CONSERVATION ASSESSMENT
FOR

Prophysaon coeruleum,
Blue-Gray Taildropper

Prophysaon coeruleum. Photograph by Bill Leonard, used with permission

Originally issued as Management Recommendations September 1999
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Revised October 2005
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Updated December 2014
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USDA Forest Service Region 6 and
USDI Bureau of Land Management, Oregon and Washington
Interagency Special Status and Sensitive Species Program

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Preface

Summary of 2014 updates:
In 2014, the framework of the original document was reformatted to more closely conform to the standards for the Forest Service and BLM for Conservation Assessment development in Region 6 (Washington and Oregon). Additions to this version of the Assessment include NatureServe ranks, photographs of the species, and a Washington distribution map based on the record database that was compiled/updated in 2014. Oregon was not a focus of the 2014 Conservation Assessment Update, since the species has no status in the state (Huff, R. 2014, *pers. comm.*). Distribution, habitat, life history, taxonomic information, and other sections in the Assessment have been updated to reflect new data and information that has become available since earlier versions of this document were produced. A textual summary of records that have been gathered between 2005 and 2014 is provided, including number and location of new records, any noteworthy range extensions, and any new documentation on FS/BLM land units in Washington. A complete assessment of the species' occurrence on Forest Service and BLM lands in Washington is also provided, including relative abundance on each unit.

Executive Summary

Species: ***Prophysaon coeruleum*** Cockerell, 1890, Blue-gray Taildropper

Taxonomic Group: Mollusks (Phylum Mollusca: Class Gastropoda, Family Anadenidae)

Taxonomic Note: Using mitochondrial DNA analysis, Wilke and Duncan (2004) found three major clades and eight subclades among specimens collected from throughout the range of this species. As such, *Prophysaon coeruleum* is now considered a species complex rather than a single species (Burke 2013). The typical blue-gray color form occurs in western Washington and Oregon, although considerable variation in color is found throughout the documented range, including a nearly black form in the Columbia Gorge in Oregon and at higher elevations in the southern parts of its range; a blue-white variety occurs in the Central Coast Range in Oregon; and a bluish-brown variety ("Klamath taildropper") in the more open, drier habitats of the southern Oregon Cascades (Burke 2013). According to Burke (2013), the latter two varieties appear to be separate species.

Management Status: This species is classified as a Sensitive Species in Washington by Region 6 of the Forest Service. Although the species occurs in Oregon, it is much more common, and not listed by either the Forest Service or BLM as Sensitive or Special Status in the state. In the Klamath province and eastern Oregon Cascades, *Prophysaon coeruleum* may be part of a complex which includes the undescribed Klamath taildropper, currently recognized as a separate taxa and an Oregon BLM/FS strategic species.

The NatureServe Status for *Prophysaon coeruleum* is as follows:

Global Status: G3G4 (2010)
National Status (United States): N3N4
State/Province Statuses: California (S1S2), Idaho (SNR), Oregon (S3), Washington (S1), British Columbia (S1)
(NatureServe 2014).

Range: The type locality of *Prophysaon coeruleum* is from Olympia, Thurston County, Washington. The range of this species complex extends from Vancouver Island, British Columbia south through the western Cascades and Puget Trough of Washington, the western Cascades and Coast Range of Oregon, to the Klamath Mountains of northern California (Ovaska et al. 2002, Burke 2013). A disjunct population inhabits the area around Lake Coeur d'Alene and as far south as Lapwai Creek in southern Nez Perce County, Idaho (Ovaska et al. 2002, Burke 2013). In the Klamath province and eastern Oregon Cascades, this species complex includes *Prophysaon* new sp., the Klamath taildropper.

Habitat: *Prophysaon coeruleum* is found in a variety of forest types and plant communities, including conifer-hardwood and mixed conifer stands. It is most often found in moist, late-successional forests where it is associated with hardwood species such as big-leaf maple, conifer logs, deep litter, fungi and mosses.

Threats: Primary threats in Washington are the loss of habitat and population isolation due to forest management practices, conversion for agricultural, urbanization and other uses, and fire. Other threats may include vertebrate and invertebrate predators (i.e., predatory snails, and beetles), which can concentrate in isolated, small habitat patches where slugs are vulnerable. In some forest stands, bigleaf maples can be suppressed by Douglas-fir and other conifers or lost as a result of selective thinning, leading to a long-term loss of this habitat element and the associated fungi species used by the species. In addition, bigleaf maple dieback is an emerging threat in some areas where this species occurs. Harvest of special forest products (i.e., harvest of mushrooms, firewood gathering, moss harvest, collection of swordfern and salal plants for ornamental transplant) are potential threats in limited habitats.

Management Considerations: Within Species Habitat Areas, fluctuations in temperature and humidity should be moderated by maintaining favorable shade and limiting adverse impacts of fire. Maintain a variety of tree and plant species, especially hardwoods, critical in providing fungal food resources used by the species. Maintain or restore microsite conditions and key habitat features at known sites; maintain habitat contiguity throughout the surrounding occupied habitat; and provide cover used for daily refugia by preserving and recruiting dead and downed woody debris. Avoid compaction of the soil and litter layer, and avoid disturbance to occupied rockslides and talus areas to provide deep seasonal refugia sites.

Research, Inventory, and Monitoring Opportunities: Some of the primary information needs are:

- Are the recognized variants of *P. coeruleum* (e.g. Klamath taildropper and other undescribed variants) separate species or subspecies?
- What is the range of habitat conditions (canopy cover, age, large woody debris, litter and duff, etc.) tolerated by the species, or required for populations to remain secure and viable?
- How do the required stand characteristics vary under different circumstances (elevation, slope, aspect, etc.)?
- What stand size is required to provide sufficient area of suitable habitat?
- How much time is required for recolonization of a site by individuals from adjacent populations?
- What seasonal refugia sites are used by the species as protection from catastrophic fire?
- What impacts, if any, are non-native mollusks having where they occur with *P. coeruleum*?

I. Introduction

A. Goal

The goal of this Conservation Assessment is to summarize existing information regarding the biology, ecology, known threats, and management considerations for this species, in order to assist managers in the formulation of options for management activities. This species is of concern due to its highly restricted distribution, limited mobility, narrow habitat requirements, and sensitivity to anthropogenic disturbance. Federal management for this species follows Region 6 Sensitive Species (SS) and/or OR/WA BLM Special Status Species (SSS) policies.

For OR/WA BLM administered lands, SSS policy details the need to manage for species conservation. For Region 6 SS policy requires the agency to maintain viable populations of all native and desired non-native wildlife, fish, and plant species in habitats distributed throughout their geographic range on National Forest System lands. Management "must not result in a loss of species viability or create significant trends toward federal listing" (FSM 2670.32) for any identified SS.

B. Scope

The geographic scope of this assessment includes consideration of the known and suspected range of the species in the planning area of the Forest Service Region 6 in Washington, where the species is listed as Sensitive. An emphasis of species-considerations is provided for federal lands; however, species-knowledge compiled from federal lands outside the planning area and non-federal lands is included as it is relevant to the overall conservation of the species. This assessment summarizes existing knowledge of a relatively little known invertebrate. A great deal of new information has been generated regarding this species in the last decade, and is incorporated here, but information updates may be necessary to keep this assessment current with time. Also, threats named here summarize known or suspected existing threats, which also may change with time. Management considerations typically apply to site-specific locations; however some larger scale issues such as population connectivity and range-wide concerns are listed. Uncertainty and inference are acknowledged where appropriate.

C. Management Status

This species is classified as a Sensitive Species in Washington by Region 6 of the Forest Service. Although the species occurs in Oregon, it is much more common, and not listed by either the Forest Service or BLM as Sensitive or Special Status in the state. However, in the Klamath province and eastern Oregon Cascades, *Prophysaon coeruleum* may be part of a complex which includes the undescribed Klamath taildropper, currently recognized as a separate taxa and an Oregon FS/BLM Strategic Species.

