U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: *Cryptomastix devia*

COMMON NAME: Puget Oregonian

LEAD REGION: Interior Region 9

DATE INFORMATION CURRENT AS OF: May 9 2020

STATUS/ACTION

_X_ Species assessment - determined either we do not have sufficient information on threats or the information on the threats does not support a proposal to list the species and, therefore, it was not elevated to Candidate status

___ Listed species petitioned for uplisting for which we have made a warranted-but-precluded finding for uplisting (this is part of the annual resubmitted petition finding)

___ Candidate that received funding for a proposed listing determination; assessment not updated

___ New candidate

___ Continuing candidate

___ Listing priority number change
Former LPN: ___
New LPN: ___

___ Candidate removal: Former LPN: ___
___ A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.
___U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.
___ F – Range is no longer a U.S. territory.
___ I – Insufficient information exists on taxonomy, or biological vulnerability and threats, to support listing.
___ M – Taxon mistakenly included in past notice of review.
___ N – Taxon does not meet the Act's definition of "species."
___ X – Taxon believed to be extinct.

Date when the species first became a Candidate (as currently defined): N/A

Petition Information:
___ Non-petitioned
_X_ Petitioned; Date petition received: March 17, 2008

90-day substantial finding FR publication date: 2011

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PREVIOUS FEDERAL ACTIONS:
In 2008, the U.S. Fish and Wildlife Service (Service) received a petition to list the Puget Oregonian snail (*Cryptomastix devia*) as endangered or threatened under the Endangered Species Act of 1973, as amended (Act; 16 U.S.C. 1531 *et seq*.) (Act) (1973, entire). We published a 90-day finding (76 FR 61826) in 2011 that found the petition presented substantial information indicating that listing the Puget Oregonian may be warranted for listing under the Endangered Species Act, and that we would begin a status review of the species.

ANIMAL/PLANT GROUP AND FAMILY:
Mollusca/ Polygridae

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE:
States/U.S. Territories: Washington, Oregon
Counties:

- Washington State: Clark, Cowlitz, Grays Harbor, King, Kittitas, Klickitat, Lewis, Mason, Pierce, Skamania, Snohomish, Thurston, Yakima.
- Oregon State: Clackamas, Columbia, Hood River, Multnomah, Wasco, Washington, Yamhill.

Countries: United States, Canada (British Columbia)

CURRENT STATES/COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE:
States/U.S. Territories: Washington, Oregon
Counties:

- Washington State: Grays Harbor, King, Pierce, Kittitas, Klickitat, Lewis, Mason, Skamania, Snohomish, Thurston and possibly others.
- Oregon State: Clackamas, Columbia, Multnomah, Yamhill, and possibly others

Countries: United States

LAND OWNERSHIP:
Of the available species records, 85 percent of observations are located on Federal lands, mostly on U. S. Forest Service (USFS) lands, with the remainder spread between lands managed by the Bureau of Land Management (BLM) and the Service. Two percent of records are located on state lands, and 13 percent are located within other land ownerships, including county, municipal, and private lands. Most of the available observations (88 percent) were recorded after the adoption of the Northwest Forest Plan (NWFP) in 1994 (USDA and USDI 1994). Of the 12 percent of the records documented from before the adoption of the NWFP (dating back as far back as 1846), most were located on non-federal lands (Foltz-Jordan and Hoffman-Black 2015, pp. 9-10).

DISTINCT POPULATION SEGMENT (DPS): N/A

BIOLOGICAL INFORMATION
A review of the taxonomy, life history, and ecology of the Puget Oregonian is presented in the Species Status Assessment (SSA) for the Puget Oregonian (USFWS 2019, entire). The biological information

detailed in the SSA serves as the basis for our finding. The SSA is based on a framework for evaluating species viability in the context of resiliency, redundancy, and representation, known collectively as the 3Rs (Smith *et al.* 2018, entire). Resiliency means having sufficiently large populations for the species to withstand stochastic events (arising from random factors). Redundancy means having a sufficient number of populations for the species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations). Representation means having the breadth of genetic makeup of the species to adapt to changing environmental conditions. A summary of the biological information from the SSA is provided below.

Taxonomy

The Puget Oregonian was first described as *Helix devia* in 1846 (Gould 1846, p.165). Six revisions of the genus name occurred between 1846 and 1940 (Burke *et al.* 1999, p. 3), with the last revision changing it to *Cryptomastix*. The taxonomic status of the Puget Oregonian is considered valid based on genetic and morphological characteristics (ITIS, May 15, 2019; Turgeon *et al.* 1998, p. 150; Perez *et al.* 2014, p. 17). There is likely some genetic variation within the species as it has a large historical range from the coast range of Oregon to the Fraser Valley and extreme southern portion of Vancouver Island, in British Columbia, Canada. To the best of our understanding, no evaluation of intra-species genetic variation has been conducted. Gene flow is likely to be constrained by the limited dispersal ability of individual snails. Furthermore, the species was probably subject to many geologic events that isolated populations geographically in glacial refugia south of the Skagit River Valley and between the Puget lobe of the Cordilleran Ice Sheet and glaciers in the Cascades during the latest glacial period (Bretz 1913; Easterbrook *et al.* 1967, p. 13).

Species Description

The Puget Oregonian (Figure 1a) is significantly larger than other *Cryptomastix* species, and is readily distinguished from them by a combination of mature shell size (20 to 24 millimeters (mm) (0.79 to 0.95 inches (in)) wide by 12.5 to 16 mm (0.5 to 0.63 in) high, with 5.5-6.0 whorls) and its distribution (Burke 2013, pp. 157-158). In addition, a prominent white parietal tooth is typically observed on the median half of the basal lip margin (Figure 1b). The umbilicus is partly covered; in coiled shells the umbilicus is the hole, indentation, or depression, formed when the inner surfaces of the whorl do not join. The shell's spire, all whorls except the last, is elevated and the periphery is rounded. The shell is medium to dark brown with grooves on the outer shell, called striae, which appear as wavy lines under the magnification (Figure 1a- e). The peristome, or thin, outer proteinaceous outer layer of the shell, is white to tan. The depressed globose-shaped shell has a heavy, broadly reflected apertural lip which partially or mostly covers the umbilicus (Figure 1a – d). The narrow umbilicus is one-eighth to one-tenth the diameter of the shell. Immature Puget Oregonians have short, hooked microscopic bristles on the dorsal surface which are lost by adulthood and are soon lost on preserved shells. Juvenile Puget Oregonians also lack the reflected apertural lip (Figure 1e).

Figure 1: Images of *Cryptomastix devia*, the Puget Oregonian, in the Cispus Watershed of Gifford Pinchot National Forest, Lewis County, Washington on May 10, 2019. A. Active adult Puget Oregonian. B. Recurved lip aperture (left), single prominent white parietal or apertural tooth (right) and overall medium to dark brown shell color are identifying characteristic of a mature individual. C and D. Size of mature snail shell width ~20 to 24 mm adult hand for scale. Faint mucus trail can be seen on hand behind moving snail. E. Live juvenile Puget Oregonian lacking recurved lip and parietal tooth. (Images USFWS)

Range /Distribution

The historical range of the Puget Oregonian includes Washington, Oregon, and up to three records in Canada, (the Fraser Valley and extreme southern portion of Vancouver Island, British Columbia). The current range is restricted to Washington and Oregon (Frest and Johannes 1995, p. 229). The three historical records from British Columbia all dated prior to 1905, and only one of the records (from Vancouver Island) is considered valid (Ovaska and Forsyth 2002, pp. 5-8). No Puget Oregonians have been found in Canada since 1905 and the species is considered extirpated in the country (Ovaska and Forsyth 2002, pp. 5-8; Foltz-Jordan and Hoffman-Black 2015, p. 10). Currently, the Service is aware of approximately 230 locations where the Puget Oregonian has been recorded in the United States (Figure 2). All but three of these records are from the eastern Olympic Peninsula to the western slopes of the Cascade Mountain Range in Washington State and within Oregon's Coast Range and Willamette Valley. Two of the remaining records on the eastern slopes of the Cascades are located within the Okanagan-Wenatchee National Forest, while the third is located within the Columbia River Valley (Foltz-Jordan and Hoffman-Black 2015, pp. 9-11). Species occurrences have been as far north as the Mount Baker-Snoqualmie National Forest near Darrington, Washington, and as far south as the Mount Hood National Forest in Oregon.

