Version 1.0

Conservation Assessment for the

Larch Mountain Salamander

(*Plethodon larselli*)

Version 1.0

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Interagency Special Status and Sensitive Species Program

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Disclaimer

This Conservation Assessment was prepared to compile the published and unpublished information on the Larch Mountain salamander (Plethodon larselli). Although the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise and be included. If you have information that will assist in conserving this species or questions concerning this conservation assessment, please contact the interagency Conservation Planning Coordinator for Region 6 Forest Service, BLM OR/WA in Portland, Oregon via the website: http://www.fs.fed.us/r6/sfpnw/issssp

Executive Summary

Species: Larch Mountain salamander (*Plethodon larselli* Burns)

Taxonomic Group: Amphibian

Management Status: U.S.D.A. Forest Service, Region 6 –Sensitive species; U.S.D.I. Bureau of Land Management: Bureau Sensitive. US Fish and Wildlife Service, species of concern; Oregon and Washington State Sensitive species; Oregon Department of Fish and Wildlife – Vulnerable species; NatureServe, Globally imperiled (G2), "imperiled" in Oregon (S2), and in Washington "rare, uncommon or threatened, but not immediately imperiled" (S3). In Oregon, it is on Oregon Natural Heritage Information Center (ORNHIC) List 2, taxa threatened with extirpation or presumed to be extirpated from the state of Oregon. Management of the species follows Forest Service 2670 Manual policy and BLM 6840 Manual direction.

Range: The Larch Mountain salamander is found along a 58 km (36 mi) stretch of the Columbia River Gorge and in isolated populations to the north in the Washington Cascade Range and to the south in the Oregon Cascade Range. In Washington, they occur to 193 km (about 120 mi) north of the Columbia River Gorge in Clark, Cowlitz, Skamania, Lewis, King, Pierce, Klickitat, and Kittitas Counties. Known Oregon populations are within about 22 km (~ 14 mi) of the Columbia River, in Multnomah and Hood River Counties. The known range of the species in Oregon and Washington is ~ 11,740 km^2 (4,550 mi^2). The species has been found from 50 to 1280 m (~160-4200 ft) in elevation. The current knowledge of the species range is likely incomplete and several range extensions have occurred over the past decade.

Specific Habitat: Larch Mountain salamanders occur in a wide array of habitat types including: 1) old-growth forests; 2) younger naturally regenerated forests in gravelly/cobble soils with residual late successional features (snags and large down logs); 3) scree and talus (forested and un-forested); and 4) lava tube entrances where debris (e.g., pieces of lava, wood, fine organic and inorganic particles) has accumulated. In a large portion of the species range, late-seral forest conditions appear to be crucial to the species existence. In other areas, combinations of rocky substrates, soils, and vegetation provide suitable cool, moist microhabitat conditions necessary for Larch Mountain salamanders to exist.

Threats: Habitat loss, degradation, and fragmentation are the main threats to this species. Alteration of forest structure and microhabitats, and microclimate regimes within surface and subsurface environments are of highest concern. Dominant anthropogenic threats include timber harvest, road construction, and scree mining. In the Cascade Range portion of the species' range, timber harvesting is the primary threat, affecting canopy closure, disturbing substrates and soils, and altering microhabitats and microclimates. In the Columbia River Gorge, the primary threats are the development of recreational facilities (i.e., trails, roads) and the construction of residential housing. However, with approximately 70% of all known federal occurrences within reserve lands, this species may be relatively well-protected from most anthropogenic disturbances. Natural disturbances, such as fire and volcanism, are considered serious potential threats.

Management Considerations: Considerations for maintaining local populations include avoiding habitat loss or degradation, and maintaining undisturbed cool, moist surface and subsurface refuges. This includes avoiding excavation or rock removal, road or campsite construction, and chemical applications within occupied habitats. While some timber harvest activities may have adverse effects by disturbing substrates and affecting microclimates, fuels reduction activities in fire-prone areas may be desired to reduce the potential for a stand-replacement fire. At occupied cave entrances, management to reduce recreation impacts (e.g., trampling) may be needed. Seasonal restrictions to cold and dry times may reduce direct effects of disturbances to surface-dwelling salamanders.

Maintaining species persistence extends beyond site-scale management. Consideration of the types, condition and distribution of habitats at multiple-scales (e.g., habitat patch, watershed) could aid in long-term persistence of Larch Mountain salamanders in the landscape.

Inventory, Monitoring, and Research Opportunities: Information gaps include -

- Distribution of the species on both the north and south side of the Columbia River Gorge.
- Distribution of suitable habitat across the species' range.
- The response of the species to disturbances including silviculture activities such as density management, fire, and fuels reduction work.
- How much area is needed for site-level persistence (what is a site?).
- General life history information including reproduction, movement, dispersal, and foraging.

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I. INTRODUCTION

Goal

The primary goal of this Conservation Assessment is to provide the most up-to-date information known about this species including life history, habitat, and potential threats, and to describe habitat and site conditions that may be desirable to maintain if management of a particular site or locality for the species is proposed. This species is a rare endemic vertebrate with a known range restricted to lands in the Cascade Range in Washington and northern Oregon. It is recognized as a potentially vulnerable species by various Federal and State agencies because it is potentially susceptible to land management activities that occur within its range, and its relative rarity, especially at locations away from the Columbia River Gorge. The goals and management considerations of this assessment are specific to Bureau of Land Management (BLM) and Forest Service lands in Oregon and Washington. The information presented here is compiled to help manage the species in accordance with Forest Service Region 6 Sensitive Species (SS) policy and Oregon/Washington BLM Special Status Species (SSS) policy. Additional information for Region 6 SS and Oregon BLM SSS is available on the Interagency Special Status Species website (http://www.fs.fed.us/r6/sfpnw/issssp/).

For Oregon/Washington BLM-administered lands, SSS policy (6840 manual and IM OR-91-57) provides details of the need to manage for species conservation.

For Region 6 of the Forest Service, 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.

Scope

We synthesize biological and ecological information for the species range-wide, relying on published accounts, reports, locality data from individuals and databases, and expert opinion. Although we did not restrict our information compilation to that coming from federal sources, our site data are largely compiled from federal lands and the scope of the management considerations of this assessment are specific to BLM and Forest Service lands in Oregon and Washington. Washington sites are known in Clark, Cowlitz, Skamania, Lewis, King, Pierce, Klickitat, and Kittitas Counties. Oregon sites occur in Multnomah, and Hood River Counties. There are several federal land management administrative units included within the species' known and suspected range: Mount Baker-Snoqualmie National Forest, Wenatchee National Forest, Gifford Pinchot National Forest, Mount Rainier National Park, Columbia River Gorge National Scenic Area, Mt. Hood National Forest, and the BLM Spokane District.

Management Status

Due to its rarity and apparent vulnerability to a variety of anthropogenic disturbances, the Larch

Mountain salamander is classified by both state and federal agencies as a species of concern. It is listed as a: U.S.D.A. Forest Service, Region 6 –Sensitive species; U.S.D.I. Bureau of Land Management – Bureau Sensitive species; Oregon Department of Fish and Wildlife – Vulnerable status, and; a Washington State Sensitive species. The USFWS considers this salamander a species of concern. NatureServe has classified this species as Globally imperiled (G2), "imperiled" in Oregon (S2), and "rare, uncommon or threatened, but not immediately imperiled" in Washington (S3). In Oregon, it is on ORNHIC List 2, taxa threatened with extirpation or presumed to be extirpated from the state of Oregon. Management of the species follows Forest Service 2670 Manual policy and BLM 6840 Manual direction.

II. CLASSIFICATION AND DESCRIPTION

Systematics

The Larch Mountain Salamander (*Plethodon larselli*) belongs to the lungless salamander family, the Plethodontidae. Burns (1954, 1962) originally described the taxon as a subspecies of the Van Dyke's salamander (*Plethodon vandykei*), but subsequent work (Burns 1964a, 1964b) resulted in it being elevated to the species level. Electrophoretic studies have found *P. larselli* to be phylogenetically close to the Jemez Mountains salamander (*Plethodon neomexicanus*), a relict species restricted to the Jemez Mountain Range of New Mexico (Highton and Larson 1979). Both *P. larselli* and *P. neomexicanus* share the diagnostic characteristic of a single phalange on the outer toe of the back feet (Stebbins 1985).

Howard et al. (1983) conducted electrophoretic studies of four *P. larselli* populations, two each from Washington and Oregon. Thirty presumptive loci were examined and of these 25 were found to be monomorphic. Of the five polymorphic loci, each alternate allele was found in only one population, while all other populations were monomorphic for the common allele. Based on these results, the investigators concluded that gene flow among the study populations was probably low or absent. Although the populations appear to be genetically distinct, they apparently have experienced very limited divergence. Patchy distribution and assumed limited dispersal capabilities of *P. larselli* may be responsible for the low heterozygosity values among the four populations assayed.

