas around Ellensburg, Washington, where one of the four sightings of the earthworm was documented, have been extensively modified by agriculture with native shrub-steppe habitats now primarily limited to steep slopes, which likely do not provide the deep loess soils required by the earthworm (see Adolfson Associates 2005). Essentially, the flat, deep-soiled moist areas required by the earthworm are the exact areas desirable for agriculture and have been extensively developed in the last eighty years.

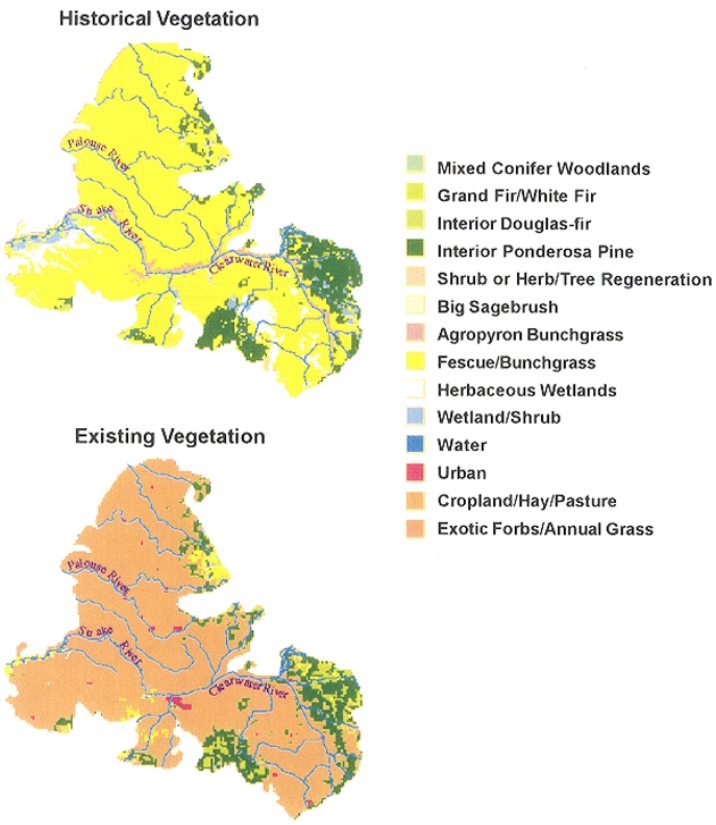


Figure 2: Change in vegetation in Palouse Bioregion (USGS LUHNA)

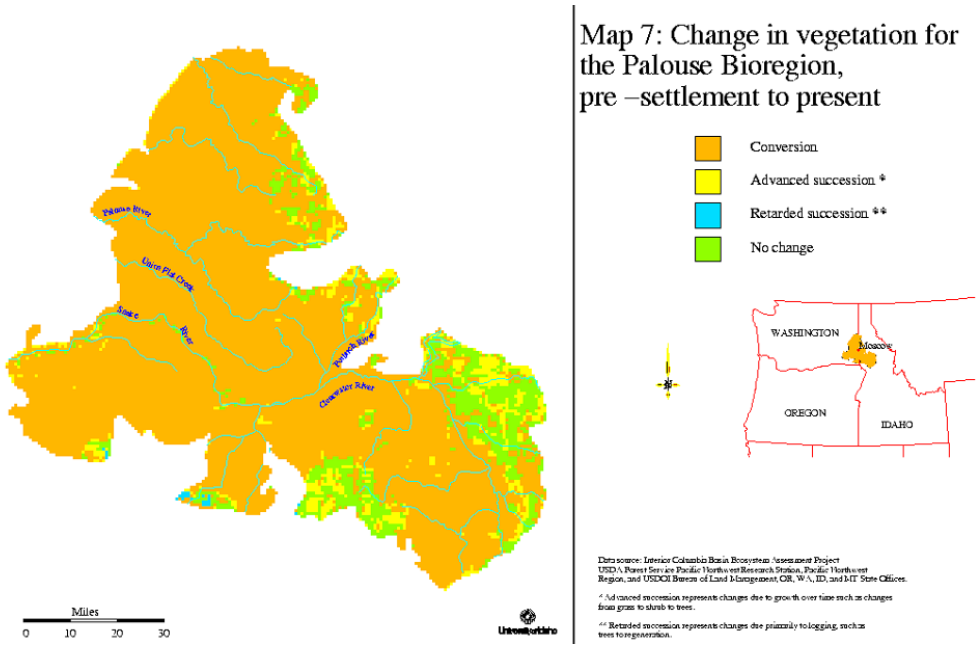


Figure 3: Change in vegetation for the Palouse Bioregion, pre-settlement to present. (USGS LUHNA)