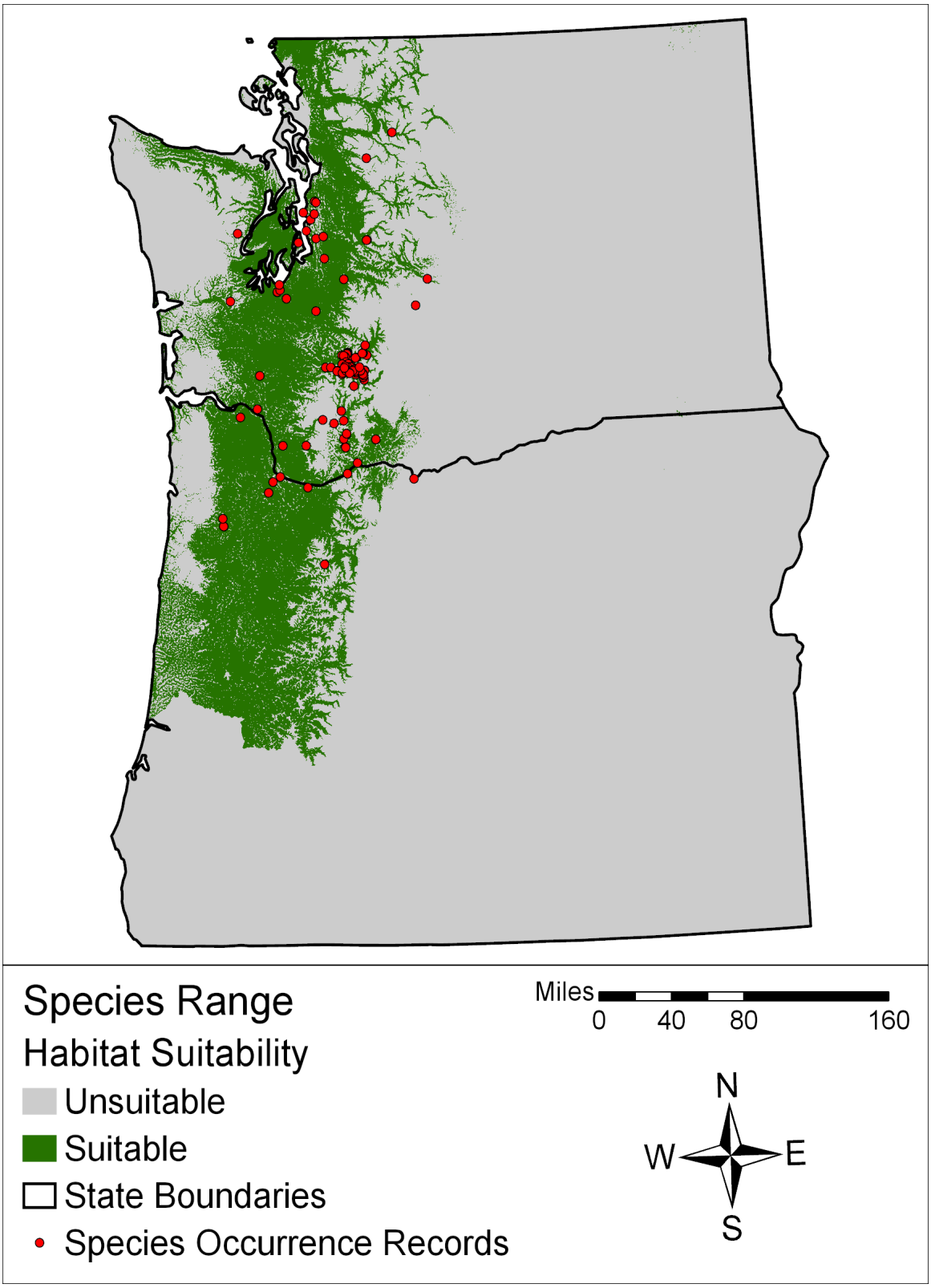

Figure 2. Current modeled range of the Puget Oregonian in Washington and Oregon. The Species Occurrence Records shown include both current and historical species records.

Demographics

In the 1990s, small numbers of Puget Oregonian were documented at sites scattered in eastern central Puget Sound (Frest and Johannes 1995, p 229). Most subsequent survey efforts have focused on Federal lands; based on these surveys the area of greatest number of contemporary records is the Cispus River Watershed (Foltz-Jordan and Hoffman-Black 2015, p. 9).

Our understanding of Puget Oregonian population size and density is extremely limited. Another species of similar size and range, the Oregon forestsnail *(Allogona townsendiana),* demonstrated a population size of 7 to 47 individuals as defined in 24 square meter study plots and had a mean snail density of 1 snail per square meter (m^2) (3.2 feet)(ft^2)) (Steensma *et al.* 2009, p. 335). The Service and USFS staff found two Puget Oregonians under swordfern skirts in a 2 m^2 (6.4 ft^2) area in 5 minutes and 4 individuals in a 10 m (33 ft) by 1 m (3.2 ft) transect survey (Le and Waterstrat 2019, pers. obs.). Although there was no information indicating either of these Puget Oregonian detections were "populations," the snails' close proximity to each other makes it likely that they have the opportunity to interact sexually.

Outside of the Cispus Watershed, most observations are of a single, or small number of, individuals. In 2019, Service staff, USFS staff, and Tom Kogut (USFS retired) revisited a prior survey plot in the Cispus watershed and found both juvenile and mature Puget Oregonians 19 years after they were first identified during a Survey and Manage inventory. This area was subject to three intense and severe fires between 1902 and 1918, and since that time was replanted and is reaching a mature forest stage (Lewis 1939, unpublished report; Donahey 2019, pers. comm.). This observation demonstrates Puget Oregonian occupancy and reproduction 80 years after stand replacing wildfire. If we make the assumption that there was no, or very limited, immigration into this survey plot then we can assume there is a persistent, reproductive population within the Cispus Watershed that has survived catastrophic events (wildfire, severe forest practices, road building, etc.).

Outside of the Cispus Watershed we know of one other location where Puget Oregonian have persisted over time. The species was observed over several years in the 4.5 hectare (ha) (11 acre (ac)) Crystal Springs Park in Tukwila, Washington (Johannes 2017a, p. 1; Johannes 2017b, p. 25).

Given multiple observational records of only a single specimen, perhaps one of the most confounding issues is the lack of information regarding whether this and other *Cryptomastix* species are hermaphrodites and capable of self-fertilization. However, certainly a single, self-reproducing individual snail is not indicative of a resilient population. Observation of self-fertilization and oviposition of viable eggs and the conditions under which they occur, in a natural setting or laboratory, would be useful to understanding the ability of this species to recovery from catastrophic or stochastic events.

Habitat/Life History

There is little specific information about the biology of the Puget Oregonian or any member of the *Cryptomastix* genus. However, the ecology and biology of another Pacific Northwest (PNW) Polygyrid snail*,* the Oregon forestsnail has been studied (Steensma *et al.* 2009, entire; Edworthy *et al.* 2012, entire) and could be used as a surrogate for information about the Puget Oregonian. We used information on the Oregon forestsnail in our status assessment as a surrogate for information on the Puget Oregonian, though the forestsnail is still a relatively little studied species, and there are identified differences between Puget Oregonians and the forestsnail that are not fully understood (Burke *et al.* 1999. p. 7).

The life cycle of any animal is the period involving the succession of one generation to the next through reproduction. The life cycle of a terrestrial gastropod can be broken into two states – the active or moving state and the dormant or roosting state (Barker 2001, p. 447). The active state is when most of the gastropods environmental needs are met for feeding, growing, movement/dispersal, mating, and egg deposition. The dormant or roosting state takes place during periods when environmental conditions are not conductive to carrying out life history activities. The gastropod sequesters itself during these periods in a benign refugia or environment; in snails this is often a mucus-plugged aperture, where the snail stays sequestered until conditions improve (Hyman 1967, p. 627; Barker 2001, p. 74; Burke, 2013, p. 13). The duration of this dormant period can be as short as 24 hours or less until the dew level and air temperature drop, or as long as months or perhaps even years in some species (Baker 1958, p. 141). The Puget Oregonian is thought to be most active in spring and fall when cooler temperature and moisture promote snail activity. Similar to most terrestrial gastropods, this species is most active during crepuscular and nocturnal hours, and perhaps also in diurnal hours during periods of cool temperature and rain (Barker 2001, pp. 461-464; Kogut 2019, pers comm.).

Terrestrial gastropods in general appear to be more common or even dependent on deciduous broadleaf forests, or forests with a mixed conifer/broadleaf composition. Gastropods in the PNW require relatively undisturbed forest floor or understory cover (Abele 2010, pp. 36-39; Frest and Johannes 1993, p. 3; Foltz-Jordan and Hoffman-Black 2012, p. 5). In general, terrestrial mollusk diversity and abundance tend to be positively correlated with the percentage of hardwood cover, ferns, woody shrubs, seeps, and wetlands (Foster and Ziegltrum p. 254; Frest and Johannes 1993, p. 3; Foltz-Jordan and Hoffman-Black 2012, p. 5). The Puget Oregonian occurs in what remains of Oregon and Washington's mature to late successional forests from the Cascade Crest west, at low to mid elevations, and on low to shallow gradients (Burke *et al.* 1999 p. 5; Foltz-Jordan and Hoffman-Black 2015, pp. 11-12). Generally the Puget Oregonian is described as a mature or old growth forest-associated species that often, but not exclusively, occurs adjacent to riparian areas above active floodplains (Foltz-Jordan and Hoffman-Black 2015, p. 11; Burke *et al.* 1999, p. 5). This description seems to describe benched river terraces up to and including the lower valley slopes where bigleaf maple often occurs (Sudsworth 1967, p. 389). The Oregon forestsnail is reported to be generally common in moist coastal forests and more restricted to riparian habitat further inland (Kozloff 1976, p. 81). The Puget Oregonian may follow a similar distribution pattern to a generalized PNW terrestrial mollusk, but that pattern is unproven because of limited demographic and distribution information and the loss of potential historical habitat in the central Puget Sound area to development.

At a finer scale, the Puget Oregonian is almost always associated with mature forest with high levels of canopy cover (typically 70 percent or greater) composed primarily or partially of bigleaf maple often mixed with other hardwoods (red alder (*Alnus rubra*) or black cottonwood (*Poplus balsamifera*) and conifers (Burke *et al.* 1999 p. 5; Foltz-Jordan and Hoffman-Black 2015, pp. 11-12) (Figure 3). Younger, smaller-diameter bigleaf maple stands, or conifer stands with a high numbers of smaller individual bigleaf maple also can also support the species (Burke *et al.* 1999, p. 6).

Figure 3. Stand level habitat of the Puget Oregonian includes overstory of mature bigleaf maple and understory with decaying large woody debris, swordfern skirts, and deep leaf and forest litter maintain a moist and cool microhabitat required for snails to be in an active state

Under the dappled canopy of the maple or mixed maple canopy, the snail has been found beneath logs and other hardwood debris, swordfern skirts, leaf litter and/or talus, and around seeps and springs; these elements create microclimates with cooler, moister conditions that appear to promote snail activity (Burke *et al.* 1999, p. 5; Foltz-Jordan and Hoffman-Black 2015, pp. 11-12). Young individuals have been reported under mosses growing on the trunks of bigleaf maple as well (Foltz-Jordan and Hoffman-Black 2015, p. 12). The specific environmental conditions that support the Puget Oregonian in its habitat are unknown but high overstory cover (≥ 70 percent) shades the forest floor and reduces evaporation rates where the snails live (Burke *et al.* 1999, p. 5; Foltz-Jordan and Hoffman-Black 2015, p. 12). In areas that are naturally wetter, lower canopy cover has been reported and it is thought increased moisture offsets the reduced level of shading (Foltz-Jordan and Hoffman-Black 2015, p. 12).

