Monadenia troglodytes troglodytes © Barry Roth

Petition to list 32 mollusk species from freshwater and terrestrial ecosystems of the northwestern United States as Threatened or Endangered under the Endangered Species Act

Prepared by Tierra Curry, Noah Greenwald, and Amanda Garty

CENTER *for* BIOLOGICAL DIVERSITY *Because life is good.*

March 13, 2008

Mr. Dirk Kempthorne
Secretary of the Interior
Department of the Interior
18th and "C" Street, N.W.
Washington, D.C. 20240

CC: Ren Lohoefener, Regional Director
US Fish and Wildlife Service
911 NE 11th Ave
Portland, OR 97232-4181

Dear Mr. Kempthorne:

The Center for Biological Diversity, Conservation Northwest, the Environmental Protection Information Center, the Klamath-Siskiyou Wildlands Center, Oregon Wild, Noah Greenwald, and Tierra Curry hereby formally petition the U.S. Fish and Wildlife Service (FWS) to list 32 species of the phylum Mollusca (henceforth "mollusk species") from freshwater and terrestrial ecosystems of the northwestern United States as Threatened or Endangered under the Endangered Species Act, and to designate critical habitat for them concurrent with listing.

Petitioners file this petition under the Endangered Species Act, 16 U.S.C. sections 1531-1543 (1982). This petition is filed under 5 U.S.C. section 553(e), and 50 C.F.R. part 424.14 (1990), which grants interested parties the right to petition for issuance of a rule from the Assistant Secretary of the Interior. The petitioners request that Critical Habitat be designated as required by 16 U.S.C. 1533(b)(6)(C) and 50 CFR 424.12, and pursuant to the Administrative Procedures Act (5 U.S.C. 553). Petitioners realize this petition sets in motion a specific process placing definite response requirements on the FWS and very specific time constraints upon those responses.

The U.S. Fish and Wildlife Service (FWS) has long recognized the benefit of consideration of protection for multiple species towards improving efficiency of listing and recovery and ultimately protection of ecosystems. In 1976, for instance, the FWS issued several proposed rules to list multiple species based on common threats, ecosystems, habitats, taxonomy, or other factors (see e.g., FWS 1976a, 1976b, 1976c). In 1992, the FWS itself stated in a legal Settlement Agreement (1992) that:

> "Defendants [FWS] recognize that a multi-species, ecosystem approach to their listing responsibilities under the ESA will assist them in better analyzing the common nature and magnitude of threats facing ecosystems, help them in understanding the relationships among imperiled species in ecosystems, and be more cost-effective than a species-by-species approach to listing responsibilities" (p. 7).

In 1994, the FWS (1994b) specifically stated its policy to undertake "Group listing decisions on a geographic, taxonomic, or ecosystem basis where possible" (p. 34724). In furtherance of this policy, the FWS (1994a) developed listing guidance that specifically encourages "Multi-species listings…when several species have common threats, habitat, distribution, landowners, or features that would group the species and provide more efficient listing and subsequent recovery" (p. iv). Accordingly, we hereby petition for 32

mollusks, all of which were formerly protected by the Survey and Manage Program of the Northwest Forest Plan.

Petitioners:

The petitioners are conservation organizations. Failure to grant the requested petition will adversely affect the aesthetic, recreational, commercial, research, and scientific interests of petitioning organizations' members and of the citizens of the United States. Morally, aesthetically, recreationally, and commercially, the public shows increasing demand and concern for wild ecosystems and for biodiversity in general.

The Center for Biological Diversity is a nonprofit conservation organization with more than 40,000 members dedicated to the protection of endangered species and wild places.

Conservation Northwest promotes the conservation of sensitive and endangered wildlife and their habitat in the northern Pacific region.

The Environmental Protection Information Center works to protect and restore ancient forests, watersheds, coastal estuaries, and native species throughout Northwestern California, including both public and industrial forestlands. EPIC uses an integrated, science-based approach, combining public education, citizen advocacy, and strategic litigation.

The Klamath-Siskiyou Wildlands Center is an advocate for the forests and wildlife of the Klamath and Rogue watersheds of northwest California and southwest Oregon. We use environmental law, science, collaboration and education to defend healthy ecosystems and help build sustainable communities.

Oregon Wild works to protect and restore Oregon's wildlands, wildlife and waters as an enduring legacy for all Oregonians.

Cryptomastix devia © William Leonard

EXECUTIVE SUMMARY

The 32 species of mollusks included in this petition are endemic to the Pacific Northwest, occurring in western Washington, Oregon, and Northern California. Seventeen of the petitioned species are aquatic (15 spring snails and 2 river snails) and 15 are terrestrial (13 land snails and 2 slugs). These species exist primarily in small isolated populations. All of the species have been recommended for listing under the Endangered Species Act by scientific experts (Frest and Johannes 1993, 1995, 2000, 2002), and all were formerly protected under the Northwest Forest Plan's Survey and Manage Program. The Oregon Natural Heritage Information Center (ORNHIC) ranks 29 of the petitioned species as critically imperiled and three as imperiled.

These mollusks are vulnerable to extinction for many reasons. Both the aquatic and terrestrial species are jeopardized by logging, grazing, wildfire, controlled burning, road construction and maintenance, pesticide application, agriculture, recreation, urbanization, mining, the spread of invasive species, and global climate change. In addition, all of the aquatic species and several of the terrestrial species which are dependent on perennially moist habitat are threatened by water pollution, dams, diversions, and stream destruction and development. The threats to these mollusks are magnified because many of the species have severely limited distributions. In addition, their life-history characteristics, such as low fecundity and high annual population turnover, make them highly intrinsically vulnerable to extinction. Seven of the species are known from only one to two sites, and nearly half of the species (15/32) occur at ten or fewer sites. Six of the species are known from 11-20 sites, and 11 species from more than 21 sites.

Petitioning these species together allows the U.S. Fish and Wildlife Service to consider their listing simultaneously, which conserves agency resources and improves efficiency.

The Endangered Species Act states that a species shall be determined to be endangered or threatened based on any one of five factors (16 U.S.C. § 1533 (a)(1)). Each of the 32 species meets one or more of these factors and thus warrants listing as a threatened or endangered species:

A. The present or threatened destruction, modification, or curtailment of habitat or range:

Habitat loss and degradation has been extensive in terrestrial and aquatic ecosystems of the Pacific Northwest. The habitat of the petitioned mollusks has been destroyed, modified, and curtailed by logging, livestock grazing, road construction and maintenance, wildfire and prescribed burning, agriculture, urbanization, mining, dams, water diversions, spring developments, and recreational developments including campgrounds, trails, and parking lots, Habitat destruction has led to population declines and the species remain severely threatened by these ongoing threats.

B. Overutilization for commercial, recreational, scientific, or educational purposes:

The petitioned mollusks are collected for scientific and educational purposes and in conjunction with other factors this could pose increasing threats to their survival, especially those that occur in only a few locations. We recognize that scientific study and collection contribute significantly to understanding species biology and that collection is a minor factor when compared to major threats such as habitat loss.

C. Disease or predation:

As key components of the food web, the petitioned mollusks are consumed by other invertebrates, fish, amphibians, reptiles, birds, and small mammals. Although naturally preyed upon, the mollusks may be increasingly threatened by predation in conjunction with the impacts of habitat loss and degradation. To the extent that these species have been reduced by other factors, natural predation could magnify the risk of extinction.

D. Other natural or human caused factors:

The petitioned species are at risk of extinction from several factors in addition to habitat loss, over-collection, and predation. Herbicide and pesticide application negatively affect both the aquatic and terrestrial species. Some of the mollusks are jeopardized by competition and predation from nonnative species. Drought, changing weather patterns, and microhabitat alteration caused by global climate change threaten the species. The mollusks are naturally limited in distribution, have poor dispersal capabilities, and exist as small, isolated populations making them vulnerable to extirpation. They are also highly intrinsically vulnerable to extinction due to low reproductive rates and high annual population turnover.

E. Inadequacy of existing regulatory mechanisms:

Existing regulatory mechanisms are inadequate to protect the petitioned species. None of the species are afforded substantial protection on private, state, or federal lands at this time. Ten of the snails occur exclusively on private lands. The species that occur on federal lands were formerly protected under the Survey and Manage Program of the Northwest Forest Plan which required pre-disturbance surveys for the species and management to protect sites where the species were found. The Survey and Manage program was eliminated in 2004, reinstated by court order in 2006, and suspended again in 2007. The removal of this program leaves the species vulnerable to habitat-destroying activities such as timber harvest. Because many of the species exist at a single or very few locations, the degradation of their habitat will likely result in the extinction of the species.

Protecting the petitioned mollusk species under the Endangered Species Act will benefit the mollusks, their ecosystems, and the citizens of the United States. Because there is a direct link between healthy mollusk populations and a healthy environment, protection of the petitioned mollusks will ultimately benefit our own communities.

I. INTRODUCTION

Terrestrial and freshwater snails and slugs are vital components of the ecosystems to which they belong (Dunk et al. 2004). Mollusks recycle plant and animal matter in soil and water, improving water quality and contributing to nutrient cycling and soil productivity (Van Cleave 1951, Mason 1970, Bronmark 1989, Dunk et al. 2004). Terrestrial snails and slugs are an important dispersal mechanism for fungal and other species, contributing to the breakdown of forest floor litter and playing a critical role in the decomposition cycle (Kogut and Duncan 2005). Empty mollusk shells are used for housing, shelter, and egg-deposition sites by insects and other arthropods, and decaying shells return calcium to the soil (Martin 2000, Niwa et al. 2001). Freshwater mollusks can comprise more than 90% of total invertebrate stream biomass (Hawkins and Furnish 1987). The reproductive cycles of many insects are dependent on snails that serve as hosts for parasitic eggs and larvae (Frest and Johannes 1993, Ball et al. 2001).

As primary consumers, both terrestrial and aquatic mollusks form a critical link in the food web, converting microorganisms, plants, fungi, and decaying material into a usable food source for a vast number of species, including other invertebrates, fish, amphibians, reptiles, birds, and mammals (e.g. South 1980, Churchfield 1984). Aquatic snails are consumed by waterfowl, amphibians, turtles, and fishes such as sculpins and trout (Duncan 2005c). Decline in terrestrial mollusk abundance has been linked to song bird decline (Graveland et al. 1994).

The important role of terrestrial mollusks in the food web is reviewed by Martin (2000) who states:

> "Terrestrial gastropods function primarily in the environment as herbivores, mycophagists (i.e., fungi eaters), and detritivores, although a few snails are carnivorous, feeding on insects, nematodes, earthworms, or other gastropods . . . Land mollusks constitute a foodsource for salamanders, frogs, toads, turtles, snakes, lizards, birds, shrews, voles, moles, rats, mice, chipmunks, and squirrels. Invertebrate predators of terrestrial mollusks include sciomyzid fly larvae, firefly larvae, carabid and staphylinid beetles, and ants" (p. 52-3).

Mollusks are useful indicators of pollution because they store extraneous chemicals in their soft parts and shells (Godan 1983). They have been described as "excellent" and "unique" indicators of ecosystem health (Strayer 1999a, Frest and Johannes 1993, 1995, 1998, 2002, Frest 2002). They are "unusually sensitive" to pollution and respond "quickly and obviously" to disturbance, making them "excellent barometers" of environmental change (Frest and Johannes 1993, Burke et al. 1999). Because mollusks are relatively sessile, they are a valuable tool for site-specific assessment of environmental quality.

An understanding of the health of mollusk populations can aid in understanding overall ecosystem vitality, in assessing restoration projects, in monitoring the status and health of

other species, and in measuring the effects of land management activities (Frest 2002). Waggoner et al. (2006) write:

> "Due to their limited dispersal capabilities, terrestrial gastropod species can make excellent study organisms for evolutionary (e.g., Hugall et al. 2003) and ecological studies (Coney et al. 1982, Cook 2001, Heller 2001, Neck 1990, Nekola and Smith 1999), as well as inferring paleoclimates and habitats (Theler et al. 2004). In addition, most species of terrestrial mollusks are restricted to particular vegetation and soil types (Burch 1955, Clark 2004, Hotopp 2002, Riggle 1976), and changes in species composition can be used to gauge impacts of both human and non-human factors effecting the environment" (p. 63).

Mollusks contribute significantly to ecosystem processes (Martin 2000). Martin (2000) concludes, "By contributing to biodiversity, snails and slugs presumably enhance the survivability and function of terrestrial ecosystems (Anonymous 1994, Cherfas 1994, Naeem et al. 1994, Pennisi 1994, Schulze and Mooney 1993)." Duncan (2005e) writes:

> "Each species occupies a specific niche, and performs its functions that, working together with all other organisms in the community, maintain a balance within that segment of the ecosystem. Minute snails are often numerous where they occur, and probably contribute significantly as primary and secondary consumers. . . to soil building, and the dissemination of spores and possibly other microbes."

The loss of the petitioned mollusk species would have unknown ecological consequences. For example, the Chelan mountainsnail, *Oreohelix n. sp. 1*, is ecologically distinct and important because it is the only gastropod that inhabits the grassy understory component of Douglas-fir-pinegrass plant associations where it occurs and where few other animals are found that function as decomposers (Duncan 2005f).

In addition to their ecological importance, usefulness as biological indicators, and inherent self-worth, snails and slugs are valuable to humanity for other reasons. For example, the endemic Pacific Northwest snail *Pristiloma arcticum crateris*, the Crater Lake tightcoil, apparently remains unfrozen under snow when air temperatures are well below freezing, and its body fluids may contain biological "anti-freeze" compounds of interest to humans (Duncan 2005e). The *Hemphillia* slug group, also endemic to the PNW, are scientifically significant because they are evolutionarily unique, appearing between snails and slugs with a shell plate that is not completely enclosed as it is in all other slug species of western North America (Wainwright and Duncan 2005). Mollusks are also fascinating and useful organisms for scientific investigation. Although humans do not generally think of gastropods as intelligent organisms, Martin (2000) writes:

> "Terrestrial gastropods have an ability to learn, i.e., they display "intelligence." The malacologist William Healey Dall (1881) once wrote a serious account about a child who had pet snails (apparently *Neohelix albolabris* or a related species) that "recognized" her voice and distinguished it from others. Garth and Mitchell (1926) used physical stimuli (heat, light, electricity) to train specimens of a land

snail to “run” a maze to a comfortable cool, dark place. Humphrey (1930) showed that the withdrawal response of *N. albolabris* disappeared upon repetition of a mechanical stimulus; i.e., the snail became habituated. Habituation disappeared after an appropriate rest. An unfavorable olfactory cue was used to train the slug *Limax maximus* to avoid normally palatable foods (Gelperin 1975). Sahley et al. (1990) showed that an initially aversive odor to *L. maximus* can be made attractive if that odor were repeatedly paired with an attractive chemostimulant. According to Carew and Sahley (1986), the higher-order features of learning seen in *L. maximus* rival that observed in such star performers in the vertebrate laboratory as pigeons, rats, and rabbits!” (p. 51).

Protecting the petitioned mollusk species under the Endangered Species Act will safeguard the species themselves and will help conserve the ecological integrity of the aquatic and terrestrial ecosystems of the Pacific Northwest.

Oreohelix n. sp. 1 © William Leonard

II. NATURAL HISTORY AND ECOLOGY

A. Taxonomy

The petitioned species are all in the phylum Mollusca, class Gastropoda. The terrestrial species are all in the order Stylommatophora, and represent seven families (Table 1). The aquatic species represent three families, and are all in the order Neotaenioglossa, except for *Vorticifex n. sp. 1*, which is in the order Basommatophora (Table 2).

Table 1. Classification of Terrestrial Mollusk Species.

Family	Genus and Species	Common Name
Arionidae	*Hemphillia burringtoni*	Burrington Jumping-slug
Bradybaenidae	*Monadenia chaceana*	Siskiyou Sideband
	Monadenia fidelis minor	Dalles Sideband
	Monadenia troglodytes troglodytes	Shasta Sideband
	Monadenia troglodytes wintu	Wintu Sideband
Limacidae	*Deroceras hesperium*	Evening Fieldslug
Oreohelicidae	*Oreohelix n. sp*	Chelan Mountainsnail
Polygyridae	*Cryptomastix devia*	Puget Oregonian
	Cryptomastix hendersoni	Columbia Oregonian
	Trilobopsis roperi	Shasta Chaparral
	Trilobopsis tehamana	Tehamana Chaparral
	Vespericola shasta	Shasta Hesperian
	Vespericola pressleyi	Big Bar Hesperian
Pristilomatidae	*Pristiloma arcticum crateris*	Crater Lake Tightcoil
Pupillidae	*Vertigo n sp.1*	Hoko Vertigo

Table 2. Classification of Aquatic Mollusk Species.

Family	Genus and Species	Common Name
Hydrobiidae	*Fluminicola n. sp. 2*	Tall Pebblesnail
	Fluminicola n. sp. 3	Diminuitive Pebblesnail
	Fluminicola n. sp. 11	Nerite Pebblesnail
	Fluminicola n. sp. 14	Potem Pebblesnail
	Fluminicola n. sp. 15	Flat-top Pebblesnail
	Fluminicola n. sp. 16	Shasta Springs Pebblesnail
	Fluminicola n. sp. 17	Disjunct Pebblesnail
	Fluminicola n. sp. 18	Globular Pebblesnail
	Fluminicola n. sp. 19	Umbilicate Pebblesnail
	Fluminicola n. sp. 20	Lost Creek Pebblesnail
	Fluminicola seminalis	Nugget Pebblesnail
	Lyogyrus n. sp. 1	Columbia Duskysnail
	Lyogyrus n. sp. 2	Masked Duskysnail
	Lyogyrus n. sp. 3	Canary Duskysnail
Pleuroceridae	*Juga O. n. sp. 2*	Basalt Juga
	Juga O. n. sp. 3	Cinnamon Juga
Planorbidae	*Vorticifex n. sp. 1*	Knobby Rams-horn

B. Distribution

The species in this petition are all endemic to the Pacific Northwest and are exceedingly restricted in distribution. Seven of the species are known from only one to two sites, and nearly half of the species (15/32) occur at ten or fewer sites. Six of the species are known from 11-20 sites, and 11 species from more than 21 sites.

C. Description

For individual species descriptions, please see the section VI below. In general, mollusks are distinguished by shell shape, body and shell coloration, sexual and digestive anatomy, and/or genetic analysis (Martin 2000).

D. General Habitat Requirements

Of the 17 petitioned aquatic species, 15 are spring snails and two are river snails. These freshwater mollusks require permanent, cold, clear, flowing, unpolluted water with low nutrient levels and high dissolved oxygen levels. Freshwater mollusks are sensitive to water pollution regardless of source (Burch 1989, Frest and Johannes 1995, 1998, 2000, Hershler and Frest 1996, Lefcort et al. 1999, 2000, 2002). They have narrow temperature tolerances and are vulnerable to seasonal or diurnal fluctuations in flow, temperature, and water chemistry (Crowl and Schnell 1990, Frest and Johannes 1995).

Of the 15 petitioned terrestrial species, 13 are land snails and two are slugs. Nine of the species are riparian associates (seven land snails and both slugs) and six are dependent on late-successional forest (five land snails and one slug). Terrestrial snails and slugs may inhabit forest litter and duff, logs and downed coarse woody debris, moss, ground vegetation, talus, and/or rockslides. Suitable habitat is influenced by vegetation, cover, moisture, and substrate (Martin 2000). They are sensitive to microhabitat alteration and desiccation, are intolerant of xeric conditions, and avoid areas with intense sun exposure (Burke et al. 1999, Frest and Johannes 1993).

E. Movement

Freshwater snails have limited dispersal abilities. Most species are considered to be "sessile for all practical purposes" (Frest and Johannes 1995). Even relatively "active" species do not travel far from their place of birth. Many species occur at only one or two springs, or in one or two locations within streams. Many exist as a series of isolated populations, between which natural and human-made barriers prevent movement of individuals and gene flow (Frest and Johannes 1993, 1995, 1998, 2000, Hershler and Frest 1996). Movement is limited by substrate, water temperature, water flow, water depth, predation, and competition with other aquatic mollusks (Frest and Johannes 1995). Dams, water diversions, spring developments, influx of pollution, stream and/or spring modifications, recreational developments and other barriers limit the dispersal of freshwater mollusks (Frest and Johannes 1995, 1998, 2000, Hershler and Frest 1996). All of the petitioned aquatic species are local endemics.

Likewise, terrestrial snails and slugs are exceedingly limited in their dispersal ability (Martin 2000). They move at a very slow rate and do not travel far from their birth location (Frest and Johannes 1993, USDA, USDI 2000). Martin (2000) notes that colonization of new habitats by terrestrial gastropods occurs "at a snail's pace." Land snails and slugs move by secreting a thin layer of mucus, and the adhesiveness of the mucus must be overcome for the organism to progress (Parker 1911, Denny 1980). Mucus secretion is energetically expensive and limits the distance over which it is profitable for a gastropod to move; the metabolic cost of movement can be considerably greater for slugs than for reptiles or mammals of similar weight (Denny 1980). Colonies often occupy relatively small areas, generally less than a few dozen square meters in total size. In one study, marked terrestrial snails moved only from 1.5-14.0 m over a three-month period (Baur and Baur 1990). If habitat quality deteriorates, terrestrial mollusks may not be able to emigrate more than 50 m (van der Laan 1971, Roth and Pressley 1986).

The majority of the petitioned species are local endemics with very limited geographic ranges, making them highly vulnerable to habitat disturbance and loss (Frest 2002, Hershler and Frest 1996, Frest and Johannes 1993, Lydeard et al. 2004). Particularly high concentrations of endemism are found in the land snail genera Monadenia (four petitioned species), Trilobopsis (two petitioned species), Vespericola (two petitioned species), and in the slug genus Hemphillia (one petitioned species) (Frest and Johannes 1993, USDA, USDI 2000). Very low mobility makes it difficult for terrestrial mollusks to recover from habitat disturbance because they are unable to relocate even if suitable areas of undisturbed habitat are available nearby:

> "Because of the extremely limited dispersal ability of these animals and their sensitivity to environmental conditions like temperature and humidity, recolonization of unoccupied habitat is extremely slow, and historical factors leave their signature in current distributions. Suitable habitat may remain unoccupied for indefinite periods of time" (USDA USDI 2007 SMR FSEIS p. 246).

Because the petitioned mollusk species are extremely limited by habitat and physiological constraints, populations with large numbers of individuals can be just as vulnerable to extinction as populations with only a few individuals, and thus population size may not be an accurate indicator of their status (Frest and Johannes 1993, 1995, 1998, 2000).

F. Life History

Mollusks exhibit a diverse array of sexual systems and reproductive strategies, a variety of reproductive behaviors, and complex genitalia, the anatomy of which is often of taxonomic importance (Leonard 1991, Martin 2000).

The petitioned freshwater mollusks have various life history strategies. Mollusks of the family Hydrobiidae (genera Fluminicola and Lyogyrus, 14 petitioned species) require

several months to reach breeding age, live for only one year, reproduce, and then die (Frest and Johannes 1995, Lysne 2003). Annual population turnover in most freshwater mollusk species is considerable, often as high as 90 percent (Frest and Johannes 1995). High annual population turnover makes aquatic mollusks particularly vulnerable to disturbance (Frest and Johannes 1993). Activities that increase sedimentation, decrease egg survivorship, or kill both larvae and adults (such as pesticide contamination), can lead to extirpation. Species of the genus Juga (two petitioned species) take three years to reach sexual maturity and generally live from five to seven years (Furnish 1990). Low fecundity rates make it difficult for freshwater mollusks to recover from population crashes.

Terrestrial snails and slugs also employ diverse life history strategies. For egg-laying species, eggs are usually deposited in pockets of moist soil, in underground nests, under rocks, logs, woody debris, or in leaf litter (Martin 2000). Life span varies considerably between taxa. Larger species may live from one to ten years, but smaller species generally live for one year and reproduce only once (Frest and Johannes 1993, 1999). Having a single lifetime reproductive event leads to high annual population turnover and increases the vulnerability of the species to extirpation. Species in the genera Vespericola (two petitioned species) and Cryptomastix (two petitioned species) typically live for two years or less, while species in the genus Monadenia (four petitioned species) typically live from eight to ten years (Frest and Johannes 1993). In general, terrestrial mollusks have low fecundity which makes them intrinsically vulnerable to extirpation.

III. STATUS

Mollusks have experienced more extinctions than any major taxonomic group—42 percent of documented animal extinctions in the last 500 years have been mollusks, 99 percent of which were non-marine species (Lydeard et al. 2004). Of the 675 reported freshwater gastropod taxa in North America, 42 are presumed to be extinct (Bogan 2006). In the western United States, freshwater and terrestrial mollusks are declining at an alarming rate (Frest 2002). Mollusks in the family Pleuroceridae, which includes the genus Juga (two petitioned species), have been identified as one of the most endangered groups of organisms in North America (Holznagel and Lydeard 2000). At least two freshwater mollusk species from the northwest have been reported as potentially extinct—the rotund physa (*Physella columbiana*) and the Dusky pebblesnail (*Fluminicola nuttalianus*) (NatureServe 2007). NatureServe ranks 29 of the petitioned species as critically imperiled (G1 or T1), and three as imperiled (G2).

None of the mollusks are protected under state or federal endangered species programs. Twenty-two of the species are included in either the Forest Service (FS) or Bureau of Land Management's (BLM) Special Status Species Program (SSSP), but this program does not provide any tangible protections for the species or their habitat. All of the species were formerly protected under the Survey and Manage Program (SMP) of the Northwest Forest Plan (NWFP) but this program has been suspended. The removal of

Survey and Manage leaves the ten species not included in SSSP without any protective status on federal lands.

IV. LEGAL REQUIREMENTS FOR DETERMINING IF SPECIES WARRANT LISTING:

Several sections of the regulations implementing the Endangered Species Act (50 CFR § 400 et seq.) are applicable to this petition. Those concerning the listing of the petitioned mollusk species as Threatened or Endangered are as follows:

424.02(e) "Endangered species" means a species that is in danger of extinction throughout all or a significant portion of its range. "Species" includes any species or subspecies that interbreeds when mature.

"Threatened species" means a species that "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (16 USC § 1532(20)).

424.11(c) "A species shall be listed…because of any one or a combination of the following factors:

1. The present or threatened destruction, modification, or curtailment of habitat or range;
2. Overutilization for commercial, recreational, scientific, or educational purposes;
3. Disease or predation;
4. The inadequacy of existing regulatory mechanisms; and
5. Other natural or manmade factors affecting its continued existence.

At least one, and in many cases three or more, of the factors set forth in § 424.11(c) are applicable to the present status of the petitioned mollusk species.