In determining that our previous petition did not present substantial information that the earthworm may be threatened or endangered, FWS (2007) agreed "that the Palouse prairie has experienced a dramatic conversion of native habitat to agricultural practices," but concluded that "information linking the effect this may have had on the earthworm is currently nonexistent." It is first important to recognize that conclusive information linking agriculture to a decline in the earthworm is not required. Rather, the standard is the best available information. This is fortunate because given the rarity of the earthworm, there will never be conclusive information of the kind postulated by FWS (2007). That said, extensive information indicates agriculture has had a severe impact on the Giant Palouse Earthworm, including information that the species was formerly abundant but is now rare, studies of similar but more common earthworms showing agriculture to be severely impacted by agriculture and studies failing to find the earthworm in agricultural areas.

It is well documented that populations of earthworms in agricultural fields are influenced by the intensity and number of soil disturbance events, including tillage and traffic, abundance and quality of food sources, the chemical environment of the soil including pesticide residues, and the soil microclimate (Edwards & Bohlen 1996, USDA-NRCS 2001). These effects are especially significant in the Palouse region, as a consequence of tillage methods, crop rotations, and fertility practices that were used and expanded during the 20th century and subsequently (Jennings et al. 1990). Effects resulting in degradation of the land base have occurred due to factors including significant topsoil losses, changes in soil structure and chemistry, and reduced soil organic matter (Jennings et al. 1990).

In part because the earthworm has become extremely rare over the past century, there is a scarcity of research data on this particular organism. In conservation biology, it is common for researchers to consider one or more species that substitute for the one of concern (Caro et al. 2005; Sappington et al. 2001). Ideally, substitutes are similar biologically or ecologically to the target, or are members of a constellation of species of which the target is one (Caro et al. 2005). In the case of the earthworm, information about agricultural impacts on the ecology of other earthworm species can be highly applicable when used in an appropriate context.

For example, in one study, Chan (2004) investigated the impact of soil tillage on the abundance and continuity of burrows formed by a native Australian earthworm, *Spenceriella hamiltoni.* It was observed that three years of conventional tillage involving disking reduced earthworm burrow density by nearly 90%. Elsewhere, earthworms were reduced by 70% compared to previously undisturbed sod after five years of plowing (Edwards and Bohlen 1996). Earthworms need moist but well-aerated soil (USDA-NRCS 2001). Reduction of earthworm burrow density due to tillage and/or soil compaction has the compounding effect of significantly reducing deep-soil aeration and infiltration rate; e.g., Chan (2004) observed a more than 8-fold reduction in maximum infiltration rate after three years of conventional tillage with concurrent reduction of earthworm burrows. Conventional tillage has another, even more direct effect on Giant Palouse Earthworm habitat: a 1978 Palouse Cooperative River Basin Study estimated that all of the original topsoil has been removed from 10 percent of Palouse cropland, and that another 60 percent of the cropland has lost 25 to 75 percent of the topsoil (Veseth 1986b).

Another impact of agriculture is the removal of organic matter utilized by the earthworm for forage. James (2000) observed that "lack of organic matter is generally a significant limiting factor for earthworms," and the "fact that most agricultural soils are depleted of organic matter likely accounts for lower abundance of earthworms in agricultural land or recently abandoned cropland." Agricultural practices also create long periods of bare soil, which can intensify the effect of weather on earthworms, such as during flooding and drought conditions and creates periods of time when food would be unavailable to the species, negatively affecting both food resource quality and quantity (James 2000).