Geographic variation and genetic structure of the Larch Mountain salamander has been examined using mitochondrial DNA (mtDNA) and random amplified polymorphic DNA (RAPD) assays (Wagner et al. 2004). They sampled 12 populations across the species' range, including sites north and south of the Columbia River in Washington and Oregon, and revealed considerable genetic differentiation among Larch Mountain salamander populations. Based on mtDNA analysis, eleven distinct genetic patterns (haplotypes) were found among twelve populations, with two southern populations showing identical patterns. RAPD analysis showed a number of population-specific characteristics (bands), with the greatest distinctions existing between the northern (Washington) and southern (Oregon) populations. They concluded the extent of genetic difference between northern and southern populations warrants each to be treated as a distinct management unit. They also concluded that southern populations exhibited reduced heterozygosity, a lower number of polymorphic alleles, and are fixed for a greater number of alleles compared to northern populations. The authors postulated that the Columbia River has acted as an effective barrier to gene flow between northern and southern populations and is likely responsible for the observed genetic differences.

The documented genetic differences between northern and southern populations of Larch Mountain salamanders provide evidence and rationale for consideration of distinct population segments or conservation unit designation. These divergent populations characterize the genetic diversity that exists within the Larch Mountain salamander genome. The distinct genetic make up among populations may afford the species a means of persisting in the face of climatic change, episodic disturbance events, and stochastic processes affecting genetic structure. Additionally, the current level of genetic diversity documented between northern and southern populations represents historical evolutionary processes that may continue on separate trajectories leading to greater levels of dissimilarity in the future, and perhaps ultimately to species-level distinctions.

Species Description

Plethodon larselli is the smallest of the western *Plethodon*. Adults range in size from 39 to 57 mm snout-vent length (SVL) and up to 105 mm total length (Crisafulli 2005). The smallest juvenile recorded is 15.0 mm SVL (Crisafulli, unpubl. data). This species has 14-16 (modal 15) costal grooves. Adult males lack mental glands. The outer toe on the hind feet is reduced in size, having a single phalange. Brodie (1970) reported significant differences in a number of morphological characters (e.g., number of teeth, dorsal stripe melanophore concentration, and size) among populations. Age-based variation in color and pigmentation occurs within populations (Brodie 1970, Crisafulli unpubl.). *Plethodon larselli* has an uneven-edged dorsal stripe, red, orange, chestnut or brown in color, with moderate to heavy infusions of melanophores (Burns 1954, 1964a, 1964b, Brodie 1970). In adults, the dorsal stripe terminates abruptly at the head but continues to the tip of the tail, where it is brightest. However, at several known locations adults have been observed lacking a dorsal stripe and instead have a fine grained mottled pattern on the dorsal surface (Crisafulli 2005, pages 133-134 photo plate). Subadults and younger adults frequently have melanophore pigmentation in a herringbone pattern down the center of the dorsal stripe. With age, this pattern often becomes obscured as melanophore density increases and appears as blotches or as an irregular stripe. The ground color is black and is most conspicuous as a narrow (i.e., 1-3 mm) stripe below the dorsal stripe. The sides have dense concentrations of iridophores (white and gold pigments), which obscure the black ground color of the sides. The iridophores are present as a band below the black stripe bordering the dorsal stripe and continue to the margin of the venter. Within this band, the iridophores are uniform on the costal folds, but are lacking in the costal grooves. The ventral surfaces of adults can be variable, ranging from whitish-gray to bright red in color. The venter has few if any melanophores present. Juveniles differ from adults in having an even dorsal stripe margin with melanophores few or lacking and a black venter with a single or multiple blotches or flecks of red pigments (Crisafulli 2005). Consequently, the young superficially resemble juvenile western red-backed salamanders (*Plethodon vehiculum)*. Characteristics of this species which distinguishes it from possible sympatric congeners are the dense and uniform iridophore pattern on its sides, its pink-to-red abdomen (on most individuals), and one phalanx on the fifth toe of the hind foot.

III. BIOLOGY AND ECOLOGY

Life History

The Larch Mountain salamander is a fully terrestrial species that does not require standing or flowing water at any time during its life history. They are primarily nocturnal and are typically active on the ground surface during the cool, wet weather of spring and fall (Crisafulli 2005). Because these animals occur over a broad elevation, temperature, and moisture range, their surface activity patterns vary by location (Nussbaum et al. 1983, Crisafulli 1999). High elevation and eastern Cascade Range populations have a much shorter surface active period compared to lower elevation and western Cascade Range populations.

Movements

While movement patterns have not been studied, individuals of this species are thought to have limited dispersal ability, making daily to seasonal vertical migrations in the ground surface as microclimate conditions change, but not extensive horizontal overland movements. Mark-recapture studies of movements are needed to confirm their suspected small home ranges. Genetic analyses indicate limited gene flow and suggest that populations have been on different evolutionary pathways for a long time.

Breeding Biology

Very little is known about reproduction in this species. A nest of *P. larselli* has never been found. Although courtship has never been described, it is thought to occur in the autumn and ova are deposited during the early spring. All information on the reproductive biology of the species has come from analyses of euthanized or anesthetized individuals collected in the Columbia River Gorge (Herrington and Larsen 1987, Nussbaum et al. 1983). Herrington and Larsen (1987) studied the reproductive biology of *P. larselli* from four sites in the Columbia River Gorge in 1981-1984. They inferred age structure of the population from size-frequency distributions of animals captured at their sites. Males were found to attain sexual maturity when they were 3 to 3.5 years of age and 39-42 mm SVL. Females were sexually mature at 4 years of age and were at least 44 mm SVL. The number of ova in a clutch ranged from 2-12 (mean=7.33, Herrington and Larsen 1987) and from 3-11 (mean=6.9, Nussbaum et al. 1983). Both studies found little correlation between female body size and number of eggs per clutch. They determined that females have a biennial ovarian cycle and, in some cases, a cycle frequency greater than every two years. Herrington and Larsen (1987) showed that males and females were found at approximately a 1:1 ratio.

Range, Distribution and Abundance

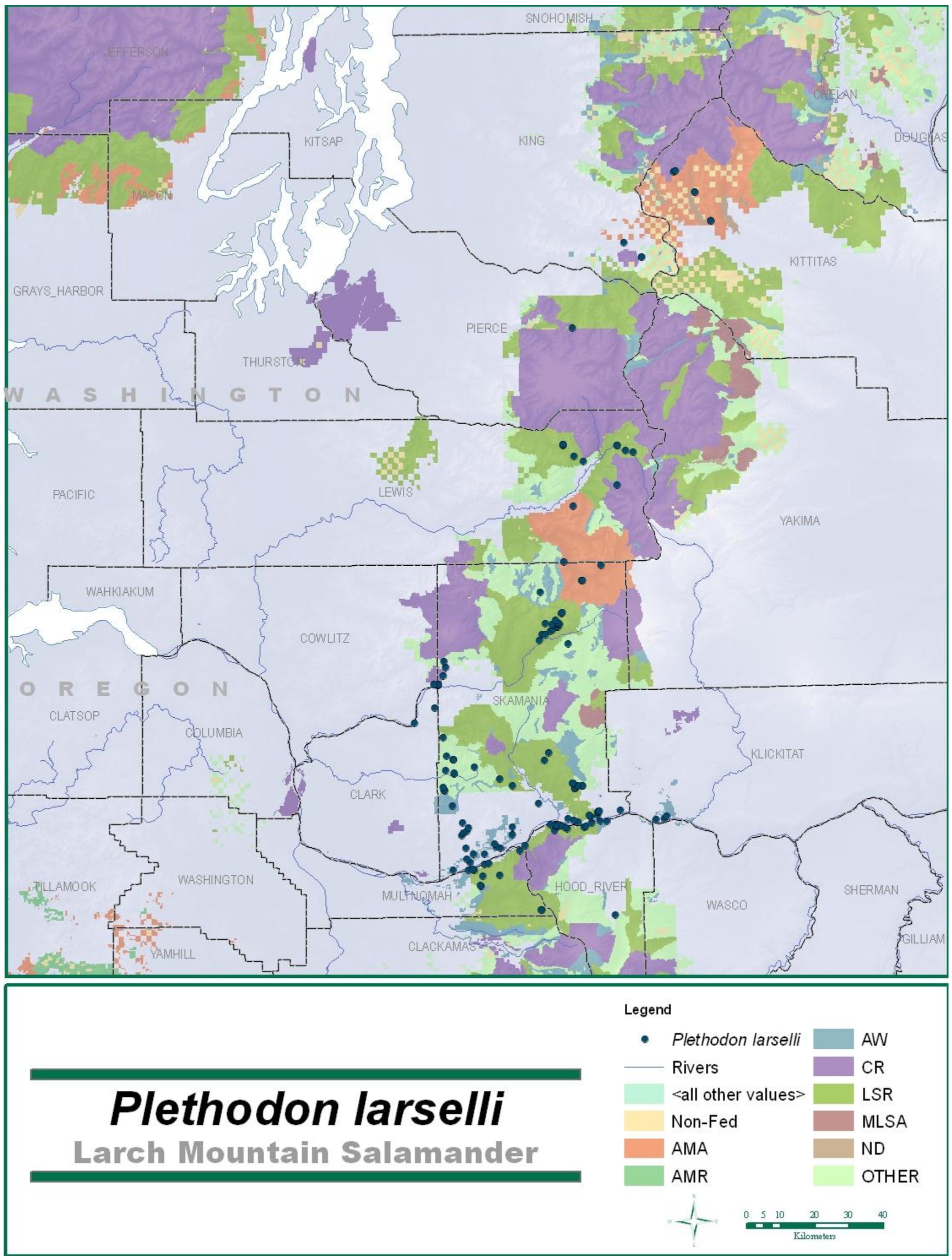
The Larch Mountain salamander occurs in an area of 11,740 km^2 (4,550 mi^2) in the Cascade Range of Washington and Oregon (Figure 1, Crisafulli 1999, Nauman and Olson 1999). It has been found from 50-1280 m (~160-4200 ft) in elevation. While from 1954-1985, sites were known only in or adjacent to a 50 km-long (31 mi) stretch of the Columbia River Gorge (e.g., Nussbaum et al. 1983), today it is found to 193 km (about 120 mi) north of the Columbia River in Clark, Cowlitz, Skamania, Lewis, King, Pierce, Klickitat, and Kittitas Counties, Washington, and to about 22 km (~ 14 mi) south of the Columbia River in Multnomah and Hood River Counties, Oregon. The current knowledge of the species range is likely incomplete and additional range extensions may include areas to the north, south and east.