V. AN OVERVIEW OF THE MAJOR THREATS TO THE PETITIONED SPECIES

A. Present or threatened destruction, modification, or curtailment of habitat or range

Mollusks are extremely sensitive to habitat disturbance because they have low mobility, low reproductive rates, and are dependent on very specific ecological conditions (Frest and Johannes 1993, 1995, USDA, USDI 1994). Habitat loss and degradation is the primary threat to the continued existence of endemic northwestern mollusks. Several species of aquatic mollusks in western North America have already become extinct due to habitat destruction:

> "Destruction of springs by grazing, logging, and human exploitation (troughing or capping for stock use; diversion for human [water supply, fish hatcheries] or stock

> use) has already caused extensive extinction of (aquatic mollusk) species throughout western North America" (Frest and Johannes 1993).

Recovery from habitat loss and degradation may be impossible for some mollusk species, especially those that exist at only one location (Frest and Johannes 1995, 1998, 2000). For others, recovery is hindered by specialized habitat needs, physiological requirements, habitat fragmentation, and/or geographic isolation. Although some of the petitioned mollusk species are more widespread, the loss of populations may be irreversible given the existence of physical, geographic, and ecological barriers to dispersal (Baur and Baur 1990, Frest and Johannes 1995, 1998, Hershler and Frest 1996). Activities that destroy and degrade mollusk habitat include logging, grazing, roads, urban and recreational development, agriculture, water pollution, mining, dams, diversions, and spring developments (Frest and Johannes 1993, 1995, 1999, Burke et al. 1999, Hershler and Frest 1996, ORNHIC 2004).

To assess the impacts of management activities on mollusks, we requested through the Freedom of Information Act, all survey or similar documents, including summary reports, biological evaluations and assessments, decision memorandums and notices, and environmental assessments, for 132 Survey and Manage species in Region 6 National Forests, and for Survey and Manage mollusks that occur in Region 5 from the beginning of the program through 2004 (FOIA R6-05-027 Jan. 9, 2004 and Nov. 29, 2004). We received a more thorough response from some national forests than others, and some documents did not contain complete information, so our results underestimate the actual number of activities that affected Survey and Manage mollusk species. The number of projects reported in this petition includes actual and potential projects for which mollusk surveys were considered or conducted. Because of the incomplete information made available to us, the small number of projects reported here is only a sample of the true number of projects with potential affects on mollusk species.

The documents provided in response to the Center's FOIA demonstrate that at least 252 projects were planned in Region 5 and 6 National Forests with potential impacts on SM mollusk species during the SM program. SM mollusks were detected at 133 of these projects, including 82 projects where one or more of the species in this petition were present. Twenty-four projects included stated mitigation measures, such as buffers, to protect mollusks, and 14 projects had stated potential negative impacts on SM mollusk species. Because of incomplete documentation and response, the total number of reported projects certainly underestimates the actual number of projects that affected SM mollusk habitat. Likewise, the number of projects with stated mitigation measures underestimates the actual number of mitigation measures taken based on the requirements of the SM program.

The National Forest records document that hundreds of management activities take place in SM mollusk habitat, and that now that the SM program has been cancelled and mitigation measures are no longer required, the habitat of these species is clearly threatened with modification and/or destruction.

Discussion of Specific Threats

1. Logging

Logging has been identified as a primary threat to 18 of the petitioned species, but given the sensitivity of mollusks to habitat alteration in general, logging threatens all of the petitioned species (Frest and Johannes 1993, Furnish and Monthey 1999, Burke et al. 1999, ORNHIC 2004). Timber harvest operations destroy and degrade habitat for both aquatic and terrestrial mollusks. For terrestrial species, logging destroys the microclimate conditions on which land snails and slugs depend. Specifically, logging reduces canopy cover, decreases shade, increases ground temperature, decreases soil moisture, compacts soil, removes cover objects such as woody debris, and increases wind which contributes to desiccation (Frest and Johannes 1993, Burke et al. 1999). Secondary impacts of logging such as slash burning, chemical spraying, and loss of forage plants are also lethal for mollusks (Frest and Johannes 1993). Because land snails and slugs are physiologically constrained to moist microhabitat and move very slowly, logging creates insurmountable barriers to dispersal contributing to genetic isolation and inhibiting recovery. If individuals survive the logging operations, they are generally unable to relocate to appropriate habitat even if it is available nearby.

Logging can extirpate populations and species and reduce snail and slug diversity for decades following harvest:

> "Any modification of habitat that decreases available moisture or increases insolation (sunlight, solar radiation) is very strongly detrimental to land mollusks. Logging tends to increase insolation to the point that most species are extirpated. . . . Tree farms, like Midwest corn fields, are generally devoid of any native mollusks . . . In our study sites in western Washington, for example, relatively undisturbed sites had a mean diversity of 10 -12 species. Recently clear-cut areas generally had no shelled species. Most areas that had been clear cut 20 – 60 years ago regained no more than two shelled species. Often the only mollusks seen alive in clear-cuts were found in very limited colonies under protected settings, such as missed trees or unburned debris piles. In our opinion, the long-term viability of such colonies is questionable, let alone their ability to serve as reservoirs to repopulate re-grown forests. Generally, only one or two slug species were at all widespread in recent clearcuts or in reforested areas up to forty years after cutting" (Frest and Johannes 1993).

Clearcuts obviously destroy mollusk habitat, but thinning operations can also lead to habitat degradation and destruction. Canopy and understory reduction alter microclimate and reduce the availability of food and cover by shifting ground-level flora from more shade-tolerant taxa, such as fungi or lichens, to primary producers like vascular plants (Carey 2000). Variable density thinning reduces the amount of coarse woody debris available as cover objects for mollusks, despite the intent of the treatment to leave all existing debris in place (Carey et al. 1999). The availability of cover objects such as large

downed wood takes a long time to recover if sufficient levels are not maintained through disturbance (Harmon and Hua 1991). Thinning projects which selectively remove hardwood species negatively affect mollusks by reducing the availability of leaf litter (Kogut and Duncan 2005).

Freshwater mollusks are also negatively impacted by timber harvest. Aquatic mollusks require clear, cold water with high dissolved oxygen levels. Logging degrades aquatic habitat via loss of shade, increased water temperature, decreased levels of dissolved oxygen, and increased sedimentation. Sedimentation can suffocate aquatic mollusks, interfere with their food supply, and kill their eggs. Clear-cut logging can extirpate aquatic mollusk populations:

> "As most (freshwater mollusks) are obligate perilithon grazers and require stable substrate, siltation, such as that resulting from clear-cutting, generally means loss of habitat and at least local extirpation" (Frest and Johannes 1993).

Logging is extensive in the Pacific Northwest. From 1950 to 2002, over 125,584 million cubic feet of timber were harvested on public and private lands in western Oregon and Washington (Adams et al. 2006). In response to the Center's request for documents related to projects where SM mollusks were surveyed for in the project area, Region 5 and 6 National Forests provided documents on 134 silvicultural projects with potential impacts on Survey and Manage mollusk species including 94 timber sales, 25 thinning projects, six fuels reduction projects, five hazardous tree removals, three salvage logging projects, and a vegetation management project. Fifty-three of the projects had stated potential impacts on the petitioned species.

This number likely vastly underestimates the actual number of silvicultural projects that took place in Regions 5 and 6 from 1994-2004 with potential impacts on SM mollusk species, but demonstrates that timber activity clearly threatens their habitat. Mitigation measures were stated to be provided for *Cryptomastix devia, C. hendersoni, Juga O. n. sp. 2, Lyogyrus n. sp. 1, Monadenia fidelis minor, Oreohelix n. sp. 1, and Vespericola pressleyi*. Mitigation measures were likely provided for other species as well, but not explicitly stated on the documents provided in response to our FOIA. Thirteen projects included stated mitigation measures such as buffers to protect mollusk habitat. Although this number is certainly an underestimate, it exemplifies the fact that without SM protections, logging projects will move forward in mollusk habitat that could extirpate snail and slug populations. Given that many of the petitioned species exist in only a few populations, this could contribute to species extinction. The suspension of the SM program leaves the petitioned species completely vulnerable to future timber harvest. Logging poses a particularly dire threat to the seven petitioned species which occur on BLM lands in Oregon that will be subject to increased timber harvest under the Western Oregon Plan Revision.

2. Livestock Grazing

Livestock grazing is the most widespread land management practice in western North America, occurring on 70 percent of western lands including wilderness areas, wildlife refuges, national forests, and some national parks (Fleischner 1994). Grazing has been referred to as "the most widespread influence on native ecosystems of western North America" (Wagner 1978, Crumpacker 1984). A survey of peer-reviewed studies on the effects of livestock grazing on stream and riparian ecosystems found that grazing negatively affects water quality and quantity, channel morphology, hydrology, soils, instream and streambank vegetation, and aquatic and riparian wildlife (Belsky et al. 1999).

Malacologist Terrence Frest calls grazing "an extremely severe problem, especially in sensitive habitats" (2002). According to Frest, "Livestock grazing is a major factor causing extirpation or reduction of both land and freshwater mollusks" (Frest 2002). Grazing is detrimental for aquatic and terrestrial snails and slugs in many ways. Mollusks and their habitats are harmed via direct trampling, soil compaction, erosion, water siltation and pollution, and drying up of springs and seeps. Manure and urine deposits alter soil and water chemistry (Frest 2002). Foraging reduces vegetation that provides both food and cover for mollusks, increases insolation and the chance of desiccation, and shifts the plant community towards unusable and exotic species (Burke et al. 1999, Frest 2002). Livestock reduce cover objects available for terrestrial snails and slugs by trampling large woody debris and other types of shelter sites that mollusks are dependent on for egg laying, aestivation, hibernation, and refuge during dry weather (Frest 2002). Litter and duff that provide both microhabitat and food for land mollusks is reduced in grazed sites (Frest 2002). Schulz and Leininger recorded twice as much litter in exclosures than in the surrounding grazed habitat (1990).

Management activities such as rangeland improvement projects can have "major deleterious effects" on mollusk habitat (Frest 2002). Range improvement typically involves piping water from natural springs to water troughs, which often results in spring destruction and the extirpation of native biota (Frest 2002).

Grazing is detrimental to mollusk habitat whether the grazing level is light or heavy. According to Frest, light grazing by domestic species "seems to have substantial negative effects on land snail diversity and abundance" (2002). After extensive studies of land snail communities throughout the west, Frest (2002) determined:

> "Heavily grazed areas often lack land snails altogether or have only introduced pest taxa. Even moderately grazed sites generally have a small fauna, often composed only of generalist species. I know of no instances in which moderate to heavy grazing improved native terrestrial or freshwater mollusk diversity or abundance, but examples of reduction or extirpation are easy to find.
>
> Together with my colleagues I have documented specific instances of land snail colony reduction or extirpation. Some of the most egregious involve seven Idaho

> land snails recommended for federal Endangered Species Act listing as threatened or endangered at the inception of the law in 1973. The two localities of a new species described in 1975 had both been either greatly damaged or destroyed by 1995—one largely by cattle grazing and the other by domestic sheep grazing. Fortunately, we were able to locate additional sites. This species is still not listed, and its present condition is unknown. We also noted instances in which a colony bisected by a fence either stopped completely or had only dead shells on the grazed side. Even if areas have been fenced off from livestock, fencing is rarely adequate, and its long-term usefulness is questionable" (2002).

Frest and Johannes assert, "To ensure survival of sensitive species, grazing should not be allowed at all at significant colony sites" (1995).

Grazing has been identified as a threat to 26 of the 32 petitioned species (81%) (Frest and Johannes 1993, Furnish and Monthey 1999, Burke et al. 1999, ORNHIC 2004). Survey and Manage records from Region 5 and 6 National Forests document that mollusk surveys were conducted for cattle allotments and range improvement projects in the habitat of the petitioned species *Deroceras hesperium*, *Monadenia chaceana*, and *M. fidelis minor*. The cancellation of the SM program means that mollusk surveys and mitigations and protection from grazing are no longer required, leaving the species vulnerable to grazing impacts.

3. Mining and Quarries

Mining generally leads to permanent and irreversible habitat alteration and can completely eliminate gastropod species. According to Frest and Johannes, "Mined areas do not appear to recover their snail fauna, even after many years" (1993). Historical and present mining operations have been identified as a potential threat to a quarter of the petitioned mollusks (8/32) (Frest and Johannes 1993, Furnish and Monthey 1999, Burke et al. 1999, ORNHIC 2004).

Survey and Manage records from Region 5 and 6 National Forests documented planned quarry development in the habitat of *Lyogyrus n. sp. 1* and *Pristiloma arcticum crateris*. To offset the indirect effects of the development of a five-acre rock pit near known *P. a. crateris* locations, mitigation measures were taken including silt fencing and the installation of sediment control devices. The termination of the SM program means that surveys and protective measures will no longer be required to protect rare mollusks from mining operations.

4. Roads and Powerlines

The direct impacts of roads on mollusk habitat include the compaction of soil (which leads to increased sedimentation, erosion and flooding), pollution from runoff, and habitat fragmentation (Fredricksen 1970, Reed et al. 1996, Riedel and Vose 2002). Both

paved and unpaved roads can act as dispersal barriers that isolate snail populations (Baur and Baur 1990). Indirect impacts of roads include increased recreational use of habitat and the introduction of nonnative species (Frest and Johannes 2000, Hastings et al. 2005). Frest (2002) states:

> "The direct effect (of road building) on an existing colony (of mollusks) is extirpation in the roadway proper; site preparation often extends the effects. Road building also increases human traffic, including foot traffic; increases exposure, insolation, and effective ground temperature; changes the local plant community; often leads to the introduction of disturbance plants and nonnative and noxious plants and animal species; and initiates damaging side effects, such as herbicide spraying. Even for larger animals, roads may be impassable migration barriers; they are even more so for smaller and soft-bodied animals like snails."

Roads and road construction and maintenance detrimentally affect the habitat of at least 19 of the 32 petitioned species (59%) (Frest and Johannes 1993, Furnish and Monthey 1999, Burke et al. 1999, ORNHIC 2004). An estimated 570 km of new roads were constructed, and approximately 5000 km of road were improved in the NWFP area from 1994-2004 (Reeves et al. 2006). Survey and Manage documents provided by Region 5 and 6 National Forests reported 18 road construction and maintenance projects potentially affecting the habitat of eight petitioned mollusk species including *Cryptomastix hendersoni, Deroceras hesperium, Juga O. n. sp. 2, Lyogyrus n. sp. 1, Lyogyrus n. sp. 2, Monadenia fidelis minor, Pristiloma arcticum crateris,* and *Trilobopsis roperi.* One project included stated mitigation measures to protect the habitat of *Trilobopsis roperi.* The documents also report that powerline maintenance activities potentially affected the habitat of *Pristiloma arcticum crateris*, but that mitigation measures were taken to protect the species. The cancellation of the SM program means that future road building and maintenance projects and powerline maintenance projects will not require surveys for mollusks, and the species could be impacted without foreknowledge. Even if the species are detected, without the SM program there is no guarantee that their habitat will be protected.

5. Urban and Suburban Development

Urban and suburban development, such as the building of businesses, industries, subdivisions, and roads, impact mollusk populations and communities (Baur and Baur 1990, Frest and Johannes 1993, 1994, 1995). Development generally makes irreversible changes to the landscape, destroying and fragmenting natural habitat and increasing pollution (Frest and Johannes 1993, 1995, Sada and Vinyard 2002, Norse 1990, Burke et al. 1999). *Cryptomastix devia, C. hendersoni,* and *Deroceras hesperium* are known to have lost sites due to urbanization, and urban and suburban development has been identified as a threat to 41 percent of the petitioned mollusks (13/32 species) (Frest and Johannes 1993, Furnish and Monthey 1999, Burke et al. 1999, ORNHIC 2004).

6. Recreation and Recreational Developments

Recreational developments and activities threaten terrestrial and aquatic mollusk habitat in several ways. Recreational developments foster air and water pollution, litter, and potentially high densities of recreationists (Houston 1971, White and Bratton 1980). Recreation can cause trampling of organisms and vegetation (Liddle 1975). Local habitat changes caused by trampling include simplification of vegetation and soil compaction which can result in overall loss of habitat diversity (Speight 1973, Liddle 1975). Recreational use of mollusk habitat can degrade water quality via sewage contamination (ORNHIC 2004). Snowmobiling and skiing can impact snails if the snow covering occupied habitats becomes compacted and loses its insulative properties, allowing the litter or ground to freeze (Burke et al. 1999, ORNHIC 2004). The detrimental effects of off-road vehicle use on wildlife habitat are well documented and include tramping of organisms, destruction of vegetation, erosion, and degraded water quality (Wuerthner 2007).

Nearly 60 percent of the petitioned mollusks are potentially impacted by recreational developments such as campgrounds, snow parks, trails, roads, and parking lots, and by recreational activities such as off-road vehicle (ORV) use (Frest and Johannes 1993, Furnish and Monthey 1999, Burke et al. 1999, ORNHIC 2004, Wainwright and Duncan 2005). Recreation has been identified as a specific threat to *Deroceras hesperium*, *Hemphillia burringtoni*, and *Pristiloma arcticum crateris* including snowmobiling, skiing, use of off-road vehicles, camping, and removal of cover objects for campfires (Burke et al. 1999, ORNHIC 2004, Duncan 2005b). ORV use threatens the habitat of *Oreohelix n. sp. 1* which uses open grassy understory habitats also preferred for dirt-biking and ORV riding (Burke et al. 1999, ORNHIC 2004). *Vespericola pressleyi* is also threatened by ORV use; Burke et al. (1999) state: "Mechanical disturbance by motor vehicles and concentrated recreational activities could contribute to extirpation by crushing snails and degrading needed habitat structures" (Burke et al. 1999).

Survey and Manage records provided by Region 5 and 6 National Forests identified 27 recreation projects in the habitat of SM mollusks including trail repair (14 projects), snow park and ski area maintenance (three projects), campground maintenance (six projects), shelter construction (one project), septic maintenance (one project), and two general recreation projects of unspecified type. Several projects took place in the habitat of petitioned species including three trails potentially affecting *Pristiloma arcticum crateris*, two trails potentially affecting *Lyogyrus n. sp. 1*, a trail potentially affecting *Oreohelix n. sp. 1*, and a campground project potentially affecting *Cryptomastix devia*. The cancellation of the SM program means that surveys and mitigation measures will no longer be required for recreational developments, leaving former SM species vulnerable to habitat loss.

7. Restoration Projects

Restoration projects, such as vegetation management or stream enhancements for fish, while beneficial to overall ecological functioning, are potentially detrimental for species that are present but not considered by the action. The 2002 Annual Species Review cites restoration projects as an example of a management practice in late-successional and riparian reserves that could result in "significant adverse impacts (for rare species) without the provisions of the Survey and Manage program" (USDA USDI 2002). Survey and Manage records from Region 5 and 6 National Forests document nine restoration projects potentially affecting four petitioned species: *Hemphillia burringtoni, Juga O. n. sp. 2, Lyogyrus n. sp. 1,* and *Pristiloma arcticum crateris.* For example, the FONSI for the Clear Branch Creek Fish Restoration project on the Mt. Hood National Forest states that the affected population of *Lyogrus n sp. 1*, the Columbia duskysnail, "may not survive the rewatering of abandoned channel." The Biological Evaluation for the Tumalo Creek Restoration Project in the Deschutes National Forest reports that the action may have short-term effects on the local population of *Pristiloma arcticum crateris*, the Crater Lake tightcoil. With the suspension of the SM program, restoration projects will not have to include surveys or mitigation measures for mollusks which could be harmed by the projects.

8. Water Pollution

Water pollution is a threat to all 17 of the petitioned aquatic mollusks and to riparian-associated terrestrial mollusks which are dependent on perennially wet microhabitat (Frest and Johannes 1993, Furnish and Monthey 1999, Burke et al. 1999, ORNHIC 2004). Freshwater snails are intolerant to many forms of water pollution and are thus threatened by any activity that leads to the contamination of their habitat (Frest and Johannes 1993). Excessive sedimentation from a variety of activities such as logging, mining, road and railroad grade construction, and grazing may smother substrates preferred by these species and may impair egg-laying or survivorship of eggs or young (Furnish and Monthey 1999). Nutrient enrichment, such as that from agricultural, industrial, or urban runoff, influences algal biomass which strongly influences water chemistry and the abundance of freshwater snails (Crowl and Schnell 1990). Freshwater mollusks are sensitive to increased temperature, decreased dissolved oxygen, changes in flow (Crowl and Schnell 1990), and to pollution from heavy metals (Khangarot and Ray 1988). These factors can act synergistically, e.g., higher water temperature can increase the sensitivity of aquatic organisms to toxic chemicals (Cairns et al. 1975).

The health of aquatic ecosystems is one of the primary environmental concerns in the Pacific Northwest (Mac et al. 1998). Logging, agricultural activities, and urban and suburban development are the primary sources of water pollution in the region (Frest and Johannes 1993, 1998, USDA, USDI 1994, FEMAT 1993). All of the river drainages where the petitioned species occur have degraded water quality including the Klamath (three species), Pit (seven species), Sacramento (eleven species), and Columbia (three species) (California Environmental Protection Agency (CEPA) 2008, Oregon Dept. of Environmental Quality (ORDEQ) 2008).

The Klamath River is listed by both Oregon and California under Section 303(d) of the Federal Clean Water Act as water quality impaired from source to mouth because of excessively warm water temperatures, low dissolved oxygen, high nutrient loads, algae blooms, sedimentation, and siltation due to habitat modification, removal of riparian vegetation, hydromodification, channelization, impoundments, grazing, irrigation and agricultural water diversions, industrial and municipal point sources, and nonpoint sources (CEPA 2008, ORDEQ 2008). Three of the petitioned species occur in the Klamath drainage, *Fluminicola n. sp 2, Fluminicola n. sp 3,* and *Fluminicola n. sp 11.* Two of the creeks where *Fluminicola n. sp. 3* occurs are listed as water-quality impaired. Jenny Creek is listed for high nutrients, high temperature, low dissolved oxygen, and sedimentation, and Fall Creek is listed for sedimentation and siltation due to road construction, habitat modification, and nonpoint sources (ORDEQ 2008, CEPA 2008).

The Pit River is listed as water-quality impaired due to nutrient enrichment from agriculture and grazing (CEPA 2008). The Pit River has been impacted by human activities including dams and diversions, mining, logging, grazing, chemical pollution, and road and railroad construction (Furnish and Monthey 1999). Seven of the petitioned species occur in the Pit River drainage: *Fluminicola n. sp. 14, Fluminicola n. sp. 18, Fluminicola n. sp. 19, Fluminicola n. sp. 20, Fluminicola seminalis*, *Lyogyrus n. sp. 3,* and *Vorticifex n. sp. 1.*

The Columbia River drainage, home to *Lyogyrus n. sp 1, Lyogyrus n. sp 2*, and *Juga O n. sp. 2* has been extensively modified for a variety of uses and is listed as water-quality impaired for a plethora of parameters (ORDEQ 2008).

The Sacramento River system has been extensively modified by humans since the 1870's for irrigation, gold mining, and other uses (Frest and Johannes 1995). The Sacramento is currently listed as water-quality impaired due to mercury and unknown toxicity from abandoned mines and unknown sources (CEPA 2008). In 1991 the Cantara Spill of the pesticide metam sodium into the river had devastating effects on river fauna, including some of the petitioned species (see individual species accounts; Frest and Johannes 1997). The species *Fluminicola n. sp. 14, Fluminicola n. sp. 15, Fluminicola n. sp. 16, Fluminicola n. sp. 17, Fluminicola n. sp. 18, Fluminicola n. sp. 19, Fluminicola n. sp. 20, Fluminicola seminalis, Juga O n. sp 3, Lyogyrus n. sp. 3,* and *Vorticifex n. sp. 1* occur in the Sacramento River drainage. Willow Creek, one of the creeks where *Juga O n. sp 3* occurs, is listed for high temperature and copper and zinc contamination from acid mine drainage (CEPA 2008).

9. Dams and Diversions

Nearly 60 percent of the petitioned species (19/32) have experienced declines due to dams and water diversions (Frest and Johannes 1993, 1995). Dams have adversely impacted aquatic species, including freshwater mollusks, throughout North America (Lydeard et al. 2004) and in the Pacific Northwest (Frest and Johannes 1993, 1995, Pringle 2000). The development of dams on the lower Columbia, upper Klamath, and Pit

rivers have eliminated rocky substrate and free-flowing habitat and have degraded water quality for mollusks (Frest and Johannes 1993, Frest and Johannes 1998, Mac et al.1998). Inundation of spring and seep habitats, altered flow regimes, fragmentation of habitat, and degradation of water quality are all adverse impacts related to the construction and maintenance of dams and diversions (Frest and Johannes 1995, 1998, 2000, Hershler et al. 2003, USFS 2003).

Recent proposals for relicensing of hydroelectric developments on the Pit River present imminent threats to mollusks (USFS 2003). Although the USFS (2003) states that negative impacts of existing dams on the Pit River could be mitigated through current relicensing, the agency notes that the existence of the dams has "seriously impacted" aquatic mollusks in the Pit River (p. B-2). The USFS (2003) reported that any increases in flow would be minimal at best, leading to summer base flows of only 20 percent of what naturally occurred, indicating that future dam operation will continue to maintain radically unnatural stream flow conditions.

10. Spring Development and Destruction

Spring development and destruction has been identified as a major cause of mollusk extirpation in western North America (Frest 2002). Causes of spring destruction include livestock grazing, logging, and human exploitation such as troughing, capping, diverting for stock use, and appropriating for human water supplies (Frest 2002). In the Pacific Northwest, springs and streams support diverse and concentrated populations of mollusks, and modification and diversion of springs for use by livestock and humans has led to mollusk extirpation (Frest 2002, FEMAT 1993, p. IV-126). Spring developments result in erosion and substrate disturbance, reduce vegetative cover, and can cause streams to dry up, generally resulting in the loss of most to all of the spring's mollusk species (Frest and Johannes 1995, Frest 2002). Frest (2002) states:

> "Spring development generally results in loss of native freshwater mollusk species, particularly endemics. Effects include drying out of the original spring and spring meadow area; disruption of soil, rock, and vegetative cover; and increased stock visits, with accompanying trampling effects and accumulation of acidic manure and urine. Unless the source area is left intact and carefully protected, development can completely extirpate the native freshwater mollusks as well as reduce diversity in other animal and plant groups."

Spring developments have been identified as a threat to nearly 60 percent of the petitioned species (19/32) (Frest 2002, Frest and Johannes 1993, 1994, 1995, 1998, Duncan 2005b). The activities associated with spring development are especially harmful to species of *Fluminicola* and *Lyogyrus* because these snails are very sensitive to pollution, siltation, warming, and hypoxia (Frest and Johannes 1993). Terrestrial mollusks that are dependent on very wet microhabitat can also be detrimentally affected by spring development and destruction. Concerning threats to the species *Deroceras hesperium*, the Evening fieldslug, Duncan (2005b) states:

> "A major concern would be degradation of occupied habitat from activities that alter the normal moisture regime, especially shade and water inputs. Many of the habitats where this species is found are wetlands less than one acre in size, which do not receive the same riparian management as do larger riparian features. In addition, actions occurring at some distance from the riparian area may cause adverse effects to the hydrology. Depending on the type of spring or seep, determination of the recharge area of the aquifer supplying the water to the area may be necessary to determine whether activities outside of the riparian reserve may affect the flow rate of the spring."