The bigleaf maple is the largest and longest living of the three maple species found in the range of the Puget Oregonian (Sudsworth 1967, pp. 386-387). The other two species, vine maple (*A. circinatum*) and Douglas maple (*A. glabrum*), are much smaller, produce smaller diameter and a smaller volume of large woody debris, and a lesser volume of leaf litter annually. Bigleaf maple is found from sea level to about 3,000 ft (900 m) in Washington and Oregon. The tree grows on a relatively wide range of soils but best growth occurs on fluvial sites and at the base of colluvial slopes. Growth is best where soils are moist, either from seepage or on fluvial sites along streambanks, but the bigleaf maple is not as tolerant of flooding as most other native forest trees (Peterson *et al.* 1999, p. 9, 16-17). During growth, bigleaf maple absorbs large quantities of nutrients, much of which are returned to the forest floor in its litter; maple has one of the highest litterfall by weight of any tree in the western states (Peterson *et al.* 1999, p. 23, referencing Tarrant *et al.* 1951). Weight of litterfall and litter nutrient content (for every macronutrient and most micronutrients) were significantly greater under maple than under Douglas-fir

(*Pseudotsuga menziesii*) on sites studied in western Oregon (Fried *et al.* 1990, p. 259). High litterfall creates both suitable forest floor microhabitat conditions and higher levels of available calcium, which is needed to produce a snail's shell; this combination may be part of the reason the Puget Oregonian is strongly associated with bigleaf maple. If that is true, it leads to the question of why other large snails such as *Monadenia*, *Allogona*, and *Ancotrema* species, while found in association with Puget Oregonian and maple, do not appear to be as tied to bigleaf maple.

While the apparent association between bigleaf maple and the Puget Oregonian is not clearly substantiated, there is a list of compelling structural, physical, chemical, and ecological reasons for the association. The bigleaf maple has several features indicating it may be an autogenic ecosystem engineer (organism that creates habitat for species through its structure, growth, and death) for Puget Oregonians and other forest species (Jones *et al.* 1994, pp. 374 -376). Several components of bigleaf maple are thought to be especially important for supporting resource and life history needs of the Puget Oregonian as discussed below.

Canopy: Regardless of size and density, the maple canopy has a shading, cooling effect on the forest floor where the Puget Oregonian resides, reducing evaporation from heat and wind, moderating moisture loss, and supporting an epiphytic community of lichen, plants, bryophytes, and fungi in its branches. The canopy also is the source of leaf litter and many of the large branches which contribute to the large woody debris on the forest floor.

Leaf litter: Bigleaf maples produce a high volume of leaf and seed/samara (the winged, "helicopter part") litter. This leaf and seed litter absorbs and retains moisture, acts as a bases for fungal decomposers (thought to be a food source for snails), insulates from moisture loss and temperature extremes reducing the severity and intensity of freezing and desiccation, and provides refugia from avian and terrestrial predators.

Large woody debris (LWD): Terrestrial gastropods rely on large woody debris for food, shelter, and as a site for breeding, and fungal food base (Harmon *et al* 1986, p. 235; Frest and Johannes 1993, p. 3). Large woody debris moderates temperature and retains moisture creating daily and season microhabitat refuges for terrestrial gastropods (Harmon *et al* 1986. p. 235, Frest and Johannes 1993, p. 3). Descriptions of the Puget Oregonian's habitat and ecology are tied to large woody debris from bigleaf maples and other native tree species (Frest and Johannes 1993, p. 30; Frest and Johannes 1995, p. 228; Duncan *et al*, 2003, p. 41; Forsyth 2004, p.153). After the removal of large woody debris from a site known to be occupied by snails, the snails were very difficult to find (Foltz-Jordan and Hoffman-Black 2015, p. 21). Other habitat types where the snail has been found include swordfern skirts, talus slopes, and seeps and adjacent habitat, all described in further detail below.

Swordfern skirts: Swordfern "skirts" or "enclosures" are the dead vegetative matter, such as the lower leaves or fronds, which instead of falling off, remain and form "skirts" of dead vegetative cover (Marco 2011, p. 1; Haggard 2000, p. 60). The Puget Oregonian is well documented in its use of swordfern skirts during the active season for this species (Burke *et al.* 1999, p. 5; Foltz-Jordan and Hoffman-Black 2015, pp. 12-13). These skirts, much like large woody debris and leaf litter, can provide cover from predators, thermal refuge during summer and winter seasons, and a moist microsite that persists later in the year than other areas on the forest floor (Haggard 2000, p. 60; Schuett-Hames 2004, pp. 38, 63, 73).

Forested springs and seeps: Appropriate moisture levels are important for terrestrial gastropods (Hyman 1967, pp. 626-627) and forested springs and seeps appear to provide an important habitat component for the Puget Oregonian in some areas. Many PNW terrestrial gastropods thrive in lowland to middle elevation moist (often riparian) forests often in areas around perennial moist areas such as springs, bogs, or marshes (Frest and Johannes 1993, p. 3). Puget Oregonians are among those often found in association with spring and seeps (Frest and Johannes 1995, p. 229; Burke *et al.* 1999, p. 6; Foltz-Jordan and Hoffman-Black 2015, p. 11); they inhabit stands with lower level of canopy cover if the forest floor is wetter (Burke *et al.* 1999, p.6).

Talus accumulations also represent an occasional habitat type for the Puget Oregonian (Foltz Jordan and Hoffman Black 2015, p. 13). Talus habitat results from the gradual accumulation of weathered rock fragments at the base of cliffs or other steep slopes (Maser *et al.*, in Thomas 1979, p. 99). Large, deep, and older talus accumulations are described as being most important to wildlife, likely because of the stability of the talus field, establishment of a vegetative community, and size of habitat it provides (Maser *et al.*, in Thomas 1979, p. 99). Individual talus slopes can be variable in rock size, aspect, and in the amount and type of vegetation present creating a broad range of thermal and moisture regimes for wildlife (Herrington in Szaro *et al.*, 1998 p. 216). The Puget Oregonian has been noted to co-occur with plethodontid salamanders in talus habitat (Crisafulli *et al.* 2008, p. 13); the snail may use larger, older, moist, mixed, bigleaf maple-forested talus areas, as a refuge from environmental extremes.

Population Estimates/Status

Analytic Units

The lack of demographic information for Puget Oregonian impeded our ability to formulate demographic metrics for assessing resiliency so we used a geographically and ecologically-based approach to defining analysis units for this species. The dispersal range of an individual Puget Oregonian is likely limited to tens of meters (Backeljau *et al.* in Barker 2001, pp. 396-397; Edworthy *et al.* 2012, pp. 878-879; Le and Waterstrat 2019, pers. obs.), and there is some evidence that other pulmonate gastropods distribute themselves along drainages into populations (Arter 1990, p. 997), but we do not know if this holds true for Puget Oregonians because we find them distributed broadly only along the Cispus River terrace (Xerces Society 2019). However, the accepted the potential dispersal distance for pulmonate snails is approximately 3,281 ft (1 kilometer (km)) (NatureServe 2019, pp. 5-6). Therefore, to define analytic units, we buffered all observations by 3,281 ft (1 km), and if they overlapped, the resulting areas were merged into a single polygon. Although we used these polygons as analytic units, we recognize that many of the units represent a single observation, and that many populations or occurrences of Puget Oregonians may exist outside the limits of our current knowledge about the species distribution. Using the 3,281 ft (1 km) distance around known occurrences, we identified 74 analytic units, and categorized them by their representative sub-basin and assigned each a unique identifier. There were 17 analytic units in the Upper Cowlitz sub-basin, 7 in the Middle Columbia and Puget Sound sub-basins, and 6 in the Lewis sub-basin. All other sub-basins had less than 5 analytic units.

Representative Areas

The Service considered the current range of the Puget Oregonian to be from the Puget Sound area of Washington south to the Mount Hood National Forest and Willamette Valley in Oregon. For this SSA, we did not find, receive, or have knowledge of genetic, morphological, or behavioral differences across the range of the species so we evaluated representation as an ecological or geographical variable.

To delineate representative areas characterizing variation in ecology across the range of the species, we looked to sub-basins using the United States Geographic Survey's Watershed Boundary Dataset HUC 8 (sub-basin). We found 60 sub-basins across the range that had potential habitat for Puget Oregonian; these we considered our representative areas. However, of the 60 sub-basins, only 23 had Puget Oregonian occurrence records. The 23 representative areas containing the 74 analytic units with records are summarized in Table 1.

Table 1: Sub-basin (HUC 8) representative areas and analytic units for the Puget Oregonian in Washington and Oregon.

REPRESENTATIVE AREA		**NUMBER OF ANALYTIC UNITS**
WASHINGTON	Middle Columbia-Hood	7
	Puget Sound	6
	Snoqualmie	2
	Upper Cowlitz	17
	Deschutes	*1*
	Duwamish	*2*
	Hood Canal	*1*
	Lake Washington	*2*
	Lewis	*6*
	Lower Cowlitz	*3*
	Naches	*1*
	Nisqually	*4*
	Puyallup	*3*
	Sauk	*1*
	Stillaguamish	*1*
	Upper Chehalis	*1*
	Upper Yakima	*1*
OREGON	*Clackamas*	*2*
	Lower Columbia-Clatskanie	*2*
	Lower Columbia-Sandy	*1*
	Lower Willamette	*3*
	Tualatin	*1*
	Yamhill	*4*

SUMMARY OF BIOLOGICAL INFORMATION

Individual needs:

Despite the advances in our understanding of the species distribution since implementation of the NWFP survey and manage program (Burke *et al.* 1999, 7; Johannes 2012, p. 9), information about the species' natural history and specific requirements of individual Puget Oregonians remains sparse. What we do understand about forest stand-level physical and biological habitat elements and how they support different stages of the snail's life history is summarized below in Table 2.