Currently, there are 103 sites known on federal lands, with most occurring on the Gifford Pinchot National Forest and Columbia River Gorge National Scenic Area, and fewer on the Mount Baker-Snoqualmie, Wenatchee and Mount Hood National Forests. Most (~70%) federal sites occur on reserved lands, including Late Successional Reserves, Congressional Reserves, and Administratively Withdrawn land use allocations (Figure 1). Currently, a habitat map has not been developed, and so an estimate of how much habitat is in the different land ownerships or allocations cannot be made.

The accrual of site information has increased steadily over the years. Nauman and Olson (1999) reported 18 total sites were known before 1980, 54 were recorded between 1980 and 1993, and 27 were found between 1993 and 1999. Of these 99 total sites known in 1999, 41 were on nonfederal lands and 58 were on federal lands. In 2004, 88 total federal sites were known (an addition of 30 federal sites) and in 2007 an additional 15 federal sites and 1 nonfederal site were entered into Agency databases (USDA and USDI 2007). These numbers tally to 103 federal and 42 non-federal sites: 145 total sites.

Across its range, the Larch Mountain salamander is patchily distributed. Surveys were conducted from 1996-2002 for the Larch Mountain Salamander under the auspices of the Northwest Forest Plan Survey and Manage Standards and Guidelines at 825 forested sites and salamanders were detected at only 55 (6.7%). These data may support the species' patchy distribution, unless the "forested site" definition for survey areas was too broad and included unsuitable habitats. Herrington and Larsen (1985) reported that in the Columbia River Gorge the species occurred discontinuously. Crisafulli (unpubl. data 1993-1995) conducted surveys for *P. larselli* in young, mature and old-growth forest stands (n= 41) in the Lewis River watershed of Washington State and found salamanders to occur at 7 of 41 sites (17%) but were abundant at only 2 of 7 locations where they were present; with a small number of individuals captured elsewhere. Few individuals also were found at all other sites in the Washington Cascade Range (Aubry et al. 1987, Washington Department of Fish and Wildlife 1993; Darda and Garvey-Darda 1995). However, Crisafulli (unpubl. data 1996-2006) has found Larch Mountain salamanders to be patchily distributed but locally abundant in a number of sites in the Columbia River Gorge and Washington Cascade Range.

Figure 1. Locations of Larch Mountain salamanders in Oregon and Washington (as of April 2007). Land-use allocations are indicated: non-federal lands (Non-Fed), inclusive of the light blue background color; adaptive management areas (AMA); adaptive management reserves (AMR); administratively withdrawn (AW); congressionally reserved (CR); late-successional reserve (LSR); managed late successional reserve (MLSA); federal lands that are not designated under the Northwest Forest Plan (ND); and matrix, riparian reserve and other unmapped allocations (Other). <all other values> includes only a few federal lands that are not designated as one of the above types.



Trippe et al. (2001) studied the spatial distribution, relative abundance, and habitat associations of the Larch Mountain salamander within two ~ 50 ha (~124 ac) sites in the Washington Cascade Range from 1998-2000. At Site 1, a total of 1150 and 1731 amphibians were captured during 1998 and 1999 surveys, respectively. Larch Mountain salamanders were the second most-abundant species representing 10% (115 and 173 animals, by year) of captures. At Site 2, surveys in 1999 and 2000 yielded 194 and 186 total amphibian captures, with Larch Mountain salamanders contributing 72% (143) and 75% (146) of all captures. Although there were substantial differences in total amphibian captures between sites both years, and between years at Site 1, the relative constancy in the total percent of captures that the Larch Mountain salamander contributed over the two years at each site is intriguing. However, with only two years of data from each site it is not possible to draw any conclusions regarding population trends. Clearly, more work is needed in this topic area.

The Larch Mountain salamander was a target species for the Cascades Resource Area (CRA), Salem BLM, 2006 Purposive Surveys. The Purposive Surveys targeted high quality habitat just south of the Columbia River Gorge. Prior to the purposive surveys, BLM project clearance surveys had never been conducted in habitat that included the primary habitat features. No suspected or confirmed specimens have been found on CRA lands.

Population Trends

Nothing is known about population trends in this species.

Habitat

Larch Mountain salamanders occupy a wide array of habitat types. These include: old-growth forests; younger naturally regenerated forests in gravelly/cobble soils with residual late successional features (snags and large down logs); scree and talus (forested and un-forested); and lava tube entrances where debris (e.g., pieces of lava, wood, fine organic and inorganic particles) has accumulated. At a coarse level of characterization, these specific habitats can be simplified into two general categories: 1) habitats with pumice-derived loamy soils; and 2) habitats with rocky substrates. The distinction between these two general habitat types may provide a useful and biologically meaningful way to view the species' habitat associations. Crisafulli (unpubl. data) suggests that substrate/soil type and vegetation are important factors in determining the suitability of a site for *P. larselli* occupancy. The relative importance of vegetation composition and structure appears to be related to the substrate/soil conditions present at a site. When rocky substrates (scree, talus or gravelly soils) are prevalent, the role of vegetation composition and structure appears to be less important; and animals are found where several vegetation types occur. In contrast, when loamy soils are present, Larch Mountain salamanders appear to be restricted to sites only with old-growth forest conditions, or confined to small isolated pockets of refugia possessing rocky substrates within the matrix of old-growth forest with loamy soils.

Loamy Soils Habitats: These habitats are primarily found in the southern Washington Cascade Range. Loamy soils were derived from weathered pumice that was deposited episodically over several millennia from the Mount St. Helens volcano. After surveying for the Larch Mountain salamander at 41 naturally regenerated forested sites during 1993, 1994, 1998 and 1999 in the Upper Lewis River drainage (Gifford Pinchot National Forest), Crisafulli (unpublished data) has identified several site characteristics and habitat features that were associated with Larch Mountain salamander occurrence. As a cautionary note, however, these data should be viewed in the context of a case study and the information should not be extrapolated to other locations in the species range. The site and habitat attributes are based on empirical data from 7 sites and 310 animal captures. The specific attributes include: forest stand age; species composition and stand structure; cover objects; elevation; percent slope; disturbance history; and soils. All sites were in the tephra (volcanic ejecta) fall-out zone created by numerous eruptions from Mount St. Helens during the past 4,000 yrs.

Stand age appears to be an important factor in determining potential habitat. Surveys were conducted in young (70-90 yrs), and late successional and old-growth stands (200 to >600 yrs). All Larch Mountain salamander captures (n=310) were in old-growth stands, suggesting that young stands may not provide the necessary requirements for this species. Alternatively, the lack of *P. larselli* in the younger stands may be attributed to the salamander's assumed sedentary nature, and following local extirpation, the species has yet to recolonize due to limited dispersal capabilities. In this sense, either lack of suitable habitat or low dispersal capabilities may preclude the species from an area following disturbance.

However, historical factors, unrelated to stand age, and also chance events may also have played a role in the species being absent from young stands. In forests growing on pumice-derived, loamy soils it appears that this species is neither resistant nor resilient to disturbance, it has neither persisted in nor colonized young stands. If true, then both natural (wildfire, volcanism) and anthropogenic (clear-cut logging) forms of disturbance are likely to be important forces shaping the distribution and abundance of this species in portions of the Cascade Range that have received numerous tephra-fall deposits. Salamanders were found to be patchily distributed, and in some cases, locally abundant in multi-layered, structurally complex old-growth forests of the Western Hemlock Zone (vegetation described in Franklin and Dyrness 1988, Topik et al. 1986). Overstory canopy coverage was generally >75%, and the amount of direct sunlight reaching 2 m (6.5 ft) above the forest floor was usually <15%. Stand understories were sparse and composed of few herbaceous and woody species. Cascade Oregon grape (*Berberis nervosa*), prince's-pine (*Chimaphila umbellata*), bunchberry dogwood (*Cornus canadensis*), red huckleberry (*Vaccinium parviflora*) and vine maple (*Acer circinatum*) were the understory species most commonly associated with salamander microhabitats. In numerous cases salamanders were found where there were a few very large Douglas-fir (*Psuedostuga menziesii*) trees and snags present in the stand (typically residuals from the previous large-scale disturbance). These large Douglas-fir snags provided an important component of the habitat for Larch Mountain salamanders. As the snags age, the bark loosens from the bole and exfoliates. The exfoliated bark was used extensively as cover objects by salamanders during the spring and autumn when surface conditions were wet.