B. Overutilization for commercial, recreational, scientific, or educational purposes:

The petitioned mollusk species are collected for scientific, educational, and survey purposes and in conjunction with other factors, this may pose increasing threats to the species. Burke et al. (1999) identify over-collection as a potential threat to four of the petitioned species, *Monadenia chaceana, M. fidelis minor, M. troglodytes troglodytes,* and *M. t. wintu.* In the Conservation Assessment for the Evening fieldslug, Duncan (2005b) cautions against inadvertent extirpation due to research activities: "*Deroceras hesperium* is a species needing much more careful study. Because it is known from very few sites, disturbance to occupied habitats for surveys or monitoring should be limited to no more than 5% of the area or be strictly regulated to prevent inadvertent extirpation by researchers and other curious people." The Conservation Assessment for *Pristiloma arcticum crateris* also recommends limiting disturbance during surveys to five percent of the area (Duncan 2005e). We recognize that scientific investigation and sampling are essential to gaining knowledge about these species and that the threat posed by collection is minor compared to habitat destruction and other factors.

C. Disease or predation:

As key components of the food web, mollusks are consumed by other invertebrates, fish, amphibians, reptiles, birds, and small mammals (South 1980, Churchfield 1984, Frest and Johannes 1993, Martin 2000). Although naturally preyed upon, the mollusks may be increasingly threatened by predation in conjunction with other impacts. To the extent that these species have been reduced by other factors, natural predation could magnify the risk of extinction. Duncan (2005b) lists predation as a threat to the petitioned species *Deroceras hesperium* especially in locally restricted areas. Concerning the petitioned species *Cryptomastix devia,* Kogut and Duncan (2005) write:

> "Concern about predators increases as habitat quality or quantity decreases. Up to three species of *Haplotrema* and *Ancotrema* (predatory snails that feed on snails, slugs, and other invertebrates) occur in the same habitats and in greater numbers than *C. devia*. Ground beetles (*Scaphinotus* sp.), specifically adapted for preying on snails, are common in northwest forests (White 1983; Kozloff 1976), and other insects as well as reptiles, amphibians, birds, and mammals also prey on them. Hiding and escape cover is provided by forest floor litter, including deep leaf

packs and fine and large woody debris. When habitat patches are limited in size and number, predators can easily focus hunting efforts and severely reduce *C. devia* populations. However, in good habitat with large numbers of hardwood patches, predators are a lesser threat to a population."

Habitat loss and fragmentation increases the risk of predation effects on the petitioned mollusks by both native and invasive species. The potential also exists for invasive species to introduce disease into native mollusk populations.

D. Other natural or human caused factors:

1. Pesticide Application

Herbicides, pesticides, and fungicides (hereafter "pesticides") are harmful to both aquatic and terrestrial mollusks (Brown 1978, Frest and Johannes 1995, 1997). Pesticides have been identified as a threat to 66 percent of the petitioned species (21/32) (Frest and Johannes 1993, 1995, 1998). Throughout the Pacific Northwest, pesticides are widely used in agricultural and silvicultural applications, landscaping, and roadside maintenance (reviewed in Everest et al. 2004). Pesticide contamination of Northwest streams and rivers is well documented (Everest et al. 2004). Mollusk mortality can result from either direct contact with pesticides or via ingestion of contaminated materials (Brooke 1991, 1993, Schuytema et al. 1994). Pesticide use to suppress hardwoods on commercial timberlands can harm mollusks directly via contamination and indirectly by reducing the availability of leaf liter (Kogut and Duncan 2005).

2. Invasive Species

Invasive species have strongly affected the distribution and abundance of North American freshwater mollusks (Strayer 1999b). The zebra mussel *(Dreissena polymorpha),* the Asian clam (*Corbicula fluminea),* and the New Zealand mudsnail (*Potamopyrgus antipodarum)* outcompete native mollusk species (Strayer 1999b). The New Zealand mudsnail, *Potamopyrgus antipodarum,* was first discovered in the mid-Snake River, Idaho in the 1980's. It is now rapidly spreading throughout the western USA and has become established in rivers in ten western states including California, Oregon, and Washington. To date, limited research has documented decreases in native macroinvertebrate populations in several rivers where the mudsnail has invaded. Its invasion has generated much concern about the potential effects it may have on native species, fisheries, and aquatic ecosystems in the western USA (New Zealand Mudsnail (*Potamopyrgus antipodarum*) in the Western USA 2007).

Alien crayfish and fishes such as the round goby and some sunfishes prey on native mollusks and affect their distribution and abundance (Hershler 1998, Hovingh 1999, Strayer 1999b). Invasive aquatic plants affect mollusks by altering the physicochemical environment, food availability, water quality, and contaminant cycling (Strayer 1999b).

Strayer (1999b) states that alien species "may be an increasingly important factor in (North American) molluscan distribution as new species arrive from other continents and established species spread throughout the continent." Both the spread of invasives and the loss of native species will likely be accelerated by global climate change (Sala et al. 2000, Zavaleta and Hulvey 2004).

In the Pacific Northwest, the introduction of nonnative species threatens both freshwater and terrestrial mollusks. Introduced mollusk species are a threat in terms of both competition, predation, and disease introduction. Invasive plants and other invasive organisms are a threat in terms of predation and ecosystem alteration (Burke et al. 1999). Invasive vegetation can alter preferred substrate conditions and reduce the availability of food and cover for snails and slugs (Burket et al. 1999, ORNHIC 2004). Exotic bird species potentially increase predation on terrestrial snails and slugs (Burke et al. 1999). Exotic plants that climb tree trunks degrade arboreal substrates for terrestrial snails that climb trees such as the Hoko vertigo (*Vertigo n. sp. 1*) (Burke et al. 1999). Nonnative species have been specifically identified as a potential threat to seven of the petitioned species, *Cryptomastix devia*, *C. hendersoni*, *Hemphillia burringtoni*, *Lyogyrus n. sp. 2*, *Vertigo n. sp. 1*, *Vespericola pressleyi*, and *Vespericola shasta* (Burke et al. 1999, ORNHIC 2004, Duncan 2005d, Kogut and Duncan 2005, Wainwright and Duncan 2005). *Cryptomastix hendersoni* is thought to be negatively impacted by nonnative trees and berry vines at low elevations sites along the Columbia River where invasive plants create heavy shade and greatly reduce the native herbaceous vegetation on which the snail depends for food and shelter (Duncan 2005a). Concerning *Cryptomastix devia*, Kogut and Duncan state:

> "Exotic slugs are increasing within the range of *C. devia*. To what extent these introduced species might compete with the native gastropods or buffer them from predation has not been demonstrated. Exotic species should be of concern because of the rapidity with which their populations increase. The mollusk fauna in most urban and suburban areas is now almost exclusively exotic species, and they are spreading into the forests, as documented in several cases in the Cowlitz and Cispus River drainages at sites containing *C. devia* populations."

3. Global Climate Change

Global climate change poses a significant threat to the petitioned mollusk species. During the 20th century, the average annual temperature in the Northwest increased by 0.6º - 1.7º C, and the average temperature is predicted to increase by 2.8º C by 2050, and by 4.1º-5.9º C by 2090 (Parson 2001). Warmer mean temperature will cause ecological zones to shift upward in latitude and altitude, and species' persistence will depend upon, among other factors, their ability to disperse to habitat with suitable microclimate conditions (Peters and Darling 1985). Terrestrial snails and slugs are extremely limited in their dispersal ability and are unlikely to be able to disperse to new habitat if the climatic conditions in their current ranges become unsuitable (Waggoner et al. 2006). Aquatic snails are also limited in their dispersal ability and range adjustments are thus unlikely for these species as well (Frest and Johannes 1995).

Climate change is expected to lead to increased frequency and intensity of drought (Field et al. 2007). Drought has already become more frequent and intense in the western United States, and vulnerability to extended drought is increasing as limited water resources are over-allocated due to population growth, economic development, and increasing agricultural, municipal, and industrial uses (Field et al. 2007). Higher air temperature and changes in the amount, form, and timing of precipitation are expected to significantly reduce snowpack in western United States (Field et al. 2007). From 1949 to 2004, the fraction of annual precipitation falling as rain instead of snow increased at three-quarters of weather stations in western U.S. mountain ranges (Field et al. 2007). The Pacific Northwest is expected to become hotter and drier in summer and warmer and wetter in winter which will lead to decreased snow pack and substantially decreased summer flows (Parson 2001). Decreased summer flows and increased air and water temperature will decrease dissolved oxygen availability for aquatic organisms (Field et al. 2007).

Increased frequency and intensity of drought will negatively impact both aquatic and terrestrial mollusks. Aquatic snails have narrow thermal and dissolved oxygen tolerances and will be detrimentally affected by reduced flow and higher water temperature (Hershler 1994, 1995, 1998, 1999, 2001, Frest and Johannes 1995). Terrestrial mollusks are dependent on moist microhabitat conditions and would be detrimentally affected by higher ground temperature and drier soil conditions (Solem 1974, Frest and Johannes 1995, 1998, 2000). The petitioned species *Monadenia troglodytes troglodytes* and *M. t. wintu* are especially vulnerable to increased summer temperatures:

> "The survival of mollusk species in semi-dry environments is especially dependent on having adequate refuge during the hot summer and cold winter months. An increase in temperature or decrease in moisture during the hot summer months is much more likely to adversely affect these species than those that live in a moist environment" (ORNHIC 2004).

The distributions of the petitioned species *Cryptomastix hendersoni* and *Vespericola Shasta* may already have been fragmented by climatic change (Burke et al. 1999, ORNHIC 2004).

Climate change is also expected to increase the intensity and occurrence of wildfire and to facilitate the spread of invasive species (Field et al. 2007), both of which are threats to the petitioned species and which are discussed above and below.

4. Fire and Fire Management Activities

In the western United States, wildfires are expected to occur with greater frequency and intensity as the climate warms, burning more often and consuming more area and more biomass (Field et al. 2007). Westerling et al. (2006) found that in response to a spring-summer warming of less than one degree Celsius, the wildfire season in the western U.S. has increased by 78 days in the last 30 years, and that burn durations of fires greater than 1000 ha in area have increased from 7.5 to 37.1 days. The forested area burned in the

western U.S. from 1987 to 2003 is 6.7 times the area burned from 1970 to 1986 (Westerling et al. 2006). Since 1980, an average of 22,000 km^2/yr has burned in U.S. wildfires, almost twice the 1920 to 1980 average of 13,000 km^2/yr (Schoennagel et al. 2004).

Wildfire and efforts to mitigate wildfire through prescribed burning have been identified as threats to 21 of the petitioned species (66%) (Frest and Johannes 1993, Burke et al. 1999, ORNHIC 2004). Fire can directly kill mollusks, destroy their habitat, and isolate populations (USDA USDI 2002). Fire can destroy logs and downed woody debris that provide mollusk microhabitat (Applegarth 1995). Effects of fire retardant and other chemicals on small snails are not known and may be deleterious, especially when dissolved in water (Duncan 2005b). Terrestrial snails and slugs evolved in a low intensity fire regime, but high intensity fires can reduce food levels below a critical threshold and lead to changes in soil moisture and texture that cannot be tolerated (ORNHIC 2004). Frest and Johannes state, "Modern fires effectively sterilize large areas of snails" (1993). Burned areas may remain unsuitable for snails and slugs for many years following the fire: "Sites that appear to be suitable habitat for many gastropods, but which have been burned in the past, support few if any species or individuals even after 50 years or longer" (USDA USDI 2000). Half of the known sites for *Oreohelix n. sp. 1* were destroyed in the 1994 Tyee Fire, and the snail has not recolonized the burned areas (Burke et al. 1999, ORNHIC 2004, Duncan 2005e). Concerning the species *Cryptomastix devia*, Kogut and Duncan (2005) state:

> "High intensity fire is particularly damaging to gastropod populations as it destroys both the snails and their habitats. Prescribed burning of slash piles can be a threat to *Cryptomastix devia* in bigleaf maple areas; there is at least one documented example of an escaped slash pile burn that resulted in the mortality of numerous *C. devia* adults at a bigleaf maple patch."

Based on obtained Survey and Manage documents, underburns and fuels reduction projects affected the habitat of at least four petitioned species including *Monadenia fidelis minor, Pristiloma arcticum crateris, Trilobopsis roperi,* and *Vespericola shasta.* Four of these projects included stated mitigation measures such as buffers to avoid harming mollusks. Mitigations were stated to be provided for *M. f. minor*. The cancellation of the SM program means that managers are no longer required to survey or mitigate for mollusk species, thus ongoing fire management projects threaten mollusk individuals and habitat.

5. Vulnerability of Small, Isolated Populations

Small, isolated populations are vulnerable to extirpation due to limited gene flow and risk of extinction from stochastic events (Allee et al. 1949, Goodman 1987, Lacy 1987, Brussard and Gilpin 1989, Hanski et al. 1996). The Affected Environment section of the FSEIS for the removal of Survey and Manage (2007) states:

> "Several different factors contribute to rarity and concerns for persistence in these animals (NWFP mollusks). Some of the species are confined to very narrow ranges in which subpopulations appear relatively well-connected demographically and genetically. However, habitat sufficiency is a serious concern due to habitat alteration or catastrophic events. Other species are found widely scattered over a large range, so range-wide habitat concerns are low, but likelihood of loss of some populations, connectivity among populations, and concern for normal biological function is high" (p. 246).

Many of the petitioned species now exist only in small isolated colonies due to strict habitat requirements, natural rarity, habitat loss and fragmentation, and other factors (Frest and Johannes 1993, 1995, 1996, 1998, 2000, Hershler and Frest 1996, Taylor 2003). Physical limitations, such as lack of mobility and naturally low population growth, heighten the susceptibility to stochastic events. Mollusk populations also tend to be highly concentrated, which increases the probability that a disturbance can lead to population extirpation (Frest and Johannes 1993). Because mollusks are naturally limited in their ability to recover from environmental catastrophe, severe population crashes could be irreversible (Frest and Johannes 1993, 1995, 1996, 1998, 2000, Lande 1993, Hanski et al. 1996, Hershler and Frest 1996, Taylor 2003). Mollusks are generally not capable of crossing unsuitable habitat to colonize new areas or to rescue extirpated populations, thus survival of individuals at known sites is critical to maintaining populations (USDA USDI 2002).

E. Inadequacy of existing regulatory mechanisms:

Existing regulatory mechanisms are completely inadequate to protect the petitioned species as none of them are afforded any substantial protection on private, state or federal lands. Ten of the species have only been detected on private lands. The mollusks that occur on federal lands were formerly protected by the Survey and Manage Program of the Northwest Forest Plan, but the suspension of the program leaves them vulnerable to extirpation. Some of the species are listed as Special Status Species by the FS and/or BLM, but this program does not provide any tangible protections for the species.

Northwest Forest Plan and Survey and Manage Program Background

In 1994 the Forest Ecosystem Management Assessment Team (FEMAT) was convened to develop alternatives for the conservation of old-growth forest ecosystems in the Pacific Northwest (western Oregon and Washington and northwestern California). The team's mission included the "maintenance or restoration of habitat conditions to support viable populations, well distributed across their current ranges, of species known (or reasonably suspected) to be associated with old-growth forest conditions" (Molina et al. 2006). The FEMAT analyses led to the development of the Northwest Forest Plan (NWFP), the geographical boundaries of which were determined by the range of the Northern Spotted Owl (*Strix occidentalis caurina*) on federal lands (23.7 million acres).

The NWFP created seven types of land allocations including Congressionally Reserved Areas, Late-Successional Reserves, Managed Late-Successional Areas, Adaptive Management Areas, Administrative Withdrawn Areas, Riparian Reserves, and Matrix lands, each with different management guidelines. Matrix lands were intended to provide for commercial timber harvest rather than to provide wildlife values, and as such "Matrix standards and guidelines do not adequately protect habitat components for mollusks" (USDA, USDI 2007). Reserves were intended to support viable populations of late-successional and old-growth associated species, but some rare species, including the petitioned mollusks, are not effectively protected by the reserve system (USDA USDI 2004).

Species assessments during NWFP development indicated that the plan's habitat provisions were not sufficient to support viable populations of some rare species. The FEMAT analyses determined that 404 species and four arthropod groups would need additional specific protection via mitigation guidelines to ensure their persistence in the plan area. The mitigation measures for these rare species were called the "Survey and Manage (SM) standards and guidelines" in the final Record of Decision (USDA USDI 1994). The SM program provided tangible protection to hundreds of rare, poorly known species of bryophytes, fungi, lichens, mollusks, and arthropods including taxa not typically considered for individual protection on federal lands (Molina et al. 2006). The SM program guidelines included: "(1) predisturbance surveys, where areas proposed for land management activities that could significantly negatively affect the species were surveyed to detect those present; (2) strategic surveys, designed to gain additional or sometimes basic knowledge about the species; (3) management of known sites to help provide a reasonable assurance of species persistence; and (4) adaptive management via an annual species review process" (Olson et al. 2007).

According to the FEMAT report, the options considered in the outcome assessment were less effective in providing for mollusks than for any other species group because of high degrees of endemism, rareness, and habitat specialization (Duncan 2005f). For the petitioned mollusk species, the FEMAT team determined, "the most important mitigation measure proposed for the species is to survey for them and provide additional mitigation as needed on a site-specific basis" (USDA, USDI 1994). Mitigation measures included management of known sites, pre-disturbance surveys, the adoption of buffer zones, and protection from grazing (USDA, USDI 1994). All of the petitioned species were managed by the guidelines of Categories 1 (manage known sites) and 2 (conduct surveys prior to habitat disturbing activities).

The 2007 cancellation of the SM program (USDA USDI 2007) leaves the petitioned mollusk species without any substantive protection on federal lands. Without required pre-disturbance surveys, the mollusks will likely remain undetected before projects occur that affect their habitat. For sessile animals like mollusks, the consequences of modifying their habitat could mean losing whole populations because they are restricted to small areas without the possibility of relocating. Further, because buffers are no longer required, even if the species were noticed, there are no regulations ensuring their protection.

The June 2007 Final Supplement to the 2004 Supplemental Environmental Impact Statement to Remove or Modify the Survey and Manage Mitigation Measure Standards and Guidelines (SMR FSEIS) assigns each SM species to one of four outcomes. An outcome is defined as "a reasoned determination of whether a particular species would be at high risk of extirpation" (p. 362). Ten of the 32 petitioned species were assigned Outcome 3, "Habitat, including known sites, is insufficient to support stable populations in the Northwest Forest Plan area" (p. 362). Two of the species were assigned Outcome 2, "Habitat, including known sites, is sufficient to support stable populations range-wide in the Northwest Forest Plan area, although there is insufficient habitat to support stable populations in a portion of the Northwest Forest Plan area" (p. 362), indicating that all of these species are potentially threatened or endangered in a significant portion of their range. The Outcome 3 species, species known to have insufficient habitat throughout their range, are: *Fluminicola n. spp. 15, 16, 17, 18, 19, 20, Fluminicola potemicus, Juga (O) n. sp. 3, Lyogyrus n. sp. 3,* and *Vorticifex n. sp. 1.* The Outcome 2 species are *Fluminicola seminalis* and *Monadenia chaceana* (SMR FSEIS p. 169). The removal of Survey and Manage jeopardizes all of the petitioned species, but for the twelve species assigned to Outcome 2 or Outcome 3, the risk of extirpation is heightened.

The petitioned mollusk species merit protection under the Endangered Species Act because it is known that the habitat available for them in reserves is not adequate to protect them from extinction. Ten of the species are only known from private lands. Although at least three of the petitioned species occur in reserves, a criterion for inclusion as a survey-and-manage species was that the reserve system and other provisions of the federal Northwest Forest Plan did not provide for species persistence (Olson et al. 2007). It is therefore specious to claim that the reserve system will adequately protect SM species without the program's mitigation measures. Molina et al. (2006) state:

> "Given the number of locations of the more rare species outside the late-successional reserves, it is not clear that the reserves alone suffice to provide habitat and geographic protection for all rare and poorly known LSOG-associated species in the Pacific Northwest."

The SM Removal FSEIS acknowledges that without the program, the reserve system alone will not protect rare mollusks from extirpation:

> "The analysis completed in 2000 and the 2001 Annual Species Review considered the protection provided to all of these species by the reserve network including Riparian Reserves. These reviews determined that for 34 (of 44 mollusks species in the NWFP area), 'The reserve system and other Standards and Guidelines of the Northwest Forest Plan do not appear to provide for a reasonable assurance of species persistence.'" (p. 248).

Not only is the habitat available in reserves insufficient to maintain viable mollusk populations, the activities that are permitted to occur in reserves are detrimental to snails and slugs. The 2002 Annual Species Review states:

> "Examples of management practices in Late-Successional Reserves and Riparian Reserves that may result in significant adverse effects without the provisions of the Survey and Manage program include: fuels treatment, thinning or selective group harvest which open the forest canopy, road construction, salvage of downed woody material, stream restoration projects that involve felling trees into channels for structure, hardwood/conifer conversion projects, mining, grazing, recreation, and development" (USDA USDI 2002).

For example, the Conservation Assessments for the Evening fieldslug and Crater Lake tightcoil, terrestrial species associated with riparian areas, states:

> "Sites for *Deroceras hesperium* are mostly on federally managed lands allocated for riparian protection. While this does not in itself ensure that these populations will be protected over time, it is a safeguard against their being impacted directly by certain management activities. They are still vulnerable to some activities, however, such as changes in the water table, grazing, prescribed fire, and possibly salvage or other silvicultural activities, as well as recreation that might establish high use (dispersed or developed) campsites on the occupied habitat of a small population (Duncan 2005b and e)."

Records obtained from Region 5 and 6 National Forests on SM mollusk species via FOIA documented 11 thinning and restoration projects in Riparian and Late-Successional Reserves with potential affects on mollusk species. Reeves et al. (2006) estimated that during the first ten years of the NWFP (1994-2004), silvicultural activities occurred on nearly 21,000 ha of riparian reserve. Although it is difficult to quantify the exact amount of timber harvested from reserves (Reeves et al. 2006), any ground-disturbing activity presents a substantial threat to sessile species such as mollusks and thus even species that occur in reserves are at risk of extirpation without mitigation measures.

The FSEIS for the removal of Survey and Manage states that eleven of the Outcome 2 and 3 mollusks can "expect significant benefits from the Aquatic Conservation Strategy (ACS) provisions if they occur on federal lands in the NWFP area" (p. 175). However, nine of the 17 petitioned aquatic snails do not occur on federal land at all, and only one of the petitioned aquatic species, *Lyogyrus n. sp. 2*, occurs exclusively on federal land. Of the Outcome 2 and 3 aquatic mollusks, *Fluminicola n. spp. 15, 16, 17, 19, 20, Juga (O) n. sp. 3, Lyogyrus n. sp. 3,* and *Vorticifex n. sp. 1* do not occur on federal land. *Fluminicola n. sp. 18* has one site on federal land (33% of known sites), *Fluminicola potemicus* has three (25% of known sites), and *Fluminicola seminalis* has five (33% of known sites).

Obviously the ACS does not protect the species that do not occur on federal land. For the species with occurrences on federal land, the ACS likely offers some protection in terms of water quality improvement and habitat protection, but these protections are limited, difficult to assess, and subject to political removal. In addition, some of the springs where mollusks could occur are too small to be included in maps and do not receive the level of protection given to larger aquatic features (Duncan 2005c). Furthermore, the BLM's Western Oregon Plan Revision, discussed in detail below, virtually eliminates ACS protections on BLM lands in Western Oregon.

In terms of the evaluating the effectiveness of the ACS, Reeves et al. (2006) state:

> "Quantitatively assessing ACS effectiveness continues to be challenging because of data availability and quality. First, the accuracy and quality of data on some activities are questionable. Data on important indicators of effectiveness, such as the amount of streams on federally managed lands with water quality and quantity problems and the volume of timber harvested in riparian reserves, are not regularly reported."

In terms of habitat protection and water quality, the SMR FSEIS states:

> "As aquatic snails, these species receive protection from the Aquatic Conservation Strategy. However, concerns for persistence remain. These concerns include factors that could directly or indirectly affect local populations while still meeting overall Aquatic Conservation Strategy goals, such as livestock grazing or activities outside the riparian buffer zone, particularly around small wetlands or springs where the riparian buffer covers only the extent of riparian vegetation. Local extirpation and species extinction of ecologically similar species in this family (Hydrobiidae) have been documented because of water diversion, livestock grazing, and groundwater withdrawal outside the riparian zone" (p. 252).

In sum, the ACS and habitat reserve system of the NWFP are not adequate to ensure the long-term persistence of the petitioned mollusk species because many occur on land outside of designated reserves, it is known that amount and distribution of habitat in the reserve system will not ensure their long-term persistence, and because activities are permitted in reserves that destroy and degrade mollusk habitat.

Special Status Species Program

The FSEIS for the removal of Survey and Manage states that former SM mollusks will receive some protection from being included in the Forest Service and/or Bureau of Land Management's Special Status Species Program (SSSP) (USDA, USDI 2007). Unlike the SSSP, however, the Survey and Manage guidelines provided tangible protection to mollusk species. Even the agencies themselves recognize that the SSSP program provides less protection than the SM guidelines, which they acknowledge "generally meet or exceed the requirements of the Special Status Species Programs" (USDA, USDI 2004). Special Status Species are not afforded any actual habitat protection; rather the agencies are only required to analyze the impacts of their actions on the mollusks as part of their duties under the National Environmental Policy Act (NEPA). This requirement in no way requires the agency to select an environmentally benign alternative, to survey for the species, or to mitigate the adverse impacts of projects and thus does not provide substantial protection to the mollusk species. Under the program, any protections afforded mollusks are entirely voluntary. Authority to disturb Special Status Species sites lies with the agency official who is responsible for authorizing the proposed habitat-disturbing activity (in Kogut and Duncan 2005). The BLM for example, concluded:

> "It continues to be the role of the line officer to determine the extent of the effort needed to complete pre-project evaluations and *whether or how* sites will be protected. Field level biologists and botanists make recommendations to the line officer, but the line officer is responsible for the decisions" (Information Bulletin No. OR-2004-145, 07/20/2004; emphasis added).

The BLM and FS developed Conservation Assessments for some former SM mollusk species. In the Conservation Assessments, under the "Managing in Species Habitat Areas" section, there is a discussion on "Management Considerations." "Management Considerations" are actions and mitigations that the deciding official *can* utilize as a means of providing for the continued persistence of the species' site. These considerations *are not required* and are intended as general information that field level personnel could utilize and apply to site-specific situations (Kogut and Duncan 2005, emphasis added).