An impact of both modern agricultural practices and livestock grazing is compaction of soils (James 2000). Soil compaction affects the soil food web, soil composition, and functional groups that live within the soil ecosystem (Niwa et al. 2001, p.13). Soil pore size is reduced (Niwa et al. 2001, p.13), thus favoring exotic earthworm species that are more tolerant of course soils than natives species (Fender and McKey-Fender 1990, p. 363-364, Edwards et al. 1995 p. 200-201).

Soil chemistry effects, notably a reduction in soil pH, have been well documented as to their deleterious effects on earthworms (James 2000). In general, earthworms do not thrive in soils with a pH below 5 (Edwards and Lofty 1977). Ma et al. (1993) determined that long-term use of certain nitrogenous fertilizers (60-180 kg N ha^{-1} yr^{-1}) drastically decreased earthworm numbers and biomass, and that the effect was related to reduction in soil pH. Annual applications of 96-112 kg N ha^{-1} are typical for winter wheat, the dominant crop in the Palouse, with applications generally higher (more than 112 kg N ha^{-1} yr^{-1}) in the eastern subregions of the Palouse (Hall et al. 1999).

According to Edwards et al. (1995), earthworms are very sensitive to ammonia-based fertilizers. Mahler (1981) reported that ammonia-based fertilizers have been the main acidifying factor in northern Idaho farmland soils, including the Palouse region. Because of this factor, there have been significant reductions in soil pH levels over a number of years, and a large percentage of agricultural soils now have pH levels below 6.0 (Mahler 1981). Soil acidification is distributed more deeply with conventional (moldboard plowing) tillage (Rasmussen and Rohde 1989). Nitrogen fertilization, like tillage, can also have deleterious effects on soil permeability, adversely affecting earthworm populations. Fireman (1945) determined that sodium nitrate fertilizer in certain western soils reduced soil permeability by 41-86%, with ammonium nitrate and ammonium sulfate also decreasing permeability, though to a lesser extent.

Herbicides, insecticides, and fungicides applied in agricultural production also take a toll on earthworm populations. An overview can be found in Edwards and Bohlen (1996). Several herbicides, fungicides and insecticides in particular are extremely toxic to earthworms. Earthworms are particularly vulnerable to herbicides that change or destroy the vegetation upon which the species depends. Approximately 70% of pesticides used in agriculture are herbicides (Kellogg et al. 2000). Growers in the Palouse apply a wide spectrum of herbicides to their crops (Hall et al. 1999). The triazine herbicides (including atrazine), which do not break down readily in soil, have demonstrated non-target effects including a negative impact on earthworm numbers (USDA-NRCS 2001). In a recent USGS survey (Wagner et al. 1995), the herbicides atrazine and simazine were frequently detected in surface-water samples from the Palouse River basin. Although a recent movement by some growers towards reduced tillage farming may lessen some

tillage impacts on earthworm habitat, it also has the unfortunate effect of increasing herbicide inputs, since herbicides largely replace tillage operations for weed control in no-till farming. Indeed, in a recent survey, 70% of no-till growers surveyed reported an increase in herbicide usage (Veseth 1986a).

Some fungicides used in production of wheat, pea, lentil, and other crops in the Palouse region have known toxicity to earthworms; e.g., benomyl (Edwards and Bohlen, 1996.) However, insecticides as a group contain a wider variety of compounds with known earthworm toxicity. Insecticides are used extensively on Palouse crops, most notably on pea (Hall et al. 1999). In one survey of Palouse pea and lentil growers in the 1980's, approximately half of the growers applied insecticide to their crop every year (Hall et al. 1999). The majority of the carbamate class of insecticides are toxic to earthworms, as are a number of organophosphate and aromatic organochlorine compounds.