Table 2: Individual Resource Needs of the Puget Oregonian. Active state (A), Dormant state (D). Eggs simply develop without additional needs and will be categorized as D

Resources	**Eggs**	**Juvenile**	**Adult**
Bigleaf maple/mixed maple forest	D	A, D	A, D
Moisture (precipitation >35 in/year - springs)	unknown	A	A
temperature 0 - 19° C	unknown	A	A
Forest floor habitat components (LWD/leaf litter/swordfern, talus)	D	A, D	A, D
Appropriate Pedosphere (primarily soil 'O' & 'A' horizons) conditions: chemistry/type, interstitial space moisture	D	D	D
Food Resources	N/A	A	A

Population needs

Despite the number of observations of the species, we can state little about the needs of an individual population of Puget Oregonians, beyond the requirement for areas of connected bigleaf maple or mixed bigleaf maple forests with appropriate understory habitat and environmental conditions as discussed previously in this assessment.

Species needs

We evaluated the species' needs in terms of the resources and/or the circumstances that support the redundancy and representation of the species. The viability of the Puget Oregonian is supported by having multiple (redundancy), self-sustaining (resiliency) analytic units distributed throughout the geographical extent of its range (representation).

THREATS

In determining whether a species meets the definition of an "endangered species" or a "threatened species," we consider the factors under section 4(a)(1) and assess the cumulative effect that the threats identified within the factors—as ameliorated or exacerbated by any existing regulatory mechanisms or conservation efforts—will have on the species now and in the foreseeable future. We define "threat" as any action or condition that is known to or is reasonably likely to negatively affect individuals of a species. This includes those actions or conditions that have a direct impact on individuals, as well as those that affect individuals through alteration of their habitat or required resources. The mere identification of "threats" is not sufficient to compel a finding that listing is warranted. Describing the negative effects of an action or condition (i.e., "threats") in light of the exposure, timing, scale, and severity at the individual, population, and species levels provides a basis upon which to make our determination. We do this in the context of the SSA framework (USFWS 2016) whereby we analyze the factors (stressors) that may negatively influence the viability of the species. Under the framework, the viability of a species is not affected by stressors that operate exclusively at the individual level; only when a stressor operates at a scope, magnitude, and intensity as to affect the resiliency of a population is it considered to influence the viability of the whole species. Therefore, only those stressors that appear to be operating at the population level are considered threats for the purposes of the status

assessment. We also use the terms "influence factor," "risk factor," and "conservation measure." We generally define influence factor here as any physical, chemical, or biological alteration of the environment that can lead to an individual response. We think of risk factors and conservation measures as two types of influence factors, one leading to a negative individual response (risk factor) and one leading to a positive individual response (conservation measure).

Current Influence Factors

The primary factors we explored in our analysis of the current condition of the species include the following: the effects of forest management, land conversion to agriculture and development, bigleaf maple die-back (disease), and wildfire.

Forest management—It is generally understood that any modification of habitat that decreases available moisture or increases insolation, like timber harvest, is detrimental to terrestrial gastropods (Frest and Johannes, 1993, pp. 3-4). However, in some instances the impacts of timber harvest may be mitigated by site conditions that retain suitable habitat conditions, such as a north-facing aspect, abundant seeps, and a well-developed and diverse understory (Foster and Ziegltrum 2012, p. 254). Bigleaf maple is not used as a commercial species at a large scale, but may be harvested to a limited extent for the musical instrument and furniture market or illegally felled by poachers. It is also not a desired species, like conifers, for commercial forest owners or state and Federal land managers to replant. Thus, it is common for areas containing bigleaf maple as a stand component to have been converted to a more homogenous composition of Douglas fir and western hemlock or other marketable tree species (Foltz-Jordan and Hoffman-Black 2015, p. 15).

Between 1945 and 1970, approximately 343,983 ha (850,000 ac) of forest land west of the Cascade Crest was permanently removed primarily for road building and urban and industrial expansion (Bolsinger 1973, p. 4). Early forest management practices and land conversion in the PNW were largely unregulated until the mid-twentieth century when national and state forest practices were codified. By the mid-1990s, prior to the enactment of the NWFP, most of the Puget Oregonian's habitat (stands of maple and mix maple forest) in the Central Sound area was logged and then heavily urbanized (Frest and Johannes 1995. p.229; Mclean and Bolsinger 1997, p. 7).

In the late 20th century, national and state regulations changed the way timber was harvested with protections for sensitive areas including the designation of riparian corridors, meant to protect water quality and instream habitat conditions, and the retention of some proportion or stem-density of the landscape in uncut timber. While these regulations provided some protections for many habitats and wildlife species, there was little emphasis on retaining maple or other hardwoods beyond those found in riparian areas. Furthermore bigleaf maple are not typically replanted or managed after harvest Peterson *et al.* 1999 pp. 3, 55). The exception to this trend is projects and forest management activities on Federal lands covered by the NWFP subject to "Survey and Manage" protocols and protections. Under the NWFP the largest conservation impact for species associated with old forest was the identification of large areas of Late-Successional Reserves, where management was aimed to benefit these species. In addition, Riparian Reserves were identified to protect aquatic and old-growth forest associated species. Including nationally designated Wilderness and other reserve land allocations, about 80 percent of the Forest Service and BLM land base in the range of the northern spotted owl was classified as "reserve" lands, where management of these lands was to benefit late-successional species, including Puget Oregonians (USDA and USDI 1994, p. A-4). Further mitigation to benefit these late-

successional associated species can include surveys prior to "habitat-disturbing" activities and protecting any site with where these species are detected.

Land Conversion to Agriculture and Development—Much of the formerly known range and habitat of the Puget Oregonian was developed for urban uses, infrastructure, or agriculture by the 1990s, including many of the Central Puget Sound locations (Mclean and Bolsinger 1997, p. 7; Burke *et al.* 1999, pp. 9, 24). The human population of Washington State alone increased by an estimated 1 million individuals since 2008 when the Puget Oregonian was petitioned to be listed (Washington State Dept. of Financial Management 2018, p. 7). Land conversion to agriculture and development leads to loss of habitat, fragmentation and isolated populations, non-native invasive plant and animal establishment, and sometimes a continual source of mortality for snails (e.g., when attempting to disperse across roads) (Foltz-Jordan and Hoffman-Black 2012, pp. 20-22). With human population growth comes the need for homes, stores, infrastructure, and resources which have and will continue to alter and eliminate habitat for the Puget Oregonian, except where some remnant habitats remain relatively protected from that growth. Despite development in the range of the snail, there are still some protected sites occupied by Puget Oregonian within urban areas such as Crystal Springs Park in Tukwila, Washington, and McAllister Springs, Thurston County, Washington (Johannes 2017a, p. 1; BLM 2019).

Bigleaf Maple dieback Disease—Since first noted around 2007 (Chadwick *et al.* 2012, p. 1), maple dieback disease has been implicated in the wide-spread mortality of maple trees (Ohmdahl *et al*. 2012, entire). The cause of the disease is unknown and multiple hypotheses have been proposed, including: positive correlations with higher temperatures, vapor pressure deficits, decreased precipitation, high levels of developed land, low levels of forested or herbaceous land, proximity to paved roads (Betzen 2018, entire), and a pathogen transmitted by an intermediate insect carrier/host (Donahey 2019, pers. comm.). Regardless of the cause, recent surveys have found that symptoms of maple dieback are common and widespread across the range of the Puget Oregonian in Washington and adjoining states (Tyson 2018, p. 29; Betzen 2019, entire). This includes several stands currently occupied by the Puget Oregonian in the Upper Cowlitz sub-basin in the heart of the species' range (Le and Waterstrat 2019, pers. obs., pp. 1-2). This disease appears to be currently killing large mature maples at both the individual and the stand level. At present, it is uncertain how severely this will impact the future condition of the Puget Oregonian, but a significant reduction of bigleaf maples, the foundation of this species' habitat, seems likely. As this tree is the foundation of Puget Oregonian habitat, it is reasonable to predict that a continued decrease in the abundance of bigleaf maple will negatively affect the snail over time. However, as noted above, Puget Oregonians have been found in stands afflicted by the disease so it is unclear what the snail's response is to the presence of the pathogen.

Wildfire—Wildfires, of both natural and human origin, have played important roles is shaping the ecosystems in the PNW (Agee 1996, pp. 3, 53). Although wildfires are a natural part of the ecosystem to which the Puget Oregonian is adapted, wildfires are recognized as lethal to snails. The timing, severity, and intensity of an individual fire determines the impacts to individuals and populations of snails (Burke *et al.* 2013, pp. 18-19; Foltz-Jordan and Hoffman-Black 2012, pp. 25-28); high-intensity fire removes habitat, directly kills individual snails, and isolates remaining populations (Foltz-Jordan and Hoffman-Black 2015, p. 17). Typically, species that find refuge during dry periods of the year when fires are most likely to occur, such as terrestrial mollusks, are afforded some protection from fire (reviewed in Foltz-Jordan and Hoffman-Black 2012, pp. 24-25). However terrestrial mollusks are very susceptible to heat and dehydration and have a very limited ability to escape wildfires or disperse into remaining areas of suitable habitat after fires (Foltz-Jordan and Hoffman=Black 2012, pp. 24-25). Puget Oregonians are reported generally lacking from areas where controlled burns were applied after timber harvest (Foltz-

Jordan and Hoffman-Black 2015, p. 17). One accidental fire was reported to result in the mortality of Puget Oregonian adults in a bigleaf maple patch when burning slash piles (Foltz-Jordan and Hoffman-Black 2015, p. 17). While we do not know the full impacts of wildfire on individual or populations of Puget Oregonians, we do know that wildfires can result in mortality and loss of habitat and that areas burned in the past currently occupied by the species (Foltz-Jordan and Hoffman-Black 2015, p. 17; Kogut, T. pers. comm. 2019). Puget Oregonians have been found in areas that were previously subject to large scale, high-intensity wildfires like the Cispus Burn in 1902, but whether snails survived this burn in refugia or recolonized over the past century is unknown. Wildfires are becoming more common, typically larger in scale, and of higher intensity than the historical fire regime (Dennison *et al.* 2014, pp. 2930 -2931).