Larch Mountain salamanders were found at elevations ranging from 600 to 1100 m (1968-3608 ft); however, most individuals were found between 800 and 1000 m (2600-3280 ft). There was a strong association between the number of animals found and percent slope of site, with 90% of all animals found on slopes >40%. Analysis of the aspect (slope exposure) data revealed no particular preference; animals were found on slopes of all cardinal directions. Litter depth ranged from 20-120 mm (~0.8 to 5 inches) and was composed of a dense layer of conifer needles in varying degrees of decay. Soils were deep (>60 cm [>23 inches]), well drained, and consisted of a series of pumice layers of varying thickness and particle size (i.e., coarse sand to 3 cm [~1 inch] pebble), that were located among layers of finely decomposed organic material/soil. The old-growth site reported in Aubry et al. (1987) and other recently discovered sites on the Cowlitz River and Wind River Ranger Districts of the Gifford Pinchot National Forest are similar to those of Crisafulli (unpublished data) described above.

Rocky Substrate Habitats: Larch Mountain salamanders occupy sites that possess a variety of rocky substrate types (e.g., Herrington 1988). Examples include; caves (basalt tubes), scree, talus and, cobble and gravel soils**.** Some rocky substrate habitats (e.g., scree) are readily identifiable, whereas others, such as certain talus or gravelly soil habitats, can be difficult to discern. This is particularly true where the rocky substrates are present with high quantities of soil or litter and support a forest with high canopy coverage or a nearly continuous mat of bryophytes. While rocky substrates appear to occur at the majority of *P. larselli* sites, the occurrence of salamanders in association with the previously discussed habitat condition, loamy soil sites in forests, is not well understood at present.

In the Columbia River Gorge, the Larch Mountain salamander has been referred to as a habitat specialist, and characterized as a talus obligate (Herrington and Larsen 1985, Kirk 1983, Nussbaum et al. 1983). Herrington and Larsen (1985) have found Larch Mountain salamanders in the Columbia River Gorge to be tightly associated with steep (>40%) forested talus areas with sparse understories. Salamanders were associated with habitats within talus that consisted of relatively small (1-6 cm [0.4-2.4 inches] in length) rocks, and during laboratory trials, they preferentially selected similarly sized substrates. At these talus sites, only a portion of the total talus area contained habitat of this size-class rock and several talus areas appeared to have suitable habitat, but lacked *P. larselli*. The talus interstices often contained large quantities of organic detritus and small quantities of soil.

In the eastern Washington Cascade Range, *P. larselli* has been found in talus that can be described as a discrete or unique habitat type on the landscape. This habitat type may be an important refuge for rock-associated species. For example, in one talus slope occupied by *P. larselli*, the snail *Cryptomastix devia* (Puget Oregonian, species of concern) also was found (P. Garvey-Darda, pers. commun., Okanogan-Wenatchee national Forest).

Vegetation composition and structure at rocky substrate habitat types is highly variable, and includes old-growth coniferous forests on one extreme and non-vascular (bryophytes and lichen) plant communities on the other. Open forest and shrub dominated vegetation types are intermediate between these extremes. The potential natural vegetation at any particular site is to a large degree dictated by the regolith and soil conditions present. Consequently, soil and substrate characteristics are important factors governing plant community development.

Caves: Senger and Crawford (1984) found *P. larselli* in 2 of 23 caves inventoried south of Mount St. Helens. At both sites, only a few individuals were observed. A return trip to one of these caves during 1986 resulted in the collection of a single individual (Aubry et al. 1987). Crisafulli (unpublish. data) conducted surveys in a subset of these caves during 1996 and found *P. larselli* in the two sites originally discovered by Senger and Crawford and located one additional cave site. The caves are located in a 1950-year-old basalt flow, which is an unusual feature of the landscape, and the use of the caves by *P. larselli* may be anomalous. The basalt caves are rare landscape features with distinct attributes that make them easily identifiable and readily delineated. At these caves with *P. larselli,* salamanders were found within ~10 m of cave entrances where gravel, cobble and organic matter occurred. These cave entrances ranged from an opening < 1m wide to ~4 x 6 m. Salamanders also were found in cave "portholes" that were essentially small <1 m twilight shafts, where loose rock material and litter could be found (C. Crisafulli, pers. observ.).

Forest Associations: As noted above, Larch Mountain salamander locations are consistently found in forested environments (exceptions being the basalt tubes and non-forested habitats containing rocky substrates described under the habitat section; please note that many salamander sites with rocky substrates occur within forest). While the species composition and forest structure of the overstory vary among known *P. larselli* sites, many areas of occupancy have >75% canopy coverage (Herrington and Larsen 1985, C. Crisafulli, unpublished data). The overstory shields the forest floor and rocky substrates from direct insolation and desiccating winds and thus ameliorates the climatic conditions. High canopy coverage, in this sense, provides and maintains more favorable microclimatic conditions in the specific microhabitats used by individual Larch Mountain salamanders. In addition to old-growth forests, Larch Mountain salamanders have been found in 70-90 year old unmanaged Douglas fir stands that established after stand replacement fires (Crisafulli, unpublished). In these cases, sites contained rocky substrates comprised of gravelly soil or cobble soil and had residual late successional habitat features (e.g., snags, downed wood). Trippe et al. (2001) found Larch Mountain salamanders to be primarily associated with the transition zone between non-vegetated scree and closed forest habitats at their rocky substrate site. Vegetation was characterized as open Douglas-fir forest and shrub-dominated communities. At their second study site, Larch Mountain salamanders were found far more often (288 versus 1 animal) in late-seral forest as compared to adjacent young plantations.

Other Factors: Larch Mountain salamander distribution and habitat-use patterns may reflect differences in available microhabitat/microclimate conditions. Across its known range, there is a strong moisture gradient, where both the total annual precipitation and the form in which the precipitation arrives vary widely. Sites in the Cascade Range receive as much as 300 cm (118 in) of precipitation annually, mostly in the form of snow, which can accumulate to 3-4 m (~ 10-13 ft) and persist from November through June. In the Columbia River Gorge, the total annual precipitation can be as low as 55 cm (~ 22 in) annually and be primarily in the form of rain. Given the degree of difference in macro/microhabitat features and abiotic conditions among sites that Larch Mountain salamanders occupy, it is likely that key aspects of their biology (e.g., reproduction and growth) and ecology (e.g., diel and seasonal activity, foraging, predation, population structure) differ as well.

There is a study underway (Crisafulli and others) to model the spatial distribution of Larch Mountain salamander habitat throughout the species entire range using biophysical data in a geographic information system. Models are being constructed based on salamander presence/absence data collected using a standard protocol (Crisafulli 1999), and include habitat data from 94 Larch Mountain salamander detection sites and 500 sites where salamanders were not detected. It is hopeful that results from this study will better define potential habitat and aid natural resource managers in decisions regarding the need to conduct surveys.

Ecological Considerations

Plethodontid salamanders are thought to have important roles in forest ecosystems, including being a significant trophic link between small ground-dwelling invertebrates and larger vertebrate predators and comprising a considerable portion of the forest vertebrate biomass in some areas (e.g., Burton and Likens 1975a, 1975b). Their general ecology and life history traits suggest they are ideal indicators of forest ecosystem integrity (Welsh and Droege 2001). The specific role of *P. larselli* in local communities or ecosystem processes has not been studied.

Although little is known of the prey consumed by the Larch Mountain salamander, Altig and Brodie (1971) conducted a dietary analysis on 23 animals captured in Oregon in October 1967. They found mites (Acarina) and Collembola to comprise 83% of the animals' diets. Additional food items included the following insect orders (%): Hemiptera (5.4), Coleoptera (2.6), Hymenoptera (2.0) and Diptera (1.3). Non-insect arthropods (e.g., spiders among others) made up an additional 5.4% of the diets.

Larch Mountain salamanders exhibit coiling behavior, and sometimes a fast coiling and uncoiling (flipping), upon disturbance. These may be an antipredator behavior. Coiling may mimic distasteful centipedes and flipping may take the individual away from a disturbance, making it difficult to find when it comes to a stop (Nussbaum et al. 1983). Predators are unknown for this species.

IV. CONSERVATION

Threats

Habitat loss, degradation, and disturbance are the primary threats to the persistence of Larch Mountain salamander populations. Important habitat features used by this species vary by macrohabitat type, and include forest structures (e.g., living and dead), rocky substrates, soils, and microsites that provide cool, moist conditions. Disturbance of macrohabitats and surface microhabitats is of primary concern. Alteration of the microhabitat and microclimatic conditions within these areas may negatively impact these salamanders. Microclimate regimes may be altered by vegetation management activities within and adjacent to occupied habitat areas. While little definitive information is known about key factors contributing to the species long-term persistence, it is perceived that some level of connectivity among neighboring populations and sub-populations is likely important.

There are numerous potential and observed threats to this salamander, yet no definitive studies have been published to document losses from specific anthropogenic disturbances. Dominant disturbances which pose threats to this species include: 1) timber harvesting (including subsequent site scarification and fuels treatment); 2) construction of roads, trails, homes, and railways; 3) mining of rock; 4) fire (both natural and human caused); 5) recreation; 6) vulcanism; and 7) chemical applications. In areas where this salamander is associated with isolated talus slopes, such as the eastern Cascade Range, impacts to those discrete patches are a concern. While fire and volcanism may have been part of the natural disturbance processes with which these animals have occurred historically, those disturbances now may pose a more severe threat due to the species' restricted and fragmented distribution, and in the face of multiple additional stressors that in combination provide heightened concern. These disturbances and their potential impacts to Larch Mountain salamanders are described in more detail below. Incidental mortality from several sources of human activity in an area may pose significant cumulative impacts to these animals.

Timber Harvest

Although there has never been a controlled experiment conducted that specifically addresses the impact that logging may have on Larch Mountain salamanders, at least three retrospective studies (including Trippe et al. 2001, above) compared forest and adjacent clear-cut sites for salamander presence and relative abundance. Herrington and Larsen (1985) reported on survey efforts conducted over three years at a mature forest site and an adjacent clear-cut site (10 yrs since harvest). No *P. larselli* were observed at the clear-cut site, but the species was found on the forested site, and the number of animals observed was stable over the sampling period. Crisafulli (unpublished data) had similar findings from an old-growth forest and two adjacent clear-cut sites that were surveyed over a two-year period in the Southern Washington Cascade Range. The forest site consistently yielded animals, whereas there were never any animals observed at the harvested sites. Direct evidence that *P. larselli* occupied any of the harvested sites prior to tree removal is lacking, but the virtually identical site characteristics, as compared to their forested counterparts, suggest that they were likely there. Clearly, there is a need to better understand the impacts various levels of timber harvesting and site preparation (scarification, fuels treatment) have on *P. larselli* populations, but this can only be done if careful monitoring of populations occurs before and after a site is disturbed.

Many studies have reported effects to other plethodontid salamanders from timber harvest, in particular regeneration or clearcut harvest practices (Ash 1997, Dupuis et al. 1995, deMaynadier and Hunter 1995, Herbeck and Larsen 1999, Grialou et al. 2000). A review of 18 studies that looked at salamander abundance after timber harvest (deMaynadier and Hunter 1995), found median abundance of amphibians was 3.5 times greater on controls over clearcuts. Petranka et al. (1993) found that *Plethodon* abundance and richness in mature forest were five times higher than those in recent clear cuts and they estimated that it would take as much as 50-70 years for clearcut populations to return to pre-clearcut levels. A comparison of recent (<5 years) clearcuts and mature (120 years) forests also suggested salamanders are eliminated or reduced to very low numbers when mature forests are clearcut (Petranka et al. 1994). In contrast, Messere and Ducey (1997) found no significant differences in abundance of red-backed salamanders in forest canopy gaps in stands that had been selectively logged, indicating that limited logging may have little effect on that species. Studies in the Pacific Northwest documented greater salamander abundance in old-growth compared to clearcuts or early seral forest (e.g., Bury and Corn 1988; Raphael 1988; Welsh and Lind 1988, 1991; Welsh 1990; Corn and Bury 1991; Dupuis et al. 1995; Ollivier et al. 2001). As with other salamanders, the impact of timber harvest on a given population will depend on the effect the impact has on the microclimate and microhabitat structure (Welsh 1990). This is expected to vary on a site-by-site basis, and with the timber management practices implemented.

Several disturbances can result from timber harvest practices. Removal of overstory may cause desiccation of rocky substrates and loss of the moss ground cover. Tree-felling and ground-based logging systems disturb the substrate resulting in destabilization of talus and substrate compaction, which reduces substrate interstices used by salamanders as refuges and for their movements. Site preparation practices such as broadcast burning removes the moss covering and consumes litter that helps to stabilize soil and talus. Much of the landscape within the range of the Larch Mountain salamander has been fragmented by past timber harvest practices and is a patchwork of stands of different seral stages, from early seral to mature forests. Sites with *P. larselli* are nested within this patchy forested regime. There are no real estimates of how much potential suitable habitat has been impacted by timber harvest activities.

Management of downslope or upslope forest may alter geomorphic and hydrologic patterns. For Larch Mountain salamanders, surface and subsurface moisture regimes may affect survival and provide cues for foraging and reproduction. Alteration of hydrologic regimes may affect activity patterns and long-term persistence of populations. The legacy of past impacts and the hazards of proposed management warrant consideration with respect to site hydrology. Likewise, geomorphic concerns from surface instability (erosion, slumping) resulting from forest management activities may disturb known sites, and warrant evaluation.

It is believed that activities in young managed stands growing on loamy soils will not pose significant threats to Larch Mountain salamanders. Typically, such areas have been clear-cut harvested, burned and possibly scarified prior to planting. The existing stand structure is typically uniform, even aged, and lacks habitat features important for the salamander. Given the extent of past activity such sites are not expected to support Larch Mountain salamanders. However, it is possible that if these areas are left alone they could potentially develop suitable habitat conditions for Larch Mountain salamanders, a process that could take several decades or longer. Colonization of suitable habitat that eventually developed in managed stands would be most likely to occur if adjacent areas contained cliff, talus or scree habitat that supported Larch Mountain salamanders. Presumably, salamanders in these rocky habitats would serve as a source population for colonization of adjacent managed stands when habitat conditions became suitable. This is conjecture, at present, however, as we have no examples of documented colonization of sites after a disturbance.

Several timber harvest activities likely pose no risk or limited risks to these salamanders. For example, hazard tree removal may have minimal disturbance to substrates, and could be done with seasonal restrictions to avoid times when salamanders are surface-active. A very localized activity may affect a few individuals but may not affect a population. Precommercial thinning or brush control, without the use of chemicals and avoiding the turnover or severe compaction of substrates, likely could be conducted in managed young stands with rocky substrates without adverse effects on these salamanders.

With many of the species' federal sites (~70%) occurring on reserved land use allocations, the threat of timber harvest activities may be largely mitigated on federal lands. However, as these activities occur on non-federal lands within the species' range, the relative value of salamander habitats on federal lands is likely increased.

Roads, Homes, Railways and Trails

The Columbia River Gorge populations of Larch Mountain salamander have been subjected to numerous habitat alterations brought on by the construction of major highways (SR 14 and I-84) and railways that bisect habitat on both sides of the Columbia River (Oregon and Washington). Furthermore, secondary roads, such as those constructed for extracting timber or for accessing homes, also are prevalent in the species range. Herrington and Larsen (1985) observed that road construction occurring in or adjacent to talus often results in extreme erosion and large changes in soil properties of the slope and a concurrent shift of the entire talus towards its base. Joint geomorphic-hydrologic changes can be dramatic from both upslope and downslope substrate disturbances. Sites altered in these ways are thought to become uninhabitable by the Larch Mountain salamander and may remain unsuitable habitat for the long-term. The development of land as home and commercial sites continues to result in the conversion of natural lands to developed areas and contribute to the fragmentation of Larch Mountain salamander habitat.

Trail construction, like roads, bisecting scree and/or steep forested sites often requires that substrate removal or blasting be done to create a tread. Blasting and excavation within known Larch Mountain salamander locations may result in direct mortality as well as indirect causes of death brought on by altered habitat conditions.

In summary, new road, campsite, railway and home development are primary threats to occupied habitats. Expansion of existing developed areas into occupied sites is similarly expected to have impacts to the species. Major reconstruction that could degrade existing habitat conditions, such as excavation, also may affect these salamanders. It is unknown to what extent these activities might occur on federal lands, but the relative value of salamander habitats on federal lands is likely increased as these types of activities occur on adjacent non-federal lands.

Mining

The removal of scree or talus for road construction may be a major impact to *P. larselli* in the Columbia River Gorge. Talus provides the raw material typically removed and crushed to specified size and used for road construction in the near vicinity. This form of local mining decreases the cost of hauling rock material from distant sources, but results in a high percentage of talus sites being altered. Herrington (1988) conducted herpetofauna surveys at 183 talus sites, of which 93 (51%) had noticeable quantities of rock removed. Another 13 sites had been deforested, leaving 42% of the sample (183 sites) as unaltered habitat. While Herrington did not report *P. larselli* distribution or abundance relative to these affected sites, he reported that the unaltered habitat (42% of the sample) yielded 73% of the total number of individuals captured, summed across 31 herpetological species detected. Of 1,017 animals captured in the study in talus, the majority (n=383, 38%) were *P. larselli*. Salamanders of the genus *Plethodon* (6 species), which have similar habitat needs, totaled 792 (78% of the sample) captures. Hence, it was implicated that the pattern of fewer animals found in the altered talus habitats reflected an adverse effect on the species abundance through the removal of suitable habitat. Alternatively, a reduced sample of animals could result from a reduced detectability of the animals in the altered habitat, which may occur if the animals are more difficult to find during surveys, for example if their surface behavior had changed and they were deeper in the substrate during sampling times. The impact that rock removal has on salamander habitat is the same as described above under road and trail construction (above). The prevalence of mining activities on federal lands within the species' range has not been determined, but is expected to be considerably lower than on non-federal lands.

Fire

Within the range of the Larch Mountain salamander, wildfire is a dominant agent of natural disturbance. Cascade Range populations on both the east and west sides have for millennia experienced low frequency, high intensity fires. These fires likely have helped shape the distributional pattern of *P. larselli* that we currently observe. High intensity fires, fueled by dry east winds during late summer and early autumn have historically consumed vast forested tracts. Stand replacement fires can result in burnt-over habitats having increased insolation and wind, and thus tending to be warmer and drier than forested sites. Hot fires also tend to consume cover objects (woody debris) and litter on the forest floor. Collectively, these sorts of change may not bode well for terrestrial salamanders; however, there are no data that directly evaluate the impacts of fire on Larch Mountain salamanders. Crisafulli (unpublished data) has found the Larch Mountain salamander at several locations in the Yacolt burn in the southern Washington Cascade Range that experienced stand replacement fires approximately 90 years prior to the surveys. This suggests that Larch Mountain salamanders were either resistant to these fires or have colonized since the disturbances. All sites that supported animals in the Yacolt burn had complex rocky substrates, which probably facilitated survival.

Impacts to Larch Mountain salamanders from either natural or prescribed fire are unstudied, however, given that fire suppression in recent years may have resulted in an increased risk of large stand replacement fire in the region, large fires that remove overstory from suitable habitat may be of highest concern for this species. Although the Larch Mountain salamander has persisted in a fire disturbance landscape, there is concern that the intensity of the local fire regime has changed and when burned may have adverse effects on the species. The relatively recent historical fire regime in particular on the east side, was one of high frequency and low or mixed intensity fire, which consisted of very frequent underburning of the forest in the summer and early fall and few stand replacement events, at least at the lower elevations. At higher elevations, a longer fire return interval and higher intensity fires occurred historically and likely resulted in more stand replacement events. The effects of a more intense level of fire disturbance due to fire suppression and fuel loading is of concern in that stand replacement fire represents a higher potential for disturbance to flora and fauna. In particular, relative to salamander habitat, it removes overstory canopy that serves to moderate surface microclimates from extremes (e.g., high temperatures and low moisture).

Recreation

Caving activities present a potential threat to Larch Mountain salamanders. Salamanders occupy some cave entrances and patchy habitats within the cave systems where breakdown and organic material has accumulated beneath skylights. While a comprehensive survey of caves within the species' potential range has not occurred, Crisafulli (unpublished data) conducted surveys of selected caves during 1995 and found several individuals, all of which were under coarse pebble to small boulder size substrates. These substrates tend to shift when traveled-over on foot and spelunkers entering the caves walk on them. Foot travel over rock rubble, which the animals use for cover, is a potential threat to the cave populations. Construction and use of recreational facilities such as campgrounds, signing and kiosks pose potential threats to Larch Mountain salamanders through habitat alteration although not a primary threat.

Vulcanism

The entire range of the Larch Mountain salamander is highly volcanic, as evidenced by the basalt flows in the Columbia River Gorge that originated from ancient shield volcanoes to the east and the more recent stratovolcanoes that punctuate the Cascade Range (Mount Hood, Mount Adams, Mount St. Helens and Mount Rainier). With the exception of Mount Adams, all of the stratovolcanoes have experienced eruptive episodes during the past 200 years. These volcanoes have had violent explosive eruptions, as Mount St. Helens reminded us during its famous 1980 eruption. Eruptions have blanketed vast areas (100's km^2) with thick (>20 cm, about 8 in) tephra. In the aftermath, the ground conditions can be extreme for decades because of removal of forest canopy, duff and litter, highly porous substrate, and increased insolation and wind, resulting in high summer surface temperature, movement of abundant fine and desiccating ash, and dry conditions. Eventually plant colonization and subsequent successional processes ameliorate the harsh environmental conditions. Plethodontid salamanders would either perish from the direct thermal and abrasive eruptive forces or succumb at a later time to the extreme and intolerable post-eruptive conditions. Crisafulli et al. (2005) and Crisafulli and Hawkins (1998) studied the biological responses of a number of vertebrate groups following the 1980 eruption of Mount St. Helens and observed only one species of Plethodontid salamander (*P. vandykei*) in severely impacted areas. This species is much more aquatic than its two congeners (*P. larselli* and *P. vehiculum*) or its close relative Ensatina, and survived the eruption in numerous thermally buffered seeps and splash zones. While pre-eruption amphibian distribution data are incomplete for the areas impacted by the 1980 eruption, it is reasonable to assume that *P. larselli* was present within the 600 km^2 (372 mi^2) blast area and was likely extirpated as a result of the eruption. Larch Mountain salamanders survived in areas outside of the blast area where cool, aerial ejected pumice was deposited to a depth of 6 cm (Crisafulli, unpubl. data).

Chemical Applications

Herbicides, pesticides, fertilizers, fire retardants, and oil and lignin road applications probably impact these animals, by absorption through their permeable skin or through the food web. It is not known to what extent chemicals have affected Larch Mountain salamanders in the past, but they may be considered a potential threat. It is likely that these activities would more commonly occur on non-reserved lands, however the spatial extent of this potential set of threats is not determined at this time and may be higher closer to roads, such as along the Columbia River Gorge.

Disease

Current research on global amphibian declines is focusing on the effects of disease agents. While disease has not been implicated for this salamander, the amphibian chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) has recently been detected in a plethodontid salamander (Cummer et al. 2005). This disease is thought to be the cause of local extirpations of montane frogs in the Washington Cascade Range and the California Sierra Nevada Range. This appears to be a fungus that is associated with cool habitats, and hence may be a threat to animals in the Cascade Range.

Disease warrants mention here to alert biologists to be aware of and report observations of ill or dead animals. Individuals or tissues collected can be analyzed at regional or national laboratories. *Bd* may be spread from field gear such as boots or nets, wildlife, translocated animals including fishes, or movement of water (e.g., during fires).

Global Climate Change

Larch Mountain salamanders occur in habitats that may be affected by predicted patterns of global climate change. However, it is uncertain if this poses a threat to the species, and if so, the extent of the threat is similarly uncertain. For example, a change in storm patterns that alters precipitation, either annual accumulation or seasonal pattern, could affect this species. Warming trends could increase the elevational extent of the species range and increase occupancy of north-facing slopes, and also restrict its distribution at lower elevations or south-southwest aspects. Hence, while existing habitats may become less suitable, it is possible that additional "new" habitats might become available for this species. However, more extremes in conditions might forestall the ability of these animals to use habitats that on average appear suitable. Warming trends also could alter fire regimes and vegetation conditions, further restricting habitats. Indirect effects from changes of prey or predator communities are likely, but are difficult to predict. Interactions of warming trends with reduced cover from timber harvest are possible. Amelioration of climate changes may be possible by retaining canopy cover and large down wood, which moderate temperature extremes in their forested habitats.

Fragmentation of Populations

Additional disturbances to habitats, including all of the potential threat factors cited above, can increase the isolation of Larch Mountain salamander populations. Whereas not all of the above threats may be effectively managed on public lands, synergisms of multiple threats may be able to be addressed over the range of the species to reduce overall impacts of interacting stressors relative to connectivity of populations. Managing for contiguity of suitable habitat conditions at larger spatial scales can reduce fragmentation.

Conservation Status

This species is of concern due to its limited distribution to the Cascade Range of Washington and northern Oregon, low numbers, fragmented habitat, timber harvest and private land management activities. With only about 150 total sites that are now compiled, the Larch Mountain salamander is still considered a rare, endemic species that warrants management emphasis. In addition, both north and south of the Columbia River many sites appear to be isolated, and large numbers of individuals are not often detected at sites. While its cryptic nature and use of subsurface habitats likely reduce its detectability and cloud our understanding of abundance patterns, this animal does not always seem to occur in high numbers within suitable habitat and optimal habitat may be patchy across the landscape. Given that this species has relatively few known sites, low reproductive rate, vagility, and genetic diversity, and is a habitat specialist, there are concerns as to the potential effects on populations from anthropogenic events. However, about 70% of currently known federal sites occur on reserved land use allocations. This suggests that the species' conservation status could be more secure because those sites would be subjected to fewer anthropogenic threats such as timber harvest, development, mining, and chemical applications.

Known Management Approaches

As noted above, with ~70% of federal sites occurring on reserved land use allocations, this species may be relatively well-protected from many types of anthropogenic disturbances. The legacy of past disturbances, patchy nature of suitable habitat, and likely low resiliency or colonization capacity of populations after disturbances may result in a pattern of isolated populations or population-clusters north and south of the Columbia River. These populations may warrant species-management for their persistence. The role of other reserved lands such as owl cores and riparian set-asides is unstudied relative to this species. Whether these smaller areas can contribute significantly to the retention of subpopulations is a critical issue, because persistence of individuals in fragmented areas of matrix or adaptive management areas may not serve the long term conservation goal of this relatively non-vagile organism.

The Columbia River Gorge National Scenic Area Management Plan specifically protects talus (and cliffs) on all ownerships (federal and nonfederal land) to protect *P. larselli*, and associated species. Any land use application within the National Scenic Area (outside of designated urban areas) that has potential to disturb this habitat is reviewed by state or Forest Service biologists and these priority habitats are protected and/or mitigated. These habitat types should persist without further loss under this Management Plan for the Columbia River Gorge subpopulation.

Management Considerations

The conservation goal for Larch Mountain salamanders is to contribute to a reasonable likelihood of long-term persistence within the range of the species, including the maintenance of well-distributed populations, and to avoid a trend toward federal listing under the Endangered Species Act.

General Objectives

- Assess and prioritize areas of the species occurrence and geographic range on federal lands relative to species management needs.

- As projects are proposed on federal lands, identify occupied sites to be managed for species persistence (FS) or to not contribute to the need to list under the ESA (BLM and FS) in accordance with Agency policy.

- At sites that are managed for the species, maintain the integrity of microhabitat and microclimate conditions.

Although recommendations can be developed for the entire range of the species, the variety of site conditions, historical and ongoing site-specific impacts, and population-specific issues warrant consideration of each site with regard to the extent of both habitat protection and possible restoration measures. Methods to identify occupied sites for management to meet agency specific policy goals may involve surveys in areas of high conservation concern or locations with limited knowledge of species distribution or abundance patterns. General threats known for historically occupied watersheds are listed above, and should be considered during development of site-level and basin-level management approaches.

Specifc Considerations

To assess and prioritize areas of the species range on federal lands relative to species' management:

- Consider conducting surveys to determine if the species is present. See the Inventory section below for potential protocols to use.
- Delineate discrete population segments to manage for well-distributed populations.
  - Consider where a site is located.
    - Sites in certain parts of the species range may take on more relevance or require additional discussion when considering where to manage Larch Mountain salamander sites.
  - Consider genetic populations.
    - In their study of genetic variation in the Larch Mountain salamander, Wagner et al. (2004) found significant variation among all assayed

populations, and the greatest level of genetic differentiation measured was between Oregon and Washington populations. This led the authors to suggest that the southern and northern populations be managed as distinct population segments or designated as conservation units. Maintenance of well-distributed sites both north and south of the Columbia River Gorge may be considered an overarching priority. In particular, provide special management emphasis to the southeastern-most populations in Oregon because of their genetic uniqueness and paucity of known sites. Management strategies and conservation plans that take into account the genetic diversity found across the Larch Mountain salamander populations can potentially increase the likelihood of maintaining these unique lineages and the taxon as a whole.

- How should a site be delineated?
  - To maintain an occupied site, an understanding of the site-extent and habitat quality may be needed. Occupied habitats range from small discrete sites to large blocks of habitat, such as entire hillsides with similar habitat conditions occurring across extensive areas. Small sites may be easily delineated, and may be relatively more susceptible to disturbance events. For large sites, species occupancy patterns and also management may vary across the site such that areas of conservative protection are identified, as well as areas for restoration or management activities that have a higher risk to salamanders or their habitat integrity. To assess site extent, surveys may be conducted or the site extent can be visually estimated. For an estimate, once the presence of salamanders has been determined at a site, all similar habitat contiguous with the site may be included as part of the site; occupancy may be assumed for contiguous similar habitat unless information demonstrates otherwise. Spatial heterogeneity in surface rock, vegetation, microclimate, and illumination (as determined by aspect and topography) may also be used to qualitatively assess habitat suitability for these ground-dwelling salamanders, but surveys will be necessary to determine occupancy. Maintenance or restoration of optimum habitat patches might be considered.

At sites managed for species persistence, maintain the integrity of microhabitat and microclimate conditions by managing ground disturbance, hydrologic, and vegetation conditions. Consider actions that may benefit the maintenance of the site.

- Maintain of substrate and vegetation integrity.
  - Maintenance of the integrity of stabilized talus, scree and associated rock outcrops should be considered during timber harvest, trail and road construction, and road, ski slope, and other maintenance activities so that the microhabitat conditions required for the species are not affected. Restricted mining activities in occupied habitats may be an important consideration. For fuels reduction work, consider hand removal of fuels from the area being managed for Larch Mountain Salamander; hand-pile outside of the area, far enough away that pile burning would not impact the substrate or microclimate.
- Maintain cool, moist microclimate conditions.
  - Retention of canopy closure is likely important in the maintenance of surface and sub-surface microclimates needed by this animal. Consider a no-harvest buffer around

occupied sites to maintain the canopy closure and associated microclimates of the adjacent site.

- Avoid chemical applications.
  - No oiling or lignin application on roads is recommended within occupied habitat. Similarly, avoid applications of pesticides, herbicides, and fire retardants on occupied habitats.
- Assess proposed management activities to identify the potential threats specific to salamanders and their habitat at the site.
  - The threats to salamanders of some activities, relative to ground disturbance, microclimate shifts, and incidental mortality, may be minimal. A minimal or short-term risk may be inappropriate at a small, isolated population, whereas it may be minor in part of a large occupied habitat block. Consider both current and predicted future site conditions when assessing threats. If the threats are unknown or more than minor, conservative measures as identified below are recommended.
- Consider road decommissioning for long-term benefits to occupied sites.
- Evaluate recreational activities at cave sites**.**
  - Cave sites may be particularly susceptible to adverse effects of disturbances. On a site-by-site basis, consider seasonal cave closures and the placement of elevated boardwalks or ladders to reduce risks of recreational impacts. Enlargement of the passageway to facilitate human entry could have negative consequences if microhabitats are altered. Restricted knowledge of the location and use of these few sites would likely benefit this species.
- Consider seasonal activity patterns of this species when implementing actions in occupied habitat.
  - A seasonal restriction of some activities may benefit this species. Disturbance of animals and their habitats during dry or cold periods (summer/winter), when animals have decreased surface activities, could reduce impacts. A seasonal restriction for any ground disturbing activity could reduce mortality of animals that are thought to retreat to below-ground refuges during their surface-inactive seasons, from about 15 July to 15 September, during dry conditions. If a ground-soaking amount of rainfall (1-2 in.) occurred at the site during this season, animals may become surface-active and be vulnerable to disturbance.

Consider connectivity issues and management in areas adjacent to and between sites.

- Adjacent-area management activities may differ between discrete habitats and larger, more extensive sites. Are neighboring localities or known sites potentially part of the same larger "population" for management? Could individuals potentially travel between sites and be part of the same breeding population? A population in a biological sense may be comprised of animals residing in several discrete localities. Maintaining connectivity (reducing fragmentation and maintaining hydrologic/geomorphic integrity) among such sites may stabilize populations such that they are less prone to extinction (see papers on metapopulation dynamics, e.g., Harrison 1991, Sjogren 1991, Bradford et al. 1993). If habitat is not contiguous between locations, consider the importance of managing the intervening area for the maintenance of connectivity among satellite habitats or sub-populations. Maintaining suitable surface habitats among sites might provide refugia for salamanders and possibly aid in their dispersal among locations, potentially benefiting the long-term persistence of a larger population. Evaluation of these concepts as they apply to the Larch Mountain salamander may be considered during both the larger scale management assessments (i.e., Watershed Analysis) and the smaller site-scale assessments associated with specific project proposals. Furthermore, large blocks of forested habitat may have "interior" conditions and not require extensive adjacent area protection to ensure edge effect amelioration and retention of cool, moist microclimates.

- Areas adjacent to occupied sites may be used by the animals for foraging or dispersal. Edge effects from management activities in adjacent areas may alter microhabitat, microclimate, or hydrologic conditions at sites. Several properties of edge are summarized in USDA and USDI (1993, V-27), including potential inputs of surface debris (litter fall, coarse wood) extending one-half to one tree height from the edge of a forest stand. These may be important habitat features for surface-dwelling salamanders and may be important to maintain. Exactly how edge effects may interact to affect suitable microclimate conditions for salamanders is unknown. Also unknown are the variances that may occur with different sorts of forest edge conditions (i.e., not all edges are clearcuts). Occupied sites that abut federal reserve land allocations (e.g., botanical reserves, owl cores, riparian reserves) with similar suitable habitat conditions for salamanders may provide larger areas for subpopulations, habitat connectivity to other sites, and reduce fragmentation of the animal across the landscape. Managing sites for the maintenance of well-distributed populations may require this expanded look of the position of sites and habitats across land allocation and ownership boundaries, and an understanding of the variety of land management activities predicted to occur in each relative to their impacts on salamanders and their habitat needs.
- Consider proximity of sites to reserve areas, maintain habitat connectivity to such areas.

Disinfect field gear between sites if disease agents become known.

- Disinfection guidelines to reduce risk of transmission of *Bd* by field gear are under development and at this time include bleaching equipment between uses in different aquatic locations (e.g., 20% bleach solution, 30 seconds, e.g., 22 ounces of liquid Clorox per gallon water; alternatively, 7% bleach solution, 10 minutes, e.g., 9 ounces of liquid Clorox per gallon water; additional guidance available at: http://www.fs.fed.us/r4/resources/aquatic/guidelines/aq_invasives_interim_fire_guidance08_final.pdf).

V. INVENTORY, MONITORING, AND RESEARCH

Data and Information Gaps

Additional data are needed to refine distribution and management effects on this species. Both monitoring and research studies may contribute to knowledge gaps. In particular, information is lacking in these major areas:

- The distribution of the species north and south of the Columbia River.

- Patterns of abundance at sites.

- The distribution of optimal habitat across the species' range relative to federal land use allocations.

- Assessment of risk factors relative to geographic distribution.

- The response of the species to all forestry activities such as density management, regeneration harvest, and prescribed fire.

- Microclimate conditions required by the species in surface and subsurface refugia, and microclimate changes with vegetation management, including edge effects.

- The role of riparian reserves and other reserve areas for population persistence at stand-to-watershed spatial scales.

- Development of a multi-scale Conservation Strategy for the species across its range on federal lands.

- Investigate how much area and what conditions (biotic and abiotic) are needed to retain site-level persistence.

- Genetic relationships between populations, geographic boundaries of discrete populations, and connectivity among populations.

- General life history information, specifically movement, dispersal, foraging and reproduction.

- Species' role in communities and ecosystem processes.

Inventory

Strategic sampling and inventories for this species are needed to assess the relative roles of federal reserved and non-reserved land use allocations for conservation of this species, distribution of the species both north and south of the Columbia River Gorge, distribution of the spatial extent of individual known sites, and distribution of habitats within the species' range. Designed surveys can also contribute to the development of a habitat model and model validation for this salamander.

A standardized survey protocol was developed to assess species presence prior to habitat disturbing activities associated with land management (Crisafulli 1999, http://www.blm.gov/or/plans/surveyandmanage/SP/Amphibians99/protoch.pdf). This protocol outlines survey procedures and environmental conditions that optimize detection probabilities.

It also lists management activities that are expected to affect these salamanders (survey triggers), as well as those that may be benign (survey exemptions). Although other survey approaches including timed searches, area-constrained searches, and opportunistic sampling are all potentially effective ways to detect this species, it is important to use standardized methods if survey results are intended to be compared across sites. Although a species-detection at a site may be the survey goal, and accomplished readily by haphazard searches, lack of detection via haphazard search methods is difficult to interpret. Also, inventories conducted by standardized methods later can be used as baseline data for monitoring.

To optimize detections of these animals in western Washington and Oregon, Crisafulli (1999) recommended surveys during moist or wet (preferably saturated) conditions, substrate temperatures between 4 and 14 degrees C, and when air temperatures have been above freezing for 3 days. However, these conditions may be difficult to meet in the more continental portion of the species' range east of the Cascade crest (Crisafulli 1999), and consequently Krupka et al. (2006) suggested that surveys in this area be conducted when substrate temperatures are between 1 and 14 degrees C and that the four days between surveys be waived. Regardless of location within the species' range, substrate should be wet or saturated and air temperatures should be above freezing for three days to proceed with surveys.

In addition, studies addressing species-habitat associations or occupancy patterns will have inference to the larger population universe if random site selection is used. Nonrandom site selection results in case studies with implications only to the sampled sites; biased samples and results may occur. Pitfall trapping and mark-recapture methods may be effective approaches for long-term site or population studies (Heyer et al. 1994). The success of artificial cover boards to survey for terrestrial salamanders has been limited in xeric forest habitats of southern Oregon (K. McDade, unpublished data), such as those occupied by *P. stormi*, but may be more effective in wetter areas (Davis 1997). Nocturnal surveys may be effective, but may be hazardous to surveyors in remote areas.

If surveys are conducted, documentation is essential. As possible, survey locations should be located with Geographic Positioning Systems (latitude and longitude: Universal Transverse Mercator [UTM] grid coordinates), and data forms should be used to consistently record survey measurements, including ambient temperature and moisture condition. Electronic data entry into a database is crucial for rare species management and status assessments. Locality data for *P. larselli* on Forest Service lands resides in the NRIS Fauna database and on BLM lands resides in the Geographic Biotic Observations (GeoBOB) database. Annual electronic entry of new survey data, both from surveys of species-detections and surveys with no species-detections, should be conducted. A well-maintained database can contribute to species management decisions, as locations of managed sites can be analyzed to address species rarity questions and species persistence objectives.

Monitoring

Accountability of land management activities at sensitive species' sites can enable monitoring and adaptive management relative to species management objectives. If impacts to sites occur, annual accomplishment reporting should be considered, and electronic data entry in NRIS provides a standard format for documentation. All applicable NRIS and GeoBOB data fields should be completed. With later monitoring, impacts to habitats or species can be recorded into NRIS or other local or regional sensitive species databases in order to facilitate persistence assessments.

Resurveys of past-populations are needed, in addition to both implementation and effectiveness monitoring of past management actions. How have populations changed over a few years to decades, and in both areas with and without management activities? How has land-use changed in the area over time? What population-specific threats were present in the 1970's, and how have they changed today? Do current timber practices continue to threaten this species at the same level as previously perceived? What protective measures have been implemented, and what were the results of this management?

Implementation and effectiveness monitoring of currently-imposed protective measures are also needed. What are the recognized threats, exposure to threats, and risks to animals or habitats at each locality and for each population? How is management addressing each identified scenario of threats, exposures, and risks per site or population? How can threats be reduced over the long term in highly sensitive areas? Do current trends in area timber harvesting, roading, or excavation need to be more directly addressed? Rather than always focusing on site-specific management, can the results of compiled risk analysis be used to generate long-term area management goals?

Examination of historical and contemporary populations is needed to address both implementation and effectiveness monitoring of past and current management actions. Unfortunately, there are very limited data on historical collection sites and animal capture information. Instead, there are scant records that include some site locations for captured animals and occasionally brief field notes that generally lack detailed description of habitat, survey effort or estimates of population size. Consequently, we are limited to working with presence/absence data. This underscores the importance of initiating work that will provide accurate site location information, detailed habitat data, and animal survey results. Monitoring should include sites that will be subjected to some form of management activity as well as at sites where no disturbance is planned.

In particular, monitoring is needed to better understand the species' response to:

- Prescribed fire for areas east of the Cascade Range
- Large, high intensity, infrequent fires on west slope of the Cascade Range
- Forest thinning
- Regeneration harvest with Northwest Forest Plan guidelines
- Volcanism
- Climate change

Research

Pertinent research questions can be developed based on the data gaps listed above. The microclimate requirements of these animals are of particular interest. The management considerations address microclimate conditions because those conditions are perceived to be of great importance, yet there are few data that quantify the relationship between animal distribution and abundance and microclimatic conditions in the field. Moreover, there is no information on how various management practices may affect microclimates or populations of these salamanders. Studies that are designed to monitor microclimate conditions and animal abundance prior to and following a variety of management activities are needed. Lastly, there is more information needed on the ecology, natural history, population genetics, reproduction, and dispersal capabilities of this species.

The continued use of the NRIS and GeoBOB databases may allow several questions of the spatial distribution of this species to be addressed for the development of landscape-level design questions. The databases also have sites at which no salamanders have been found during previous surveys. If these unoccupied sites were also mapped, relationships in salamander distributions relative to the spatial distribution of rocky substrates, rock outcrop size, vegetation types, slope, aspect, topography, elevation, riparian areas, land allocation, land ownership, historical disturbances, and current disturbances could begin to be assessed.

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VII. DEFINITIONS

Persistence

The likelihood that a species will continue to exist, or occur, within a geographic area of interest over a defined period of time. Includes the concept that the species is a functioning member of the ecological community of the area.

Site (Occupied)

The location where an individual or population of the target species (taxonomic entity) was located, observed, or presumed to exist and represents individual detections, reproductive sites or local populations. Specific definitions and dimensions may differ depending on the species in question and may be the area (polygon) described by connecting nearby or functionally contiguous detections in the same geographic location. This term also refers to those located in the future (USDA, USDI 1994).

Natural Heritage Program Definitions

Globally Imperiled

G2 – Imperiled because of rarity or because other factors demonstrably make it very vulnerable to extinction, typically with 6-20 occurrences.

State Imperiled

S2 –Imperiled because of rarity or because of other factors demonstrably making it very vulnerable to extinction throughout its range.

S3 – Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors.

Oregon Natural Heritage Information Center (ORNHIC) List 2- contains taxa that are threatened with extirpation or presumed to be extirpated from the state of Oregon. These are often peripheral or disjunct species which are of concern when considering species diversity within Oregon's borders. They can be very significant when protecting the genetic diversity of a taxon. ORNHIC regards extreme rarity as a significant threat and has included species which are very rare in Oregon on this list.

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