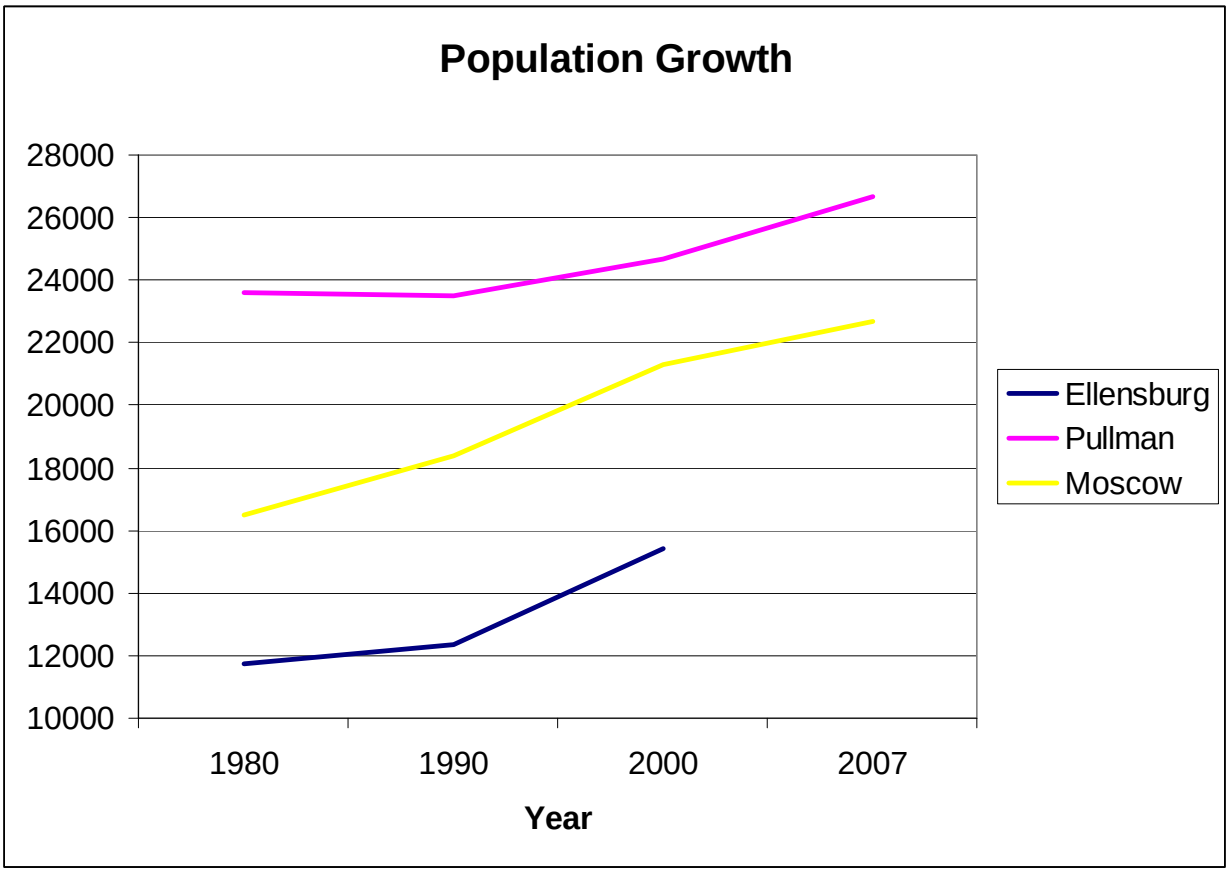
Given the impacts of agriculture on earthworm habitat, it is not surprising that recent studies of earthworms in the Palouse Region failed to find the Palouse Giant Earthworm despite its apparent historic abundance. As discussed in detail above, both Fauci and Bezdicek (2002) and Sánchez-de León and Johnson-Maynard (2008) extensively searched agricultural areas and prairie remnants for earthworms and only the latter successfully found a Giant Palouse Earthworm in a prairie remnant. In support of the severe impact of agriculture on the earthworm, Sánchez-de León and Johnson-Maynard (2008) concluded:

> As mentioned previously, land use change from native vegetation to agriculture and habitat fragmentation in the Palouse region was extensive resulting in a reduction of more than 99% of the Palouse prairie ecosystem (Noss et al. 1995; Lichthardt and Moseley 1997; Black et al. 1998). Extensive land use conversion n to agriculture in the Palouse must have severely reduced available habitat for *D. americanus* and promoted undetected disturbance in the remaining prairie patches. In addition, the remaining prairie remnants could represent a low quality habitat for native earthworms. Remaining prairie remnants tend to have shallow and rocky soils in contrast to the deep, silt-loam textured soil that characterizes the area (Lichthardt and Moseley 1997). Lower quality of the remaining habitat for native earthworms could represent an undetected, but ecologically significant change produced by habitat fragmentation in the Palouse region.