Current Condition and the 3Rs

To assess resiliency within the analytic units we developed a series of scoring criteria focused on the limited occurrence information available and our modeled habitat information (Table 3). The first criterion, "temporal relevance of occurrence," categorizes how recent the last observation of the species was (defined in Table 3); this reflects our level of certainty as to whether a population or individual snail may still occur in an analytic unit. The second criterion focuses on the number of observations of the Puget Oregonian in each analytic unit. As stated, there are no abundance surveys or estimates for this species, only occupancy and observational reports. For the purposes of this assessment, we assume that the more frequently the species has been encountered or reported the more likely it is to be more abundant than rare in an analytic unit. We were unable to factor relative differences in amount of search effort into our analysis at this stage. The third and fourth criteria focus on the extent of modeled suitable habitat within and surrounding an analytic unit. These metrics, habitat quality and potential surrounding habitat connectivity and quality, define coarse categorical habitat thresholds which can be applied uniformly across the analytic units (Table 3).

Table 3: Categorical definitions used to assess the current condition of the analytic units of Puget Oregonian.

Score	Temporal relevance of occurrence	Number of occurrences	Habitat Quality	Potential adjacent habitat connectivity and quality
3	Contemporary: after 1994 (NWFP Survey and management)	Common: > 20 observations in a analytic unit	High suitability: Assumed forest stand with bigleaf maple tree and understory habitat components at 75 to 100 percent modeled suitable habitat and on average greater than .6 value of NDVI values for analytic unit	High connectivity: Within analytic unit and in a one kilometer radius habitat contains contiguous forest stand with bigleaf maple tree and understory habitat components at 75 to 100 percent modeled suitable habitat and on average greater than .6 value of NDVI values for analytic unit.
2	Late century: 1970 - 1994	Uncommon: 20 - 10 observations in an analytic unit	Suitable: Assumed forest stand with bigleaf maple tree component and understory habitat components and 50 to 75 percent modeled suitable habitat and average greater than .6 value of NDVI values for analytic unit of NDVI values for analytic unit.	Moderate connectivity: within analytic unit and a one kilometer radius habitat contains contiguous forest stand with bigleaf maple tree and understory habitat components at 50 to 75 percent modeled suitable habitat and on average greater than .6 value of NDVI values for analytic unit.
1	Mid-century: 1950 - 1970	Rare: 10 - 3 observations	Low suitability: Assumed patches of forest stand with bigleaf maple tree component and understory habitat components and 25 to 50 percent modeled suitable habitat and a 0.4 to 0.6 NDVI value for analytic unit.	Low connectivity: within analytic unit and a one kilometer radius habitat contains contiguous forest stand with bigleaf maple tree and understory habitat components at 25 to 50 percent modeled suitable habitat and on a 0.4 to 0.6 NDVI value for analytic unit.
0	Historical: earlier than 1970	Not viable or unknown: 2 or less observations	Not suitable: no longer habitat (land conversion, fire, logging, no longer maple component) or less than 25 percent modeled suitable habitat and less than and less than 0.4 value of NDVI values for analytic unit.	Isolated: Within a one kilometer radius no habitat exists (i.e. land conversion, fire, logging, no longer maple component) or less than 25 percent modeled suitable habitat and less than 0.4 value of NDVI values for analytic unit.

Due to the significant lack of data for this species, the Service had enough information on the above criteria to assess and define a current condition for only 15 of the 74 analytic units. We assume these 15 units are currently occupied by Puget Oregonians based primarily on at least one contemporary

observation (since 1994). These include: Middle Columbia-Hood-4, Middle Columbia-Hood-7, Puget Sound-1, Puget Sound-6, Snoqualmie-1, Snoqualmie-2, Upper Cowlitz-2, Upper Cowlitz-3, Upper Cowlitz-5, Upper Cowlitz-6, Upper Cowlitz-7, Upper Cowlitz-11, Upper Cowlitz-13, Upper Cowlitz-15, and Upper Cowlitz-16. The other 59 analytic units have so little demographic information available and the record of their occurrence is old enough (categorized as either "mid-century" or "historical"), such that we could not assess their current condition. These "unknown" analytic units will, however, be considered in the overall representation and redundancy of the species viability.

When summarizing the resiliency level we averaged the score of each category for each unit. The average score was then used as an index of resiliency. We considered units with a score of zero for categories 1 and 2 to have an unknown resiliency status regardless of the average score. This was done because, based on current available information, there appear to be areas of suitable habitat unoccupied by the snail. Additionally, we do not feel that we can assess resiliency for the unit or the species from a half-century old observation or a single observation of the species. The summary of current condition for the 15 analytic units that we had enough information to analyze is detailed below in Table 4.

Table 4: Current Condition of the Puget Oregonian resiliency units with assumed occupancy.

Analytic Unit Name	**Temporal relevance of occurrence**	**Number of occurrences**	**Habitat Quality**	**Potential surrounding habitat connectivity and quality**	**Resiliency level***
Snoqualmie-1	Contemporary	Rare	High Suitability	Moderate Connectivity	Moderate
Snoqualmie-2	Mid-Century	Rare	Suitable	Moderate Connectivity	Low
Upper Cowlitz-2	Contemporary	Common	High Suitability	Moderate Connectivity	High
Upper Cowlitz-3	Contemporary	Common	High Suitability	High Connectivity	High
Upper Cowlitz-5	Contemporary	Rare	Low Suitability	Low Connectivity	Low
Upper Cowlitz-6	Contemporary	Common	High Suitability	High Connectivity	High
Upper Cowlitz-7	Contemporary	Common	High Suitability	High Connectivity	High
Upper Cowlitz-11	Contemporary	Rare	High Suitability	High Connectivity	High
Upper Cowlitz-13	Contemporary	Rare	High Suitability	High Connectivity	High

Analytic Unit Name	Temporal relevance of occurrence	Number of occurrences	Habitat Quality	Potential surrounding habitat connectivity and quality	Resiliency level*
Upper Cowlitz-15	Contemporary	Rare	High Suitability	High Connectivity	High
Upper Cowlitz-16	Contemporary	Rare	High Suitability	High Connectivity	High
* There are 59 additional identified and mapped analytic units for this species which the Service was unable to determine a current resiliency condition at this time (USFWS 2019, Appendix III).					

As indicated above, the majority of the analytic units we analyzed had a high level (10) of resiliency, and only a few had moderate (2) or low (3) levels. This is more a result of a dearth of information about the species, which led us to the assumption that where there are contemporary records of more than two observations per analytic unit we can assume that there are enough individuals to constitute a recent "population" that must have some level of resiliency. We are unable to determine a level of resiliency for the overwhelming (59 out of 74 or 80 percent) number of analytic units.

Redundancy and Representation—The greater the number of populations/subpopulations, and the more widely they are distributed, the lower the likelihood a single catastrophic event will cause a species to become extinct. The Puget Oregonian is a moderately wide-ranging PNW-endemic species with an assumed extant distribution across nearly 400 km (250 miles)(mi) north to south at elevations from sea level to 2700 ft (823 m) in mature hardwood forest habitat. The Service has identified 74 unique analytic units, albeit unequally distributed across its range. We have enough information to analyze the condition of 15 of the units. Twelve of the 15 had "high" resiliency, and there was at least one "high" analytic unit in each of four representative areas. It appears that Puget Oregonians have a large current range and multiple representative areas. Because of this, catastrophic events are unlikely to cause the species to become extinct. However we were unable to evaluate the resiliency of the majority (80 percent) of individual "populations" across the range. Therefore at this time, redundancy is characterized by 74 populations with mostly undeterminable resiliency, well distributed across the range of the species. Compared to known historical condition, the extirpation of the populations in British Columbia and the eastern central Puget Sound populations indicate some level of decline in representation and redundancy over time. The representative areas for the snail are summarized in Table 5. The table also includes total number of analytic units in each representative area and the level of resiliency for those units with adequate information for analysis. For 19 of 23 (82 percent) of the Representative Areas, we have no understanding of resiliency within the representative area.

Table 5: Representative areas for the snail, with current condition of analytic units with assumed occupancy.

	REPRESENTATIVE AREA (total number of analytic units in Area)	**ANALYTIC UNITS with assumed occupancy**	**CURRENT CONDITION**
WASHINGTON	Middle Columbia-Hood (7 units, 5 in "*unknown*" condition)		
		Middle Columbia-Hood-4	High
		Middle Columbia-Hood-7	High
	Puget Sound (8 units, 6 in "*unknown*" condition)		
		Puget Sound-1	High
		Puget Sound-6	Low
	Snoqualmie (2 units)		
		Snoqualmie-1	High
		Snoqualmie-2	Moderate
	Upper Cowlitz (17 units, 8 in "*unknown*" condition)		
		Upper Cowlitz-2	High
		Upper Cowlitz-3	High
		Upper Cowlitz-5	Low
		Upper Cowlitz-6	High
		Upper Cowlitz-7	High
		Upper Cowlitz-11	High
		Upper Cowlitz-13	High
		Upper Cowlitz-15	High
		Upper Cowlitz-16	High
	Deschutes (1 unit)	*n/a*	*unknown*
	Duwamish (2 units)	*n/a*	*unknown*
	Hood Canal (1 unit)	*n/a*	*unknown*
	Lake Washington (2 units)	*n/a*	*unknown*
	Lewis (6 units)	*n/a*	*unknown*
	Lower Cowlitz (3 units)	*n/a*	*unknown*
	Naches (1 units)	*n/a*	*unknown*
	Nisqually (4 units)	*n/a*	*unknown*
	Puyallup (3 units)	*n/a*	*unknown*
	Sauk (1 unit)	*n/a*	*unknown*
	Stillaguamish (1 unit)	*n/a*	*unknown*
	Upper Chehalis (1 unit)	*n/a*	*unknown*
	Upper Yakima (1 unit)	*n/a*	*unknown*
OREGON	*Clackamas (2 units)*	*n/a*	*unknown*
	Lower Columbia-Clatskanie (2 units)	*n/a*	*unknown*
	Lower Columbia-Sandy (1 unit)	*n/a*	*unknown*
	Lower Willamette (3 units)	*n/a*	*unknown*
	Tualatin (1 unit)	*n/a*	*unknown*
	Yamhill (4 units)	*n/a*	*unknown*

Summary of Current Condition

The current condition of Puget Oregonian is characterized by 12 highly resilient analytic units, one moderately resilient unit, two units with low resiliency, and 59 units with unknown resiliency (Figure 4). Redundancy appears adequate given these units are distributed throughout the range of the species. Furthermore, the 74 analytic units are distributed across 23 representative areas throughout the range of the species, and the 12 highly resilient units are distributed across four different representative areas, perhaps enhancing the adaptive capacity of the species. Note that Figure 4 not only displays the limited knowledge of occupied locations for the species, but also the high level of uncertainty regarding the species resiliency across the species known and modeled distribution. The majority of the records and information about the species comes from the Cispus Watershed of Cowlitz County, Washington represented by the cluster of analytic units with high resiliency.