The NatureServe Status for *Prophysaon coeruleum* is as follows:
Global Status: G3G4 (2010)
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(NatureServe 2014).

Prophysaon coeruleum is considered to be a Category A species under the Survey and Manage standards and Guidelines, in both California and Washington, based on the low number of occurrences, its low detection rate in suitable habitat and its small range.

II. Classification and Description

A. Systematic and Synonymy
Family: Anadenidae
Species: *Prophysaon coeruleum* Cockerell, 1890, Blue-gray Taildropper

Prophysaon coeruleum was first described by Cockerell.

Taxonomic Note: Wilke and Duncan (2004) examined genetic structure of *P. coeruleum* throughout the species' range using markers from two mitochondrial genes. Within the overall range, the analysis showed a complex genetic structure and revealed three major clades, presumed to be about 2.6 – 5.9 million years old. Superimposed on this deep phylogenetic structure is a shallow structure with a total of eight minor clades. This shallow structure is less than 2 million years old and probably reflects perturbations associated with Pleistocene glaciations. The genetic distances among the three major clades are similar to or greater than those between other species of *Prophysaon*, and it is likely that the form currently known as "*Prophysaon coeruleum*" represents a complex of cryptic species (Wilke and Duncan 2004).

The Washington specimens were found to be part of a large major clade that includes southern Vancouver Island south through the Cascade Mountains in Washington State to south-central Oregon; a disjunct population in Idaho is also included within this major clade. This major clade, in turn, consists of three minor clades – a northern contingent, a small clade in south-central Oregon, and a curious clade with representatives in both southern Oregon and northern Idaho. The Washington specimens are a part of the large northern minor clade, along with representatives from British Columbia and Oregon. Therefore, the Washington populations do not represent a genetically distinct clade.

Most of the genetic fragmentation is found within the southern portion of the species' range, especially in the Klamath region in southern Oregon which has resulted in several "clades" or variants in that region (Wilke and Duncan 2004). As yet, none of these subsets of the parent species have been officially named or described as subspecies or separate species, although one group has unofficially been described by Frest and Johannes in several inventory documents as *Prophysaon* new species, commonly known as the Klamath taildropper (Frest and Johannes 1999, 2000). This analysis also revealed that the three known color traits in *P. coeruleum* do not represent monophyletic groups and do not match the patterns of genetic structure found. It is argued that the color traits are perhaps a response to different levels of UV-radiation (Wilke and Duncan 2004).

Given the above findings, *Prophysaon coeruleum* is now considered a species complex rather than a single species (Burke 2013).

B. Species Description

This taxon belongs to a genus in the family Anadenidae, a family of mostly small slugs with the pneumostomes located a little forward of the midpoint in the right side of the mantle, or near to or slightly posterior to the midpoint (Burke 2013). There are four genera in this family that occur in the Pacific Northwest: *Prophysaon, Kootenaia, Carinacauda,* and *Securicauda.* Of these, only *Prophysaon* contains several species; the others have only one known species each. Burke (2013) recognizes eight species within the genus *Prophysaon* native to temperate forests of the Pacific Northwest. Differences in the anatomical characteristics of the distal genitalia have been used to identify two subgenera (Pilsbry 1948): *Mimetarion*, which includes *P. vanattae, P. obscurum, P. fasciatum, and P. humile*; and *Prophysaon*, which includes the remaining species (*P. andersoni, P. boreale, P. coeruleum, P. dubium, and P. foliolatum*) (Ovaska et al. 2004). *Prophysaon coeruleum* can be distinguished from the other *Prophysaon* species by the following combination of characters (see key in Burke 2013): lacking in dark colored dorso-lateral bands behind the mantle; smaller body size (20-40 mm long when extended) with longitudinal or oblique deeply impressed grooves, without conspicuous spots, blue-gray with whitish flecks in the integument but no other colored markings; parallel longitundinal ridges and grooves on the tail.

P. coeruleum is described as follows (Burke 2013): nearly uniform blue-gray with scattered white flecks in the integument. The color is occasionally lighter on the sides and the sole may be white. Adults are 20-40 mm long when extended, although smaller, young animals are usually found in the field. Prominent grooves and ridges on the tail are horizontal and generally parallel, although occasionally interconnecting, and they become obliquely angled on the sides with increasing slope nearer and below the mantle. The mantle is about one-third the overall length, with the pneumostome just forward of the middle, and it may be covered with fine granules (small rounded bumps) (Burke 2013). The reproductive system of *Prophysaon coeruleum* is illustrated in Ovaska et al. (2004).

The following is quoted in Pilsbry (1948). Type description, "Length (in alcohol) 22 ½ mill., in motion, 43 mill. Body and mantle clear blue-gray, paler at sides, sole white. Mantle finely granulated, broad, without markings. Length of mantle 7 mm, breadth 5 mm Respiratory orifice 2 ½ mm from anterior border. Body subcylindrical, tapering, pointed. Distance from posterior end of mantle to end of body, 10 3/4 mm The reticulations take the form of longitudinal equidistant lines, occasionally joined by transverse lines, or coalescing. Sole not differentiated into tracts . . . . The neck is long and white, or very pale. (Cockerell)". Pilsbry adds, ". . . about 25 mm. long. The general color is clear payne's gray, the head and neck paler. Back with close, deep longitudinal grooves, which, on the sides, become oblique and more spaced, and more anteriorly they radiate vertically below the mantle." P. B. Randolph quoted in Pilsbry, 1948, stated "*Prophysaon coeruleum* is an exceedingly distinct species, distinguished by its color and the character of its reticulations…the very narrow foot-margin, with an unusually distinct border above, is another distinguishing feature." (Pilsbry 1948).

According to Burke (2013), the typical blue-gray color form occurs in western Washington and Oregon, although considerable variation in color is found throughout the documented range, including a nearly black form in the Columbia Gorge in Oregon and at higher elevations in the southern parts of its range; a blue-white variety in the Central Coast Range in Oregon; and a bluish-brown variety (“Klamath taildropper”) in the more open habitats of the southern Oregon

Cascades (Burke 2013). The latter two varieties appear to be separate species (Burke 2013). Frest & Johannes (1999, 2000) report apparent external differences of the Klamath taildropper from typical *P. coeruleum* in the color and habitat. Its color is more blue-brown than blue-gray, and the sole color is grey rather than white. It occurs in drier habitats in the Southern Oregon Cascades, extending down the east slopes. Other than that, it appears the same, exteriorly, as typical *P. coeruleum*, but a description of its internal morphology has not yet been published.