Urban Sprawl. The Giant Palouse Earthworm's habitat is threatened by the extensive conversion of its native habitat to rural and suburban sprawl. The region has recently undergone a surge in both high density housing construction and rural sub-division, as well as the associated infrastructure to support these immigrants. Within the city limits of Ellensburg and Pullman, WA and Moscow, ID, populations grew by 76%, 88% and 73%, respectively between 1980 and 2007, or 2000 in the case of Ellensburg (Information available at www.census.gov, figure 4). This does not count population growth in suburban or rural areas, which was likely even greater.

The development of urban and suburban housing and apartment complex development results in dense and compacted soils, and often the topsoil is removed. This soil scenario sets up conditions favorable for invasive earthworms and intolerant of native earthworms, according to Johnson-

Maynard (2009). It is unlikely that the Palouse Giant Earthworm survives in areas of urban and suburban sprawl.



With this growth in population, there has been a concordant expansion of infrastructure, particularly roads. State and federal highways are being re-constructed and re-located to expedite motorized traffic, frequently utilizing previously undeveloped landscapes with little or no regard for wildlife habitat requirements. Idaho Transportation Department (ITD), for example, has proposed an expansion of Highway 95 (US 95, Thorncreek Road to Moscow, Stage 1 DHP-NH-4110(156) Key No. 9294 Date-10/6/06). One of the routes for this major ground-disturbing project, E2 (see Figure 4- U.S. 95 Thorncreek Road to Moscow, Map of Three Alternatives) is through the Paradise Ridge natural area near Moscow, Idaho. Paradise Ridge is considered Giant Palouse Earthworm habitat because of its high quality native vegetation and un-altered soils. In fact, earthworms recently collected in this natural area are considered by some scientists to be *D. americanus*. (University of Idaho, 2008). This proposed route for US Highway 95 would alter and fragment a significant portion of the few remaining Giant Palouse Earthworm habitats. This project is a clear and immediate threat to this species.

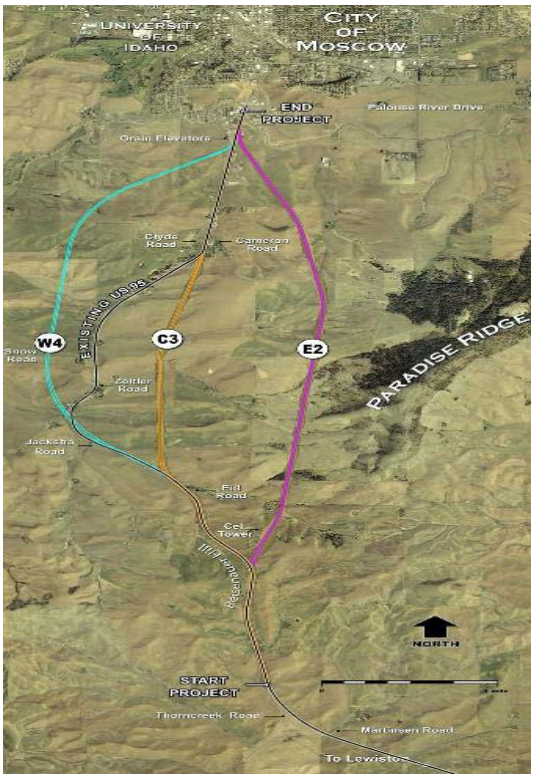


Figure 4- U.S. 95 Thorncreek Road to Moscow, Map of Three Alternatives

As such, urban sprawl represents a serious threat to the continued existence of the Palouse Giant Earthworm.

Livestock grazing. Livestock grazing is a pervasive land use in the range of the Giant Palouse Earthworm. James (2000) summarized the impacts of livestock grazing on earthworms and their habitat, concluding that grazing affects earthworms through "manure deposition" that "reduces available leaf litterfall," killing of roots, which can increase soil detritus up to a point and thereby alter soil invertebrate communities, and compaction of soils, "thereby making burrowing and feeding more difficult for earthworms." The specific effects of livestock grazing on the Giant Palouse Earthworm have not been studied, nor are they likely to be studied in the near future because there are too few earthworms to study. That said, James (2000) concluded: "cattle trampling has a blanket negative effect that results in a decline in earthworm populations," and thus the best available information indicates livestock grazing is a threat to the species.

2. Inadequacy of existing regulatory mechanisms;

There are currently no federal, state, or local regulations that adequately protect the Giant Palouse Earthworm or its habitat. In particular, there are no regulations specific to the earthworm itself. The Washington Department of Wildlife does list the earthworm as a candidate for listing as threatened or endangered, which they define as a species that "the Department will review for possible listing as State Endangered, Threatened, or Sensitive" and as a species of concern, which includes "those species listed as State Endangered, State Threatened, State Sensitive, or State Candidate" (see http://wdfw.wa.gov/wlm/diversty/soc/soc.htm). Besides indicating that the earthworm warrants protection as a threatened or endangered species, these

designations do not provide any substantive regulatory protections, such as protection against harm or habitat destruction.

The "Palouse Subbasin Management Plan" (PSMP) was developed by the Palouse-Rock Lake Conservation District at the behest of the Northwest Power and Conservation Council (NWPCC) and contains a number of recommendations that if implemented could benefit the Giant Palouse Earthworm (Palouse Subbasin Management Plan 2004). Specifically, the PSMP includes three objectives that seek to protect or restore Giant Palouse Earthworm habitat, including objectives 7, 8, and 15, which seek to "protect native grassland habitat within the Palouse subbasin," "restore lost or degraded grassland habitat within the Palouse subbasin," and "increase wildlife habitat value on agricultural land for focal species support." These are commendable objectives, but they are entirely voluntary in nature; neither the Conservation District nor NWPCC have authority to enforce any of the provisions of the Plan, and there is no guaranteed funding to ensure the objectives are met. As such, the PSMP does not qualify as a regulatory mechanism that would obviate the need for listing.

In 2003, the Forest Service, Bureau of Land Management, Fish and Wildlife Service, Environmental Protection Agency, and NOAA Fisheries signed a memorandum of understanding agreeing to implement the "Interior Columbia Basin Strategy" (U.S. Forest Service et al. 2003), which was an outgrowth of the Interior Columbia Basin Ecosystem Management Project (see http://www.icbemp.gov/html/icbhome.html). Neither the MOU nor the accompanying strategy specifically mention the Giant Palouse Earthworm or create any regulatory protections to provide protections for its habitat. Rather, they prescribe a number of broad principles that should be considered and adopted during future planning processes, such as development of resource management plans or project planning. For example, the strategy states that "management plans shall address ways to maintain and secure terrestrial habitats that are comparable to those classified by the science findings as "source" habitats that have declined substantially in geographic extent from the historical to the current period and habitats that have old-forest characteristics," which does include habitats that are potential habitat for the earthworm. The vague language of the strategy, however, makes such action entirely voluntary with no guarantee that any habitat for the earthworm will be protected or restored, let alone sufficient habitat for its survival or recovery.

We know of no other regulations or plans that provide any protection for the Giant Palouse Earthworm or its habitat.

Another threat to the earthworm is exotic earthworms, which in recent centuries have come to dominate moist soils of North America (see above). Currently, there are no regulations governing the import of earthworms into the U.S. The Federal Plant Pest Act (FPPA) (7 U.S.C. § 150aa-150jj, May 23, 1957, as amended 1968, 1981, 1983, 1988 and 1994) does allow the Animal and Plant Health Inspection Service (APHIS) to control imports containing soil that might carry pathogens, but earthworms are not classified as pathogens. Hendrix and Bohlen (2002) observed: "In the absence of pathogens, it appears that any earthworm species may be imported, that is, there is no specific consideration of earthworms as invasive organisms" (p. 809). They go on to suggest that without regulatory reform invasions by new and already known species will continue to occur (p. 809). The introduction of new invasive species of earthworms

carries the risk of the introductions of pathogens (see summary of factor C above) carried by exotics from infected areas. There are no regulations to prevent this from occurring.

E: Other natural or manmade factors affecting its continued existence.

Exotic earthworms. In addition to habitat destruction, *D. americanus* is severely threatened by invasion by exotic earthworms (James 1995, James 2000, Fauci and Bezdicek 2002, Sánchez-de León and Johnson-Maynard 2008). The major concerns regarding exotic earthworms described by Hendrix and Bohlen (2002) are the "potential for certain species to invade new habitats and, once established, the effects they may have on other organisms and soil processes within those habitats". Not only are the native species threatened, but the ecosystem is threatened with the loss of the important beneficial functions that the native species provides within the soil ecosystem. Exotics often perform very different functional roles in the soil ecosystem than the earthworms they displace.

Two recent surveys of both agricultural and native prairie remnants found that exotic earthworms dominated both areas and that they had likely contributed to the demise of the Giant Palouse Earthworm (Fauci and Bezdicek 2002, Sánchez-de León and Johnson-Maynard 2008). Fauci and Bezdicek (2002) extensively searched deep burrows for Giant Palouse Earthworm, but did not find the species and concluded:

> Worm species that live in permanent deep burrows, like the night crawler (*Lumbricus terrestris*) can escape shallow sampling by withdrawing into their burrows. We checked sites with large diameter worm burrows (greater than 6mm) carefully because *D. americanus* is believed to inhabit permanent or semi-permanent deep vertical burrows much like *L. terrestris* and adults of both species are of similar diameter. However, at all sites with large diameter burrows, we found adult *L. terrestris*.

Likewise, Sánchez-de León and Johnson-Maynard (2008) found that exotic earthworm species dominated in both disturbed habitat, where no Giant Palouse earthworms were found, and in native habitat, where only a single Giant Palouse Earthworm was found. Based on these results and the extensive literature documenting replacement of native earthworms by exotics, they concluded:

> Our results suggest that the combined effects of land-use change, habitat fragmentation and competitive interactions have resulted in the decimation of native earthworm populations and dominance of invasive earthworms in native and non-native grasslands of the Palouse region.

Other Exotic Species. In general, native earthworms are vulnerable to habitat disturbance and invasion by exotic species (James 1995, p.5). Invasion of exotic species is a twofold threat to the Giant Palouse Earthworm. First, exotic plants and animals pose a threat to the native shrub and grassland habitat upon which the species depends. Second, native earthworm species are susceptible to the invasion of exotic earthworm species that are better able to adapt to a degraded environment.

Non-native plants and animals have been both intentionally and accidentally introduced into the Palouse bioregion ecosystem (USDA LUHNA). Invasion of Kentucky bluegrass is common on deep soil sites (Palouse Subbasin Management Plan 2004). Much of the native interior grasslands have been replaced by agricultural crops or severely reduced as a result of competitors, such as cheatgrass. On the shallower and drier soils, cheatgrass is the likely dominant. Yellow star thistle has become the dominant species in many disturbed areas (Palouse Subbasin Management Plan 2004). It is likely that these species do not provide the same quality and quantity of forage as native vegetation.

Global climate change. Since Fender and McKey-Fender (1990, page 366) describe annual precipitation as a parameter of *D. americanus*' habitat, it is likely that changing weather patterns caused by global warming will impact this species' habitat and distribution.

Conclusion

The Giant Palouse Earthworm (*D. americanus*) qualifies for protection under the Endangered Species Act. The species has been recommended for protection from state agencies, federal agencies, and international agencies. This species faces multiple threats from agriculture, sub-urban and rural development, road and highway expansion projects and maintenance, inadequacy of existing regulatory mechanisms, and the competition of exotic species. Habitat degradation has also increased the vulnerability of this species to disturbance regimes and weather, such as flooding, drought, erosion, and global warming.

Due to the threat of extinction, the small population size, and the numerous factors threatening the species and its remaining habitat, the petitioners request that the U.S. Fish and Wildlife Service emergency list the earthworm as an endangered species. Furthermore, the petitioners request designation of Critical Habitat concurrent with listing, as is required by the law, in order to protect and restore the native habitat upon which the Giant Palouse Earthworm depends.

The Giant Palouse Earthworm is at severe risk of extinct in the near future without these protection measures.

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