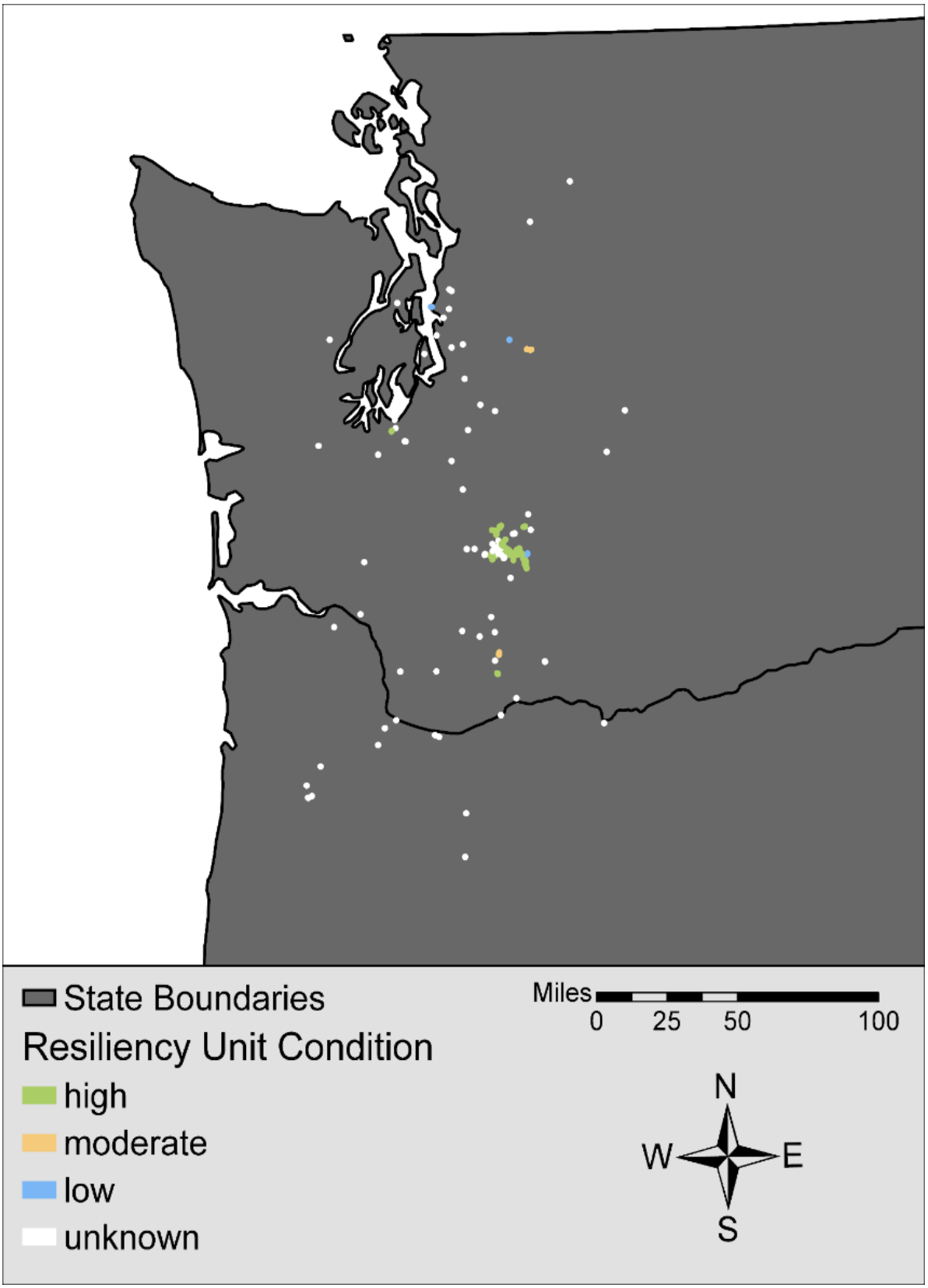

Figure 4. Puget Oregonian analytic units and their current condition.

Future Condition

Future Influence Factors

For the purposes of analyzing future conditions, we considered only those influence factors for which there is enough information to reasonably predict the severity or presence of the factor into the future, and how changes in that severity or presence will impact the Puget Oregonian; these include timber harvest, land use conversion, and the effects of climate change. We considered how those specific risk factors might combine to affect suitable habitat for the species, as we lack the information to determine how specific levels of change in the risk factors will impact the species.

Timber Harvest and Land Use Conversion—As multi-use management is one of the USFS's core missions, timber harvest is likely to continue occurring on lands managed by the agency. However, we expect the extent and intensity of habitat degradation due to timber harvest will be relatively limited, due to surveys and conservation measures in place for Survey and Manage species under the NWFP. Additionally, while timber management does at times occur within mixed stands, stands composed mostly of bigleaf maples are not usually targeted for timber harvest, limiting potential habitat degradation, and potentially leading to long-term habitat improvement through bigleaf maple release. Urban development and sprawl outside federal lands are likely to continue to encroach on forested lands that may serve as suitable habitat for the species. We expect that future human population increases and the resulting urbanization and land use conversion will likely lead to a reduction of available species habitat.

Effects of Climate Change—Projected climate changes within the range of the Puget Oregonian snail that could affect the species include changes to temperature, precipitation, fire risk, and flood risk. We analyzed the effects of climate change in areas that overlap with known Puget Oregonian snail populations through the middle of the century using data obtained from the Northwest Climate Toolbox, developed by members of the Applied Climate Science Lab at the University of Idaho (Hegewisch *et al*. 2019). The climate models were presented as two different emissions scenarios out to a range of years between 2040 and 2069; therefore, for the purposes of this status review we characterize the time frame of our future condition projections as mid-century. Global climate model results derived using accepted Representative Concentration Pathway (RCP) of greenhouse gas emissions or concentrations largely follow the same trajectory until mid-century and diverge beyond that point, resulting in greater uncertainty in the latter part of the century (IPCC 2014, p. 59).

Following global trends, average annual temperatures are expected to rise in the Pacific Northwest. At the same time, temperature variability is also expected to increase, leading to an expected increase in the number of warm days (warmer than 86 degrees Fahrenheit) during summertime. Overall, total annual precipitation will likely remain relatively constant with climate change, but variability in precipitation patterns is predicted to increase. Changes in precipitation vary by season, and location within the range of the snail. Throughout the entire range, summer precipitation is predicted to decrease, while winter precipitation is predicted to increase. In the northern portion of the snail's range, spring and fall precipitation is expected to increase, while in the southern portion of the range, it is expected to decrease. The hotter and drier summer conditions will likely lead to higher fire risk, due to drier soils, and drier and more abundant fuels, and may lead to an increase in bigleaf maple dieback disease. As part of the expected increase in winter precipitation, and the increased amount of precipitation expected to fall as rain rather than snow, we also expect an increase in the number and

intensity of extreme precipitation events and thereby the frequency and severity of floods; this could impact locations that are currently not flood-prone, where the Puget Oregonian might be found.

Due to longer, hotter, and drier summer conditions, Puget Oregonian snail activity will likely be more limited during the summer. Combined with more extreme projected climate conditions during winters, the snail will likely cease activity earlier and become active again later, both seasonally and daily. Additionally, it is unknown how long the species is able to remain in a state of estivation. If the increasing length of summer conditions extends beyond the amount of time the snail can remain alive in estivation or the species is unable to adjust the timing of their active periods, predicted climate change could lead to reduced survival of the species during summers. Alternatively, if the snails adjust the timing of their active periods, projected climate change may not affect the survival of the species during future summers.

Future Scenarios

For our analysis of the Puget Oregonian's future condition at each site, we constructed four future scenarios focused on possible future trends in the quality and connectivity of habitat for the species (Table 6). These scenarios are meant to cover a large breadth of future conditions that could occur in Puget Oregonian populations, and all scenarios may not be equally plausible. For the future condition analysis, we used corresponding climate modeling data to develop our projections.

We expect climate change to negatively affect the macro- and microhabitat conditions required by the Puget Oregonian, and that the severity of change will be greater under a higher emissions scenario (RCP 8.5) than a lower emissions scenario (RCP 4.5). However, because we do not have enough information on the biology of the Puget Oregonian to determine how much climate-related habitat change the species can tolerate and what threshold levels of change will result in significant effects on the species, at this time it is impossible for us to quantitatively differentiate between the effects of climate change under a low emissions scenario (RCP 4.5) and a high emissions scenario (RCP 8.5). Therefore, considering the significant magnitude of change occurring under even a lower-emissions scenario (RCP 4.5), we assume that both emissions scenarios will result in similar negative effects on the species and its habitat, at different unquantifiable levels of severity out to mid-century (2040-2069).

Table 6: Future scenarios used to estimate future conditions at each of the 15 analytic units.