As noted above, a recent analysis of mitochondrial DNA of *P. coeruleum*, including specimens identified as the Klamath taildropper, indicates that color is not a reliable character with which to distinguish between these two groups (Wilke and Duncan 2004). The conclusion of this study is that these taxa cannot be distinguished from each other based on color, or on any other external features. The color markings of individuals found to be similar genetically to the Klamath taildropper do not all conform to the written description of Frest 2000. Blue specimens from western Oregon (Kelsey Creek in the Rogue River drainage, approximately five miles from the southern boundary of the Roseburg District BLM) fall into the same molecular clade as dark specimens from Winema National Forest identified as the Klamath taildropper. Other specimens from the Roseburg District, which were identical in external appearance to the Kelsey Creek specimens, were found to be genetically similar to the large clade of nominal *P. coeruleum* found from Roseburg north through western Oregon. Genetic information currently forms the sole basis for separation of the two taxa. There is no way, short of molecular analysis, to know whether sites recorded as *P. coeruleum* may be the Klamath taildropper. Both taxa may be more properly ascribed to one large species complex. Another blue variant, possibly a separate species of *Prophysaon,* is found in Douglas and Jackson counties of southern Oregon. This slug varies externally from *P. coeruleum* by a lighter, more translucent blue color caused by a greater abundance of the white pigments in the integument, but more distinctly by a different pattern of tubercles on the tail. This variant has low, not deeply delineated rectangular tubercles opposed to the well-defined ridges and grooves of typical. Wilke & Davis (2000) did not find that this variant was genetically different from nominal *P. coeruleum.*

III. Biology and Ecology

A. Life History

Like most terrestrial gastropods, *Prophysaon* are hermaphroditic, having both male and female organs. Although not confirmed specifically for *Prophysaon*, self-fertilization has been demonstrated in some species of gastropods, but cross-fertilization is the norm. Bayne (1973) discussed the complexities of the Pulmonate reproductive system, and studied mechanisms by which allosperms (sperm from another) exert dominance over autosperms (sperm from oneself) during fertilization. Thus, ". . . self-fertilization is normally avoided, but remains a possible alternative to cross-fertilization." The advantage is in normally avoiding potentially deleterious inbreeding, yet retaining the option to reproduce if a mate is not available.

Slugs are generally oviparous (egg laying). Eggs of *Prophysaon* slugs can be found in groups of several to many in cool damp spots such as under logs or pieces of wood on the shaded forest floor. This species appears to have an annual life cycle, maturing and reproducing within one year. An absence of observations of adults in the early spring, both in British Columbia and the United States, suggest that few or no individuals survive to their second year. The slugs probably

over-winter as eggs, which then hatch in the spring. Clutch size and details of the reproduction are unknown.

B. Activity Pattern and Movements

Little is known about the movement patterns of this species. Like most terrestrial mollusks, these slugs are probably relatively sedentary and have poor dispersal abilities, as evidenced by the species' scattered distribution throughout its range. Small pockets of greater density and the presence of suitable but unoccupied habitat further suggest this possibility.

C. Food Habits

The blue-gray taildropper is apparently primarily mycophagous, eating fungus (Mcgraw, Duncan and Cazares 2002). Slugs of this species have been observed consuming above-ground fungal fruiting bodies and using the hollowed stipes of several fungal species as protected sites for mating and temporary refugia. Fecal analysis of *P. coeruleum* has revealed spores from numerous underground mycorrhizal truffle species, especially during the fall season. Through its foraging, this slug disseminates spores and hyphal fragments of mycorrhiza and other fungi on which it feeds (McGraw, Duncan and Cazares 2002).

D. Range, Distribution, and Abundance

The range of *Prophysaon coeruleum* (species complex) extends from Vancouver Island, British Columbia, and Canada, south through western Oregon, to the western slopes of the southern Oregon Cascades, and into northern California (Burke 2013). A disjunct population inhabits the area around Lake Coeur d'Alene and as far south as Lapwai Creek in southern Nez Perce County, Idaho (Burke 2013). Elevations of known sites (including Oregon, British Columbia, Washington, and Idaho) are from near sea level to 1370 meters (4500 feet) (Branson and Branson 1984; Ovaska et al. 2004).

<u>Summary of historic and recent records</u>:

The type locality for *Prophysaon coeruleum* is Olympia, Washington. Pilsbry (1948) reported records of this species from Olympia, Thurston County, and Seattle, King County, Washington; and Portland, Multnomah County; Oswego, Clackamas County; and Corvallis, Benton County, Oregon. Branson and Branson (1984) collected one from each of 6 sites in Oregon (2 sites from each of Clackamas and Lane counties, and 1 from each of Marion, and Jackson counties). *Prophysaon coeruleum* has been found frequently in the Coast Range and western Cascades of Oregon, and at very few, scattered sites in British Columbia, and western Washington. Frest and Johannes (1996) added that the range of this species may extend as far east as Upper Klamath Lake and potentially along the eastern flank of the Cascades in Washington and Oregon.
One specimen from Idaho indicated that an additional population of *P. coeruleum* occurs in the Blue Mountains of Idaho, based on genetic similarity to the northern Oregon clade (Wilke and Duncan 2004). Three specimens from Siskiyou County, California have extended the range to that region, although according to Ovaska et al. (2004), there is some question whether the California specimens indeed belong to this species, since similar, undescribed species have also been found in the southern Oregon Cascades (Kelley et al. 1999, USDA Forest Service and USDI BLM 2000, Nancy Duncan *pers. comm. in* Ovaska et al. 2004). Ovaska et al. (2004) reports a small number of additional sites/records from Vancouver Island, British Columbia; Washington; and northern Idaho. Washington findings from this study are described below:

In Washington we found *P. coeruleum* at 2 sites in the Cispus River watershed and at 1 site on Pin Creek, a tributary to the lower Columbia River. The slugs appeared to be most abundant at the Kraus Ridge site in the Cispus watershed (11 detections). One of us (TB) has found *P. coeruleum* at this site on several previous occasions. The Iron Creek site is about 4 km southwest of the Kraus Ridge site and on the opposite side of the Cispus River. In several visits we have found only a single specimen of *P. coeruleum* at this site. There is a 3rd site in this area, approximately 7 km northeast of the Kraus Ridge site at 442 m elevation, from which a single P. coeruleum was collected on 14 November 2001. The specimen was identified by Tom Kogut, Cowlitz Ranger District biologist, but was not collected (T. Kogut personal communication). The species appears to have a very restricted distribution in Washington. Surveys by the U.S. Forest Service and U.S. Bureau of Land Management found no additional sites in Washington but found several localities for the species in western Oregon and also extended its range into northern California [but see above].

Distribution on FS/BLM lands: In Washington, this species is Documented on the Gifford Pinchot National Forest (ISSSSP 2011) and Suspected on the Columbia River Gorge National Scenic Area and the Okanogan-Wenatchee National Forest (ISSSSP 2011).

Further details regarding FS/BLM distribution: Known Washington records are primarily from the Cowlitz Valley Ranger District on the Gifford Pinchot National Forest (Cispus River watershed), where the species is rare (a total of eight records, have been reported from the Forest, mostly from a small area in the vicinity of Kraus Ridge).

Summary of Recent Data: Prior to 2004, only a few Washington locations were identified in the Interagency Database, three of which were from the Cowlitz Valley Ranger District on the Gifford Pinchot National Forest. Since 2004, only one new record of this species has been recorded in Washington, in the vicinity of known sites (Ovaska et al. 2004; GeoBOB 2014; NRIS 2014). Neither the number of records, range, nor habitat use has significantly expanded in Washington in recent years.

Species Abundance:
Records of the blue-gray taildropper were scarce prior to implementation of the Northwest Forest Plan, Branson and Branson (1984) providing the only published sightings since Pilsbry (1948). It has since been found to be quite common in parts of southwestern Oregon, especially Lane and Douglas counties. It is also found to be locally abundant, though scattered in distribution, over other parts of its range in Oregon. In British Columbia, Idaho, Washington, and California, there are few locations for this species, and where found, individuals are usually widely separated from each other and appear to be solitary.

In Washington, which includes the type locality, the blue-gray taildropper is rare. Branson (1977, 1980) did not find this species at 353 locations surveyed in the Washington Cascades or the Olympic Peninsula. Branson (1977) wrote, "Although reported from Olympia (type locality) by Henderson (1929a) and Dall (1910), I did not secure slugs with the characters of this species." Frest and Johannes (1993) reported it not found by them prior to 1993. It was one of the rarest

gastropods found by Burke (1996) during four weeks of searching in the Lower Cispus Watershed on the Randle Ranger District, Gifford Pinchot National Forest, in 1995. Only three individuals were observed, all within about 5 acres in a large old growth western hemlock stand (Burke 1996). Other specimens have since been found in the vicinity (Ovaska et al. 2004). Random grid surveys in Washington, conducted under the Survey and Manage program, did not locate this species in any plots searched. Ovaska et al. (2004) conducted surveys on approximately 300 sites in Washington's eastern Cascade Mountains and on >130 sites between the Cascade Crest and the Pacific Ocean, Washington. This species was found at just 3 sites, including one where it had been previously detected. Currently, there are six known localities for the species in Washington State, including two presumably extirpated sites; three recent sites on the Gifford Pinchot; and one recent private-land site in Cowlitz County (NRIS 2014; GeoBOB 2014; Ovaska et al. 2004).

Based on surveys conducted on the Cowlitz Valley Ranger District, this species occurs very rarely and in low densities in Washington, with one individual found at most documented localities (Ovaska et al. 2014, NRIS 2014, GeoBOB 2014).

E. Population Trends

Although detection of this species has increased since the mid-1990's in Oregon, this likely reflects increases in survey effort rather than increases in population number and size through time. In Washington, the majority of known detections are from a small area in the Gifford Pinchot National Forest, where most detections have been relatively recent, and changes in population number and size through time are not known. Local extirpations or declines have not been documented, although habitat loss in some areas of the species range is very apparent, e.g., Olympia (the 1900 type locality) and Seattle (1913 locality) have been largely converted to urban land uses, and there have been no records of this species in the area in recent years.

F. Demography

The distribution of the species throughout the northern portion of its range appears to be highly fragmented and consists of geographically isolated populations. For example, there are only a few recent locality records from western Washington, although extensive surveys have been conducted in this area (Ovaska et al. 2004). The reasons for the fragmentation are unclear and may reflect a combination of past climatic changes and habitat modification through human activities.

F. Habitat

Prophysaon coeruleum occurs in moist conifer forests, where it is found in forest floor litter in association with Douglas-fir logs and other woody debris (Burke 2013). Although not restricted to old-growth forests, this species appears to require old-growth attributes, such as abundant coarse woody debris and moist forest floor conditions including small woody debris, and relatively thick layers of litter and duff (Kelley et al. 1999). The old-growth association of this species appears more important in the Washington part of its range; in western Oregon the species is more abundant and may occur in moist second-growth stands, as long as late-successional attributes remain in sufficient quantity. In recent Washington surveys, Ovaska et al. (2004) report three Washington sites: a >250-year-old stand of western hemlock, Douglas-fir, and bigleaf maple with sword fern understory; a 2nd-growth stand of western hemlock, Douglas-fir, and bigleaf

maple with sword fern understory; and a 50-year-old stand of bigleaf maple, western redcedar, and bitter cherry (*Prunus emarginata*) with sword fern. Sites detected in Idaho and British Columbia were in second-growth stands (Ovaska et al. 2004).

Prophysaon coeruleum sites are usually dominated by conifers, but there is often a strong hardwood component. Following surveys for this species in British Columbia, Washington, and Idaho, Ovaska et al. (2004) report that all sites with *P. coeruleum* were in moist forest stands with a deciduous component of bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus balsamifera*), or in one case quaking aspen (*Populus tremuloides*). Sword ferns (*Polystichum munitum*), indicating moist conditions, were typically present. In Washington, Burke and Hanson found it in a western hemlock/sword fern plant association, under bark and among mosses under conifer logs and under bits of small, usually conifer debris. According to P. B. Randolph, "it occurs solitary in dark fir woods under damp logs" (Pilsbry 1948). In southern Oregon, it may be found among forest floor litter and debris usually in stands where the ground is moist and well shaded. It appears to be generally more closely associated with conifers and conifer debris than some of the other mollusks that it co-occurs with, specifically *P. dubium, Cryptomastix devia,* and *Megomphix hemphilli*, which appear to prefer hardwoods.

This slug is usually found on shaded ground, covered by fairly deep, moist (but not wet or saturated) layers of litter and duff. The species has been found in a range of forest canopy closure levels. In an analysis of data from Coos Bay and Roseburg BLM Districts, approximately 10% of known locations occurred in areas where canopy closure averaged less than 50%, and the majority of sites were in areas with canopy closure greater than 70%. Sites located in the Klamath/Siskiyou province occurred in less dense canopy than those in more northern provinces. Oregon sites with large populations have an abundance of large and small woody debris (conifer and hardwood) scattered over the ground, and large logs (greater than 20 inches average diameter) covering 1000 or more linear feet per acre. Logs of decomposition class 2-4 appear to be used most often.

The Deixis Collection database (2012) provides microhabitat conditions for this species in the Gifford Pinchot National Forest, including: "under bark of a bigleaf maple on grassy shoulder of road running through old-growth Douglas fir/western hemlock stand (western hemlock/sword fern plant association)"; and "underside of bigleaf maple leaves within the same old-growth stand" (Deixis Collection 2012).

Many snails and slugs, including *P. coeruleum*, use talus, rock fissures and/or riparian habitats where, under certain conditions, suitable microsites may occur as a result of combinations of environmental features. These deep rock refugia sites also provide protection to individuals during intense fire events, which form the nucleus of newly expanding colonies after such events (Duncan 2004). In a study examining survival of *P. coeruleum* after a low-moderate intensity wildfire event in southern Oregon, it was found that pre-fire sites were lost in areas where there was no deep rock refugia or riparian moisture, while sites in situations with deep rock refugia and subsurface moisture survived for at least two years after the fire (Duncan 2004).

G. Ecological Considerations

Terrestrial gastropods make a significant contribution to the biomass and energy in boreal forests, where they comprise at least 2.5% of the animal biomass and 6% of the animal energy (highly conservative estimates based only on active gastropods on the forest floor) (reviewed in Foltz Jordan & Black 2012).

Decomposition and nutrient cycling: As primary consumers of plant, animal, and fungal matter, gastropods aid in forest decomposition processes and contribute to nutrient cycling, soil formation, and soil productivity (reviewed in Foltz Jordan & Black 2012). For example, the slug *Ariolimax columbianus* speeds up nutrient cycling by ingesting large amounts of living and senescing plants, and subsequently excreting the partially digested plant tissue. Snails and slugs further contribute to the breakdown of forest floor litter by aiding in the dispersal of some fungi, and by physically and chemically altering plant material in ways that appear to promote fungal and bacterial growth. *Prophysaon coeruleum* is known to consume above-ground fungal fruiting bodies, and through its foraging, disseminates spores and hyphal fragments of mycorrhiza and other fungi on which it feeds (McGraw, Duncan and Cazares 2002).

Food for wildlife: Terrestrial gastropods are an important food source to a vast number of species, including salamanders, frogs, toads, turtles, snakes, lizards, birds, shrews, voles, moles, rats, mice, chipmunks, and squirrels (reviewed in Foltz Jordan & Black 2012). Invertebrate predators of terrestrial mollusks include sciomyzid fly larvae, firefly larvae, parasitic wasp larvae, carabid and staphylinid beetles, ants, spiders, harvestmen, and predatory mollusks. Additionally, the reproductive cycles of some nematodes and trematodes (flatworms) are dependent on snails and slugs as intermediate hosts for their parasitic eggs and larvae (reviewed in Foltz Jordan & Black 2012). The unique tail-dropping behavior exhibited by *Prophysaon coeruleum* is a strategy to escape predators, such as the haplotreme snails.

Plant pollination and seed dispersal: Although pollination by snails (malacophily) is a rare and obscure phenomenon, at least one study clearly demonstrates the significant role of a snail (*Lamellaxis gracile*) in the pollination of a flowering plant (Convolvulaceae: *Volvulopsis nummularium),* especially on rainy days when the activity of bees is completely lacking (reviewed in Foltz Jordan & Black 2012). Since some slugs consume fruit and excrete seeds, these animals can play a significant role in seed dispersal (albeit over short distances) and also appear to increase seed germination rates of some flowering plants (reviewed in Foltz Jordan & Black 2012).

Indicators of environmental health: Due to limited mobility, small home ranges, defined habitat preferences, and acute sensitivity to environmental conditions, snails and slugs are excellent and unique indicators of ecosystem health (reviewed in Foltz Jordan & Black 2012). Since terrestrial gastropods cannot easily escape areas that are subjected to disturbance, changes in gastropod abundance and diversity reflect the immediate impact of natural or experimental disturbance in their habitat. As such, gastropods provide managers with a valuable tool for site-specific assessment of environmental and community change (reviewed in Foltz Jordan & Black 2012).

IV. Conservation

A. Threats to Species

Any natural occurrences or anthropogenic activities that reduce the quality and/or quantity of this species' habitat may threaten this species. Quality habitat, as described above, is important to these slugs for maintaining a balanced biotic community to support them, and for escaping predators. While they are known to be mycophagous, at least in part, the lack of detail on their ecology points out the importance of a diversity of vegetation within their habitats, to provide a variety of fungi and other potentially required but as yet unknown elements. Specific threats to this species are as follows:

Urbanization and agriculture- Much of the formerly known range of *P. coeruleum*, including Olympia and Seattle, has been developed for urbanization or agriculture. Currently, habitat disturbances and modifications such as timber harvest, fire, and development appear to be the greatest threats to this species.

Timber Management- Logging and clearing of relatively intact forest and grazing of logged areas has occurred across the species' Oregon and Washington range. Herbicide spraying on private commercial forest lands to remove hardwoods has resulted in widespread loss of this habitat component across the landscape. *Prophysaon coeruleum*, like other forest mollusks, depend on numerous forest attributes that are frequently associated with old growth or intact forests, including shadiness and humidity, a stable microclimate, adequate calcium content, diverse vegetation, a sufficient amount of litter and coarse woody debris, and habitat continuity (*reviewed in* Foltz Jordan & Black 2012). These habitat dependencies, coupled with limited mobility with which to escape unfavorable conditions, suggest that silviculture activities and associated microhabitat changes would negatively impact this species at logged locations. Foltz Jordan & Black (2012) identify numerous ways in which tree harvest can significantly impact terrestrial gastropods, including increases in microclimate extremes; changes in forest vegetation and litter; reductions in coarse woody debris; soil compaction and other changes in microhabitat structure; population fragmentation; and changes in genetic population structure.

Forest succession- In some mid-seral stands in the Cispus River watershed (e.g. "Cispus burn" sites on the Gifford Pinchot National Forest), bigleaf maple trees are often overtopped and outcompeted by faster growing conifers such as Douglas-fir. Management of forest stands which selects against hardwoods also may result in a loss of this habitat component. The loss of bigleaf maple trees in these areas will reduce future habitat suitability for *P. coeruleum*, and strategies to retain this maple habitat component should be explored.

Recent maple tree die-off in Western Washington- Over the past several years, widespread bigleaf maple mortality in the Gifford Pinchot National Forest (as well as elsewhere in western Washington and Oregon) has been documented by the Forest Service, DNR, and others (Omdal & Ramsey-Kroll 2012, Kogut 2014 *pers. comm.*). Symptoms included yellow flagging of large branches, small leaf size, and partial or entire crown dieback (Omdal & Ramsey-Kroll 2012). Once symptoms are observed, tree death typically occurs in two to three years (Kogut 2014, *pers. comm.*). To date, research efforts aimed at identifying the disease agent of this dieback have been inconclusive (Ramsey-Kroll 2014, *pers. comm.*). The most formal investigation of this issue was

conducted in 2011 by Daniel Omdal & Amy Ramsey-Kroll (WA DNR), who examined 60 different sites across western Washington where bigleaf maple trees were exhibiting symptoms of dieback and decline. Damage agents that could be observed with the naked eye and through some minor root excavation were noted, and samples were collected and tested for *Verticillium*. All results came back negative for *Verticillium* and no other damage agent trends (e.g., *Armillaria* or *Ganoderma* root diseases, insects, abiotics) were found (Omdal & Ramsey-Kroll 2012). A small number of samples tested positive for the bacteria *Xyllela fastidiosa*, however these results have not been reproducible during follow up studies by Holly Kearns and Kristen Chadwick (USFS) on the Gifford Pinchot, in which most, if not all, leaf samples tested for *Xylella* came back negative (Ramsey-Kroll 2014, *pers. comm.*). In addition to the *Xylella* and *Verticillium* tests described above, the Forest Service has also conducted tests to look for *Phytophthora* species on bigleaf maple foliage, again with negative results (Ramsey-Kroll 2014, *pers. comm.*).

Regardless of the disease vector, the widespread bigleaf maple mortality described above is quickly removing one of the most valuable wildlife tree species for a wide variety of rare Pacific Northwest species, including mollusks, amphibians, arthropods and migratory birds (Kogut 2014, *pers. comm.*). *Prophysaon coeruleum* is not as closely associated with bigleaf maple as some of the other mollusks that it co-occurs with, specifically *P. dubium, Cryptomastix devia*, and *Megomphix hemphilli*. However, *P. coeruleum* sites typically have a strong bigleaf maple component. For example, Ovaska et al. (2004) report that all sites with *P. coeruleum* were in moist forest stands with a deciduous component of bigleaf maple (*Acer macrophyllum*), and Deixis (2012) reports collections of this species in bigleaf maple litter and under bigleaf maple bark. It is expected that when maples die from a site, populations of sensitive mollusks will be unable to persist as well, since the deep maple leaf litter will decay without replenishment, resulting in widespread habitat loss for the mollusks (Kogut 2014, *pers. comm.*). The bigleaf maple mortality has already affected entire stands of maple in the Cowlitz and Cispus drainages of the Gifford Pinchot National Forest.

Road construction and maintenance- Construction of new roads and maintenance of existing roads is a threat across the species' range. Roadways eliminate and degrade snail habitat, cause direct mortality in snails, and hinder snails' ability to disperse (reviewed in Foltz Jordan & Black 2012). Mollusk populations are not only extirpated in the roadway proper, but impacts can extend into adjacent habitat as well, due to site preparation, road construction, vehicle use, and maintenance activities. For a complete review of ecological impacts of roadways on snails including environmental contaminants, traffic and desiccation-related mortality, roads as distribution barriers, and road-related changes in the direction and intensity of gene flow, see Foltz Jordan & Black (2012).

High intensity fire- Although natural and anthropogenic fire have played major roles in shaping forest ecosystems in the Pacific Northwest, the impacts of fire management on invertebrate communities are often highly variable. Fire has the potential to negatively influence gastropods in several ways: directly, by fire-related mortality, and indirectly, by altering microclimate conditions, and by reducing, eliminating, or otherwise altering resources, including vegetation, fungi, leaf-litter, duff, woody debris, and other habitat elements pertaining to shelter or food (*reviewed in* Foltz Jordan & Black 2012). The degree of fire-related impact and the potential for

animals to rebound post-impact are related to a number of factors, namely, the degree of exposure to lethal temperature, the stress experienced in the post-fire environment, the suitability of post-treatment vegetation as habitat, and the ability to rebuild numbers in the site (from survivors and/or colonizers). Direct mortality due to fire exposure can be avoided by animals either in space (i.e., by escaping/retreating into shelter from fire) or in time (i.e., by being in a physiologically least susceptible stage at the time of burn). In general, less decline has been recorded for species below ground, or within or beneath unburned wood, and greater decline for species in the herb (fuel) layer or near the soil surface, particularly for individuals with low mobility. Mobility is important in both fire avoidance (e.g., the ability to escape approaching flames and reach suitable unburned habitat) and in post-fire recolonization (e.g., the ability to reach burned sites from unburned sites) (*reviewed in* Foltz Jordan & Black 2012).

Since *P. coeruleum* lives for the most part on vegetation and in litter, has limited mobility and poor active dispersal aptitudes, and is sensitive to desiccation, this species is considered highly vulnerable to fire itself and to subsequent habitat destruction.

Predation- Concern about predators increases as habitat quality or quantity decreases. Up to three species of *Haplotrema* and *Ancotrema* (predatory snails that feed on snails, slugs, and other invertebrates) occur in the same habitats and in greater numbers than Prophysaons. Ground beetles (*Scaphinotus* sp.), specifically adapted for preying on snails, are common in northwest forests (White 1983; Kozloff 1976), and other insects as well as reptiles, amphibians, birds, and mammals also prey on them. Hiding and escape cover is provided by forest floor litter, including deep leaf packs and fine and large woody debris. When habitat patches are limited in size and number, predators can easily focus hunting efforts and severely reduce *P. coeruleum* populations. However, in good habitat with large numbers of hardwood patches, predators are a lesser threat to a population.

Competition from exotic slugs- Exotic slugs are increasing within the range of *P. coeruleum*. The extent to which these introduced species might compete with the native gastropods or buffer them from predation has not been demonstrated. Exotic species are of concern because of the rapidity with which their populations increase. The mollusk fauna in most urban and suburban areas is now almost exclusively exotic species, and they are spreading into the forests, as documented in several cases in the Cowlitz and Cispus River drainages.

Harvest of forest products- Harvest of special forest products can be a threat in limited habitat areas. Raking the forest floor for mushrooms, or removal of hardwood logs for firewood could be particularly damaging, as well as harvest of swordfern plants for ornamental transplants. The harvest of moss mats from bigleaf maple trees should be strongly discouraged, as these provide potentially important habitats for juvenile mollusks.

B. Conservation Status

1. Overview

Prophysaon coeruleum is considered vulnerable to extinction or extirpation in Washington due to limited distribution, very low number of occurrences, conversion of much of the historic range to urban area, apparent extirpation from historic sites, narrow habitat requirements, and a number of threats that are expected to impact the long-term survival of this species across its range. The majority of detections in Washington are from a small area in the Gifford Pinchot National Forest, where population trends are not known, and forest management practices and widespread mortality of bigleaf maple are known threats. This species is listed as Endangered in Canada (COSEWIC 2006) due to extreme rarity and habitat loss, among other factors.

Due to limited mobility and narrow habitat preferences, this species, like many other terrestrial snails and slugs, cannot easily escape unfavorable habitat changes, and is thus highly impacted by environmental disturbance (*reviewed in* Foltz Jordan & Black 2012). These life history factors suggest that populations are especially vulnerable to habitat change or other changes in the environment.

2. Status History

Prophysaon coeruleum was listed under both the "Protect Sites From Grazing" Standard and Guideline, and Table C-3, Survey Strategies 1 and 2 of the Survey and Manage Standard and Guidelines (USDA, 1994). In 1999, it was considered to be a rare species in Washington, based on the low number of occurrences, and its low detection rate in suitable habitat and was placed in Survey and Manage Category A. The Washington Natural Heritage Program gives the species Global ranking G4, State ranking S1 (apparently globally secure but with cause for long-term concern; critically imperiled within the state because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation). In 2004, Region 6 of the Forest Service classified this species as a Sensitive Species in Washington state.

Although the species occurs in Oregon, there is little concern for the species there (as evidenced by the Heritage rankings) and it is not listed by either Agency as Sensitive or Special Status in Oregon. However, in the Klamath province and eastern Oregon Cascades, *Prophysaon coeruleum* may part of a complex which includes the undescribed Klamath taildropper, currently recognized as a separate taxa and an Oregon FS/BLM strategic species.

3. Major Habitat and Viability Considerations

Analysis is needed on the morphology and ecology of the variants that could be similar species or subspecies. Before anything can be concluded about the security of this (or these) species, their relationships need to be determined, and differences between their habitats and ecology clearly distinguished.

For species of patchy distribution, concerns for viability increase as habitat areas decrease in number and size toward a critical threshold. As population size decreases there is a greater possibility of catastrophic loss of local or limited populations. The quality of remaining habitats becomes more critical. With a smaller population, there is a greater potential for isolation of populations which could lead to the potential for the deleterious effects of inbreeding. There is also increased chance of population loss from predation, pathogens or other causes.

Loss of suitable conditions for mycorhizal fungal populations in managed forests is a concern for the continued viability of this species. It is known that severe burning and exposure to hot, dry conditions results in the loss of these critical elements of forest ecosystems. It is expected that forest practices that result in the loss of the fungal community, reduced plant diversity and less than suitable conditions for slug species, which aid in fungal dispersal, could ultimately result in less productive and unhealthy forests.

4. Distribution Relative to Land Allocations

Three of the sites on the Cowlitz Valley (Randle) Ranger District are in Late- Successional Reserves. A recent (2003) site from southwest Washington (Tributary to Pin Creek) is on private land (Leonard 2014, *pers. comm.*). Historic Olympia (1900) and Seattle (1913) sites are presumed extirpated.

Existing protections (land use allocations, Northwest Forest Plan Standard and Guidelines, agency best management practices, etc.) may be in need of supplementation for the long-term conservation of this subspecies, although requirements to conduct surveys prior to habitat-disturbing activities and to manage known sites can provide substantial protection. Given the central distribution of this species on Gifford Pinchot National Forest in Washington, it is also expected that Region 6 and OR/WA BLM manage sufficient habitat to influence conservation outcomes. Management actions in this region may help alleviate threats to the most viable known populations of *P. coeruleum*, and maintain habitat conditions for this species.

C. Known Management Approaches and Considerations

1. Management Goals for the Taxon

Management for this species follows Forest Service Region 6 Sensitive Species (SS) policy, and/or Oregon and Washington BLM Special Status Species (SSS) policy. For Oregon and Washington Bureau of Land Management administered lands, SSS policy details the need to manage for species conservation. For Region 6 of the Forest Service, Sensitive Species policy requires the agency to maintain viable populations of all native and desired non-native wildlife, fish, and plant species in habitats distributed throughout their geographic range on National Forest System lands. Management should also not create significant trends towards federal listing, for any identified Sensitive species.

2. Management Recommendations:

There are several management and restoration activities that could maintain conditions for *P. coeruleum.* Management actions include addressing habitat suitability, providing connectivity among populations, minimizing spread of invasive species, and reducing loss and fragmentation of habitat through forest management practices. In addition to *P. coeruleum*, other rare gastropods associated with similar habitat requirements are expected to benefit from these management actions.

3. Identification of Species Habitat Areas

All known sites on federal lands administered by the Forest Service and/or BLM in Washington are identified as areas where the information presented in this Conservation Assessment could be applied. A species habitat area is defined as the suitable habitat occupied by a known population plus the surrounding habitat needed to support the species at the site.

This document addresses management at two spatial scales. At the local population scale, a species habitat area is designed to support a functional population of individuals. The size of such areas is based on estimates of dispersal distances in similar-sized terrestrial mollusks and estimates of genetic neighborhood, or deme, size and the environmental tolerances of the species. Based on the small size and limited dispersal ability of this species, the size required to sustain a population of interacting individuals may range in size, depending on the extent of contiguous habitat and the amount of surrounding habitat needed to maintain suitable moisture conditions. Of central concern is protecting the site from mechanical damage and conserving temperature and humidity regimes at the site. Drier, more open stands, southerly or westerly aspects, upper slopes, etc., generally indicate the need for larger Habitat Areas. As new data is compiled, consideration should be given to daily and yearly activity cycles of the species as this data is collected.

At the smallest scale, within each habitat area, some habitat elements, such as large down wood and rock features, should be protected from disturbance, to provide for the critical periods in the animals' life history (aestivation, hibernation, reproduction). See section below for recommendations. In all cases, the water source, including its average flow rate and associated aquifer, should be identified and managed.

In addition to managing this species within species habitat areas, attempts should be made to connect habitat areas to each other or to other reserves such as riparian reserves and LSR's; either directly, by locating them adjacent to occupied habitat within reserves, or indirectly, by retaining suitable quantities of key habitat elements in harvest or project areas to provide a potential bridge or temporary "bank account" to accelerate future habitat development.

4. Management Within Species Habitat Areas

The objective of species habitat areas is to maintain habitat conditions such that species viability will be maintained at an appropriate scale, in accordance with agency policies.

Management considerations should focus on maintaining the favorable daily and seasonal temperature and moisture regimes of the microsites in which these gastropods occur (i.e., ground level microclimates and cover components). Sufficient overstory crown cover and understory vegetation should be retained to shade the ground, provide humidity through evapotranspiration, and impede air movement that would tend to displace the cool moist air. Maintenance and recruitment of large and small woody debris is important, as is a layer of litter and duff on the forest floor. These components provide cool moist places in which the animals spend the days, hide from predators, deposit their eggs, and find food.

Attempt to maintain habitat contiguity by extending boundaries of Species Habitat Areas to meet other reserve areas such as Riparian Reserves, LSRs etc., to minimize fragmentation of

populations.

This species can tolerate some degree of disturbance to its habitat, as evidenced by its occurrence in second-growth forests and in forest edge habitats in some parts of the range. However, the responses of this species to specific forest disturbances and forest management are not well understood, especially in Washington where the species is rare and population trends are not known. The disturbance and management response of terrestrial gastropods, in general, may offer valuable insight when managing for *P. coeruleum*. A recent review of the literature on the effects of forest land management on terrestrial mollusks (Foltz Jordan & Black 2012) suggests the following:

- While some level of exposure in the physical environment is tolerated by certain mollusks, most species are extremely sensitive to temperature and moisture extremes.
- The majority of snails and slugs are dependent on litter from deciduous trees and have higher abundances in multispecies forests with strong broadleaf components. Additionally, mollusks in deciduous forests appear to rebound from disturbance more quickly than in coniferous forests.
- Forests with old-growth characteristics supply microhabitat and microclimate conditions capable of supporting a diversity of mollusks, and forest age is often positively correlated with mollusk richness and abundance.
- Refugia are critical to gastropod recolonization potential and community resilience following forest disturbance. Since land mollusks are small animals with limited mobility and dispersal capabilities, the maintenance of refugia in disturbed habitat is particularly important for this group. Refugia should include logs, snags, fallen branches, and other forms of coarse woody debris, as well as areas with thick leaf-litter. Woody debris and litter provide islands of habitat, food, and protection from microclimatic extremes, increasing species' tolerance of temporarily inhospitable environments.
- In order to reduce microclimate extremes and protect gastropods, partial cuts should be favored over clearcuts, aggregated (group) retention over dispersed retention or thinning, and larger group retention over smaller group retention. In particular, harvesting with large group retention helps to maintain preharvest boreal gastropod assemblages and will likely conserve boreal gastropod species if used as a tool for biodiversity management.
- Fragmented habitat limits the dispersal and post-disturbance recolonization potential of gastropods. Tracts of intact forest and connected groups of old trees help provide dispersal corridors for gastropods and can lead to significant increases in the survival of disturbance-sensitive species.
- Techniques that minimize soil compaction and damage to (or removal of) the organic layer favor survival of gastropods. For example, Timberjacks have been found to cause less damage to the organic mat and resident invertebrate populations than feller bunchers, single-grip harvesters, and grapple skidders.
- Due to the tendency of mollusks to avoid non-vegetated and/or dry environments, even narrow, unpaved roads with low traffic densities are barriers to the dispersal of mollusks.
- Numerous studies have found negative and long-lasting responses of gastropods to fire, including population extirpation and reductions in abundance and species richness. Small burns surrounded by unburned plots have been most successful at maintaining gastropod

community structure. Although there is little information comparing gastropod responses to differences in burn severity and frequency, it is presumed that a fire regime involving low-intensity burns at infrequent fire-return intervals would best maintain gastropod communities.

Within Species Habitat Areas consider the following:

- Minimize disturbance of the forest floor litter, duff, and woody debris.
- Maintain existing canopy closure of trees within a large enough area to moderate fluctuations of temperature and humidity on the site.
- Maintain a component of hardwood trees and shrubs, including big-leaf maple trees (oldest preferred) and other hardwoods, to provide a constant supply of logs, leaves, and leaf mold. Site specific conditions will normally determine the optimum mix of tree species, but mixed stands of conifer and hardwoods may provide the best habitat.
- Maintain or enhance the naturally occurring diversity of plant species. This will increase the range of hosts for a variety of species of fungi and make other food substrates available throughout the season. It will also provide assurance that specific plant species, if found to be critical in the life cycle of these mollusk species, are not inadvertently lost.
- Maintain important cover and microhabitats by preserving dead and downed woody debris (especially Class 2 - 4). Manage for future sources of coarse woody debris in the habitat area, using the DecAID model or other appropriate method for estimating the natural amounts found in the habitat type. Falling trees to provide logs in stands where insufficient numbers occur may be done, but is not recommended unless the resulting canopy cover will provide sufficient shade to maintain cool, moist conditions.
- Limit activities which cause soil compaction or disturbance to forest floor litter, rock or woody debris or which release silt or toxic chemicals into the water within species habitat areas.
- Protect occupied areas from road construction, quarrying, and other major site disturbing activities that may cause temperature and/or humidity changes within the interspaces or instability within the slope.
- Avoid prescribed burning within Species Habitat Areas, and protect them from wildfire by fuels management in adjacent areas and other means. Prescribed fire treatments could be used to maintain the herbaceous vegetation and to reduce fuel loading outside of species habitat areas to protect those areas from catastrophic wildfire events (Burke 2014, *pers. comm.*).
- Exotic species of both plants and animals are entering habitats occupied by this species. Protect inhabited areas from introductions of non-native species. This includes restricting use of un-washed vehicles that could carry weed seeds or other exotics, and use of hay bales or other nonnative mulching materials and planting mixes used for erosion control. If exotic species are found, measures to control them should be implemented if feasible. Measures to control exotic species should not be adverse to *P. coeruleum* and other native species.

V. Research, Inventory, and Monitoring Opportunities

The objective of this section is to identify opportunities for additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. While the research, inventory, and monitoring information is not required, these

recommendations should be addressed by a coordinating body at the Regional level.

A. Data Gaps and Information Needs

Additional data could help resolve several questions. First, taxonomy of the blue-gray taildropper needs to be clarified, and published. Until this is done, the true range and habitat data for *P. coeruleum* cannot be validated. Variants of the blue-grey taildroppers in southern Oregon, and northern California, may be separate species. There is a recognized difference in the habitats occupied by the dark variant (Klamath taildropper) which generally uses drier areas and more open habitats. Characteristics of habitats used by the Klamath variant and typical *P. coeruleum* should not be combined for analysis because that would confuse habitat descriptions. Each of the different variants and their habitat data need to be recorded separately in order to evaluate species (or subspecies) status and clarify management needs and recommendations when these differences are resolved.

Once the taxonomy is defined, the following questions should be addressed:

- What is the specific range of this species?
- What is the range of habitat conditions tolerated by the species? What is the range of conditions required for populations to remain secure and viable?
    - How does this species disperse to other suitable habitat patches, and what limits its dispersal capability? What is the typical dispersal distance in a lifetime?
    - How large are local populations, and how does this affect long-term viability of occupied sites?
- What are the biological, physical, and chemical attributes of this species' habitat?
    - Plant associations
    - Specific plant species required/used
    - Specific foods
    - Amount of large woody debris
    - Optimum forest crown cover to maintain desired conditions
    - Other stand structure and components (e.g., small woody debris, litter, duff, water, etc.)
    - Elevation
    - Soil types, geology, trace elements, pH
    - Temperature & humidity

B. Research Questions

Bigleaf maple ecosystems, an important habitat of this slug, would benefit from a detailed evaluation of the quality of these habitats and an assessment of potential natural and anthopogenic threats/conflicts facing them (British Columbia Ministry of Environment 2008). Mixed-wood stands with a high proportion (>15%) of this species including groves of old trees are relatively uncommon in the Pacific Northwest, and often have high biodiversity values. For example, older bigleaf maples support remarkable and luxuriant epiphyte (moss, lichen, liverwort, fern) communities on their trunks, stems, and branches; they contribute significantly to nutrient cycling and calcium sequestration through the weight of their leaf fall, high nutrient content, and relatively rapid decay rates; and they provide abundant coarse woody debris and nurse logs when they fall (Peterson et al. 1999; British Columbia Ministry of Environment 2008).

Further research on the dieback and decline of bigleaf maple in Washington and Oregon is needed. Very little work has been done on this issue since 2011, and although several diseases (e.g., *Verticillium, Phytophthora,* and *Xylella fastidiosa*) have been ruled out, the disease agent is still unknown (Ramsey-Kroll 2014, *pers. comm.*).

Additional research questions are as follows:

- Are the recognized varieties of *P. coeruleum* separate species or subspecies?
- Can mid-seral, conifer forest habitat for this species be enhanced through commercial thinning or other practices (e.g. snag creation), specifically to maintain and stimulate growth of bigleaf maple trees for *P. coeruleum* habitat? If so, which method(s) are the most effective?
- What stand size is required to provide sufficient area of suitable habitat?
- What stand characteristics (canopy cover, age, large woody debris, litter and duff, etc.) are required to support the required conditions?
- How do the required stand characteristics vary under different circumstances (elevation, slope, aspect, geographical location, etc.)?
- What is the response of the species to fire under various intensities and seasons?
- What seasonal refugia sites are used by the species as protection from catastrophic fire?
- What are the seasonal movement patterns and how long is required for recolonization of a site by species from adjacent populations? How does this recolonization occur, and what are its limits? What stand size is required to provide sufficient area of suitable habitat?
- What are the effects of herbicides and other chemicals used in forest management on mollusk species?
- What effects are non-native gastropods having, if any, where they occur with *P. coeruleum*?

C. Monitoring Opportunities

Since the security of this species in Washington is questionable, monitoring existing populations is considered a critical conservation measure for this species. Monitoring known sites is recommended to track trends in populations (numbers, size and density), reproduction, and quantity/quality of habitats. Monitoring is also recommended to determine impacts on habitats and populations from management activities, natural disturbances, and vegetative succession.

Monitoring recommendations include:

- Conduct surveys in spring and fall after the first heavy rainfall or frost.
- Record all environmental conditions where these species are found to better understand their habitats and management needs.
- Through surveys and studies, determine the extent of the species range, and the habitats and ecology of the species.
- Monitor sites for conditions and trends of populations.

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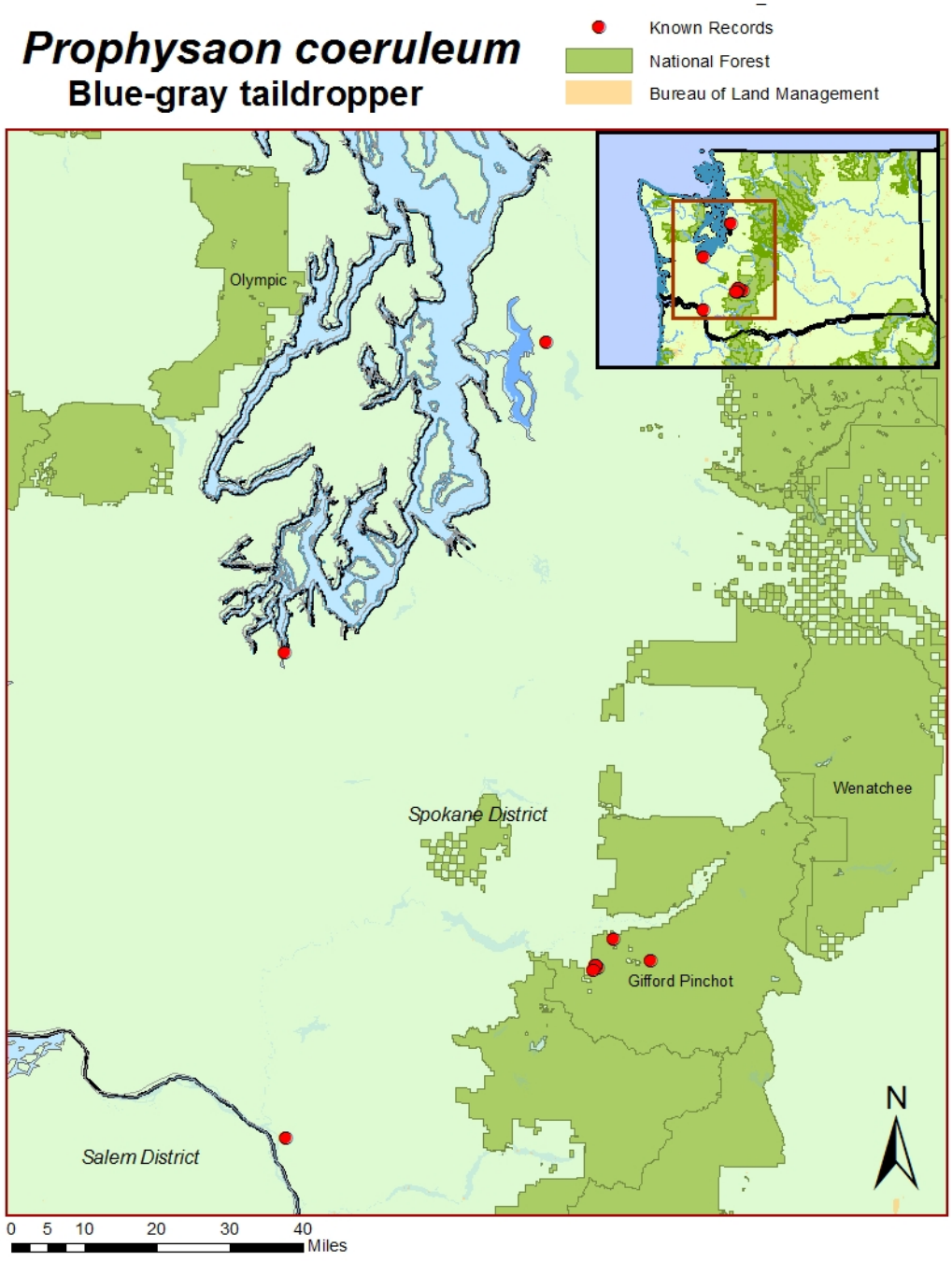
VII. PHOTOGRAPHS

Prophysaon coeruleum. Photograph by Bill Leonard, used with permission

VIII. DISTRIBUTION MAP



Map showing *P. coeruleum* records in Washington relative to Forest Service and BLM land. Records from Oregon, where this species is abundant, are not shown. Localities in the vicinity of Olympia and Seattle, Washington are historic (1900; 1913) and considered extirpated.