SPECIES FACT SHEET

Scientific Name: *Driloleirus americanus* (Smith, 1897)
Common Name: Giant Palouse Earthworm, Washington Giant Earthworm
Phylum: Annelida
Class: Clitellata
Order: Haplotaxida
Family: Megascolecidae

Taxonomic Note:

This species was originally placed in the genus *Megascolides* (Smith 1897) and later placed into the genus *Driloleirus* (Fender and McKey-Fender 1990). Morphological differences have been noted between specimens of *Driloleirus* collected from the western and eastern edges of this species' range, but recent genetic research by Johnson-Maynard and Baugher (2015) does not support recognition of separate central Washington and Palouse *Driloleirus* species. However, some genetic clustering has been identified among specimens collected across the range (Johnson-Maynard and Baugher 2015), and additional analysis is in progress to determine whether populations may consist of subspecies (Baugher, personal communication).

Conservation Status:

Global Status: G1 (February 2006)
National Status: United States (N1) (February 2006)
State Statuses: Washington (S1)
(NatureServe 2015)

Washington Natural Heritage Program: S2 (September 2014)
IUCN Red List: VU – Vulnerable

Idaho Natural Heritage Program has not ranked this species.

Technical Description:

Adult: Smith (1897; 1937) described distinguishing characters of adult *Driloleirus americanus*, reporting that total length ranges from 150-190 mm and diameter at somite 18 ranges from 6-10 mm, although these

measurements may be influenced by preservation method. Fender and McKey-Fender (1990) report that congeners may reach more than 600 mm in length, but lengths of this size have not been verified for this species (USFWS 2011). The number of somites ranges between 218 and 246 (Smith 1937).

Setae are described as inconspicuous, and some may be lacking although setae sacs are present. Penial setae were present on somite 18 in some specimens and absent in others and are described as "very closely paired, long, slender, curved in sagittal plane, with distal one-third projecting posteriad from openings, and finely sculptured near tips" (Smith 1937). Both the penial setae and male pores are located on transversely elongate papillae with the pores close and to the side of the setae. Spermathecae are paired and pores are located anteriorly in segments 8 and 9 (Smith 1937).

The clitellum is reddish-tan in color and incomplete ventrally (saddle-shaped), and dorsal pores are also located posteriorly. Intersegmental papillae are circular, median and ventral on 14/15, 15/16, and 16/17 and paired ventrally on 19/20 and 20/21 (as well as 21/22 in some specimens; Smith 1937). The clitellum is also typically associated with segments 13-18 as compared to lumbricids, in which the clitellum occurs posterior to segment 18 (Fender and McKey-Fender 1990). Adults have been reported as pale in coloration (USFWS 2011) and the anterior and posterior ends appear bulbous (Fender and McKey-Fender 1990).

Immature: Juveniles may be difficult to identify as they lack a clitellum, which is a diagnostic feature for a number of earthworm species. Juvenile color is also variable, in part due to soil conditions. Generally sexually-mature earthworms are necessary for identification (USFWS 2011).

Life History:

Most species of earthworms native to the Pacific Northwest likely reproduce in the winter and early spring months and spend much of the summer in aestivation (Fender and McKey-Fender 1990). Three main life history strategies have been identified for earthworms, characterized by the species' distribution within the soil profile: epigeic, endogeic, and anecic. This species has been identified as both endogeic (occurring within the upper mineral horizons and feeding on decomposing organic matter) and anecic (forming burrows spanning soil horizons and feeding on less-decomposed organic matter near or at the surface; Edwards and Bohlen 1996; USFWS 2011). USFWS (2011) cites evidence suggesting this species is anecic, including deep burrows (reported as deep as 15 feet or more; Smith 1897) and the presence of surface castings.

Anecic earthworms are also described as large, relatively long-lived with longer generation times, somewhat mobile, with the ability to rapidly withdraw into burrows, less active during periods of drought, and at high risk of predation when at the surface (Edwards and Bohlen 1996).

Range, Distribution, and Abundance:

Range: This species is reported as the only native earthworm from the Palouse prairie (Xu et al. 2013), a region spanning parts of eastern Washington, northwestern Idaho, and northeastern Oregon. The species was previously believed to be limited in range to the Palouse; however, the species was documented in the 1980s from a site near Ellensburg, Washington. In addition, surveys were conducted at 54 sites in 2011 and 49 sites in 2012 in the East Cascades by staff at Washington Natural Heritage Program (WDFW 2013). These and more recent surveys have resulted in nearly 30 documented observations in the state of Washington. Range size in Washington is thought to span 3,500-5,000 km^2, although the western boundary is not well understood (Fleckenstein 2014). The species is known from several sites near Moscow, Idaho (USFWS 2011).

Distribution: East Cascades sites are located near the towns of Ellensburg, Cle Elum and Leavenworth, Washington. The species also ranges into Latah County, Idaho and has been documented in Chelan, Kittitas and Whitman counties in Washington (USFWS 2011; Fleckenstein 2014).

BLM/Forest Service Land: This species is documented on the Okanogan-Wenatchee National Forest. The species is suspected on the Mount Baker-Snoqualmie National Forest given its proximity to sites on the Okanogan-Wenatchee National Forest (20 miles from documented sites) and available habitat (dry-mesic fir and Douglas-fir forest; USGS 2011). The species is also suspected on the Umatilla National Forest, as it has been reported in ponderosa pine, Douglas-fir, and fir forest habitat (WDFW 2013), which comprise approximately 45% of forested habitat on the Umatilla NF (Christensen et al. 2007). Additionally, the species has been reported from eastern Washington less than 20 miles from the Umatilla NF boundary (Wells et al. 1983). Similarly, the species is suspected on the Wallowa-Whitman National Forest, which is located less than 35 miles from a reported occurrence and also contains mixed conifer forest (USGS 2011).

This species is documented on the Spokane District, BLM. It is suspected on the Vale District, BLM, which is located less than 30 miles from a reported occurrence and contains some mixed conifer forest habitat (USGS 2011).

Abundance: The original description of this species was accompanied by a report by the original collector that the species was "very abundant" (Smith 1897). Johnson-Maynard and Baugher (2015) estimated 6.25 worms/m^2 at a site in central Washington based on a single specimen collection in a hand sorted collection plot. At one site, they also reported 13 juvenile specimens from an area adjacent to the hand sorted collection plot. Xu et al. (2013) reported an average of 0.28 worms/m^2 across sampling sites and 9 worms/m^2 during one sampling event. Sánchez-de León and Johnson-Maynard (2008) reported 0.8 worms/m^2 at a Palouse prairie site in Washington based on the collection of a single individual. However, the authors caution that remnant Palouse prairie sites in Idaho and Washington may represent poor-quality habitat for the species given their shallow soils and rocky or steep nature.

Additionally, the hand sorting sampling method used may underestimate the species' abundance, and distribution and abundance may be patchy and seasonally variable. Thus, the species' current abundance is difficult to assess given its fossorial habit and challenges associated with sampling. The number of recent observations could therefore be a result of reduction in abundance compared to Smith's (1897) historical account, inadequate sampling methods, or a combination of these factors (USFWS 2011).

Habitat Associations:

The species has been found in deep and shallow loamy soils (WDFW 2013; Johnson-Maynard and Baugher 2015), silt loam soils (Xu et al. 2013), and sandy loam and sandy clay loam soils (Johnson-Maynard and Baugher 2015). The species may tolerate soils with coarser textures (such as gravel) and sand content ranging from 37 to 74%, although estimates correspond to the upper soil profile (USFWS 2011; Johnson-Maynard and Baugher 2015). Information regarding surficial soil deposits is available for many areas (NRCS 2016), but subsoil conditions may be more important for assessing this species' distribution because this species is suspected to live in deep burrows (Johnson-Maynard and Baugher 2015). An early unconfirmed observation of burrows as deep as 15 feet was reported (Smith 1897).

In Palouse prairie habitat, this species was located in sites with the highest plant diversity and highest native plant diversity (Xu et al. 2013). Habitat associations include open or scattered ponderosa pine with arrowleaf

balsamroot, dense grass, and lupine; wet meadow; remnant Palouse prairie; grass/forb opening in pine or fir forest; Douglas-fir forest; hawthorn thicket; and shrub steppe (Wells et al. 1983; Sánchez-de León and Johnson-Maynard 2009; USFWS 2011; WDFW 2013). In central Washington, the species is reported from sites ranging from ~500 to ~1,220 meters in elevation and with slopes between 0 and 20% (Johnson-Maynard and Baugher 2015).

Threats:

In a petition to the USFWS to list *D. americanus* under the Endangered Species Act, petitioners (FOC et al. 2009) identified habitat loss and fragmentation as an immediate threat to the species. The species was previously believed to be restricted to Palouse prairie habitat (USFWS 2011). Nearly all native Palouse prairie has been converted to agriculture and what remains is fragmented, occurs in small patches (<2 hectares), and consists of thin, rocky soil (Looney and Eigenbrode 2012). *D. americanus* has not been collected from agricultural areas although earthworm surveys have been conducted (USFWS 2011). More recently the species has been reported from the East Cascades (USFWS 2011; WDFW 2013; Fleckenstein 2014). Although a similar magnitude of habitat loss and conversion has not occurred in the east Cascades, the effects of habitat loss, conversion, or fragmentation on the species are not well understood.

Other threats identified by the petitioners and evaluated by USFWS (2011) include general impacts to soil characteristics (disturbance, pesticide use, and soil microclimate), soil compaction, alteration of soil chemistry, tillage and agriculture, grazing, urban and rural development, and forest management. In general, USFWS (2011) cited a lack of information regarding negative effects of these proposed threats to the species.

Invasive nonnative earthworms were also identified as an immediate threat to the species (FOC 2009). These exotics are dominant in the Palouse region in urban areas, agricultural areas, and native and nonnative grassland habitat (James 2000; Fauci and Bezdicek 2002; Smetak et al. 2007; Sánchez-de León and Johnson-Maynard 2009). USFWS (2011) determined that due to limited sampling, insufficient sampling methods, and conflicting evidence regarding native-invasive earthworm interactions, it is not currently possible to draw conclusions regarding the impacts of invasive nonnative earthworms on *D. americanus*.

Conservation Considerations:

Research: The USFWS (2011) indicated that "there are significant scientific uncertainties regarding the [giant Palouse earthworm's] distribution, habitat diversity, biology, and population trends, which need to be resolved to be able to conduct a credible scientific assessment of potential threats to the species." Additional research in these areas, as well as evaluation of threats to the species would provide valuable information that could inform conservation efforts for this species.

Inventory: Inventories for this species could be conducted in areas providing habitat and soils similar to recent collection sites to establish the species' range. Genetic research is in progress to enable non-lethal species identification using castings or burrow scrapes (Johnson-Maynard and Baugher 2015; Baugher, personal communication), which could reduce impacts to the species from more intensive survey efforts. Additional efforts to evaluate and improve survey methods, both increasing effectiveness and reducing destructiveness, could be included in future surveys.

Management: Little is known about this species' distribution or current threats to populations; however, based on potential threats to the species (discussed in USFWS 2011), the following general recommendations are provided:

- Limit land management activities that disturb soils or have the potential to impact soil microclimate, such as those that create bare soil or reduce surface litter or affect soil temperature and moisture.
- Avoid tillage, pesticide application, and heavy grazing or trampling of potential *D. americanus* habitats.
- Maintain existing Palouse prairie remnants or other grassland habitats within the species' known range.

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ATTACHMENT 1: References
ATTACHMENT 2: List of pertinent or knowledgeable contacts
ATTACHMENT 3: Map of species' occurrence in Washington
ATTACHMENT 4: Photographs of this species
ATTACHMENT 5: Survey protocol

ATTACHMENT 1: References

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ATTACHMENT 2: List of pertinent or knowledgeable contacts

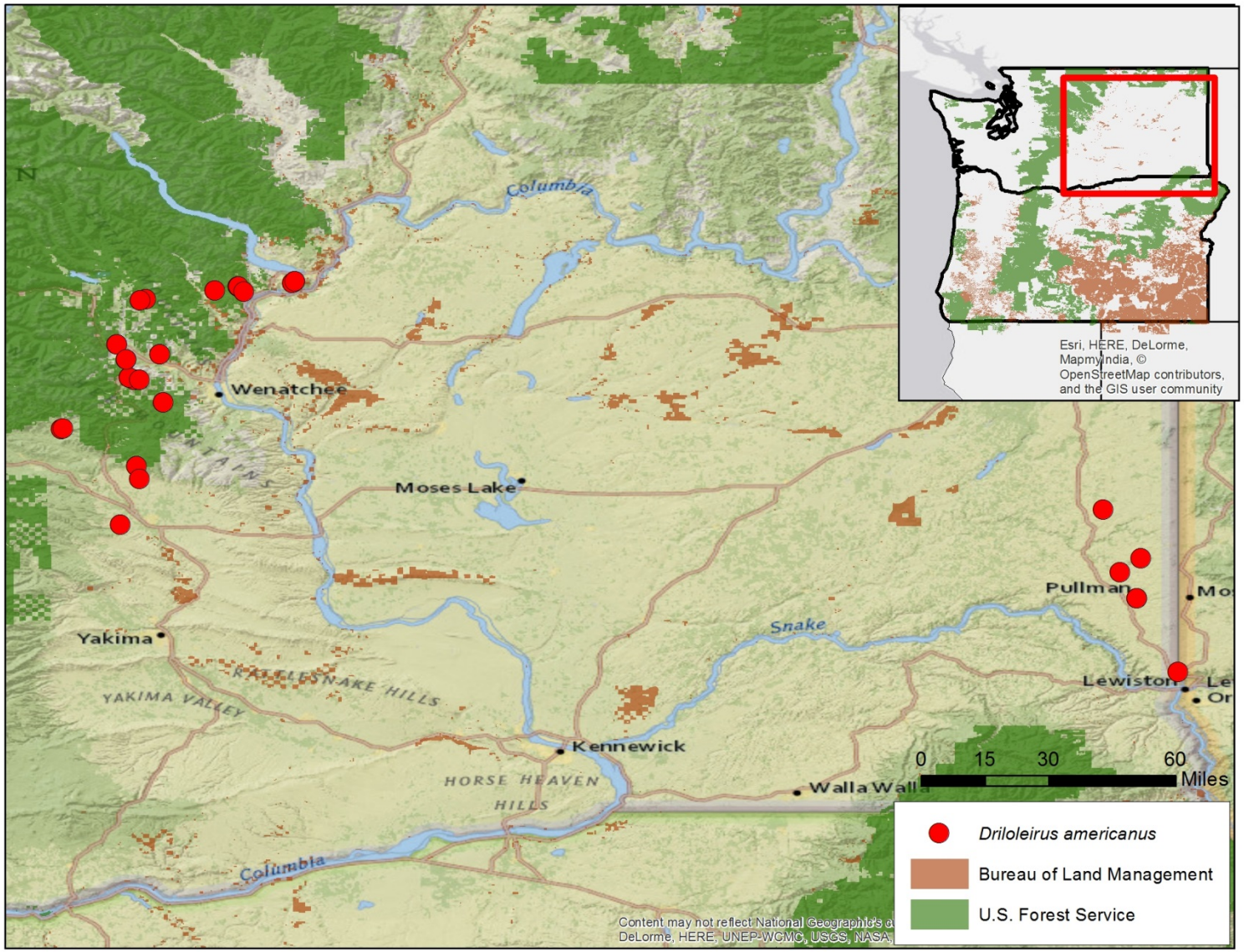
Michael Westwind (Bill Fender), independent consultant

Jodi Johnson-Maynard, University of Idaho

Chris Baugher, University of Idaho

John Fleckenstein, Washington Natural Heritage Program

ATTACHMENT 3: Map of species' occurrence in Washington



ATTACHMENT 4: Photographs of this species

Photo of *Driloleirus americanus* © Chris Baugher. Image licensed under Creative Commons (http://creativecommons.org/licenses/by-nc/2.0/), which permits one to "Share — copy and redistribute the material in any medium or format." Image and licensing information available online: http://eol.org/data_objects/31735403.

Photo of *Driloleirus americanus* castings (scale provided in centimeters) © Chris Baugher, University of Idaho and used with permission.

ATTACHMENT 5: Survey Protocol

How:

Although *Driloleirus americanus* has been found at the surface, surveys have typically included hand sorting or electroshocking to extract specimens from soil (USFWS 2011). Hand sorting is typically not recommended for anecic species due to their tendency to form deep burrows (Clapperton et al. 2007), but this method has been successful in recent survey efforts and is considered the current best method for collecting live specimens of this species (Fleckenstein, personal communication; Baugher, personal communication).

Hand sorting consists of removing a volume of soil from a collection plot, which varies in dimension depending on the species and soil profile of interest. Soil is removed using a tool such as a spade or trowel, metal corer, or plastic PVC collar. Sorting can be conducted in any soil type, but soils should be examined one layer at a time, and layers should not be mixed. Soil can be transferred to a plastic sheet from which it is hand sorted, soil clods are broken up, and earthworms are sieved. Once examined, soil can be deposited on a light-colored tray or container. Soil should be returned in the same order and layer as it was extracted. Water can also be used when sieving to increase efficiency (Clapperton et al. 2007). Note, however, that hand sorting is considered destructive, as large soil pits (30cm x 30 cm x 50cm deep, Xu et al. 2013; 60cm x 60 cm, USFWS 2011) are dug, and soil is sieved to extract earthworms. Fleckenstein (personal communication) successfully located the species in multiple locations using this method when searching in the vicinity of castings.

Xu et al. (2013) tested several methods, including electroshocking with soil probes, which was used to successfully collect specimens of *D. americanus*, although the authors noted that efficacy of electroshocking may be influenced by soil moisture and conductivity. Electroshocking can be conducted by placing soil probes within a sampling area of a chosen size and applying an alternating current (Xu et al. 2013 applied 200V) to probes in cycles of 1 minute. Weyers et al. (2008) describe a design for building and operating an electroshocking device for earthworm sampling. A combination of electroshocking and hand sorting the top 10 cm of soil is recommended when soil moisture is low (below 20%) or to reduce disturbance (Xu et al. 2013). Xu et al. (2013) did not successfully collect specimens when testing application of allyl isothiocyanate (AITC) to the soil, one type of chemical irritant that can cause earthworms to move to the soil surface (Clapperton et al. 2007).

Species identification methods have typically required specimen preservation and dissection, but genetic data is currently being used to develop environmental DNA (eDNA) sampling techniques (Johnson-Maynard and Baugher 2015; Baugher, personal communication). Collection of casts or burrow scrapes may be useful for species detection in the future, and is considered preferable to whole animal collection as it is nondestructive and noninvasive (Johnson-Maynard and Baugher 2015).

Where:

This species' habitat associations are not well understood, as recent observations indicate it occurs in habitat as diverse as open ponderosa pine forest with an herbaceous understory; open pine or fir forest; Douglas-fir forest; remnant Palouse prairie; and shrub steppe (Wells et al. 1983; Sánchez-de León and Johnson-Maynard 2009; USFWS 2011; WDFW 2013). The species has not been reported from agricultural lands (USFWS 2011). It has been collected from loamy soils of varying depths and silt, sand and clay content (WDFW 2013; Xu et al. 2013; Johnson-Maynard and Baugher 2015), and the species is thought to be more tolerant of soils with coarser textures (USFWS 2011; Johnson-Maynard and Baugher 2015). Surveys are therefore recommended in loamy soils in grassland or open forest within habitats similar to those of existing collection sites. WDFW (2013) indicates surveys should be prioritized north and south of the currently known range in the East Cascades.

Because the species is known to deposit casts at the soil surface, the presence of castings can also be used to identify locations for further surveys. Castings may be larger for larger earthworms like *D. americanus* (Fleckenstein, personal communication; Baugher, personal communication), and thus the presence of larger castings could be used to identify priority survey sites.

When:

The species has been detected from March through June and in November (Sánchez-de León and Johnson-Maynard 2008; Xu et al. 2013; Fleckenstein, unpublished data). Xu et al. (2013) conducted surveys after snowmelt when soil moisture was high (>20%) and again in November following fall precipitation. As with *D. macelfreshi* (Foltz 2009), sampling is recommended when soils are moist, temperatures are above freezing, and during generally damp conditions.