Scenario #1	Scenario #2	Scenario #3	Scenario #4
No significant reduction in habitat quality	No significant reduction in habitat quality	Significant reduction in habitat quality	Significant reduction in habitat quality
No significant reduction in habitat connectivity	Significant reduction in habitat connectivity	No significant reduction in habitat connectivity	Significant reduction in habitat connectivity

Future Condition and the 3Rs

We analyzed how the effects of the future scenarios changed the site condition rating for the locations with detections of the Puget Oregonian. We created three condition categories to characterize future site condition as described below. Similar to the current condition analysis, we arrived at an overall future condition at each site by looking at habitat quality and habitat connectivity. Because we have no demographic data to determine population trends of the species at each site, we assumed that if a

population is more robust today (it is more common and recently detected), it has a better chance of persisting into the future. For habitat quality and connectivity, we considered the current habitat conditions under the four future scenarios to arrive at future habitat conditions. As we are unable to predict the severity of change in habitat conditions, we analyze a range of possible futures for each scenario, at each site. We characterized the future condition of the analytic units according to the following overall condition categories:

> High: The site currently has relatively numerous and recent species records, and the site will retain relatively high habitat quality and connectivity, as defined in Table 3. Both the species and habitat are relatively likely to persist at the site.
>
> Moderate: Considering the four factors contributing to site conditions as described above, overall conditions are intermediate, as defined in Table 3. Moderate conditions in the future may result from either moderate conditions of the four factors overall, or from some factors being high and others being low. For example, a site would be considered to be in moderate condition if species records are relatively numerous and recent, indicating some level of resilience, but habitat quality and connectivity are in low to moderate conditions. The species and/or habitat may persist at the site, but may be affected by additional stressors.
>
> Low: The four factors contributing to site condition are in relatively poor condition individually, and overall, as defined in Table 3. Existing Puget Oregonian populations are likely not robust currently, and habitat conditions will be relatively poor. Both the species and habitat are unlikely to persist at the site.

While there is the possibility of the presence of climate refugia that might serve to buffer the Puget Oregonian from the effects of climate change in some locations in the description of future scenarios, the scale of available climate projection data is too coarse to determine where those refugia might be for the species and which specific sites might serve as climate refugia. Most available climate prediction datasets have a spatial resolution of about 820 ft (250 m), which is suitable for landscape-scale analysis and generalized conclusions about the effects of climate change. However, the scale of these data is too coarse to differentiate between fine-scale future conditions in order to identify refugia at scales relevant to the species (i.e. a site down to about 33 ft (10 m). This leads to significant uncertainty as to whether or not any of the Puget Oregonian sites will be a climate refugium with at most mild declines in condition, or be affected by the other risk factors in a way that will result in locally severe declines in habitat suitability and/or connectivity. To capture this uncertainty in future condition rankings (particularly for scenarios 2 and 3) we display a range of condition somewhere between low and high rather than a more specific ranking.

Results of future scenarios are summarized in Table 7. The description for these ranges of site condition categories correspond to the three categories described above. Similar to our analysis of current conditions of the analytic units, we were unable to analyze the future conditions of 59 analytic units under the four future scenarios, due to insufficient data. The condition of those 59 units under the future scenarios remains unknown.

Table 7. Summary of current and future condition of Puget Oregonian in future scenarios. The remaining 59 units of unknown condition due to insufficient information have been omitted from this table.

Representative Unit	Current condition	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Middle Columbia-Hood					
Middle Columbia-Hood-4	high	High	moderate	moderate	low - moderate
Middle Columbia-Hood-7	moderate	moderate	moderate	low - moderate	low - moderate
Puget Sound					
Puget Sound-1	high	High	moderate	moderate	low - moderate
Puget Sound-6	low	Low	low	low	low
Snoqualmie					
Snoqualmie-1	moderate	moderate	moderate	low - moderate	low - moderate
Snoqualmie-2	low	Low	low	low	low
Upper Cowlitz					
Upper Cowlitz-2	high	high	moderate - high	moderate - high	low - moderate
Upper Cowlitz-3	high	high	moderate - high	moderate - high	low - high
Upper Cowlitz-5	low	low	low	low	low
Upper Cowlitz-6	high	high	moderate - high	moderate - high	low - high
Upper Cowlitz-7	high	high	moderate - high	moderate - high	low - high
Upper Cowlitz-11	high	high	moderate	moderate	low - moderate
Upper Cowlitz-13	high	high	moderate	moderate	low - moderate
Upper Cowlitz-15	high	high	moderate	moderate	low - moderate
Upper Cowlitz-16	high	high	moderate	moderate	low - moderate

Summary of Future Condition

Overall, our future scenarios project that the future condition of Puget Oregonian will likely decrease across the range of the species. In general, we expect the amount, quality, and connectivity of Puget Oregonian habitat to decline in the future as climate change and human activity adversely affect bigleaf maple, microhabitat conditions, and habitat connectivity. While lack of data prevented us from evaluating the current and future conditions of all 74 analytic units, we expect this general decline in habitat conditions to also occur in the 59 'unknown' units based on our understanding of modeled habitat across the range. We anticipate the future resiliency of the 15 assessed analytic units to decline in three out of the four scenarios by the middle of the century, but are unable to predict the severity of decline within each analytic unit. Redundancy for Puget Oregonian is also difficult to project because we don't have enough information to project the probability of persistence of any particular analytic unit. The 15 analytic units with assumed occupancy are found in only four of the 23 representative areas with occurrence records in the range, but it is unclear what the contribution of these four areas is to the overall representation of the species on the landscape.

SUMMARY OF THREATS

While we have some understanding of the ecological needs of the Puget Oregonian and factors likely influencing species viability, we lack substantial information regarding the life history and ecology of the species. We suspect that the species has lost some historical species-level viability primarily due to forest management, land conversion to agriculture and development, and wildfire. We anticipate that the effects of climate change and bigleaf maple dieback disease will impact Puget Oregonian detection sites to some extent into the future, although the response that the snail will have to these changes remains unclear.

DETERMINATION OF THE PUGET OREGONIAN'S STATUS

Section 4 of the Act (16 U.S.C. § 1533) and its implementing regulations (50 CFR Part 424) set forth the procedures for determining whether a species meets the definition of an endangered species or a threatened species. The Act defines "endangered species" as a species "in danger of extinction throughout all or a significant portion of its range," and "threatened species" as a species "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The Act requires that we determine whether a species meets the definition of "endangered species" or "threatened species" because of any of the following factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) Overutilization for commercial, recreational, scientific, or educational purposes; (C) Disease or predation; (D) The inadequacy of existing regulatory mechanisms; or (E) Other natural or manmade factors affecting its continued existence.

Status Throughout All of Its Range

In our SSA (USFWS 2019, entire), we evaluated all potential threats to the Puget Oregonian including the following: the effects of current and potential future habitat loss, modification, and fragmentation from forest management; land conversion to agriculture and development; big leaf maple dieback disease; and wildfire (Factor A) and how the influence of those factors on the species might change in the future due to the effects of climate change. We also evaluated existing regulatory mechanisms and conservation measures (Factor D) and whether they reduce or ameliorate potential threats to the species. We found no information indicating that the Puget Oregonian is currently overutilized for

commercial, recreational, scientific, or educational purposes (Factor B), or is currently impacted at a population scale by predation or disease (Factor C), or other natural or manmade factors (Factor E), nor did we find information to suggest that the species will be impacted by these factors in the future.

After evaluating available information, we could not determine a population trend for the Puget Oregonian. The species' known range has increased from when the species was first described in 1913. A single reliable record from Vancouver Island in 1940 indicates there may have been a population in British Columbia, Canada but after additional, contemporary work the species appears to be extirpated in the province. We found that that habitat appears to be affected in most analytic units to various degrees by forest management, land conversion, and big leaf maple dieback disease (Factor A), but due to a dearth of information on the species, we lack a clear understanding of what this means to the overall viability of the species. Most of the sites where the Puget Oregonian has been detected are located on public land, and though some habitat conservation measures are occurring, these measures do not fully ameliorate potential habitat loss, modification, and fragmentation (Factor D).

The Upper Cowlitz sub-basin contains the majority of observations and biological information on the species, making it the basis for most of our assumptions about the species' resource needs. Habitat characteristics that appear important to Puget Oregonian due to their contribution to moist and cool conditions on the forest floor include bigleaf maple stands or mixed bigleaf maple stands, and microhabitat features such as large woody debris, swordfern skirts, and leaf litter. However, there are many aspects of the Puget Oregonian's habitat needs that are not clear including exactly what features drive occurrence of the snail at any given site. Furthermore, though we have some understanding of what threats might affect the species habitat (Factor A), the species has been found in areas after some of these threats have acted on the landscape including areas with trees affected by big leaf maple dieback and areas that have been burned by large wildfires. Information gaps on the species' response to influence factors prevents us from understanding why the species would remain in these areas post-impact. Therefore, we do not know the magnitude with which these factors actually currently influence Puget Oregonian population resiliency and how much the factors may influence resiliency in the future.

Most occurrence records for this species come from the Cispus River watershed in Washington administered by the Gifford Pinchot National Forest, Cowlitz Ranger District, and date after the 1994 implementation of the NWFP (USDA and USDI 1994) survey and manage program that focused surveys on areas where USFS projects were being considered. Based on available survey data, the species appears to be fairly common and well distributed within suitable habitat in the Upper Cowlitz sub-basin, however, outside of this sub-basin, species records are relatively rare. Furthermore, some of the sub-basins with identified suitable habitat have not yet been comprehensively searched for the species, so there may be other occurrences of the snail beyond those we currently know. Since we were petitioned to list the Puget Oregonian in 2008, individuals of the species have been discovered at additional sites.

Because of the lack of available information, the SSA process for the Puget Oregonian was limited in its ability to assess the current resiliency, redundancy, and representation of the species. Though we have detection records for the species, the available data do not provide a clear understanding of abundance, population size, population structure, dispersal distance, level of genetic exchange, or reproductive capacity for the species at any of its known sites.

The majority of sites with occurrences that had enough information for analysis appear to be primarily highly resilient. However, there are 59 additional occurrences of unknown resiliency where we cannot assess the status of any populations. Though the species does not appear to be particularly abundant,

the snail's known distribution across a large area (redundancy), with resilient populations in four different watersheds (representation), does allow for potential recovery of the species from catastrophic events. In summary, the available information does not indicate that the Puget Oregonian is presently in danger of extinction throughout its range. Therefore, after assessing the best available information, we find the Puget Oregonian does not meet the definition of an endangered species.