The SSSP does not adequately protect the petitioned mollusk species because it provides no actual habitat protection, and even if it did, not all SM species are included in the program. Twenty-two of the petitioned mollusks are listed as Special Status Species (SSS) in either the FS or BLM program. Nine of the petitioned aquatic snails are not included in the program because the California Forest Service does not list unnamed species (SMR FSEIS p.175). One of the terrestrial mollusks, the Siskiyou Sideband (*Monadenia chaceana*), is listed as a Forest Service Special Status species in Oregon but not in California, even though 88% of its range is in California. Furthermore, the BLM's Western Oregon Plan Revision weakens protections for Special Status Species on BLM lands in western Oregon.

The Western Oregon Plan Revision

The Western Oregon Plan Revision (WOPR) proposed by the Bureau of Land Management (BLM) presents a substantial threat to the seven petitioned species which occur on BLM lands in Oregon:

1. Puget Oregonian, *Cryptomastix devia* (Salem BLM: Cascades RA, Marys Peak RA, Tillamook RA)
2. Evening fieldslug, *Deroceras hesperium* (Salem BLM: Cascades RA, Marys Peak RA, Tillamook RA)
3. Diminuitive pebblesnail, *Fluminicola n. sp. 3* (Medford BLM)
4. Nerite pebblesnail, *Fluminicola n. sp. 11* (, Medford BLM)
5. Siskiyou or Chace sideband, *Monadenia chaceana* (Lakeview BLM: Klamath RA; Medford BLM: Ashland RA, Grants Pass RA)
6. Crater Lake tightcoil, *Pristiloma arcticum crateris* (Eugene BLM: McKenzie RA, South Valley RA; Lakeview BLM: Klamath RA; Medford BLM: Butte Falls RA; Roseburg BLM: South River RA, Swiftriver RA; Salem BLM: Cascades RA)
7. Tehamana Chaparral, *Trilobopsis tehamana* (Lakeview BLM: Klamath RA; Medford BLM: Ashland RA, Grants Pass RA)

The stated purpose of the WOPR is to shift the dominant use of BLM lands to timber production in order to increase timber harvest levels: "The BLM is proposing to revise existing plans to replace the Northwest Forest Plan land-use allocations and management direction because the BLM's plan evaluations found harvest levels have not been achieving the timber harvest levels directed by existing plans" (p. 3). The WOPR will allow increased timber harvest in late-successional areas, decrease mollusk habitat, and increase habitat fragmentation.

In the Draft Environmental Impact Statement, the BLM selected Alternative 2 as the preferred alternative. Alternative 2 replaces the Northwest Forest Plan's late successional reserves (LSRs), with late-successional management areas (LSMAs). Whereas the LSR provision allowed no treatment of stands older than 80 years, the LSMA allows treatment "to promote the development of suitable habitat" (p. 110). This language permits increased timber harvest activities in former late successional reserves. Elements of the WOPR which threaten mollusks include changing the rotation to emulate the timber industry's short rotation practices (p. 111), and increasing the annual sale quantity of timber from 268 mmbf (under the No Action Alternative) to 727 mmbf under Alternative 2 (p. 112). Harvest acres are increased from 62,000 acres under the No Action alternative to 143,000 acres under Alternative 2 (p. 722). The amount of regeneration harvest acres increases from 38% under the no action alternative to 65% under alternative 2, the preferred alternative (p. 598). Alternative 2 admittedly "increases the risk of local extirpation for forest floor highly endemic wildlife species" and "decreases suitable wildlife habitat" (p. 112).

The WOPR DEIS weakens already meager protections for BLM Sensitive Species. Although the petitioned species that occur on BLM lands in Oregon are included in the Sensitive Species program, the language of the WOPR makes clear that timber harvest activities take precedence over species protection: "The BLM would accord specific protection to BLM sensitive or assessment species on O&C lands *where protection would not conflict with sustained yield forest management in areas dedicated to timber production*" (p. 14 -15, emphasis added). The BLM acknowledges that the WOPR puts Special Status Species at greater risk of population and habitat losses. Under the WOPR, Special Status Species would only be provided with conservation measures at sites that are not in the harvest land base unless twenty or fewer populations of a species are known to exist (p. 596):

> "Under the action alternatives, conservation measures from the BLM Special Status Species Policy would be applied on Public Domain lands and O&C lands that are not in the harvest land base. With the exception of the conifer habitat group, all other habitat groups occur primarily on Public Domain and O&C lands not in the harvest land base. Conservation measures would not be applied to populations of species in the conifer habitat group that occur within the O&C harvest land base unless 20 or fewer populations of a species are known to exist. Timber harvest including silvicultural treatments in young stands, hazardous fuels treatments, and road construction, are major activities that would affect populations in the conifer habitat group . . . The known populations of species in

> the conifer habitat group located in the harvest land base would be subject to greater risk of population and habitat losses through management actions"(p. 596).

Under these criteria, *Monadenia chaceana, Cryptomastix devia,* and possibly *Deroceras hesperium* would not be protected by the SSSP. The WOPR DEIS divides Special Status Species into five groups based on habitat requirements. Terrestrial mollusks, including *Cryptomastix devia* and *Monadenia chaceana,* are in Group 5, Forest Floor Associates, which the DEIS acknowledges will lose habitat under the WOPR:

> "Species in group 5 are comprised of amphibians and mollusk species associated with mature or structurally complex forests, upland, forest floor communities. These species respond to changes to canopy cover, down wood, and soil moisture. Regeneration harvests and the associated impact to adjacent forests would result in the loss of habitat. This is due to the breakage and movement of existing forest structure during harvest and the decreases in soil and down wood moisture levels due to increased light and wind penetration into adjacent stands" (p. 717).

To evaluate the effects of habitat degradation under the WOPR on forest floor species, BLM produced a model ranking habitat quality in response to increased timber harvest. The DEIS acknowledges that Alternative 2 scores low in terms of habitat quality and does not provide for the retention of legacy structures (downed wood and snags) which provide critical mollusk microhabitat:

> "Twenty random watersheds were modeled to evaluate the effects of regeneration harvests and legacy requirements on forest floor species. Structural stages from nonforest and stand establishment to structurally complex stands were scored based on habitat value. Differences between the alternatives in the amount of habitat within habitat quality categories 0 to 3 would occur as a result of legacy retention and the amount of harvesting activities. Since Alternatives 1 and 2 do not have legacy retention requirements, they would have more habitat with a 0 to 3 score compared to the No Action Alternative and Alternative 1. Legacy structures (downed wood and snags) are key habitat features in enabling forest floor species to maintain a presence in a stand when regeneration harvests occur" (p. 720 – 721).

The WOPR DEIS blatantly states that under the preferred alternative on certain lands conservation measures will not be applied and as a result some populations will not survive timber harvest activities:

> "Under the action alternatives, in regeneration harvests and partial harvests on O&C harvest base lands, few populations of species in the conifer forest habitat group would survive because of multiple fuels and silvicultural treatments associated with treating forests in the stand establishment structural stage classification within a 3 to 20 year period of time. This would also occur because no conservation measures under BLM special status species policy would be applied, except where populations of species are 20 or fewer" (p. 598).

The petitioned species *Deroceras hesperium, Fluminicola n. sp. 3, Fluminicola n. sp. 11*, and *Pristiloma arcticum crateris* are placed in Group 2 which the BLM describes as habitat specialists not expected to occur in areas subject to timber harvest. Group 2 species are "assumed to not be affected by the alternatives and are not further analyzed." Based on the habitat needs and reported threats to these species, however, even timber harvest adjacent to their habitat could degrade water quality, increase sun and wind exposure and risk of desiccation, and increase habitat fragmentation. These species are in fact highly likely to be affected by the proposed management changes in the WOPR because they are riparian- associated (*D. hesperium* and *P.a. crateris*) and aquatic species (*Fluminicola spp*.) and the WOPR drastically reduces the protections of the Aquatic Conservation Strategy.

By allowing higher levels of timber harvest, increasing habitat fragmentation, and destroying known sites of Sensitive Species, the BLM's WOPR increases the risk of extinction for patchily distributed rare mollusk species. For example, the Conservation Assessment for *Cryptomastix devia* states:

> "For species with patchy distribution, concerns for viability increase as habitat areas decrease in number and size toward a critical threshold. The probability of catastrophic loss of local or limited habitats increases, the quality of remaining habitats may decrease (especially if management is directed toward maintaining minimum quality or quantities), potential for deleterious effects of inbreeding increases, and chance of population loss from predation, pathogens, or other causes increases as population size decreases" (Kogut and Duncan 2005).

In sum, existing regulatory mechanisms are not adequate to protect the 32 species of snails and slugs presented in this petition. These endemic species currently have no tangible protection on federal, state, or private land.

VI. INDIVIDUAL SPECIES ACCOUNTS

This section provides information on the taxonomy, description, range, habitat requirements, status, known threats, and land management of the petitioned species. The species' descriptions provide a general overview and are not intended to be diagnostic. For consistency, the reported number of localities for each species is based on Table 2-13 (vol. 1, ch. 2, p. 92) in the June 2007 FSEIS for Survey and Manage Removal. The number of locations reported in this table differs from the number reported in other accounts for some species.

> **1. Canary duskysnail (*Lyogyrus n. sp. 3, Colligyrus convexus*)** (Hershler, Frest, Liu, and Johannes 2003)

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails). The Canary duskysnail was described by Hershler et al. (2003) and is a valid taxon.

Description. This very small snail (1.4 – 1.9 mm) has a thin yellow transparent shell sometimes with a brownish to dark brown or black coating which seldom covers the whole shell. The conch is subturbinate to low conical (Frest and Johannes 1999).

Range. The Canary duskysnail is an endemic species restricted to major springs of the Pit River Drainage in Shasta, Lassen, and Modoc counties, California (Frest and Johannes 1993). It is known from only one to seven sites. Frest and Johannes (1999) reported that locations could be possible in Lassen and Shasta National Forests near Fall River Mills and Hat Creek.

Habitat requirements. This snail occurs in shallow water in very large springs on the underside of loose but stable boulders and cobbles which often have encrusting red algae (Frest and Johannes 1999).

Status. The Canary duskysnail is ranked as critically imperiled (G1S1 (CA)) due to its restricted range, low number of occurences, and lack of protected locations (ORNHIC 2004). The Oregon Natural Heritage Information Center (ORNHIC) reports two sites for the species (2004), but the June 2007 Survey and Manage FSEIS reports only a single extant site. The species is Survey and Manage removal Outcome 3, high risk of extirpation due to insufficient habitat, and is not included in either the FS or BLM Special Status Species Program. Frest and Johannes (1993) suggest California and federal endangered listing status.

Known threats. The Canary duskysnail's habitat has been severely degraded by human activities including mining, logging, grazing, chemical pollution, road and railroad construction, and water diversions (Furnish and Monthey 1999). Dams, diversions, and spring developments have caused historical habitat loss and continue to threaten the species (Frest and Johannes 1993, 1995, Hershler et al. 2003, USFS 2003). Recent proposals for relicensing of hydroelectric developments on the Pit River pose imminent threats (USFS 2003). Water pollution is also a serious threat to the species (Frest and Johannes 1993, 1997). The Pit River is listed on the State of California's list of water quality limited segments because of organic enrichment and high nutrient levels from grazing and agriculture (CEPA 2008). Recreational developments and recreation activities may be negatively impacting the species and its habitat because known sites are near boat ramps, parking lots, trails, and footbridges.

Land management. There are no known occurrences of this species on federal land. Frest and Johannes (1999) suggest that the species might occur in the Lassen and Shasta National Forests.

2. Puget Oregonian *(Cryptomastix devia)*

Taxonomy. Order Stylommatophora (terrestrial slugs and snails), Family Polygyridae. The species was described by Gould in 1846.

Description. The Puget Oregonian is the largest Cryptomastix, measuring 18-25 mm. It has a depressed shell that is glossy yellowish to brown with irregular shallow spiral striae. It is distinguished by a distinct parietal tooth in the aperture.

Range. *Cryptomastix devia* occurred historically from Southern Vancouver Island, B.C. to the west end of the Columbia River Gorge in King, Clark, Skamania, and Thurston Counties in WA, and Multnomah Co., OR (Frest and Johannes 1993). It is currently found at 177 scattered locations in King and Thurston Counties, WA, and is predicted to occur at Fort Lewis and near Carson, WA (Frest and Johannes 1995c, ORNHIC 2004). Surviving colonies are made up of very few individuals, and only 13-40 occurrences are thought to have good viability (Frest and Johannes 1995, ORNHIC 2004).

Habitat requirements. The Puget Oregonian is found in late-successional forests and riparian areas at low to middle elevations (Frest and Johannes 1995). It prefers moist valleys, ravines, gorges, or talus sites near permanent or persistent water in areas not subject to frequent flooding, and is found under moss, ferns, in leaf litter, or under coarse woody debris such as downed logs (Frest and Johannes 1995, Kogut and Duncan 2005). This snail may be found in non-riparian habitat with sufficient moisture and is associated with hardwoods such as big leaf maple (*Acer macrophylum*) and understory plants such as swordfern (*Polystichum munitum)* interspersed in coniferous habitat (Kogut and Duncan 2005).

Status. The Puget Oregonian is critically imperiled in Oregon and imperiled range-wide and in Washington (G3S1(OR) S2(WA)) due to its restricted range, scattered sites, and low abundance (ORNHIC 2004). The species has been extirpated from many historical locations and is considered to be in "strong decline throughout its range" in terms of number of sites and numbers of individuals (Frest and Johannes (1995). It is a BLM Sensitive Species in Oregon and Washington and FS Special Status Species in Region 6. This snail was Survey and Manage Category A which required management of all known locations. Due to loss of historic sites, loss of habitat, continuing threats to remaining habitat, and rarity at extant sites, Frest and Johannes (1995) recommend state and federal listing.

Known threats. Because the Puget Oregonian is a regional endemic associated with old-growth forests, much of its habitat has been logged. Based on FOIA files obtained from national forests, during the Survey and Manage program this species was detected in nine timber sales and a commercial thinning. Buffers were stated to be provided for the snail during one of the timber sales, but based on SM requirements, mitigation measures were likely taken during all of the sales. The suspension of the SM program leaves the species without protection during future timber harvests. Grazing also threatens this snail, as do other activities that degrade riparian habitat (Frest and Johannes 1995). In addition, sites have been lost due to urbanization (Frest and Johannes 1995). This snail has also been detected in a campground, which makes recreation a threat for this species.

Kogut and Duncan (2005) report the primary threats to this species as forest management practices, habitat conversion for agriculture, urbanization, and other uses, and fire. In terms of additional threats they state, "Other threats may include vertebrate and invertebrate predators (i.e., predatory snails, and beetles), which can concentrate in isolated, small habitat patches where snails are vulnerable. In some forest stands, bigleaf maples can be suppressed by Douglas-fir and other conifers or lost as a result of selective thinning, leading to a long-term loss of habitat for the species. Harvest of special forest products (i.e., raking for mushrooms, firewood gathering, moss harvest from maple sites, collection of swordfern plants for ornamental transplant) are potential threats in limited habitats. Large numbers of invasive slugs have been documented in several *C. devia* sites on the Cowlitz Valley Ranger District, Gifford Pinchot National Forest, but the effects to this native snail have not been documented."

Land management. The majority of known locations for this species are on federal land (148/177) (SMR FSEIS 2007). The Inter-Agency Conservation Assessment for this species reports 178 locations, 141 of which are in the Cowlitz and Cispus River drainages of the Gifford Pinchot National Forest. It occurs within Late-Successional Reserves (LSRs) in the Lower Cispus Watershed, Cowlitz Valley Ranger District of the Gifford Pinchot NF, and within the edge of the Cispus Adaptive Management Area (AMA) (Burke 1996 unpublished report). It might occur in AMAs of the Olympic and Gifford Pinchot National Forests (USDA, Forest Service, and USDI Bureau of Land Management 1974: J2-307). It is also known from the vicinity of the Mount Baker-Snoqualmie and Mount Hood National Forests, the Salem BLM District, and the Columbia River Gorge National Scenic Area. It is expected to occur on the Wenatchee National Forest. Many of the historical sites for this species are in the area of Seattle and its suburbs. It might still occur in a few parks where natural forest stands exist, but it is likely that most historic sites have been developed.

3. Columbia Oregonian *(Cryptomastix hendersoni)*

Taxonomy. Order Stylommatophora (terrestrial slugs and snails), Family Polygyridae. The species was described by Pilsbry in 1928.

Description. *Cryptomastix hendersoni* is 15- 20 mm in diameter and has a brown shell with somewhat depressed spires (Burke et al. 1999).

Range. The Columbia Oregonian is an endemic species confined to a narrow range around the Columbia River**.** It historically occurred in parts of the central and eastern Columbia River Gorge in Hood River, Wasco, and Sherman Counties, OR, and in Skamania and Klickitat Counties, WA. (Frest and Johannes 1993). The species still survives in Klickitat County, WA., and Wasco and Sherman Counties, Oregon. Most locations are found in the Columbia River Gorge National Scenic Area (Frest and Johannes 1993). It also occurs on upland locations on the Mt. Hood National Forest, and the montane populations might represent a separate subspecies (Duncan 2005a).

Habitat requirements. The Columbia Oregonian is a riparian associate generally found within 100 meters of streams, seeps, and springs in moist talus, leaf litter, or under logs and debris (Kelley et al. 1999). It also occurs at mid-elevation, non-riparian sites in mature upland hemlock forests where sufficient moisture and coolness are provided by woody debris and a relatively closed canopy (Duncan 2005a).

Status. *Cryptomastix hendersoni* is critically imperiled throughout its range (G1G2, S1S2 (OR), S1(WA)) due to its low number of occurrences and the unlikelihood that new locations will be found (ORNHIC 2004). The species is exhibiting a downward trend in both distribution and abundance, and there have been known population extirpations (Frest and Johannes 1995). It has experienced a decline of 10-30% in population and/or range (ORNHIC 2004). It is a BLM Sensitive Species in Oregon and FS Special Status Species in Region 6. It is a Bureau of Land Management Tracking Species in Washington. This snail was Survey and Manage Category A, which required management of all known locations. Frest and Johannes (1993) recommend state and federal endangered listing.

Known threats. The Columbia Oregonian is sensitive to any habitat disturbance that causes soil compaction or reduces soil moisture (ORNHIC 2004). Most of its known habitat has been fragmented by major highways including I-84/US 30 and WA 14 and by Burlington Northern and Union Pacific railroad tracks (Frest and Johannes 1995). The species is threatened by urbanization from the surrounding cities of Portland, the Dalles, and Hood River, and by recreation and recreational developments in the Columbia River Gorge National Scenic Area. Other documented threats to the species include logging, fire, grazing, agriculture, roadside spraying, climate change, and nonnative species (Frest and Johannes 1995, Burke et al. 1999, ORNHIC 2004). Along the Columbia River the species is threatened by the impoundment or diversion of spring-fed streams and water pollution and loss of edible plants due to grazing (Duncan 2005a). Upland locations of this species are threatened by activities that reduce canopy cover or remove old woody debris (Duncan 2005a). Based on FOIA records obtained from national forests on Survey and Manage mollusks, this snail was detected at four timber sales and a road maintenance project. One of the timber sales included stated buffers to protect the species. The suspension of the SM program means that mitigation measures will no longer be provided for this or other rare mollusks during timber harvest and other activities. The FSEIS for the removal of the Survey and Manage provisions acknowledges that some known sites for this species are likely to be lost without the program's protections (p. 249). The ORNHIC (2004) considers threats to this species to be moderate to severe and imminent for a significant (20-60%) part of the population.

Land management. The SMR FSEIS reports 22 total sites for the Columbia Oregonian, 18 of which are on federal land (2007). There are 13 known sites in the Columbia River Gorge from the Dalles to Rufus (ORNHIC 2004). Duncan (2005a) reports that the interagency regional database contains a total of 45 documented locations for this species, 17 of which represent upland locations on the Mt. Hood National Forest.

4. Evening fieldslug *(Deroceras hesperium)*

Taxonomy. Order Stylommatophora (terrestrial slugs and snails), Family Limacidae. The species was described by Pilsbry in 1944.

Description. The Evening fieldslug is approximately 16 mm long. The mantle is brown with light spots, and the rest of the body is a lighter brown with faint brown spotting (Burke et al. 1999).

Range. The historic distribution of *Deroceras hesperium* ranged from the western Cascades to the Pacific Ocean, beginning at the Lower Columbia River in Oregon to Vancouver Island in British Columbia (Frest and Johannes 1993). The species is currently distributed in three general areas: northwestern Oregon, the northern Olympic Peninsula, and the northeast coast of Vancouver Island (Burke et al.1999).

Habitat requirements. The Evening fieldslug is one of the least known slugs in the Western United States (Burke et al. 1999). It has been described as a "truly rare species" (ORNHIC 2004). It has been found in low to mid-elevation forests with hemlock, grand fir, maples, ferns, mosses, black cottonwood, spruce, and salmonberry (Branson 1977). Like other slugs, it probably uses moist talus, liter, debris, and ground vegetation. It requires very moist microhabitat and has been associated with riparian areas and perennially wet meadows in forested habitats (Burke et al. 1999, Duncan 2005b). Duncan (2005b) states, "Because of the apparent need for stable environments that remain wet throughout the year, suitable habitat may be considered to be limited to moist surface vegetation and cover objects within 30 m. (98 ft.) of perennial wetlands, springs, seeps and riparian areas. Areas with coastal fog may allow the species to occupy habitats farther from open water."

Status. The Evening fieldslug is critically imperiled in Oregon and Washington and imperiled rangewide (G2S1 (OR) S1 (WA)) due to its low number of occurrences (20) and little likelihood of new detections (ORNHIC 2004, 2007). It is a BLM Sensitive Species in Oregon and a FS Region 6 Special Status Species. The species was Survey and Manage Category B which required management of all known sites. The species has experienced substantial declines (50-75%) (ORNHIC 2004), and Frest and Johannes (1993) recommend federal and state listing.

Known threats. The greatest threat to the Evening fieldslug is habitat loss due to human activities (Burke et al. 1999). Because the species is so rare and so poorly known, any activity that destroys or degrades its habitat presents serious threats to the survival of the species (ORNHIC 2004). Based on information from FOIA Survey and Manage documents from national forests, this species was detected at a timber sale, a road maintenance project, and a grazing allotment. Duncan (2005b) states that the primary threats to this species are "habitat loss from draining and conversion of wet meadows for agricultural, urbanization, grazing, forest management and other uses; and from fire. Natural threats may include ingrowth of conifer or hardwood tree and shrub species in historically herbaceous habitats, changes in hydrology that reduce the availability of

water in wetlands, and exposure to vertebrate and invertebrate predators (i.e., predatory snails and beetles), especially in locally restricted areas." Duncan also identifies recreation as a threat to the species, particularly off-road vehicle use, camping on occupied sites, firewood gathering, and snowmobiling or skiing that compacts snow and litter and potentially leads to freezing.

Land management. There are 20 known sites for *Deroceras hesperium*, 14 of which are on federal land (SMR FSEIS 2007). One known site is near a campground in Olympic National Park and one is near the Makah Indian Reservation where protection is uncertain (ORNHIC 2004). One site is in Canada and has unknown protective status (ORNHIC 2004). Duncan (2005b) reports that there are 19 known sites for this species documented in the interagency species database, and that random grid surveys across the Northwest Forest Plan area in Oregon and Washington, conducted under the Survey and Manage program, did not locate this species in any of 498 plots searched. Duncan (2005b) states: "The current situation of four historic locations that occurred in the Portland area is unknown, but they are not presumed extant. None of the other currently known sites are in Late Successional Reserves or other withdrawn lands; federal land sites are all located within Matrix land allocations with most within riparian reserves. Many sites occupied by this species are associated with wetlands less than one acre in size, which do not receive the same extent of riparian reserve management as do larger water bodies. In these sites the species may occur outside of the area where riparian reserve management is generally applied."

5. Tall pebblesnail *(Fluminicola n. sp. 2)*

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails). The species was identified as *Fluminicola n. sp. 2* in Frest and Johannes (1996).

Description. The Tall pebblesnail is small to moderately sized (3.6-5.0 mm height; 2.7-3.1 mm width) with a tall conical shell and evenly black body, tentacles, and mantle (Frest and Johannes 1999, Duncan 2005c).

Range. The Tall pebblesnail is only known to occur at a single site, Harriman Spring, which drains into Upper Klamath Lake, Klamath County, Oregon (Furnish et al.1997).

Habitat requirements. The single site where *Fluminicola n. sp. 2* occurs is a large, very cold, oligotrophic spring with cobble-gravel substrate and depth seasonally ranging from a few centimeters to a meter. The spring has large colonies (from 1-10 cms in diameter) of the blue-green alga *Nostoc pruniformes*. This snail likely feeds by grazing on periphyton and perilithon (Duncan 2005c).

Status. The Tall pebblesnail is critically imperiled (G1S1 (OR)) because it occurs at only a single unprotected location (ORNHIC 2004). Intensive survey efforts have not led to new detections (USDA, USDI 2007). It is a BLM Sensitive Species in Oregon and a FS Special Status Species in Region 6. Frest and Johannes (1993) state that this species should be federally and state listed as endangered.

Known threats. Because this snail occurs at only one site, any habitat-disrupting activity could cause the species to become extinct. The springs draining into Upper Klamath Lake have been impacted by road building, grazing, irrigation and water diversions (Furnish and Monthey 1999). This species is also threatened by dredging, log storage and transport, eutrophication and pollution associated with agricultural, urban, and industrial pollution, and lake level fluctuation (Duncan 2005c). ORNHIC (2004) categorizes threats to this species as severe and imminent.

Land management. The single known location for this species is on private land near the Winema National Forest (ORNHIC 2004).

6. Diminuitive pebblesnail *(Fluminicola n. sp. 3)*

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails).

Description. The height and width of *Fluminicola n. sp 3* are almost equal (2.4 mm height and 1.8-2.0 mm width). It is small for the genus with a moderately thick low conical shell that is consistently coiled and semitransparent (Frest and Johannes 1999).

Range. The Diminuitive pebblesnail occurs at six sites in spring complexes in the middle Klamath River Drainage, below upper Klamath Lake and above Copco Reservoir in Klamath County (Frest and Johannes 2000). Previously reported sites in California are now believed to be erroneous (SMR FSEIS 2007).

Habitat requirements. *Fluminicola n. sp. 3* is found in shaded areas in exceptionally cold springs and their outflows. This species is a perilithon and periphyton grazer and is found only in areas with excellent water quality, gravel-boulder substrate, and very clear flowing water (Frest and Johannes 1995).

Status. The Diminuitive pebblesnail is critically imperiled (G1S1 (CA) (OR)) because of its restricted range, low number of occurrences, and lack of protected locations (ORNHIC 2004). It is a BLM Sensitive Species in Oregon and a FS Special Status Species in Region 6. Frest and Johannes (2000) recommend listing this species as endangered at the state and federal level.

Known threats. Known threats to this snail include logging, grazing, water diversions, water pollution, development, and road construction (Frest and Johannes 1999, Furnish and Monthey 1999). The ORNHIC classifies threats to this species as substantial and imminent for most (> 60%) of the population, occurrences, or area (2004). The 2007 FSEIS for the removal of the Survey and Manage Program states, “Rarity, limited distribution and narrow range could mean that the loss of sites could result in habitat insufficient to support stable populations” (p. 251). In addition, the Diminuitive pebblesnail has high intrinsic vulnerability to extirpation because it has a low

reproductive rate and is a habitat specialist with very narrow ecological specificity (ORNHIC 2004).

Land management. Three of six known sites for *Fluminicola n. sp. 3* occur on federal land including the Medford District BLM. Other sites are located on private land owned by Weyerhauser and Timberlands (ORNHIC 2004, Frest and Johannes 2000, SMR FSEIS 2007). The species might occur on lands that are part of the Yreka, California municipal water supply. There are no known protected occurrences (ORNHIC 2004).

7. Shasta springs pebblesnail (*Fluminicola n. sp. 16)*

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails). The species has also been described as *Fluminicola n. sp. 4* (Frest and Johannes 1993).

Description. The Shasta springs pebblesnail has an adult height of about 3.5 mm and a low conic spire with approximately four whorls and a blunt protoconch. The shell is green and moderately thick and the body is dark gray except for the base of the foot. The operculum is dark orange-brown (Furnish and Monthey 1999).

Range. *Fluminicola n. sp. 16* is an Upper Sacramento River endemic found only in the Shasta Springs area.

Habitat requirements. *Fluminicola n. sp. 16* generally occurs in lower portions of large cold springs, among Rorippa beds (watercress) and on cobbles and pebbles. It may be associated with other endemic Fluminicola species, or with *Juga (O.) n. sp. 3.* The species has been found at sites ranging from 744-890 m in elevation (Frest and Johannes 1999).

Status. The Shasta springs pebblesnail is critically imperiled (G1S1 (CA)) due its restricted range, low number of occurrences (17), and lack of protected locations (ORNHIC 2004). It is not included in FS or BLM Special Status Species Programs. It is Survey and Manage removal Outcome 3, insufficient habitat to support stable populations (SMR FSEIS 2007). Because of the species' limited occurrence, habitat loss and/or degradation, and ongoing threats to the species, Frest and Johannes (1993b, 1995c) recommend listing the Shasta Springs pebblesnail as endangered under the Endangered Species Act.

Known threats. Much of the Shasta springs pebblesnail's habitat has been destroyed and/or degraded as a result of water diversions, impoundments, and spring developments. The species is also threatened by domestic livestock grazing, logging, mining, road construction, and water pollution (Frest and Johannes 1993b, 1995c, 1997c, Furnish and Monthey 1999). The species is reported to have been negatively impacted by the 1991 Cantara Spill of metam sodium into the Sacramento River (Frest and Johannes 1997c). *Fluminicola n. sp. 16* has high intrinsic vulnerability to extirpation due to strict ecological requirements and slow reproductive rate (ORNHIC 2004).

Land management. There are 17 known locations for the species, none of which are on federal land.

8. Nerite pebblesnail *(Fluminicola n. sp. 11)*

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails).

Description. *Fluminicola n. sp 11* is small to medium-sized for the genus (3.0-3.3 mm height; width 2.4-2.8 mm) with an opaque, solid white shell and a continuously coiled spire (Frest and Johannes 1999).

Range. This species is endemic to the Klamath River drainage in Jackson County, Oregon (Frest and Johannes 1999).

Habitat requirements. The Nerite pebblesnail is found in large cold springs with gravel or boulder substrate and exceptional water quality (Frest and Johannes 1999).

Status. The Nerite pebblesnail is critically imperiled throughout its range (G1S1 (OR)) due its limited number of occurrences (19) and lack of protected locations (ORNHIC 2004). Frest and Johannes (1999) suggest state and federal listing as endangered. It is included in the BLM's Special Status Species Program.

Known threats. *Fluminicola n. sp 11* is threatened by logging, grazing, and water diversions (Frest and Johannes 1999, ORNHIC 2004). Threats are reported to be substantial and imminent for most of the population or area (>60%) (ORNHIC 2004). The FSEIS for the removal of the Survey and Manage program states, "Rarity, limited distribution, and narrow range could mean that the loss of sites could result in habitat insufficient to support stable populations" (SMR FSEIS p. 252).

Land management. Fifteen of 19 known sites for this species are on federal land. It occurs on Medford District BLM lands, on private lands owner by Weyerhauser, and on lands that are part of the Yreka, California municipal water supply (Frest and Johannes 1999).

9. Potem pebblesnail (*Fluminicola potemicus, Fluminicola n. sp. 14*)

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails). Formally described in Hershler et al. 2007. The species has previously been identified as *Fluminicola n. sp. 2* (Frest and Johannes 1995c).

Description. *Fluminicola n. sp. 14* has a medium-high conic spire, ranging to approximately 4 mm in height, and adults have about 4.5 whorls. The shell is thick and green, and the protoconch is small and flattened (Frest and Johannes 1995).

Range. The Potem pebblesnail is endemic to the upper Sacramento River and Pit River drainages of northern California (Frest and Johannes 1995c). Despite intensive survey efforts at 231 sites, the species has been detected at only 12 locations (Frest and Johannes 1995, Furnish et al.1997, ORNHIC 2004).

Habitat requirements. *Fluminicola n. sp. 14* is found in small, shallow, perennial cold springs and spring runs that are shaded (Frest and Johannes 1999). The species has been found at sites ranging from 439-963 m in elevation (Furnish and Monthey 1999).

Status. The Potem pebblesnail is critically imperiled (G1G2, S1S2 (CA)) due to its restricted range, limited number of occurrences, and lack of protected locations (ORNHIC 2004). It is not listed in FS or BLM Special Status Species Programs. It is Survey and Manage removal Outcome 3, insufficient habitat to support stable populations (SMR FSEIS 2007). Because of the species' limited occurrence, habitat loss and/or degradation, and ongoing threats, Frest and Johannes (1993, 1995) recommend state and federal listing for the Potem pebblesnail.

Known threats. Habitat throughout the Potem pebblesnail's range has been destroyed and/or degraded as a result of water diversions, impoundments, and spring developments (Frest and Johannes 1995, 1997, Hershler et al. 2003). The species is also threatened by domestic livestock grazing, logging, mining, road construction, and water pollution (Frest and Johannes 1993, 1995, 1997). The species is reported to have been negatively impacted by the 1991 Cantara Spill of the pesticide metam sodium into the Sacramento River (Frest and Johannes 1997). ORNHIC (2004) considers threats to this species to be substantial and imminent. The Potem pebblesnail has high intrinsic vulnerability to extirpation due to its low reproductive rate (ORNHIC 2004).

Land management. There are 12 known locations for the species, three of which are on federal land (SMR FSEIS 2007). There is at least one known location in the Shasta National Forest (Frest and Johannes 1999). The species might occur in the Whiskeytown-Shasta-Trinity National Recreation Area and other areas managed by Lassen National Forest.

10. Flat-top pebblesnail (*Fluminicola n. sp. 15*)

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails). The species has also been identified as *Fluminicola n. sp. 3* (Frest and Johannes 1995c).

Description. *Fluminicola n. sp. 15* has a tall conic spire with flattened, even whorls and a large, flat protoconch. The shell is comparatively thin, translucent, and yellow. Adults have about 4 whorls and a height of 2.5 mm. The body and mantle are colorless (Frest and Johannes 1995).

Range. The Flat-top pebblesnail is an Upper Sacramento River endemic in Shasta County, California. It is known to occur at four spring sites on both sides of the Sacramento River at Shasta Springs and Mossbrae Falls (Frest and Johannes 1993, 1995).

Habitat requirements. *Fluminicola n. sp. 15* is found in cold perennial springs. It is associated with aquatic vegetation including water cress (*Rorippa sp.*), monkey flower (*Mimulus sp.*), horsetail (*Equisetum sp.*), pondweed (*Potamogeton filiformis*), mosses, and lichens. Occupied sites range in elevation from 439-1375 m (Furnish and Monthey 1999).

Status. The Flat-top pebblesnail is critically imperiled (G1S1 (CA)) due its restricted range, limited number of occurrences (4), and lack of protected locations (ORNHIC 2004). It is not included in FS or BLM Special Status Species Programs and is Survey and Manage removal Outcome 3, insufficient habitat to support stable populations (SMR FSEIS 2007). Frest and Johannes (1993) suggest state and federal listing for the species because of its rarity and because most of the springs in its range have been destroyed.

Known threats. Much of this snails habitat has been destroyed and/or degraded as a result of water diversions, impoundments, and spring developments (Frest and Johannes 1993, 1995, 1997). These activities, in addition to domestic livestock grazing and water pollution, pose ongoing threats to the species and its habitat (Frest and Johannes 1993, 1995, 1997). The species is reported to have been negatively impacted by the 1991 Cantara Spill of metam sodium into the Sacramento River (Frest and Johannes 1997).

Land management. The Flat-top pebblesnail occurs at only four sites, none of which are on federal land (SMR FSEIS 2007).

11. Disjunct pebblesnail (*Fluminicola n. sp. 17*)

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails).
The species has also been identified as *Fluminicola n. sp. 5* (Frest and Johannes 1995c).

Description. The Disjunct pebblesnail has been described as "spectacular" (Furnish and Monthey 1999). It is moderately sized (3.3 mm) with a dark green shell that sometimes has whitish streaks. It has a grey-dusted body and a black mantle. The spire is flat-topped and then normally coiled for about 1-1.5 additional whorls. The remaining two whorls are distinctly disjunct, and the final whorl is strongly descending. All of the whorls are strongly convex except for the first one (Furnish and Monthey 1999).

Range. *Fluminicola n. sp. 17* is an Upper Sacramento River endemic and is known from only 2 – 3 sites in the Shasta Springs area (Furnish and Monthey 1999).

Habitat requirements. The Disjunct pebblesnail is found in cold perennial springs with aquatic vegetation such as water cress (*Rorippa sp.*), monkey flower (*Mimulus sp.*),

horsetail (*Equisetum sp.*), pondweed (*Potamogeton filiformis*), mosses, and lichens. Occupied sites range in elevation from 439-1375 m (Furnish and Monthey 1999).

Status. The Disjunct pebblesnail is critically imperiled (G1S1 (CA)) due to its restricted range, limited number of occurrences (2-3), and lack of protected locations (ORNHIC 2004). There are only 2 - 3 known sites for the species (SMR FSEIS 2007). It is not listed in FS or BLM Special Status Species Programs, and is Survey and Manage removal Outcome 3, insufficient habitat to support stable populations. Because of the species' limited occurrences, habitat loss and/or degradation, and ongoing threats to the species, Frest and Johannes (1993b, 1995c) recommend listing the Disjunct pebblesnail as endangered federally and in California.

Known threats. Much of the habitat for *Fluminicola n. sp. 17* has been destroyed and/or degraded as a result of water diversions, impoundments, and spring developments (Frest and Johannes 1993b, 1995c, 1997c). The species is also threatened by domestic livestock grazing and water pollution (Frest and Johannes 1993b, 1995c, 1997c). The species is reported to have been negatively impacted by the 1991 Cantara Spill of metam sodium into the Sacramento River (Frest and Johannes 1997c).

Land management. The Disjunct pebblesnail is confined to 2 – 3 sites in the Shasta Springs area of the Upper Sacramento River. There are no known locations on federal land (SMR FSEIS 2007).

12. Globular pebblesnail (*Fluminicola n. sp. 18*)

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails). The species has also been identified as *Fluminicola n. sp. 6* (Frest and Johannes 1995c).

Description. *Fluminicola n. sp. 18* is small (2.5 mm) with approximately four even whorls that are convex after the protoconch. The shell is thin, yellow, and semi-translucent, the body and mantle are pigmentless, and the eye spots are large (Furnish and Monthey 1999).

Range. The Globular pebblesnail is known from only three sites in the upper Sacramento and Pit River drainages (ORNHIC 2004).

Habitat requirements. *Fluminicola n. sp. 18* uses small perennial springs and spring headwaters.

Status. The Globular pebblesnail is critically imperiled due to its restricted range, low number of occurrences (3), and lack of protected locations (G1S1 (CA)) (ORNHIC 2004). It is not included in FS or BLM Special Status Species Programs, and it is Survey and Manage Removal Outcome 3, insufficient habitat to support stable populations. Frest and Johannes (1993b, 1995c) recommend listing the Globular pebblesnail as endangered federally and in California.

Known threats. *Fluminicola n. sp. 18* has been negatively impacted by water diversions, impoundments, and spring developments (Frest and Johannes 1993b, 1995c, 1997c, Hershler et al. 2003). The species is also threatened by grazing and water pollution and was detrimentally affected by the 1991 spill of the pesticide metam sodium into the Sacramento River (Frest and Johannes 1993b, 1995c, 1997c).

Land management. There are three known locations for the Globular pebblesnail, one of which is in a Designated Conservation Area (DCA CD-82) in the Shasta National Forest.

13. Umbilicate pebblesnail (*Fluminicola n. sp. 19*)

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails). The species has also been identified as *Fluminicola n. sp. 7* (Frest and Johannes 1995).

Description. *Fluminicola n. sp. 19* has a low conic spire with a large flat protoconch and very blunt apex. The lower whorls are strongly convex, and the shell is thin and green with occasional distinct white spiral streaks on the early whorls. The body and mantle are dark. Adults are approximately 4.3 mm in height with 4-4.5 whorls (Furnish and Monthey 1999).

Range. The Umbilicate pebblesnail is a local endemic known from only a single large spring that is part of the source of Hat Creek in the Pit River drainage of northern California (Frest and Johannes 1995).

Habitat requirements. *Fluminicola n. sp. 19* occurs in a single, cold, spring pool and outflow complex with aquatic vegetation including water cress (*Rorippa sp.*) and speedwell (*Veronica sp.) (*Furnish and Monthey 1999).

Status. The Umbilicate pebblesnail is critically imperiled because it occurs at only a single, unprotected location (G1S1 (CA) (ORNHIC 2004)). It is not included in FS or BLM Special Status Species Programs, and is Survey and Manage Removal Outcome 3, insufficient habitat to support stable populations. Frest and Johannes (1993) state, "Listing as endangered federally and in California is justified. We have not found the species at other locations in the same creek drainage as the only known site, nor elsewhere in the Pit drainage."

Known threats. Because this snail occurs at only a single location, any alteration to its habitat could cause the species to become extinct. Specifically, *Fluminicola n. sp. 19* is threatened by water pollution, water diversions, impoundments, spring developments, and grazing. In addition, the single spring complex in which the species occurs has been impacted by road construction and human traffic (Frest and Johannes 1993b, 1995c, 1997c, Hershler et al. 2003).

Land management. ORNHIC (2004) reports that the single known site for this species is in Lassen National Forest in Shasta County, California. The FSEIS for the removal of Survey and Manage reports that there are no known occurrences on federal land (p. 169).

14. Lost Creek pebblesnail (*Fluminicola n. sp. 20*)

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails). The species has also been identified as *Fluminicola n. sp. 8* (Frest and Johannes 1995).

Description. The Lost Creek pebblesnail has a moderately tall (3.4 mm) conic spire with about 4.5 whorls at maturity. The apex is blunt and the protoconch is large and flat. The shell is thin and greenish, sometimes with white streaks. The upper surface of the body is gray and the mantle is black (Furnish and Monthey 1999).

Range. *Fluminicola n. sp. 20* is known only from Lost Creek, a single spring-fed creek in Lassen National Forest, Shasta County, California (Frest and Johannes 1995).

Habitat requirements. *Fluminicola n. sp. 20* lives in swift flowing water, generally near shore, on sand-cobble substrates and aquatic plants including watercress (*Rorippa sp.)* and water hemlock (*Cicuta sp.*) (Furnish and Monthey 1999).

Status. The Lost Creek pebblesnail is critically imperiled (G1S1 (CA)) because it is known from only one unprotected creek (ORNHIC 2004). It is not included in FS or BLM Special Status Species Programs, and is Survey and Manage Removal Outcome 3, insufficient habitat to support stable populations. Frest and Johannes (1993b, 1995c) recommend listing the Lost Creek pebblesnail as endangered federally and in California.

Known threats. *Fluminicola n. sp. 20* has high intrinsic vulnerability to extirpation because of its life-history characteristics including high annual population turnover and extremely limited dispersal abilities (ORNHIC 2004). Threats to the species include water pollution from chemical spills and from sewage contamination due to grazing and human recreation. A small-scale hydropower development on Hat Creek and existing dams on the Sacramento River and the Pit River have caused extensive destruction of aquatic snail habitat in the past by slowing flow and increasing temperature and sedimentation. The species is also threatened by excessive sedimentation from logging, mining, road and railroad grade construction, and grazing (Frest and Johannes 1999, Furnish and Monthey 1999).

Land Management. Frest and Johannes (1999) report two occupied sites in Lassen National Forest in Shasta County. The June 2007 Survey and Manage removal FSEIS reports no locations on federal land.

15. Nugget pebblesnail (*Fluminicola seminalis*) Hinds 1842

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails). The species has previously been referred to as *Paludina seminalis* Hinds 1842, *Melania seminalis* (Hinds) Lea 1856, *Bithinia seminalis* (Hinds) Carpenter 1857, *Amnicola seminalis* (Hinds) Cooper 1860, *Lithoglyphus cumingii* Frauenfeld 1863, *Melania (Paludina) seminalis* (Hinds) Carpenter 1864, *Paludina cumingii* Frauenfeld 1864, *Lithoglyphus cumingi* [*sic*] (Frauenfeld) Pilsbry 1899, *Fluminicola seminis* [*sic*] (Hinds) Wenz 1939, *Fluminicola seminaris* [*sic*] (Hinds) Wenz 1939, *Lithoglyphus seminalis* (Hinds) Taylor 1966, 1981.

Description. The Nugget pebblesnail has a thick green shell, a medium-high conic spire (4 mm), and about 4.5 whorls. The protoconch is small and flattened, and the shell apex is blunt (Furnish and Monthey 1999).

Range. *Fluminicola seminalis* is endemic to the Sacramento River basin including the Pit and McCloud River drainages and a few large spring-fed tributaries in Shasta, Modoc, and Lassen Counties, CA. (Hershler and Frest 1996). The species is now presumed to be extinct on the main stem of the Sacramento River due to the 1991 spill of the pesticide metam sodium into the river (Hershler and Frest 1996). Before the spill the species had already been extirpated over much of its former range in the Sacramento River (Taylor 1981). The snail now survives only at 22 sites in the Pit River drainage (Frest and Johannes 1995c, Hershler and Frest 1996).

Habitat requirements. This snail generally prefers large, cold, clear, well-oxygenated streams and rivers with stable gravel-boulder substrate, but is also known to occur in large spring pools with soft, mud substrates (Taylor 1981, Frest and Johannes 1995). It is generally found at low elevations (Frest and Johannes 1999).

Status. The Nugget pebblesnail is imperiled (G2 S1S2 (CA)) because it is "severely declining in abundance and distribution, and has been extirpated over much of its former range" (ORNHIC 2004). It is included in the FS Special Status Species Program and is Survey and Manage removal Outcome 2, insufficient habitat to support stable populations in a portion of its range (SMR FSEIS 2007). Because of population declines, significant range loss, and ongoing threats to the species, Frest and Johannes (1993) recommend listing the Nugget pebblesnail as endangered under the Endangered Species Act.

Known threats. The Nugget pebblesnail's habitat has been destroyed and/or degraded by water pollution, fire, logging, dams, diversions, spring developments, construction of roads and railroads, urbanization, mining, grazing, and recreation (Frest and Johannes 1993, 1995, Hershler et al. 2003, SMR FSEIS 2007). The species was extirpated from the main stem of the Sacramento River by the 1991 Cantara spill (Hershler and Frest 1996). The snail was also negatively impacted by the 1992 Burney fire and subsequent salvage logging (SMR FSEIS 2007 p. 175). In addition, this snail is highly intrinsically vulnerable to extinction because individuals breed only once and then die. Annual population turnover generally exceeds 90 percent so any condition that impairs egg laying or survivorship of eggs or young may result in extirpation (ORNHIC 2004).

Because this species range has been so severely reduced, the FSEIS for the removal of Survey and Manage reports that the "loss of any known sites would have a substantial effect on population interactions and the distribution of the species as a whole" (p. 254).

Land Management The Survey and Manage Removal FSEIS (2007) reports 15 extant sites for this species, five of which are on federal land including two sites in the Shasta National Forest and three in the Whiskeytown-Shasta-Trinity National Recreation Area. The snail was known to occur on the Shasta and Lassen National Forests (DCA OD-58, DCA CD-82, and in or on the edge of DCA CD- 81) (Frest and Johannes 1999). Furnish and Monthey (1999) report that there are no known protected occurrences.

16. Burrington or Keeled jumping-slug *(Hemphillia burringtoni)*

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Arionidae. This slug was described by Pilsbry in 1948.

Description. *Hemphillia burringtoni* is a relatively small slug measuring from 8 -20 mm with gray and black speckling. It has a depressed body and a prominent keel on its tail (Burke et al. 1999). Evolutionarily, *Hemphillia* are a unique group of slugs endemic to the Pacific Northwest, that appear between snails and slugs, with a shell plate that is not completely enclosed as it is in all other slug species of western North America. This species is called a jumping-slug because it can flip its tail and "jump" off of vegetation or logs to escape from predators (in Wainwright and Duncan 2005).

Range. The Keeled jumping slug is found primarily on the Olympic Peninsula, WA. Historic locations included Clallam, Grays Harbor, Island, Pacific, and Thurston Counties (Branson 1977). Its historic range may have extended across the Puget Trough to the western Cascade Range in Washington and south to the Coast Range of northwestern Oregon (Burke et al.1999, Kelley et al. 1999). New locations have been found on the Olympic and Gifford Pinchot National Forests and in Clallam, Jefferson, Grays Harbor and Mason Counties on the Olympic Peninsula and in Skamania County in the western Washington Cascades (Wainwright and Duncan 2005).

Habitat requirements. *Hemphillia burringtoni* is associated with riparian areas and late-successional rain forest (Frest and Johannes 1993). It requires shaded and moist forest floor conditions, litter and duff layers, and large woody debris such as decomposing logs. It occurs from sea level to 1050 m elevation (Branson 1977, 1984). The species also uses younger forest. Wainwright and Duncan (2005) state: "*Hemphillia burringtoni* has been documented in a wide range of forest conditions. These include several old-growth sites and many in second growth conifer forests between 40 - 80 years old. Only a small number of old-growth sites have been located, due to the focus on project surveys for commercial thinning timber sales (Ziegltrum 2000). It is important to note that most records are the results of surveys conducted for project clearances, which were mostly proposed commercial thinnings in young, second growth forests of Douglas-fir

(*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), western redcedar (T*huja plicata*), Sitka spruce (*Picea sitchensis*) and occasionally Pacific silver fir (*Abies amabalis*). Therefore, only a small portion of potential *H. burringtoni* old growth habitat was inventoried, and the importance of this type of habitat for the species may be understated."

Status. The Keeled jumping-slug is critically imperiled (G1G2 S1S2 (WA)) because of its limited number of occurrences (ORNHIC 2004). It was moved from Survey and Manage Category A to Category E because of difficulties in taxonomy and identification. Both of these Categories required management of all known sites. It is on the Regional Forester's Sensitive Species List in Washington only. Frest and Johannes (1993) recommend listing this species as threatened in Washington and federally.

Known threats. Threats to this species include the loss and fragmentation of its habitat due to forest management, urbanization, agriculture, and recreational developments. This slug is also threatened by competition and predation from invasive species, natural predation in restricted areas, and fire (Burke et al. 1999, ORNHIC 2004, Wainwright and Duncan 2005). According to FOIA documents obtained from national forests, during the Survey and Manage Program this slug was detected at four timber sales, three restoration projects, and a road maintenance project. The termination of SM protections means that pre-disturbance surveys and mitigation measures will no longer be required for this slug or other rare mollusks, leaving them vulnerable to extirpation.

Land management. There are currently 62 known sites for the Keeled jumping-slug, 24 of which are on federal land (SMR FSEIS 2007). There are known sites in Olympic National Park, Olympic National Forest, and Gifford Pinchot National Forest (ORNHIC 2004, Wainwright and Duncan 2005). Most of the *H. burringtoni* sites on the Olympic National Forest are in an Adaptive Management Area, with a few sites in Late Successional Reserves, and most sites on the Gifford Pinchot National Forest are in Matrix lands with two sites in Late Successional Reserves (Wainwright and Duncan 2005). The species also occurs on the Quinault Indian Reservation and in a state park (Wainwright and Duncan 2005). Wainwright and Duncan (2005) state that as of 2005 there were 23 records for this species in the Interagency species database, and that some records of *H. burringtoni* may have been misidentified and may actually be *H. glandulosa*.

17. Basalt juga *(Juga (Oreobasis.) n. sp. 2)*

Taxonomy. Order Neotaenioglossa, Family Pleuroceridae (river snails). This species was described by Frest and Johannes 1999. *Juga* species have been previously assigned to *Goniobasis, Oreobasis, Oxytrema*, and *Melania.*

Description. The Basalt juga is moderately sized (height 22.1 mm, width 9.5 mm) with a thick, white to semitransparent shell and a yellowish periostracum. The shell generally has three yellow bands (Frest and Johannes 1999).

Range. The Basalt juga occurs in a narrow range of low-elevation springs in the central and eastern portions of the Columbia River Gorge in Hood River and Wasco Counties, Oregon, and in Klickitat and Skamania counties, Washington (Frest and Johannes 1995, Duncan 2005c).

Habitat requirements. This snail is a perilithon grazer and is restricted to perennial, cold, pristine springs in small drainages and tributaries at low elevations. It is dependent on high levels of dissolved oxygen and is intolerant of water pollution, sedimentation, or elevated water temperature. Occupied springs are in forested areas, have sand-gravel-cobble substrate, and are often surrounded by basalt talus (Frest and Johannes 1995, Duncan 2005c).

Status. The Basalt juga is critically imperiled (G1S1 (OR)) because of its restricted range, limited number of occurrences (10), and demonstrated threats to its habitat (ORNHIC 2004). It is included in the FS Special Status Species Program in Region 6 and is a BLM Sensitive Species in Oregon. Frest and Johannes (1995) note that there have been recent population extirpations for the species and state, "This species is definitely declining, in terms of number of sites and area occupied." Frest and Johannes recommend Endangered Species Act protection for the species (1993, 1995).

Known threats. Threats to the Basalt juga are considered to be moderate to severe and imminent for most (> 60%) of the population, occurrences, or area (ORNHIC 2004). Much of the species habitat has been impacted by highway and railway development, logging, grazing, and water diversions for public, private, and stock water supplies, fish hatcheries and lumber mills. The species habitat was also negatively affected by severe range fires in 1993 (Frest and Johannes 1995). Survey and Manage FOIA documents reveal that the species was detected at four timber sales, three road maintenance projects, and a restoration project. One of the timber sales included stated mitigation measures to protect the species. The suspension of the SM program leaves this snail vulnerable to future timber harvest and other habitat-degrading activities. The FSEIS for the removal of Survey and Manage states that some known sites for the species are likely to be lost without the program's protections (p. 258).

Land management. The SMR FSEIS reports ten known sites for the Basalt juga, four of which are on federal land. Duncan (2005c) reports 28 sites for this snail. This species occurs in the Columbia River Gorge National Scenic Area, on the Mt. Hood and Gifford Pinchot National Forests, and on private lands (Frest and Johannes 1995c, Duncan 2005c).

18. Cinnamon juga (*Juga (Oreobasis.) n. sp. 3)*

Taxonomy. Order Neotaenioglossa, Family Pleuroceridae (river snails). *Juga* species have been previously assigned to *Goniobasis, Oreobasis, Oxytrema,* and *Melania*.

Description. The Cinnamon juga has a deep cinnamon red shell that is so dark it can appear black in the field. The inside of the shell is purplish brown. The whorls have channeled sutures and are rather flat-sided (Furnish and Monthey 1999).

Range. The Cinnamon juga is known from only 4 - 8 sites in the Shasta Springs complex in the upper Sacramento River drainage in Siskiyou County, California. The sites are all within 1.5 miles of each other (Frest and Johannes 1995a). It has been reported in Shasta Springs, Mossbrae Falls spring complex, Cantara Bend on the Sacramento River, Upper Soda Springs and below McBride Springs on Willow Creek (Frest and Johannes1999, Furnish et al. 1997).

Habitat requirements. The Cinnamon juga is found in large, cold springs and spring runs with sand-cobble substrate or exposed basalt bedrock (Frest and Johannes 1999).

Status. The Cinnamon juga is critically imperiled (G1G2 S1S2 (CA)) because of its restricted range, limited number of occurrences (4), demonstrated threats to its habitat, and lack of protected locations ORNHIC 2004). It is not included in FS or BLM Special Status Species Programs and it is Survey and Manage removal Outcome 3, insufficient habitat to support stable populations. Because of habitat loss and/or degradation throughout the species' range, the species' limited occurrence, and ongoing threats, Frest and Johannes (1993b, 1995c) recommend listing the Cinnamon juga as endangered under the Endangered Species Act.

Known threats. The known locations for this species are near the Southern Union Pacific Railroad tracks which have substantially modified the lower part of the springs there. The species' habitat has also been impacted by spraying and water diversions (Frest and Johannes 1995). Additional threats to the Cinnamon juga include water pollution, grazing, development, and recreation (Frest and Johannes 1993b, 1995c, 1997c). The FSEIS for the removal of Survey and Manage states, "The loss of even a single site could result in habitat insufficient to support stable populations because of the rarity and narrow range of this species" (p. 258).

Land Management. There are four known sites for this species, none of which are on federal land (SMR FSEIS 2007).

19. Columbia duskysnail *(Lyogyrus n. sp. 1)*

Taxonomy. Order Neotaenioglossa, Family Hydrobiidae (spring snails), Subfamily Amnicolinae. It may be present in collections as *L. greggi*.

Description. The Columbia duskysnail is a small (1.4- 2.3 mm height; width 1.4 mm) aquatic snail with a high conical blunt top. The shell is off-white, light gray or light tan and translucent with a periostracum that is clear or somewhat yellow (Frest and Johannes 1999).

Range. The Columbia duskysnail is endemic to springs and spring outflows in the Columbia River Gorge in both Washington and Oregon (Frest and Johannes 1999).

Habitat requirements. This species is found in well oxygenated, cold, clear springs and spring outflows (Frest and Johannes 1999).

Status. The Columbia duskysnail is imperiled (G2S2 (OR) (WA)) due to limited number of occurrences and no known protected areas (ORNHIC 2004). Duncan (2005c) reports that the species is G1S1. It is included in the FS Special Status Species Program in Region 6 and is a BLM Sensitive Species in Oregon. It is on the Washington State Monitor Species List and is a BLM Bureau Tracking species in Washington. Frest and Johannes (1993) suggest Oregon, Washington, and federal endangered listing status.

Known threats. The Columbia duskysnail is threatened by water diversions, dams, road and railroad construction, logging, spraying, grazing, fire, and recreation (Frest and Johannes 1999, Furnish and Monthey 1999, ORNHIC 2004, Duncan 2005c). Records from the Survey and Manage program obtained from national forests reveal that the snail was detected at 15 timber sales, seven road maintenance activities, two recreational projects, and a restoration project. Three of the timber sales included stated mitigation measures to protect the species. The cancellation of the SM program means that pre-disturbance surveys and mitigation measures will no longer be required to protect this species during future timber harvests or other habitat-degrading activities. The FSEIS for Survey and Manage removal acknowledges that some known sites for this species are likely to be lost without the program's mitigations (p. 259).

Land management. The Columbia duskysnail is known from 64 sites, 52 of which are on federal land**.** It is found in the Columbia River Gorge National Scenic Area, Gifford Pinchot National Forest, Mount Hood National Forest, and Beacon Rock, Benson and Wahkeena Falls State Parks (Frest and Johannes 1999). It also occurs on at least 12 sites on private land (ORNHIC 2004).

20. Masked or Washington duskysnail *(Lyogyrus n. sp. 2)*

Taxonomy. Subclass Prosobranchia, Family Hydrobiidae (spring snails). Listed as *Lyogyrus n. sp. 2* in Frest and Johannes (1995: 185; 1999: 73; Frest, 1999). Common name called Washington Duskysnail in Frest and Johannes (1999: 73) and Masked Duskysnail in Frest and Johannes (1995: 185) and Furnish and Monthey (1999). Common name called Masked or Washington Duskysnail in Furnish et al. (1997). Not to be confused with *Amnicola sp. 2,* also called the Washington Duskysnail, where it co-occurs at one site (NatureServe).

Description. *Lyogyrus n. sp. 2* is large for the genus with a height of 3.0- 5.2 mm and a width of 2.1- 3.0 mm. The whorls are convex and even, and the shell has a rounded

periphery and very deep suture. The shell is thin and partly translucent (Frest and Johannes 1999).

Range. The Masked duskysnail is now known from only two kettle lakes (3 - 4 sites) on the periphery of the Columbia drainage in Washington State. Curlew Lake is in Ferry County and Fish Lake is partially within the Wenatchee National Forest in Chelan County. Historically the species likely ranged from northern Washington south to northcentral Oregon and east to the Idaho panhandle and into northwestern Montana (Furnish and Monthey 1999).

Habitat requirements. *Lyogyrus n. sp. 2* is a kettle lake inhabitant and riparian associate that lives in lentic ecosystems on oxygenated mud substrates with sizable numbers of waterlogged deciduous leaves and aquatic plants such as *Potamogeton crispus, Elodea, Myriophyllum spicatum, Ceratophyllum densum,* and *Chara* (Monthey 1998).

Status. The Masked duskysnail is critically imperiled (G1S1 (OR) (WA)) due to a limited number of occurrences (3-4), restricted range, and no known protected sites (ORNHIC 2004). The species has declined moderately to substantially (25 – 75%) (ORNHIC 2004). It is included in the FS Special Status Species Program in Region 6. It was Survey and Manage Category A, manage all known sites. Frest and Johannes (1993) suggest Washington and federal endangered listing status.

Known threats. The primary threats to the Masked duskysnail include urbanization and water pollution from herbicides, pesticides, and petroleum products, and eutrophication from fertilization and septic tank drainage (Furnish and Monthey 1999). Eutrophication problems have resulted in citizen complaints and initiation of cleanup programs in both lakes where this species occurs, as both lakes are highly eutrophic with abundant growth of aquatic macrophytes and algae (Duncan 2005d). Duncan (2005d) states, "This may be an unhealthy situation for the species and current small colonies may represent remnants of past populations, but further studies on the basic ecology of the species are necessary for this determination." The species is also potentially threatened by chemical applications to control fish, insects, and aquatic plants, and by invasive fish and plant species (Furnish and Monthey 1999, Duncan 2005d). Any activity that decreases water clarity, alters dissolved oxygen levels, or interferes with algal growth patterns and/or aquatic vegetation could be detrimental to the Masked duskysnail (Furnish and Monthey 1999). Another potential threat is water diversion for irrigation purposes and altered water temperature, although these threats are unlikely due to the large size of the lakes (Duncan 2005d).

Survey and Manage documents obtained from national forests indicate that potential impacts to this snail were considered during the planning of a road maintenance project. The FSEIS for the removal of Survey and Manage acknowledges that known sites for the species could be lost because of the termination of the program (p. 259). Given that the species only currently exists at 3 – 4 sites, the loss of a single site significantly increases the risk of extinction. Because this is an annual species, even temporary disturbances

which cause the loss of a population during a single year could result in site extirpation (Duncan 2005d).

Land management. The June 2007 Survey and Manage Removal FSEIS reports three known sites for the species, all on federal land. ORNHIC (2004) reports four sites for the species, including one in the Wenatchee National Forest and one on private land (Frest and Johannes 1999). Duncan (2005d) reports two sites on private land (Curlew Lake), and two sites within the Wenatchee National Forest (Fish Lake) close to Chiwawa LSR. The FS lands bordering Fish Lake are in a Riparian Reserve.

21. Siskiyou sideband (*Monadenia chaceana*)

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Bradybaenidae. This species was formally described in Turgeon et al. 1998.

Description. The Siskiyou sideband is 18-26 mm in diameter and has a yellowish to reddish brown shell with low spiration (Kelley et al. 1999).

Range. The known range for the Siskiyou sideband extends from the Shasta and Little Shasta River Drainages in Siskiyou County, California, north to Douglas County, Oregon, and west into the Shasta-Trinity National Forest (Burke et al. 1999).

Habitat requirements. The Siskiyou sideband requires moist microhabitat and is largely dependent on woody debris and downed logs. It is found in both late-successional forest and open talus and rocky areas with appropriate microhabitat conditions (Burke et al. 1999).

Status. The Siskiyou sideband is critically imperiled (G1Q S1 (OR) (CA)) because of its restricted range, low abundance, scattered sites, and lack of protected locations (ORNHIC 2004). The Q in the ranking G1Q indicates that the taxonomy of *Monadenia chaceana* is incompletely understood. There is evidence of genetically and ecologically distinct populations within the species each of which occupy relatively small ranges (Roth 2002). It is a FS and BLM Special Status Species in OR, and a BLM Special Status Species in CA. It is not included in the FS SSSP in California, even though 88% of known federal sites in CA are on National Forest lands (SMR FSEIS 2007 p. 175). The Siskiyou sideband is Survey and Manage Removal Outcome 2, insufficient habitat to support stable populations in a portion of its range. Frest and Johannes (1993) suggest California and federal endangered listing status.

Known threats. *Monadenia chaceana* is sensitive to any activity that alters microhabitat conditions where it occurs including canopy and understory reduction and removal of coarse woody debris. The species is threatened by logging, thinning, and prescribed burning (SMR FSEIS 2007). The Siskiyou sideband can survive late summer wildfires because it typically aestivates during this time of year. Prescribed burning, however, poses a threat because it generally takes place in the spring or fall when the species is

most active on the surface (SMR FSEIS p. 261). Frest and Johannes (2000) state that urban and agricultural expansion in Shasta Valley, talus mining, and road construction threaten this species. National forest records from the Survey and Manage program document that this species was detected at three timber sales and a grazing allotment. ORNHIC (2004) consider threats to this species to be moderate to severe and imminent for a significant portion (20-60%) of the population, occurrences or range. The removal of Survey and Manage provisions contributes to the risk of extirpation for this species:

> "Because of the widely scattered pattern of population for this species, loss of sites or population areas would reduce population interaction, connectivity, and normal biological function, and could result in habitat (including known sites) insufficient to support stable populations in significant portions of the species' range in California . . ." (SMR FSEIS p. 261-262).

Land management. The Siskiyou sideband is found on private lands, BLM lands, and in the Shasta Trinity National Forest. None of the known sites are protected, although some may occur in Riparian Reserves (Burke et al. 1999). Of 223 known sites, 206 are on federal land (SMR FSEIS 2007).

22. Dalles sideband *(Monadenia fidelis minor)* Binney

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Bradybaenidae. The concept reference for this species is from USFWS 1989.

Description. The Dalles sideband has a rough shell with sharp growth lines. It is yellowish brown with a chestnut-colored base and measures 20-25 mm in diameter (Kelley et al. 1999).

Range. *Monadenia fidelis minor* is known from the central and eastern Columbia River Gorge of Washington and Oregon including Wasco County, OR., and Klickitat County, WA. There are at least 15 known sites in the vicinity of the Dalles on both sides of the river. The species also occurs in the Deschutes River drainage (Burke et al. 1999).

Habitat requirements. The Dalles sideband is dependent on moist microhabitat. It is associated with moist talus and rocky substrates in riparian habitats. In steppe or dry forest plant communities it is found around but not in seeps and springs. The species also uses downed woody debris (Burke et al.1999, Kelley et al. 1999). It is often found in north-facing basalt talus (Niwa et al. 2001).

Status. The Dalles sideband is a critically imperiled subspecies (G4G5T1 S1 (OR) (WA) SRF (CA)) due to restricted range, scattered sites, and low abundance (ORNHIC 2004). Formerly it was a Category 2 Candidate for federal listing. It is included in the FS Special Status Species Program in OR and WA. Frest and Johannes (2000) recommend endangered listing federally and in Oregon and Washington.

Known threats. The Dalles sideband is threatened by road construction and maintenance, pesticide application, fire, recreation, development, grazing, and over-collection (Burke et al. 1999, Niwa et al. 2001). Road building and modification have destroyed or fragmented some colonies, and much of the original range is heavily grazed (Niwa et al. 2001). Historically, the species was negatively impacted by the use of talus for dam development along the Columbia River (Burke et al. 1999). Based on Survey and Manage documents from national forests, this snail was detected at six timber sales, four fire management projects, a road maintenance project, and a grazing allotment. Mitigation measures were stated to be taken at two of the timber sales and two underburns. The cancellation of the SM program leaves this snail without any protection during future habitat-disturbing projects. The FSEIS for the removal of Survey and Manage states that some known sites for the species may be lost since mitigation measures are no longer required for the species (p. 262).

Land management. *Monadenia fidelis minor* is known from 98 sites, 97 of which are on federal land (SMR FSEIS 2007).

23. Shasta sideband *(Monadenia troglodytes troglodytes)*

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Bradybaenidae.

Description. The Shasta sideband has a white to light tan shell with reddish-brown sidebands. The body is gray to black with a light dorsal stripe and a reddish-purple tint. It appears somewhat flattened in profile and is 20.5- 29.0 mm in diameter (Kelley et al. 1999).

Range. The Shasta sideband is a very rare species and is confined to a narrow range near Shasta Lake in northern California (SMR FSEIS 2007).

Habitat requirements. This species inhabits limestone substrates in rocky areas or along talus slopes in open, brush covered, or pine-oak woodlands (Burke et al. 1999).

Status. The Shasta sideband is critically imperiled (G1G2T1 S1 (CA)) due to restricted range, scattered sites, low abundance, and no known protected occurrences (ORNHIC 2004). It was formerly a Category 2 candidate for federal listing. It is included in the FS Special Status Species Program. Frest and Johannes (1993) recommend California and federal endangered listing status.

Known threats. *Monadenia troglodytes troglodytes* is threatened by any activity that alters microhabitat conditions by decreasing soil moisture, raising ground temperature, or reducing food supply. Specific threats include timber harvest, road construction and maintenance, pesticide application, fire, recreation, and overcollection (Burke et al. 1999). The removal of Survey and Manage will likely result in the loss of known sites for this species (SMR FSEIS 2007 p. 263)

Land management. Of nine known locations for this species, eight are on Forest Service land. The species occurs entirely on Matrix lands with no protected locations (Burke et al. 1999).

24. Wintu sideband *(Monadenia troglodytes wintu)*

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Bradybaenidae.

Description. The Wintu sideband is approximately 20.5 to 29.0 mm in diameter and has a depressed white to light tan shell and an almost flattened profile. The shell has a brown peripheral band that is bordered by whitish bands, and the body is gray to black (Kelley et. al 1999).

Range. The Wintu sideband is very rare and is confined to a narrow range near Shasta Lake in northern California (SMR FSEIS 2007).

Habitat requirements. *Monadenia troglodytes wintu* inhabits limestone substrates in rocky areas or along talus slopes in open, brush covered, or pine-oak woodlands (Burke et al. 1999).

Status. The Wintu sideband is critically imperiled (G1G2T1 S1 (CA)) due to its very restricted range and unknown information on abundance (ORNHIC 2004). It is included in the FS Special Status Species Program. The nominate subspecies was a federal candidate for listing (Frest and Johannes 1993). Frest and Johannes (1993) suggest California and federal endangered listing status.

Known threats. The Wintu sideband is threatened by any activity that alters microhabitat conditions by decreasing soil moisture, raising ground temperature, or reducing food supply. Specific threats include timber harvest, road construction and maintenance, pesticide application, fire, recreation, and overcollection (Burke et al. 1999). The removal of Survey and Manage will likely result in the loss of known sites for this species (SMR FSEIS 2007 p. 263)

Land management. Seven of 8 known sites for the Wintu sideband are on federal land (SMR FSEIS 2007). Most sites are located on Administratively Withdrawn Areas (Burke et al. 1999).

25. Chelan mountainsnail *(Oreohelix n. sp. 1)*

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Oreohelicidae. This species was described by Burke et al. 1999.

Description. The shell of the Chelan mountainsnail is approximately 18 mm in diameter and is off-white with two brown bands and a rounded periphery. The shell is lined with conic-shaped spires (Kelley et al. 1999).

Range. *Oreohelix n. sp. 1* is a local endemic restricted to the eastern foothills of the Cascades in Chelan County, Washington. Its narrow range is centered on the Wenatchee National Forest (Burke et al. 1999). Duncan (2005f) reports that the eastern boundary of the accepted range is the Columbia River, the northern boundary is the shore of Lake Chelan, the western boundary the line between the Douglas fir and grand fir forest series, and the southern boundary is the Wenatchee River.

Habitat requirements. The Chelan mountainsnail is dependent on moist microhabitat including schist talus, ground vegetation, and low shrubs. The species is found in arid transition forests (i.e., Ponderosa pine / Pinegrass-Bluebunch-Wheatgrass, Douglas fir / Bearberry-Bitterbrush, and Douglas fir / Pinegrass-Elk Sedge plant associations) and sometimes a short distance into adjacent shrub/steppe communities. *Oreohelix n. sp 1* usually occurs in the more mature stands, with relatively dense low understory (i.e., pinegrass, elk sedge), a good layer of litter and duff, and scattered shrubs (e.g., serviceberry), or in talus. They may be found between the litter and duff layers, under small or large woody debris or on or between rocks imbedded in the ground (Burke et al. 1999). The typical site occurs within concave landforms that accumulate and maintain moisture more efficiently than the surrounding landscape. Elevations range from 365 to 800 meters (Duncan 2005f). This species is ecologically distinct and important because it is the only gastropod that inhabits the grassy understory component of Douglas-fir/pinegrass plant associations. It is adapted to the outwardly appearing dry conditions of these sites, where few other animals are found other than arthropods that function as decomposers (Duncan 2005f).

Status. *Oreohelix n. sp. 1* is critically imperiled (G1S1 (WA)) due to severe declines in distribution and abundance, including extirpation over much of its former range (ORNHIC 2004). The species is very rapidly declining (50-70% of population, range, and/or area occupied) and ongoing threats are moderate to severe and imminent for most (> 60%) occurrences (ORNHIC 2004). The species has been directly impacted over a widespread area, causing irreversible damage or requiring long-term recovery (ORNHIC 2004). It was Survey and Manage Category A, manage all known sites. It is included in the FS Special Status Species Program in Region 6. Frest and Johannes (1993) suggest Washington and federal endangered listing status.

Known threats. High intensity fire is one of the greatest threats to this species, as it is adapted to the historical low intensity seasonal fire regime, but not to modern fires. Fires impact the snail through direct mortality, reduction of food supply, alterations in soil texture and moisture, and loss of existing and future vegetative cover and duff (Burke et al. 1999). Ingrowth of understory vegetation may result in reduced habitat quality, and increase the risk of intense wildfire (Duncan 2005f). The 1994 Tyee Fire destroyed seven of 14 known sites for the species, and the snail was unable to successfully recolonize the burned areas (Burke et al. 1999, ORNHIC 2004, Duncan 2005f). Another

known site for the species has been detrimentally impacted by road construction (Burke et al. 1994). Other threats to the Chelan mountainsnail include heavy grazing, recreation, especially off-road vehicle use, and timber harvest. The survival of the snail is threatened by any activity that disturbs the talus, compacts the soil, reduces ground cover, alters temperature or moisture, and/or creates barriers to dispersal (Burke et al. 1999).

The Chelan mountainsnail is highly intrinsically vulnerable to extinction because of its life-history characteristics. Populations are very slow to recover from disturbance and extirpated populations are unlikely to become reestablished through natural recolonization (ORNHIC 2004).

National Forest Survey and Manage documents indicate that this species was detected at a timber sale and a thinning/prescribed burning project for which mitigation measures were enacted. The termination of the SM program leaves the species without protection from future habitat-disturbing projects. The FSEIS for the removal of Survey and Manage acknowledges that some known sites for the species are likely to be lost without the program's protections (p. 264).

Land management. The Chelan mountainsnail is primarily found in the Wenatchee National Forest, Entiat and Chelan Ranger Districts (Burke et al. 1999). Entiat Ranger District sites are managed as Matrix/EW1 (mule deer winter range) and Matrix/GF (general forest extraction). Other known sites are in the Entiat Key Watershed area (Burke et al. 1999). The FSEIS for the removal of Survey and Manage reports 104 sites for the Chelan mountainsnail, 86 of which are on federal land. ORNHIC (2004) reports seven remaining sites for the species none of which are protected. Duncan (2005f) reports 57 locations in the Interagency Species Database as of September 2005, with 40 more not yet entered. Random grid surveys across the Northwest Forest Plan area in Oregon and Washington, conducted under the Survey and Manage program, did not locate this species in any of 498 plots searched (Duncan 2005f).

26. Crater Lake tightcoil *(Pristiloma arcticum crateris).* Pilsbry 1946.

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Zonitidae.

Description. The Crater Lake tightcoil measures up to 2.75 mm in diameter, and 1.5 mm in height. The pinkish-buff shell is smooth and glossy, with a rounded periphery and fine close spirals (Kelley et al. 1999).

Range. *Pristiloma arcticum crateris* is sparsely distributed throughout the Oregon Cascades at moderate to high elevations (over 610 m). It occurs from the Winema National Forest in southern Oregon to the Bull Run watershed in northern Oregon (Duncan 2005e). The species is predicted to occur in widely scattered populations throughout the Oregon Cascades on the Umpqua and Willamette National Forests and parts of BLM districts adjacent to these forests east of Interstate 5. The species might also occur on the Gifford Pinchot National Forest (Burke et al.1999, Kelley et al. 1999).

Habitat requirements. The Crater Lake tightcoil inhabits wet conifer forests utilizing ground cover such as logs, woody debris, mosses, sedges, or litter (Burke et al. 1999). This terrestrial snail requires a perennially moist environment and has been associated with riparian areas and wetlands, seeps, and springs (Kelley et al. 1999). The species has been found in Ponderosa pine/ Douglas fir forest openings such as spring-fed meadows with abundant sedges and grasses and along mountain streams (Frest and Johannes 2000). It is generally found in areas which remain under snow for long periods in the winter (Duncan 2005e). This snail grazes on microscopic periphyton (bacteria, fungi, yeasts and other microscopic organisms) found on moist surfaces of wood, green and decaying vegetation and rocks. It is known from high-elevation sites and apparently remains unfrozen under snow when air temperatures are well below freezing. Its body fluids may contain biological "anti-freeze" compounds of interest to humans (Duncan 2005e).

Status. The Crater Lake tightcoil is a critically imperiled subspecies (G4T1 S1 (OR) (WA)) due to its limited number of occurrences (ORNHIC 2004). Duncan (2005e) reports that the species is G1S1. ORNHIC (2007) lists the species as G3G4T3 S1 (OR). It is a BLM Sensitive Species in Oregon and FS Special Status Species in Region 6. Frest and Johannes (1993) recommend listing the species as threatened on the state and federal level.

Known threats. *Pristiloma arcticum crateris* requires moist, covered, undisturbed microhabitat and is threatened by activities that degrade these conditions. Known threats to the species include loss and degradation of wetland habitat, grazing, logging, fire retardants, prescribed burning and wildfire, heavy equipment operation, construction, and activities that compact soil or snow (Burke et al. 1999, Frest and Johannes 2000, Duncan 2005e). Recreation poses a particular threat to this species including snowmobiling, ORV use, and foot traffic. Duncan (2005e) states: "Pristilomas have very thin, fragile shells, and they are easily damaged. Since many streamside sites are in areas where access by fishermen may cause inadvertent damage, signs or other means to control foot traffic may be warranted." Part of the snail's habitat in spring meadows around Upper Klamath Lake has been lost and degraded by channelization, diversion for irrigation, and grazing (Frest and Johannes 2000). Survey and Manage records obtained from national forests indicate that this species was detected at four restoration projects, three road maintenance activities, two timber sales, a quarry, a controlled-burn unit, a powerline maintenance activity, and another project of unidentified type. Mitigation measures were stated to be provided for the species at the quarry, the powerline maintenance activity, and one of the restoration projects. The suspension of the SM program means that pre-disturbance surveys and mitigation measures will no longer be required to protect this species during future habitat-degrading activities. ORNHIC (2004) considers threats to the Crater Lake tightcoil to be severe and imminent for most (>60%) of the population.

This snail is also inherently susceptible to extinction because it likely has a one-year life span and produces only one clutch of eggs (Frest and Johannes 1995). Therefore, the loss of a single cohort could have devastating consequences on the population (Duncan 2005e).

Land management. There are 209 known sites for the Crater Lake tightcoil all of which are on federal land (SMR FSEIS 2007). *Pristiloma arcticum crateris* is known or suspected to occur on the Rogue River, Winema, Mt. Hood, Umpqua, Willamette, and Gifford Pinchot National Forests and also on BLM lands (Kelley et al. 1999, Burke et al.1999). Duncan (2005e) reports 160 locations. Forty-six percent of locations within NWFP boundaries are in Late Successional Reserves or other withdrawn lands. Duncan (2005e) states: "Many sites occupied by this species are associated with wetlands less than one acre in size, which do not receive the same extent of riparian reserve protection as do larger water bodies. In these types of sites, the species may occur outside of the area where riparian reserve protection is required."

27. Shasta chaparral *(Trilobopsis roperi)*. Pilsbry 1889.

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Polygyridae.

Description. Measuring 8-9 mm in diameter, the shell of the Shasta chaparral is depressed with almost flat spirals and 5.8-6.2 whorls. The shell is a matte cinnamon brown and the mantle has black spots (Kelley et al. 1999).

Range. *Trilobopsis roperi* is a local endemic to Shasta County, California (Burke et al. 1999).

Habitat requirements. This species is generally found within 100 meters of lightly to deeply shaded limestone rockslides, draws, or caves, with a cover of shrubs or oak (Kelley et al. 1999). During the summer, this species may be found under rocks or large woody debris that provide moist microhabitat. During wet seasons, it may be found away from refugia foraging for green vegetation and fruit, feces, old leaves, leaf mold, and fungi (Burke et al. 1999).

Status. The Shasta chaparral is critically imperiled (G1 S1 (CA)) due to its limited range and few occurrences (ORNHIC 2004). It is included in the FS Special Status Species Program (CA). According to Frest and Johannes (2002), this species should be listed by the State of California and federal government as endangered.

Known threats. The Shasta chaparral is threatened by activities that decrease soil moisture, reduce vegetative cover, and alter microhabitat conditions where it occurs. Known threats to the species include road building and maintenance, pesticide application, fire, urbanization in the Redding area, recreation, and over-collecting (Burke et al. 1999, Frest and Johannes 2000). Recent wildfires have destroyed part of the snail's habitat in the Shasta-Trinity National Forest, and surveys revealed dead individuals killed by the fire (Jones Fire Management Project EA). The species habitat was historically degraded by limestone quarrying and mining (Frest and Johannes 2000). One known site for the species is now under Shasta Lake (Burke et al. 1999). Survey and Manage documents obtained from national forests indicate that the snail was detected at a road

maintenance project and a fuels-reduction project. The fuels-reduction project included stated buffers to protect the species. The cancellation of the SM program leaves the species without protection during future habitat-degrading activities. The FSEIS for the removal of Survey and Manage acknowledges that known sites for the species are likely to be lost without required mitigation measures (p. 264).

Land management. Of 146 known sites for the Shasta chaparral, 140 are on federal land (SMR FSEIS 2007). Sites are suspected in the Whiskeytown-Shasta-Trinity National Recreation Area (Burke et al. 1999).

28. Tehama chaparral *(Trilobopsis tehamana)*. Pilsbry 1928.

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Polygyridae.

Description. The Tehama chaparral measures 7 mm in diameter, has a depressed shell with virtually flat spirals, an impressed suture, and 5.4-5.5 whorls. The shell is yellowish brown with a matte surface and the mantle is black spotted (Kelley et al. 1999).

Range. This species is a local endemic known from 12 locations in Tehama, Butte, and Siskiyou Counties, California (Burke et al. 1999, SMR FSEIS 2007).

Habitat requirements. *Trilobopsis tehamana* uses moist microhabitat including rocky talus, leaf litter, and woody debris. It is often found within 100 m of limestone outcrops (Burke et al. 1999).

Status. The Tehama chaparral is critically imperiled (G1S1 (CA)) due to its limited range and low number of occurrences (ORHNIC 2004). It is included in FS and BLM Special Status Species Programs in CA. According to Frest and Johannes (2002), this species should be listed by the State of California and federal government as endangered.

Known threats. This species is threatened by recreation, urbanization in the northern Central Valley, and road building in critical habitats on public lands (Frest and Johannes 2000). Historically, limestone quarrying and mining led to the loss and degradation of its habitat. Other threats include fire, pesticide application, and over-collecting (Burke et al. 1999). The removal of the Survey and Manage program will also lead to the loss of known sites for this species (SMR FSEIS 2007 p. 266).

Land management. There are 12 known locations for the Tehama chaparral, nine of which are on federal land (SMR FSEIS 2007). Two known sites are on matrix lands, and two sites are outside the range of the Northern Spotted Owl (Burke et al. 1999).

29. Hoko vertigo *(Vertigo n. sp. 1)*

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Pupillidae. The concept reference for this species is Burke et al. 1999.

Description. The 2.5 mm shell of the Hoko vertigo is shaped like an insect pupa or bee hive. It is vaguely cylindrical with rounded ends, and is brownish, dark amber or cinnamon brown, and relatively smooth and glossy. The single parietal lamella (or "parietal tooth") is fairly prominent. In adults the basal lamellae are fused laterally into a blade-like tooth which is a key feature of this species (Burke et al. 1999).

Range. The Hoko vertigo is known from only one to two sites on the Olympic Peninsula in the Hoko River drainage in Clallam County, WA (Kelley et al. 1999). The FSEIS for the removal of Survey and Manage reports only one known location for the species, on non-federal land adjacent to the Olympic National Forest.

Habitat requirements. The Hoko vertigo is an old-growth associate and riparian species which is generally found within 200 m of streams, seeps, or springs. It is an arboreal species which can be found on the smooth trunks and lower limbs of deciduous trees and shrubs or more rarely, in leaf litter (Burke et al. 1999, Kelley et al. 1999).

Status. *Vertigo n. sp. 1* is critically imperiled (G1S1 (WA)) due to limited range and low number of occurrences (1) (ORNHIC 2004). It is included in the FS Special Status Species Program in Region 6. It is on the Washington State Monitor Species List and is a Tracking Species for BLM in Washington. It was Survey and Manage Category A, manage all known sites. Frest and Johannes (1993) suggest listing the species as endangered in Washington state and federally.

Known threats. Logging is the most imminent threat to the Hoko vertigo. The snail's habitat has been logged extensively and is fragmented by numerous logging roads (Burke et al. 1999). The FSEIS for the removal of Survey and Manage reports a single known location for the species, which is on non-federal land "in an area subject to substantial timber harvest" (p. 266). Because the entire range of the Hoko vertigo is on non-federal land, the species is in dire need of Endangered Species Act protection. The 2004 Survey and Manage Removal FSEIS states that "substantial risks of extirpation will remain even with appropriate management of federal lands" (USDA, USDI 1994, p. 171).

Optimal habitat for the species is limited to old-growth areas, which have been seriously reduced by logging and which exist as islands that are subject to disturbance by fire, flooding, or other stochastic events (Burke et al. 1999). Because the snail's habitat exists as islands of old-growth trees surrounded by clear-cuts, the species is now exposed to more wind and relatively drier air which could act as a stressor (Burke et al. 1999). Other threats to the species include the harvesting of special forest products such as mosses and lichens, recreation, the spread of invasive species, including climbing vines, predatory birds, and other gastropods, the application of pesticides or other chemicals, and road maintenance (Burke et al. 1999). Because of the snail's extremely limited distribution, any alteration to its habitat threatens the survival of the species (Burke et al. 1999). In

addition, the Hoko vertigo is highly intrinsically vulnerable to extirpation because of its life-history characteristics including low reproductive and fecundity rate (ORNHIC 2004).

Land management. The Hoko vertigo occurs at a single site on non-federal land within 10 km of the Soleduck Ranger District, Olympic National Forest and 20 km from BLM lands along the Soleduck River in Clallam County (Burke et al. 1999, SMR FSEIS 2007).

30. Big Bar hesperian *(Vespericola pressleyi).* Roth 1985.

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Polygyridae.

Description. The Big Bar hesperian is 12.4-17.5 mm in diameter with a depressed-helicoid shell with 5.5-6.4 whorls. The shell is matte brown with a pinkish lip and the body is charcoal gray with a pinkish buff undertone and a light grey mantle collar. The mantle is about 70% covered with black spots.

Range. *Vespericola pressleyi* is endemic to northern Trinity County, CA. There are four known sites within 1 km of Big Bar on the Trinity River, a site along Treloar Creek that joins the Trinity River at Big Bar, and a site at a spring on the east side of Barnum Ridge about 10 km northwest of Big Bar (Burke et al.1999).

Habitat requirements. The Big Bar hesperian is an old-growth and riparian associate that appears to be restricted to permanently damp habitats near seeps, springs, and stable streams. All known locations are shaded by dense alder and maples (Frest and Johannes 1993, Burke et al. 1999).

Status. This species is critically imperiled (G1S1 (CA)) due to its restricted range, scattered sites, and low abundance (ORNHIC 2004). It is included in FS and BLM Special Status Species Programs (SMR FSEIS 2007). Frest and Johannes (1993) recommend state and federal listing as endangered.

Known threats. The Big Bar hesperian is threatened by activities that alter the shaded habitat and microclimate on which it depends including timber harvest, grazing, fire, and any form of mechanical disturbance. The species is also threatened by pesticide application, invasive species, and recreation (Burke et al. 1999). Part of the snail's habitat in the Shasta-Trinity National Forest was destroyed by fire in 2001 (Hyampom Fuels Reduction Project Decision Memo 2004). Survey and Manage documents report that buffers were provided to protect this species during a timber sale. The suspension of the SM program leaves the species without protection during future habitat-degrading activities.

Land management. There are 27 known locations for the Big Bar hesperian, all of which are on federal land (SMR FSEIS 2007). Locations are in the Big Bar Ranger District of the Trinity National Forest and within the Hayfork AMA (Burke et al. 1999).

31. Shasta hesperian ***(Vespericola shasta)***. Berry 1921.

Taxonomy. Order Stylommatophora (terrestrial snails and slugs), Family Polygyridae.

Description. The Shasta hesperian is 12.7 - 14.5 mm in diameter with a depressed helicoid shell with straight-sided spires, a moderately impressed suture, and 5.5-6.0 whorls. The shell is shiny brown with an olive or pinkish tint (Kelley et al. 1999).

Range. This species is endemic to the upper Sacramento watershed in Shasta County, CA. Specific locations include Flume Creek, Burney Creek, O'Brien Creek, Brock Creek, and Slate Creek (Burke et al. 1999).

Habitat requirements. This snail is an old-growth associate found in riparian zones, springs, seeps, marshes, and the mouths of caves (Frest and Johannes 1993). It uses cover objects such as loose rocks, woody debris, and decaying leaves. It appears to be confined to areas with perennial dampness and available cover. Alluvial limestone may contribute to habitat quality for this species (Burke et al. 1999).

Status. The Shasta hesperian is critically imperiled (G1S1 (CA)) due to its restricted range and scattered locations (ORNHIC 2004). It is declining very rapidly throughout 50-70% of its population, range, and/or area (ORNHIC 2004). Frest and Johannes (1993) propose listing the species as endangered in California and federally.

Known threats. This species is threatened by timber harvest, grazing, chemical pollution, nonnative species, and climate change. Historically the habitat of the Shasta hesperian was fragmented by gold mining and extensive grazing (Burke et al. 1999). This species is known from few sites, has a small geographic range, and "seems to be truly rare and vulnerable to extinction if there were adverse modifications of inhabited locations" (Burke et al. 1999). Survey and Manage documents obtained from the Shasta-Trinity national forest indicate that this species was detected at a timber sale, a fuels reduction project, and a project of unidentified type. Mitigation measures were stated to be taken to protect the species during the fuels-reduction project. The suspension of the SM program means that pre-disturbance surveys and mitigation measures are no longer required to protect this rare species, leaving it vulnerable to habitat-degrading activities. The removal of the Survey and Manage program is likely to lead to the loss of known sites for this species (SMR FSEIS 2007, p. 264).

Land management. Of the 78 known locations for *Vespericola shasta*, 72 are on federal land (SMR FSEIS 2007). ORNHIC (2004) reports only seven localities for this species, six historic locations within the administrative boundaries of Shasta National Forest and within 1.6 km of federal land, and one current location on federal land (Burke et al. 1999). There are no known protected occurrences.

32. Knobby rams-horn *(Vorticifex n. sp. 1)*

Taxonomy. Order Basommatophora, Family Planorbidae (Ramshorn snails).

Description. The Knobby rams-horn has been described as "unusual" (Furnish and Monthey 1999). It has a peripheral keel with short, spine-like protuberances and a heavily-ribbed shell with distinct varices. The shell is thin and translucent and ranges in color from green-brown to dark reddish-brown with a height of 1 cm or less. (Furnish and Monthey 1999).

Range. The Knobby Rams-horn is a relatively new species that has been found only at two sites in Shasta County, California (Frest and Johannes 1999). It is endemic to spring complexes of the Pit River drainage in Shasta, Modoc, and Lassen Counties (Frest and Johannes 1999).

Habitat requirements. The two sites where this species has been found are in a very large, pristine spring complex and its outflow. The water is very cold and clear and has high levels of dissolved oxygen (Frest and Johannes 1999). Individuals are found on the surface of cobbles and boulders mostly covered with encrusting red algae (Furnish and Monthey 1999).

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Status. The Knobby rams-horn is critically imperiled (G1S1 (CA)) because of its limited number of occurrences and restricted range (ORNHIC 2004). There are only two known locations for the species, and it is not included in the FS or BLM Special Status Species Programs. It is Survey and Manage Removal Outcome 3, insufficient habitat to support stable populations. Frest and Johannes (1993) advise listing the species as endangered in California and federally.

Known threats. The largest threat to the Knobby rams-horn is habitat loss and degradation. Habitats associated with the Pit River have been significantly degraded by logging, grazing, mining, chemical pollution, road and railroad construction, and water diversions (Furnish and Monthey 1999). Most large Pit River spring complexes have been modified by water diversions for hatcheries and hydropower projects (Frest and Johannes 1993). ORNHIC consider threats to this species to be moderate to severe and imminent for most (> 60%) of the population, occurrences, or area (2004).

Land management. There are two known locations for the Knobby rams-horn, both of which are on private land next to the Shasta National Forest (Frest and Johannes 1999). There are no known protected occurrences for this species.

VII. RECOMMENDATIONS FOR RECOVERY

Protecting these 32 gastropod species as threatened or endangered is an essential step towards ensuring their survival. Following listing, we support several actions to ensure

the conservation of these species. The Endangered Species Act requires conservation efforts to facilitate recovery in its definition of conserve as seen below:

> "The terms 'conserve,' 'conserving,' and 'conservation' mean to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer necessary. Such methods and procedures include, but are not limited to, all activities associated with scientific resources management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transplantation, and, in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, may include regulated taking (16 U.S.C. § 1532 (3)).

In the context of protection as threatened or endangered species with critical habitat designation, the following measures are recommended by the Center for Biological Diversity to effectively conserve the 32 petitioned mollusk species:

- Protect all known sites for all petitioned species from habitat degrading activities. Conduct pre-disturbance surveys before habitat-altering activities are conducted in known or potential mollusk habitat. Manage all known sites of all petitioned species to protect individuals and their habitat from potentially damaging activities by implementing buffer zones, following, at the very least, the provisions of the Survey and Manage program.

- Conduct strategic surveys in potential mollusk habitat to gain a greater understanding of the distribution and ecology of these species, and protect all new occurrences of all detected species.

- Protect the microhabitat conditions on which terrestrial mollusks depend by maintaining canopy closure and shade, downed woody debris, natural understory vegetation, litter, and duff. Protect areas large enough to moderate fluctuations in humidity and temperature and to buffer known sites from increased exposure to sun and wind. Where necessary to maintain suitable microclimate for riparian-dependent species, increase Riparian Reserve widths to provide optimal habitat.

- Keep heavy equipment out of habitat areas and prohibit activities that would cause soil compaction.

- Prohibit grazing in all known habitat for all petitioned species.

- Maintain deciduous trees and native plant diversity to provide logs and leaves as food and cover.

- Maintain and/or restore native riparian plant communities to provide shade, reduce sedimentation, and provide litter fall nutrients.

- Protect the species from recreation by closing habitat areas to ORV use, snowmobile use, camping, firewood gathering, and foot traffic.

- Prohibit activities that would lower the water table and/or reduce soil moisture level and potentially alter the vegetative community.

- Avoid prescribed burns in occupied habitat and manage adjacent habitat to reduce the risk of catastrophic fire in occupied habitat for species in dry areas adapted to high frequency low intensity fire regimes.

- Protect the water bodies which support aquatic mollusks by limiting activities which decrease water quality including dams and water diversions, spring development and destruction, grazing, agriculture, pesticide application, mining, and silvicultural activities, etc., following, at the very least, the original provisions of the Aquatic Conservation Strategy. If necessary increase Riparian Reserve width to maintain water quality.

- Protect water quality by modifying human activities resulting in the introduction of septic tank leachate, sediments, oils, pesticides, etc.

- Protect occupied talus and rockslide areas from quarrying, road construction, and other ground-disturbing activities.

- Enact legislation to drastically reduce greenhouse gas emissions to curb global climate change.

- Protect mollusk habitat from exotic species and prevent and control invasives in a manner that does not expose the mollusks to potentially toxic chemicals.

- Limit site disturbance for surveys, monitoring, and other activities to less than five percent of habitat areas.

VIII. REQUEST FOR CRITICAL HABITAT DESIGNATION

The Center for Biological Diversity requests and strongly recommends critical habitat designation concurrent with species' listing. Critical habitat should be designated in all known locations for all petitioned mollusk species.

The Secretary shall designate critical habitat concurrent with determination that a species is endangered or threatened as required by the Endangered Species Act (16 U.S.C. 1533(a)(3A)). Critical habitat is defined by Section 3 of the ESA as:

(i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of

the species and (II) which may require special management considerations or protection; and

(ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species.16 U.S.C. §1532(5).

Therefore, critical habitat should ensure an adequate amount of protected habitat in a spatial configuration that allows for the long-term survival and recovery of the species, including a network of interconnected reserves that provide for self-sustaining populations, genetic interchange, migration and dispersal. These are basic tenets of conservation biology.

The designation and protection of critical habitat "provide[s] a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." 16 U.S.C. §1536(a)(2). The designation of critical habitat provides listed species with additional protections under Section 7 of the ESA. The Section 7 consultation requirements provide that no action authorized, funded, or carried out by any federal agency will "jeopardize the continued existence of any endangered species or threatened species *or result in the destruction or adverse modification of [critical habitat]*." 16 U.S.C. §1536(a)(2) (emph. added). A more scrutinizing level of consultation is conducted when habitat is designated as "critical." If critical habitat is involved in the consultation, the project must not impede recovery of the species. In comparison, a project that may affect a species' occupied habitat that is not officially designated as "critical habitat" must only show that its impact on that habitat will not jeopardize the continued existence of the species.

Several courts of appeal have recently invalidated the Service's position that critical habitat does not provide additional benefit above and beyond listing alone, holding that such a position violates congressional intent and the plain language of the Act. These rulings have emphasized that critical habitat provides additional protection to species, primarily through the requirement that actions not impede recovery and through the protection of unoccupied habitat, and thus it adds an additional layer of protection to the consultation requirement. *See, e.g. Gifford Pinchot Task Force v. U.S. Fish and Wildlife Serv.*, 378 F.3d 1059, 1069-1070 (9th Cir. 2004); *Sierra Club v. U.S. Fish and Wildlife Serv.*, 245 F.3d 434, 441-42 (5th Cir. 2001); *N.M. Cattle Growers Ass'n v. United States Fish and Wildlife Serv.*, 248 F.3d 1277, 1283 & n. 2 (10th Cir. 2001) (holding invalid the Service's regulation defining destruction or adverse modification of critical habitat in terms of impeding the recovery *and* survival of a species and determining jeopardy consultation is not functionally equivalent to consultation under the destruction/adverse modification standard). These cases should lie to rest further efforts on the part of the Service to argue that critical habitat is irrelevant.

The Ninth Circuit's decision reiterated that recovery is a key purpose of the Endangered Species Act, one that is largely implemented through the critical habitat provisions of the

Act. The court noted that the Service had been operating under regulations that failed to acknowledge the crucial and distinct role of critical habitat: "That the agency was operating under a regulation that we now hold was impermissible has an inescapable bearing on the requisite showing of whether the [Service] considered recovery in its critical habitat inquiry." *Gifford Pinchot* at 1071.

Critical habitat designation also protects species by helping to define the meaning of "harm" under Section 9 of the ESA, which prohibits unlawful "take" of listed species, including harming the species through habitat degradation. Although "take" through habitat degradation is not expressly limited to harm to "critical habitat," it is practically much easier to demonstrate the significance of the impact to a species' habitat where that habitat has already been deemed "essential," or "critical," to the species' continued survival. *See Palila v. Hawaii Department of Land and Natural Resources*, 852 F. 2d 1106 (9th Cir. 1988).

Critical habitat also helps species by providing for agency accountability through the citizen suit provision of the Act. The citizen suit provision permits members of the public to seek judicial review of the agency's compliance with its mandatory statutory duty to consider the habitat needs of imperiled species. Also, the designation of critical habitat provides valuable information for the implementation of recovery plans.

Endangered Species Act "critical habitat" protections are a crucial tool to recover endangered species. A peer-reviewed study in the April 2005 issue of BioScience, "The Effectiveness of the Endangered Species Act: A Quantitative Analysis," concludes that species with critical habitat for two or more years are more than twice as likely to have improving population trends than species without.

In sum, critical habitat is a separate and additional requirement of the Act that provides important protections for listed species not otherwise provided by law. Without designated critical habitat the rare and ecologically important mollusk species in this petition will likely be extirpated. Critical habitat should include all known sites for the species as well as habitats that are ecologically connected to known sites, such as upstream sites where activities could degrade water quality for downstream mollusks, or activities in adjacent habitat which could increase solar and wind exposure for known locations of terrestrial mollusks. Critical habitat should also be large enough to provide dispersal habitat to buffer the potential effects of climate change on the ranges of these species. The primary threat to the continued existence of these irreplaceable species is habitat destruction. Critical habitat designation will thus provide a clear benefit for these species.

IX. CONCLUSION

The 32 species of snails and slugs presented in this petition clearly merit protection under the Endangered Species Act. Nearly half of the species (15/32) occur at ten or fewer sites. Their inclusion in the Survey and Manage Program of the Northwest Forest Plan

verifies both their rarity and importance. The suspension of the SM program leaves them highly vulnerable to extirpation. These mollusk species are found only in the Pacific Northwest and collectively they play a critical role in the region's ecology. Protection of these species through listing and critical habitat designation is necessary to ensure their continued existence.

IX. REFERENCES

Adams, D.M., R.W. Haynes, and A.J. Daigneault. 2006. Estimated timber harvest by U.S. region and ownership, 1950-2002. USDA Forest Service Pacific Northwest Research Station General Technical Report PNW-GTR-659, Portland, OR. 64 pp.

Agee, J.K. 1998. The landscape ecology of western forest fire regimes. Northwest Science 72: 24-34.

Allee, W.C., A.E. Emerson, O. Park, T. Park, and K.P. Schmidt. 1949. Principles of animal ecology. Saunders, Philadelphia. 837 pp.

Animal and Plant Health Inspection Service. 2002. Rangeland grasshopper and mormon cricket suppression program. Final Environmental Impact Statement. USDA Animal and Plant Health Inspection Service, 4700 River Road, Unit 134, Riverdale, MD 20737.

Applegarth, J. 1995. Invertebrates of special status or special concern in the Eugene District. USDI BLM, Eugene, Or. 126 pp.

Ball, M. C., M. W. Lankester, and S. P. Mahoney. 2001. Factors affecting the distribution and transmission of *Elaphostrongylus rangiferi* (Protostrongylidae) in caribou (*Rangifer tarandus caribou*) of Newfoundland, Canada. Canadian Journal of Zoology 79:1265–1277.

Baur, A, and B. Baur. 1990. Are roads barriers to dispersal in the land snail *Arianta arbustorum*? Canadian Journal of Zoology 68(3): 613-617.

Belsky, A.J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on streams and riparian ecosystems in the western United States. Journal of Soil and Water Conservation 54(1): 419-431.

Bogan, A.E. 2006. Conservation and extinction of the freshwater molluscan fauna of North America. p. 373-383 In: Sturm, C.F., T.A. Pearce, and A. Valdes. (Eds.) 2006. The Mollusks: A Guide to Their Study, Collection, and Preservation. American Malacological Society. Boca Raton: Universal Publishers. 445 pp.

Bronmark, Christer. 1989. Interactions between epiphytes, macrophytes, and freshwater snails: a review. Journal of Molluscan Studies 55(2):299-311

Brooke, L.T. 1991. Results of Freshwater Exposures with the Chemicals Atrazine, Biphenyl, Butachlor, Carbaryl, Carbazole, Dibenzofuran, 3, 3-Dichorobenzidine, Dichlorvos. Center for Lake Superior Environmental Studies, University of Wisconsin, Superior, WI: 110.

Brooke, L.T. 1993. Acute and Chronic Toxicity of Nonylphenol to Ten Species of Aquatic Organisms. U.S. Environmental Protection Agency, Contract No. 68-C1-0034. Duluth, MN

Brown, A.W.A. 1978. Ecology of Pesticides. John Wiley and Sons, Inc. 525 p.

Brussard, P.F., and M.E. Gilpin. 1989. Demographic and genetic problems of small populations. In U.S. Seal, E.T. Thorne, M.A. Bogan, and S.H. Anderson, eds. Conservation biology and the black-footed ferret. Yale University Press, New Haven. 302 pp.

Burch, J.B. 1989. North American Freshwater Snails. Hamburg, MI: Malacological Publications.

Burke, T., J. Applegarth, T. Weasma, N. Duncan (ed). 1999. Management recommendations for survey and manage terrestrial mollusks. Version 2.0. Report submitted to USDI BLM, Salem, OR.

Cairns, Jr., J., A.G. Heath, and B.C. Parke. 1975. The effects of temperature upon the toxicity of chemicals to aquatic organisms. Hydrobiologia 47(1):135-171.

California Environmental Protection Agency. 2008. State Water Resources Control Board. 2006 Clean Water Act Section 303(d) list of water quality limited segments. http://www.swrcb.ca.gov/tmdl/303d_lists2006approved.html . Last accessed Jan. 23, 2008.

Carey, A.B. 2000. Effects of new forest management strategies. Ecological Applications 10: 248-257.

Carey A.B., D.R. Thysell, and A.W. Brodie. 1999. The forest ecosystem study: background, rationale, implementation, baseline condition, silvicultural assessment. USDA Forest Service General Tech Report PNW-GTR-457. Pacific Northwest Research Station, Portland, Oregon.

California Fish and Game. 2004. California Fish and Game Code Sections 2050, et seq., "California Endangered Species Act." Webpage accessed at http://www.dfg.ca.gov/hcpb/ceqacesa/cesa/incidental/cesa_policy_law.shtml. Last accessed January 31, 2004.

Chapman, J. 2003. *P. antipodarum* invades the Oregon coast. Minutes of *Potamopyrgus antipodarum* in the Western USA: Conference 2003. August 26 and 27, 2003.

Churchfield, S. 1984. Dietary separation in three species of shrew inhabiting water-cress beds. Journal of Zoology 204: 211–228.

Crowl, T.A., and G.D. Schnell. 1990, Factors determining population density and size distribution of a freshwater snail in streams: effects of spatial scale. Oikos 59(3):359-367.

Crumpacker, D.W. 1984. Regional riparian research and a multi-university approach to the special problem of livestock grazing in the Rocky Mountains and Great Plains. p. 413-422 in R.E. Warner and K. Hendrix, ed. California riparian systems: Ecology, conservation, and productive management. Berkeley: Univ. of California Press.

Denny, M. 1980. Locomotion: the cost of gastropod crawling. Science 208(4449):1288-1290.

Duncan, N. 2005a. Conservation Assessment for *Cryptomastix hendersoni*, Columbia Oregonian. Originally issued as Applegarth, J. Management Recommendations. February 1999. Revised Sept. 2005. USDA Forest Service Region 6 and USDI Bureau of Land Management, Oregon and Washington. 15 pp.

Duncan, N. 2005b. Conservation Assessment for *Deroceras hesperium*, Evening fieldslug. Originally issued as Burke, T.E. Management Recommendations, February 1998. Revised Sept. 2005. USDA Forest Service Region 6 and USDI Bureau of Land Management, Oregon and Washington. 16 pp.

Duncan, N. 2005c. Conservation Assessments for Mollusk Species associated with springs and spring runs: *Fluminicola new species 2, 3, 11, Vorticifex klamathensis sinitsini; Juga (Oreobasis) new species 2*; and *Lyogyrus new spp. 1* v. 2.0. Originally issued as Furnish, J.L. and R.W. Monthey, December 1998. Revised October 2005. USDA Forest Service Region 6 and USDI Bureau of Land Management, Oregon and Washington. 17 pp.

Duncan, N. 2005d. Conservation Assessment for *Lyogyrus n. sp. 2*, Masked Duskysnail. Originally issued as: Monthey, R. Management Recommendations, December 1998. Revised October 2005. USDA Forest Service Region 6 and USDI Bureau of Land Management, Oregon and Washington. 10 pp.

Duncan, N. 2005e. Conservation Assessment for *Pristiloma arcticum crateris*, Crater Lake Tightcoil. Originally issued as: Gowan, D. and T.E. Burke, Management Recommendations, October 1999. Reconfigured September 2004. USDA Forest Service Region 6 and USDI Bureau of Land Management, Oregon and Washington. 17 pp.

Duncan, N. 2005f. Conservation Assessment for *Oreohelix n. sp.* 1, Chelan Mountainsnail. Originally issued as: Burke, T.E. Management Recommendations, February 1999. Revised October 2005. USDA Forest Service Region 6 and USDI Bureau of Land Management, Oregon and Washington. 22 pp.

Duncan, N. 2005g. Conservation Assesment for *Vertigo n. sp*., Hoko Vertigo. Originally issued as: Applegarth, J.S. Management Recommendations, February 1999. Revised October 2005. USDA Forest Service Region 6 and USDI Bureau of Land Management, Oregon and Washington. 15 pp.

Dunk, J.R., W.J. Zielinski, and H.K. Preisler. 2004. Predicting the occurrence of rare mollusks in northern California forests. Ecological Applications, 14(3): 713–729.

EPA. 1997a. Climate Change and Washington. United States Environmental Protection Agency, Office of Policy. EPA 230-F-97-008uu.

EPA. 1997b. Climate Change and California. United States Environmental Protection Agency, Office of Policy, Evaluation and Planning. EPA 320-F-97-008e.

Everest, F.H., Stouder, D.J., Kakoyannis, C., Houston, L., Stankey, G., Kline, J., and R. Alig. 2004. A Review of Scientific Information on Issues Related to the Use and Management of Water Resources in the Pacific Northwest. General Technical Report PNW-GTR-595 United States Department of Agriculture Forest Service Pacific Northwest Research Station May 2004. 142 pp.

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652. http://www.ipccinfo.com/wg2report_north_america.php

Forest Ecosystem Management Assessment Team [FEMAT]. 1993. Forest ecosystem management: an ecological, economic, and social assessment. Portland, OR: U.S. Department of Agriculture; U.S. Department of the Interior [and others].

Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8(3): 629-644.

Fredricksen, RL. 1970. Erosion and sedimentation following road construction and timber harvest on unstable soils in three small western Oregon watersheds. USDA Forest Service Research Paper PNW-104. 15 pp.

Frest, T.J. 2002. Native snails: Indicators of Ecosystem Health. p. 211-215, in: Welfare Ranching, G. Wuerthner and M. Matteson (Eds.). Island Press, Sausalito, California.

Frest, T.J. and E.J. Johannes. 1993a. Land Snail Survey of the Black Hills National Forest, South Dakota and Wyoming. Final Report to USDA Forest Service and USDI Fish and Wildlife Service. Deixis Consultants, 2517 NE 65th St, Seattle, WA 98115. 156 p.

Frest, T.J., and E.J. Johannes. 1993b. Mollusc Species of Special Concern Within the Range of the Northern Spotted Owl with an Addendum Addressing New Management Options Proposed in June, 1993. Final Report to Forest Ecosystem Management Working Group, USDA Forest Service. Deixis Consultants, 2517 NE 65th St, Seattle, WA 98115. 98 p.

Frest, T.J. and E.J. Johannes. 1995a. Interior Columbia Basin Mollusk Species of Special Concern. Final Report to Interior Columbia Basin Ecosystem Management Project. Deixis Consultants, 2517 NE 65th St, Seattle, WA 98115. 362 p.

Frest, T.J. and E.J. Johannes. 1995b. Land Snail Survey of the Lower Salmon River Drainage, Idaho. Final Report to USDI Bureau of Land Management. Deixis Consultants, 2517 NE 65th St, Seattle, WA 98115. 142 p.

Frest, T.J. and E.J. Johannes. 1995c. Freshwater Molluscs of the Upper Sacramento System, California, with Particular Reference to the Cantara Spill. 1994 Yearly Report Prepared for State of California Department of Fish and Game. Deixis Consultants, 2517 NE 65th St, Seattle, WA 98115. 88 p.

Frest, T.J. and E.J. Johannes. 1996. Additional Information on Certain Mollusk Species of Special Concern Occurring Within the Range of the Northern Spotted Owl. Deixis Consultants, 2517 NE 65th St, Seattle, WA 98115. 150 p.

Frest, T.J. and E.J. Johannes. 1997a. Land Snails of the Lucile Caves ACEC. U.S. Department of the Interior, Bureau of Land Management, Idaho State Office, Boise, Idaho. Technical Bulletin 97-16. 9 p.

Frest, T.J. and E.J. Johannes. 1997b. Land Snail Survey of the Lower Salmon River Drainage, Idaho. U.S. Department of the Interior, Bureau of Land Management, Idaho State Office, Boise. Idaho Technical Bulletin 97-18. 142 p.

Frest, T.J. and E.J. Johannes. 1997c. Upper Sacramento System Freshwater Mollusk Monitoring, California, with Particular Reference to the Cantara Spill. 1996 Year Report for Cantara Trustee Council. Deixis Consultants 2517 NE 65th St, Seattle, WA 98115. 39 p.

Frest, T.J. and E. J. Johannes. 1998. Freshwater Mollusks of the Upper Klamath Lake Drainage, Oregon. Deixis Consultants 2517 NE 65th St, Seattle, WA 98115. vii + 380 pp.

Frest, T.J. and E. J Johannes. 2000a. A Baseline Mollusk Survey of Southwestern Oregon, with emphasis on the Rogue and Umpqua River Drainages. Deixis Consultants, 2517 NE 65th St, Seattle, WA 98115. vii + 433 pp.

Frest, T.J. and E. J. Johannes. 2000b. A Mollusk Survey of Klamath and Sycan marshes and vicinity. Deixis Consultants, 2517 NE 65th St, Seattle, WA 98115. ii + 77 pp., appendices.

Frest, T.J. and E.J. Johannes. 2002a. Land Snail Survey of the Black Hills National Forest, South Dakota and Wyoming, Summary Report, 1991-2001. Final Report to the USDA Forest Service, Black Hills National Forest. Deixis Consultants, 2517 NE 65th St, Seattle, WA 98115. 127 p.

Frest, T.J. and E.J. Johannes. 2002b. Biogeography, Endemism, and Ecology of an Ancient Lake Mollusk Fauna: Upper Klamath Lake Drainage, South-Central Oregon. Pp. 3-11 – 3-25 in Everett, U., M. George, and A King, Proceedings of the 2001 Klamath Basin Fish and Water Management Symposium.

Furnish, J.L. 1990. Factors affecting the growth, production and distribution of the stream snail *Juga silicula* (Gould). Ph.D. Dissertation, Oregon State University. 173 p.

Furnish, J.L., and R. Monthey. 1999. Management Recommendations for Aquatic Mollusks. Version 2.0. Report submitted to USDI Bureau of Land Management, Salem, OR, December 1998.

Furnish, J., R. Monthey, and J. Applegarth. 1997. Survey protocol for terrestrial mollusk species from the Northwest Forest Plan. Version 2.0. Report to the USDI Bureau of Land Management, Salem, Oregon, October 29, 1997. Unpaginated.

Godan, D. 1983. Pest Slugs and Snails: Biology and Control. Springer-Verlag, New York, NY. 445 pp.

Goodman, D. 1987. The demography of chance extinction. p. 11-34 in M.E. Soule, ed. Viable populations for conservation. Cambride: Univ. Press. 189 pp.

Graveland, J., R. van der Wal, J.H. van Balen, and A.J. van Noordwijk. 1994. Poor reproduction in forest passerines from decline of snail abundance on acidified soils. Nature 368:446–448.

Hanski, I., A. Moilanen, and M. Gullenberg. 1996. Minimum viable metapopulation size. American Naturalist 147:527-541.

Harmon, M.E., and C. Hua. 1991. Coarse woody-debris dynamics in two old-growth ecosystems. Bioscience 41: 604-610.

Hastings, A., Cuddington, K., Davies, K.F., Dugaw, C.J., Elmendorf, S. Amy Freestone, A., Harrison, S., Holland, M., Lambrinos, J., Malvadkar, U., Melbourne, B.A., Moore, K., Taylor, C., and D. Thomson. 2005. The spatial spread of invasions: new developments in theory and evidence. Ecology Letters 8 (1):91–101.

Hawkins, C.P., and J.K. Furnish. 1987. Are Snails Important Competitors in Stream Ecosystems? *Oikos* 49(2):209-220.

Hershler, R., T.J. Frest, H. Liu, and E.J. Johannes. 2003. Rissooidean Snails from the Pit River, California. The Veliger 46(4): 275-304.

Hershler, R. 2001. Systematics of the North and Central American Aquatic Snail Genus Tryonia (Rissooidea: Hydrobiidae). Smithsonian Contributions to Zoology 612.

Hershler, R. 1999. A systematic review of the Hydrobiid snails (Gastropoda: Rissooidea) of the Great Basin, Western United States. Part II. The Veliger 42(4): 306-337.

Hershler, R. 1998. A systematic review of the hydrobiid snails in the Great Basin , Western United States: Part I, Genus Pyrgulopsis. Veliger 41(1):1-132.

Hershler, R. 1995a. Conservation of Springsnails in the Great Basin: Simple Solutions Complicated by Political Realities. In American Malacological Union, Program and Abstracts, 61st Annual Meeting.

Hershler, R. 1995b. New freshwater snails of the genus Pyrgulopsis (Rissooidea: Hydrobiidae) from California. The Veliger 38: 343-373.

Hershler, R. 1994. A Review of the North American Freshwater Snail Genus Pyrgulopsis (Hydrobiidae). Smithsonian Contributions to Zoology 554.

Hershler, R. and T.J. Frest. 1996. A review of the North American freshwater snail genus Fluminicola (Hydrobiidae). Smithsonian Contributions to Zoology 583.

Holznagel, W.E. and C. Lydeard. 2000. A molecular phylogeny of North American Pleuroceridae (Gastropoda: Cerithioidea) based on mitochondrial 16S rDNA sequences. Journal of Molluscan Studies 66: 233-257.

Houston, D. B. 1971. Ecosystems of National Parks. Science 172:648-651.

Hovingh, P. 1999. Selected aquatic fauna observations in western Wyoming. Unpublished report by Peter Hovingh, 721 Second Avenue, Salt Lake City, Utah 84103.

Information Bulletin No. OR-2004-145. EMS TRANSMISSION 07/20/2004

http://www.blm.gov/nhp/efoia/or/fy2004/ib/ib-or-2004-145.htm

ISAB (Independent Scientific Advisory Board for the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and National Marine Fisheries Service). 2007. Climate Change Impacts on Columbia River Basin Fish and Wildlife. May 11, 2007. ISAB 2007-2. 136 pp.

Kelley R., S. Dowlan, N. Duncan, and T. Burke. 1999. Field Guide to Survey and Manage Terrestrial Mollusk Species from the Northwest Forest Plan. Bureau of Land Management, Oregon State Office, Portland, Oregon. 114 pp.

Khangarot, B.S., and P.K. Ray. 1988. Sensitivity of freshwater pulmonate snails,*Lymnaea luteola* L., to heavy metals. Bulletin of Environmental Contamination and Toxicology 41(2):208-213.

Kogut, T. and N. Duncan. 2005. Conservation Assessment for *Cryptomastix devia*, Puget Oregonian. Originally issued as Burke, T.E. Management Recommendations, September 1999. Reconfigured Sept. 2005. USDA Forest Service Region 6 and USDI Bureau of Land Management, Oregon and Washington. 24 pp.

Lacy, R.C. 1987. Loss of genetic diversity from managed populations: interacting effects of drift, mutation, immigration, selection, and population subdivision. Conservation Biology 1:143-158.

Lande, R. 1993. Risks of population extinction from demographic and environmental stochasticity and random catastrophes. American Naturalist. 142:911-927.

Lefcort, H., S.M. Thomson, E.E. Cowles, H.L. Harowicz, B.M. Livaudais, W.E. Roberts, and W.F. Ettinger. 1999. The importance of fear: predator and heavy metal mediated competition between tadpoles (Rana luteiventris) and snails (Lymnaea pulustris). Ecological Applications 9: 1477-1489.

Lefcort, H., E. Ammann, and S.M. Eiger. 2000. Antipredatory behavior as an index of heavy-metal pollution? A test using snails and caddisflies. Archives of Environmental Contamination and Toxicology 38: 311-316.

Lefcort, H., M.Q. Aguon, K.A. Bond, R. Chapman, R. Chaquette, J. Clark, P. Kornachuk, B.Z. Lang, and J.C. Martin. 2002. Indirect effects of heavy metals on parasites may cause shifts in snail species compositions. Archives of Environmental Contamination and Toxicology 43: 34-41.

Leonard J.L. 1991. Sexual conflict and the mating systems of simultaneously hermaphroditic gastropods. American Malacological Bulletin. 9(1):45–58.

Liddle, M. J. 1975. A selective review of the ecological effects of human trampling on natural ecosystems. Biological Conservation 17:17-36.

Lydeard, C., R.H. Cowie, W.F. Ponder, A.E. Bogan, P. Bouchet, S.A. Clark, K.S. Cummings, T.J. Frest, O. Gargminy, D.G. Herbert, R. Hershler, K.E. Perez, B. Roth, M. Seddon, E.E. Strong, and F.G. Thompson. 2004. The global decline of nonmarine mollusks. BioScience 54(4): 321-330.

Lysne, S. 2003. The life history and ecology of two endangered Snake River gastropods: Utah valvata (*Valvata utahensis*: Call) and Idaho springsnail (*Pyrgulopsis idahoensis: Pilsbry*). M.S. Thesis, Boise State University. 103 p.

Mac, M. J., P. A. Opler, C. E. Puckett Haecker, and P. D. Doran. 1998. Status and trends of the nation's biological resources. 2 vols. U.S. Department of the Interior, U.S. Geological Survey, Reston, Va. 964 pp.

Martin, S.M. 2000. Terrestrial snails and slugs (Mollusca: Gastropoda) of Maine. Northeastern Naturalist 7(1):33–88.

Mason, C.F. 1970. Snail populations, beech litter production, and the role of snails in litter decomposition. Oecologia 5(3): 215-239.

McCarty, J.P. 2001. Ecological consequences of recent climate change. Conservation Biology 15(2):320-331.

Molina, R., B.G. Marcot, and R. Lesher. 2006. Protecting Rare, Old-Growth, Forest-Associated Species under the Survey and Manage Program Guidelines of the Northwest Forest Plan. Conservation Biology 20(2): 306-318.

NatureServe. 2007. www.natureserve.org

New Zealand Mudsnail in the Western USA. 2004. Website accessed at http://www.esg.montana.edu/aim/mollusca/nzms/. Last accessed May 6, 2004.

Niwa, C.G. et al. 2001. Invertebrates of the Columbia River Basin Assessment Area. USDA Forest Service PNW Research Station USDI BLM General Technical Report PNW GRT 512 June 2001.

Norse, E.A. 1990. Ancient Forests of the Pacific Northwest. The Wilderness Society and Island Press, Washington, D.C.

Noss, R.F., C. Carroll, K. Vance-Borland, and G. Wuethner. 2002. A multicriteria assessment of the irreplaceability and vulnerability of sites in the Greater Yellowstone Ecosystem. Conservation Biology 16: 895-908.

Olson, Deanna H.; Van Norman, Kelli J.; Huff, Robert D. 2007. The utility of strategic surveys for rare and little-known species under the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-708. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 48 p.

Oregon Department of Environmental Quality. 2008. Water quality assessment integrated reports and 303(d) lists. http://www.deq.state.or.us/wq/assessment/rpt0406.htm Last accessed Jan. 23, 2008.

ORNHIC. 2004. Survey and Manage species assessment.
Oregon Natural Heritage Information Center. http://oregonstate.edu/ornhic/survey-manage.html

Parker, G.H. 1911. The mechanism of locomotion in gastropods. Journal of Morphology, 22(1):155-170.

Parson, E.A. 2001. Potential consequences of climate variability and change for the Pacific Northwest. Pp. 247-280 *In:* National Assessment Synthesis Team. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change. Report for the US Global Climate Change Research Program. Cambridge, UK: University Press. 620 pp.

Peters, R.L. and J.D.S. Darling. 1985. The greenhouse effect and nature reserves. Bioscience 35(11):707-717.

Pringle CM, Freeman MC, Freeman BJ. 2000.Regional effects of hydrologic alterations on riverine macrobiota in the New World: Tropical–temperate comparisons. BioScience 50: 807–823.

Rader, R.B., M.C. Belk, and M.J. Keleher. 2003. The introduction of an invasive snail (Melanoides tuberculata) to spring ecosystems of the Bonneville Basin, Utah. Journal of Freshwater Ecology 18(4): 647-657.

Rapp, V. 2004. Western forests, fire risk, and climate change. Science update: Issue 6, January 2004. USDA Forest Service Pacific Northwest Research Station. 12 pp.

Reed, R.A., J. Johnson-Barnard, and W.L. Baker. 1996. Contribution of Roads to Forest Fragmentation in the Rocky Mountains. Conservation Biology 10(4):1098-1106.

Reeves, G.H., J.E. Williams, K.M. Burnett, and K. Gallo. 2006. The Aquatic Conservation Strategy of the Northwest Forest Plan. Conservation Biology 20(2): 319-329.

Richter, K.O. 1979. Aspects of nutrient cycling by *Ariolimax columbianus* (Mollusca: Arionidae) in Pacific Northwest coniferous forests. Pedobiologia 19:60–74.

Riedel, M.S., and J.M. Vose, 2002. Forest road erosion, sediment transport, and model validation in the Southern Appalachians. USDA Forest Service, Southern Research Station, Coweeta Hydrologic Laboratory. Presented at: Second Federal Interagency Hydrologic Modeling Conference, July 28-August 1, 2002, Riviera Hotel, Las Vegas, Nevada.

Roth, B. 2002. Taxonomy and classification of Helminthoglypta. Memorandum submitted under BLM purchase order HAB020406. 13 pp.

Roth, B., and P. H. Pressley. 1986. Observations on the range and natural history of *Monadenia setosa* (Gastropoda: Pulmonata) in the Klamath Mountains, California, and the taxonomy of some related species. Veliger 29:169–182.

Sada, D.W. and G.L. Vinyard. 2002. Anthropogenic changes in biogeography of Great Basin aquatic biota. Pages 277-293 in Hershler, R., D.B. Madsen, and D.R. Currey, eds. 2002. Great Basin Aquatic Systems History. Smithsonian contributions to the Earth Science 33.

Sala, O.E. 2000. Global biodiversity scenarios for the year 2100. Science 287(5459): 1770-1774.

Schoennagel, T., T.T. Veblen, and W.H. Romme. 2004. The interaction of fire, fuels, and climate across Rocky Mountain forests. Bioscience 54(7):661-676.

Schulz, T.T., and W.C. Leininger. 1990. Differences in riparian vegetation structure between grazed areas and exclosures. Journal of Range Management 43: 295-299.

Schuytema, G.S., A.V. Nebeker, and W.L. Griffis. 1994. Effects of dietary exposure to forest pesticides on the brown garden snail *Helix aspersa* Müller. Archives of Environmental Contamination and Toxicology 26:23-28.

Solem, A.G. 1974. The Shell Makers. Introducing Mollusks. Wiley-Interscience, New York. 289 pp.

South, A. 1980. A technique for the assessment of predation by birds and mammals on the slug *Deroceras reticulatum* (Mu¨ ller) (Pulmonata: Limacidae). Journal of Conchology 30:229–234.

Speight, M. C. D. 1973. Outdoor recreation and its ecological effects: A bibliography and review. Univ. College of London, U.K., Discuss. Pap. Conserv. 4. 35pp.

Strayer, D.L. 1999a. Freshwater mollusks and water quality. Journal of the North American Benthological Society 18(1):1.

Strayer, D.L. 1999b. Effects of alien species on freshwater mollusks in North America. Journal of the North American Benthological Society 18(1):74-98.

Taylor, D.W. 2003. Introduction to Physidae (Gastropoda: Hygrophila): Biogeography, classification, morphology. Revista de Biolgía Tropical 51 (Supplement 1): 1-287.

Taylor, D.W. 1981. Freshwater mollusks of California: a distributional checklist. California Fish and Game 67(3): 140-163.

Turgeon, D.D., J.F. Quinn, Jr., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F.G. Thompson, M. Vecchione, and J.D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. 2nd Edition. American Fisheries Society Special Publication 26, Bethesda, Maryland: 526 pp.

U.S. Department of Agriculture; U.S. Department of the Interior [USDA and USDI]. 1994a. Final supplemental environmental impact statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl [Northwest Forest Plan]. Portland, OR. 2 vol.

U.S. Department of Agriculture; U.S. Department of the Interior [USDA and USDI]. 1994b. Record of decision on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl [Northwest Forest Plan]. Portland, OR.

U.S. Department of Agriculture; U.S. Department of the Interior [USDA and USDI]. 2000. Final supplemental environmental impact statement for amendment to the survey and manage, protection buffer, and other mitigation measures standards and guidelines. Portland, OR. 2 vol.

U.S. Department of Agriculture; U.S. Department of the Interior [USDA and USDI] Species Review Panel. 2002. Internal working document. Unpublished compilation. On file with: Regional Ecosystem Office, PO Box 3623, Portland, OR. 97208.

U.S. Department of Agriculture; U.S. Department of the Interior [USDA and USDI]. 2004a. Final supplemental environmental impact statement to remove or modify the survey and manage mitigation measure standards and guidelines. Portland, OR. 2 vol. http://www.or.blm.gov/nwfpnepa/index.htm#March 23, 2004. (30 June 2006).

U.S. Department of Agriculture; U.S. Department of the Interior [USDA and USDI]. 2004b. Record of decision to remove or modify the survey and manage mitigation measure standards and guidelines in Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl. Portland, OR. http://www.or.blm.gov/nwfpnepa/index.htm#March 23, 2004. (30 June 2006).

U.S. Department of Agriculture; U.S. Department of the Interior [USDA and USDI]. 2004c. Survey and manage: fiscal year 2003 annual status report. Portland, OR. http://www.or.blm.gov/surveyandmanage/AnnualStatusReport/2003/S_and_M-2003.pdf. (30 August 2005).

U.S. Department of Agriculture; U.S. Department of the Interior [USDA and USDI]. 2007. Final Supplement to the 2004 Supplemental Environmental Impact Statement to Remove or Modify the Survey and Manage Mitigation Measure Standards and Guidelines. Portland, OR. June 2007.

USFS. 2003a. Biological Evaluation, Aquatic Vertebrates and Invertebrates, Pit 3, 4, and 5 Hydroelectric Project (FERC No. 233-081). USDA Forest Service, Shasta-Trinity and Lassen National Forests. Prepared May 2003.

USFS. 2003b. Forest Service Final Section 4(e) Conditions, Section 10(a) Recommendations and Comments, Pit 3, 4, and 5 Hydroelectric Project, FERC No. 233. USDA Forest Service, Office of the General Counsel, San Francisco. Submitted November 14, 2003.

U.S. Fish and Wildlife Service. 1989. Endangered and threatened wildlife and plants; animal notice of review. Federal Register, Department of the Interior 54(4): 554-579.

USFWS. 1976a. Endangered and Threatened Wildlife and Plants: Proposed Endangered or Threatened Status for 32 U.S. Snails. 41 Fed. Reg. 17742-17748 (April 28, 1976).

USFWS. 1976b. Endangered and Threatened Wildlife and Plants: Proposal to Determine 2 Birds, 1 Lizard, 3 Snails, and 1 Insect, all indigenous to the California Channel Islands, to be Endangered Species. 41 Fed. Reg. 22073-22075 (June 1, 1976).

USFWS. 1976c. Endangered and Threatened Wildlife and Plants: Determination that Six Species of Butterflies are Endangered Species. 41 Fed. Reg. 22041-22044 (June 1, 1976).

Van Cleave, H.J. 1951. Snails in their relations to the soil. The Biologist, 34(1-2):3-9.

van der Laan, K. L. 1971. The population ecology of the terrestrial snail, *Helminthoglypta arrosa* (Pulmonata: Helicida). Dissertation. University of California, Berkeley, California, USA.

Waggoner, J., S. A. Clark, K.E. Perez, and C. Lydeard. 2006. A survey of terrestrial gastropods of the Sipsey Wilderness (Bankhead National Forest), Alabama. Southeastern Naturalist 5(1):57-68.

Wagner, F.H. 1978. Livestock grazing and the livestock industry. p. 121-145 in H.P. Brokaw, ed. Wildlife and America. Council on Environmental Quality, Washington D.C.

Wainwright, M. and N. Duncan. 2005. Conservation Assessment for Four Species of the Genus Hemphillia. Originally issued as: Burke, T.E. Management Recommendations, February 1998. Revised October 2005. USDA Forest Service Region 6 and USDI Bureau of Land Management, Oregon and Washington. 34 pp.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science 313(5789):940-943.

White, P. S. and S. P. Bratton. 1980. After preservation: Philosophical and practical problems of change. Biological Conservation 18:241-255.

Wuerthner, G., ed. 2007. Thrillcraft: The Environmental Consequences of Motorized Recreation. White River Junction, VT: Chelsea Green. 274 pp.

Zavaleta, E.S. and K.B. Hulvey. 2004. Realistic species losses disproportionately reduce grassland resistance to biological invaders. Science 306(5699):1175-1177.

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