Having found that the Puget Oregonian is not in danger of extinction throughout its range, we next evaluated whether the species is in danger of extinction in the foreseeable future throughout its range. Under the Act, a threatened species is any species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (16 U.S.C. § 1532(20)). The term foreseeable future extends only so far into the future as the Services can reasonably determine that both the future threats and the species' responses to those threats are likely (84 FR 44753). The key statutory difference between a threatened species and an endangered species is the timing of when a species may be in danger of extinction, either now (endangered species) or in the foreseeable future (threatened species). For the purposes of this determination, we consider the foreseeable future to be mid-century, between the years 2040 and 2069.

To assess future conditions of the species, we considered the effects of climate change for both RCP 4.5 and RCP 8.5 on the species' modeled habitat requirements. Effects under these emission scenarios included increases in temperature, changes in seasonal precipitation and soil moisture, increased risk of floods and other extreme weather events, and increased fire risk. We also considered other risk factors, including human population growth in the PNW, forest management, and big leaf maple dieback disease. We identified four future scenarios; the results of our scenarios had one which projected no change from current condition, and three scenarios which projected various levels of decline in habitat conditions. Similar to the assessment of current condition, we did not project the future condition of 59 analytic units with uncertain occupancy, but found the habitat in these areas would likely experience similar changes.

As a result of the effects of projected climate change, we expect the suitability and availability of current Puget Oregonian habitat on the landscape to decrease. The geographic area that provides suitable habitat for the species may decrease, and the seasonal conditions for activity may decrease or shift such that that risk to the survival of Puget Oregonians may increase. However, the specific scope and magnitude of these potential effects are very uncertain. Over time, the assumed resource needs of the species may diminish in quantity and quality as stressors to these habitat features increase in the future. If the resource needs of the species diminish, we expect there would be a corresponding decline in the resiliency, redundancy, and representation of the species. However, our limited understanding of how the species may respond to changes in its environment over time creates a wide range of possibilities for the future condition of the 15 analytic units for which we had sufficient information. Overall, while the resiliency of the 15 units may decline under the future scenarios, we cannot project to what level the resiliency would decline. None of the information on environmental stressors in the future indicate their magnitude and scope would be at a level that would put the viability of the species at risk, though the lack of clarity on potential species response leaves us unable to project a meaningful probability of or likelihood of persistence of any particular analytic units.

The Puget Oregonian's current distribution in at least 15 sites across a relatively large area (redundancy) and in at least four different sub-basins (representation) will support its ability to maintain resiliency in the midst of future disturbance events. Furthermore, the species' ability to take refuge in small areas (micro-habitat) contributes to its expected resiliency, and its potential for various modes of

reproduction could further improve our understanding of its resiliency. Since we were petitioned to list the species in 2008, individual snails have been discovered at additional sites. Though the features of the species' habitat will likely change in the future, and climate projections help to predict the scope and magnitude of some of those environmental changes, we don't know how the species will respond to those changes. The species has been found in areas previously impacted by some factors that are assumed to be stressors (bigleaf maple dieback disease and wildfire). In summary, the available information does not indicate that the Puget Oregonian is in danger of extinction throughout its range in the foreseeable future. Therefore, after assessing the best available information, we conclude that the Puget Oregonian does not meet the definition of a threatened species.

Thus, after evaluating threats to the species and assessing the cumulative effect of the threats under the section 4(a)(1) factors based on the best available information, we determine that the Puget Oregonian is not in danger of extinction now or likely to become so in the foreseeable future throughout all of its range.

Status Throughout a Significant Portion of Its Range

Under the Act and our implementing regulations, a species may warrant listing if it is in danger of extinction or likely to become so in the foreseeable future throughout all or a significant portion of its range. Having determined that the Puget Oregonian is not in danger of extinction or likely to become so in the foreseeable future throughout all of its range, we now consider whether it may be in danger of extinction or likely to become so in the foreseeable future in a significant portion of its range—that is, whether there is any portion of the species' range for which it is true that both (1) the portion is significant; and, (2) the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. Depending on the case, it might be more efficient for us to address the "significance" question or the "status" question first. We can choose to address either question first. Regardless of which question we address first, if we reach a negative answer with respect to the first question that we address, we do not need to evaluate the other question for that portion of the species' range.

In undertaking this analysis for Puget Oregonian, we choose to address the status question first — we consider information pertaining to the geographic distribution of both the species and the threats that the species faces to identify any portions of the range where the species is endangered or threatened. For the Puget Oregonian, we considered whether the threats are geographically concentrated in any portion of the species' range at a biologically meaningful scale. We examined the following potential threats: habitat loss, modification, and fragmentation from forest management, land conversion to agriculture and development, big leaf maple dieback disease, wildfire, and the effects of climate change, including cumulative effects. We found no concentration of threats in any portion of the Puget Oregonian's range at a biologically meaningful scale. Therefore, no portion of the species' range can provide a basis for determining that the species is in danger of extinction now or likely to become so in the foreseeable future in a significant portion of its range, and we find the species is not in danger of extinction now or likely to become so in the foreseeable future in any significant portion of its range. This is consistent with the courts' holdings in *Desert Survivors* v. *Department of the Interior*, No. 16-cv-01165-JCS, 2018 WL 4053447 (N.D. Cal. Aug. 24, 2018), and *Center for Biological Diversity v. Jewell*, 248 F. Supp. 3d , 946, 959 (D. Ariz. 2017).

Determination of Status

Our review of the best available scientific and commercial information indicates that the Puget Oregonian does not meet the definition of an endangered species or a threatened species in accordance with sections 3(6) and 3(20) of the Act. Therefore, we find that listing the Puget Oregonian as an endangered or threatened species under the Act is not warranted at this time.

BATCHED NOTICE LANGUAGE

Previous Federal Actions

In 2008, the U.S. Fish and Wildlife Service (Service) received a petition to list the Puget Oregonian (*Crytpomastix devia*) as endangered or threatened under the Endangered Species Act of 1973, as amended (Act; 16 U.S.C. 1531 *et seq*.) (Act) (1973, entire). We published a 90-day finding (76 FR 61826) in 2011 that found the petition presented substantial information indicating that listing the Puget Oregonian may be warranted for listing under the Endangered Species Act, and that we would begin a status review of the species.

Summary of Finding

The Puget Oregonian inhabits moist, conifer-forest habitats that include some level of deciduous tree community composition. The species is most commonly located in stands with bigleaf maple (*Acer macrophyllum*) that occur along stream and river terraces or other habitats with a flat or gentle slope. Within that landscape the species' habitat niche appears to be near or under big leaf maple crowns and in, or under, hardwood logs and other woody material, leaf litter, moist talus, and the lowest fronds of western swordfern (*Polystichum munitum*). The Puget Oregonian is found in the Cascade Range and Puget Trough in Washington, and south into the foothills of the Coast Range and Willamette Valley, in Oregon; they are recognized as extirpated from British Columbia, Canada. Most occurrence records for this species come from the Cispus River watershed in Washington administered by the Gifford Pinchot National Forest, Cowlitz Ranger District, and date after the 1994 implementation of the Northwest Forest Plan's survey and manage program that focused surveys on areas where U. S. Forest Service projects were being considered. Some of the sub-basins with potential suitable habitat for the Puget Oregonian have not been surveyed for the species.

The primary stressors affecting the Puget Oregonian's biological status appear to include the effects of past, current, and future habitat loss, modification, and fragmentation (Factor A) from forest management, land conversion to agriculture and development, big leaf maple dieback disease, and wildfire. However, our understanding of species response to stressors is incomplete given that the species has been found in areas that had been previously impacted by some of these influence factors (bigleaf maple dieback disease and wildfire). The available data provides no information on whether there is a declining or increasing population trend and limited information on whether the range of the species has contracted or expanded in the last century. Ten of the 15 assessed units with assumed occupancy appear to be highly resilient. We did not assess the resiliency of the remaining 59 units with unknown current occupancy. Though the species does not appear to be particularly abundant, the snail's apparent distribution across a large area (redundancy), with resilient populations in four different sub-basins (representation) does indicate the species is likely to withstand catastrophic events in one or more watersheds and still persist.

The assumed resource needs of the Puget Oregonian are likely to diminish in quantity and quality over time with future increases in environmental stressors including the effects of climate change, human

population growth in the PNW, forest management, and big leaf maple dieback disease. If suitable habitat diminishes, as expected, we would anticipate a corresponding decline in the resiliency, redundancy, and representation of the species. However, the Puget Oregonian's current distribution in at least 15 sites across in at least four different sub-basins will support its ability to maintain resiliency to the mid-21st century. Furthermore, the species' ability to take refuge in small areas (micro-habitat) could add to the future resiliency of populations.

We know that features of the species' habitat may change in the future, and we can project the scope and magnitude of some of those environmental changes. However, our incomplete understanding of how the species may respond to changes in its environment over time creates a wide range of possibilities for the future condition of the 15 analytic units for which we had sufficient analytic information. No available information indicates that the future magnitude and scope of potential environmental stressors would be at a level that would put the viability of the species at risk, though the lack of clarity on species response leaves us unable to project a meaningful likelihood of persistence of any particular analytic unit.

Therefore, we find that listing the Puget Oregonian as an endangered species or threatened species under the Act is not warranted. A detailed discussion of the basis for this finding can be found in the Puget Oregonian species assessment and other supporting documents (see ADDRESSES, above).

COORDINATION WITH STATES

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment: Washington, Oregon, and British Columbia, Canada
Indicate which State(s) did not provide any information or comments: N/A

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U.S. FISH AND WILDLIFE SERVICE
SCIENTIFIC NAME: *Cryptomastix devia*
COMMON NAME: Puget Oregonian
LEAD REGION: Interior Region 9
DATE INFORMATION CURRENT AS OF: May 9 2020

APPROVAL/CONCURRENCE:

Approve: ROBYN THORSON Digitally signed by ROBYN THORSON Date: 2020.06.22 13:14:23 -07'00'

Regional Director, U.S. Fish and Wildlife Service Date

Concur: AURELIA SKIPWITH Digitally signed by AURELIA SKIPWITH Date: 2020.11.19 17:26:24 -05'00'

Director, U.S. Fish and Wildlife Service

Date

Do not concur: _____

Director, U.S. Fish and Wildlife Service

Date

Director's Remarks:

Date of annual review:
Conducted by: