

**Conservation Assessment
For
Vertigo n. sp.,
Hoko Vertigo**

**Originally issued as
Management Recommendations
February 1999**

John S. Applegarth

**Revised
October 2005
Nancy Duncan**

**USDA Forest Service Region 6 and
USDI Bureau of Land Management, Oregon and Washington**

TABLE OF CONTENTS

EXECUTIVE SUMMARY	4
I. NATURAL HISTORY	5
A. Taxonomic/Nomenclatural History	5
B. Species Description	5
1. Morphology	5
2. Reproductive Biology	6
3. Ecology	6
C. Range, Known Sites	6
D. Habitat Characteristics and Species Abundance	7
II. CURRENT SPECIES SITUATION	8
A. Status History	8
B. Major Habitat and Viability Considerations	8
C. Threats to the Species	9
D. Distribution Relative to Land Allocations	9
III. MANAGEMENT GOALS AND OBJECTIVES	9
IV. HABITAT MANAGEMENT	9
A. Lessons from History	9
B. Identification of Species Habitat Areas	10
C. Management Within Species Habitat Areas	10
D. Other Management Issues and Considerations	11
V. RESEARCH, INVENTORY, AND MONITORING OPPORTUNITIES	11
A. Data Gaps and Information Needs	12
B. Research Questions	12
C. Monitoring Needs and Recommendations	12
VI. REFERENCES	13

Preface:

Converting Survey and Manage Management Recommendations into Conservation Assessments

Much of the content in this document was included in previously transmitted Management Recommendations developed for use with Survey and Manage Standards and Guidelines. With the removal of those Standards and Guidelines, the Management Recommendations have been reconfigured into Conservation Assessments to fit Special Status/Sensitive Species Program (SSSSP) objectives and language. Changes include: the removal of terminology specific to Survey and Manage Standards and Guidelines, the addition of Oregon Natural Heritage Information Center ranks for the species, and the addition of USDA Forest Service and USDI Bureau of Land Management (BLM) Special Status/Sensitive Species status and policy. Habitat, range, and taxonomic information have also been updated to be current with data gathered since the Management Recommendations were initially issued. The framework of the original document is maintained in order to expedite getting this information to field units. For this reason this document does not entirely conform to recently adopted standards for the Forest Service and BLM for Conservation Assessment development in Oregon and Washington.

Assumptions about site management

In the Final Supplemental Environmental Impact Statement (FSEIS) and Record of Decision (ROD) to Remove or Modify the Survey and Manage Standards and Guidelines (USDA and USDI 2004), assumptions were made as to how former Survey and Manage species would be managed under Agency Special Status/Sensitive Species policies. Under the assumptions in the FSEIS, the ROD stated “The assumption used in the final SEIS for managing known sites under the Special Status Species Programs was that sites needed to prevent a listing under the Endangered Species Act would be managed. For species currently included in Survey and Manage Categories A, B and E (which require management of all known sites), it is anticipated that only in rare cases would a site not be needed to prevent a listing.... Authority to disturb special status species sites lies with the agency official who is responsible for authorizing the proposed habitat-disturbing activity”. This species was in Category A at the time of the signing of the ROD, and the above assumptions apply to this species’ management under the agencies’ SSSSP.

Management Considerations

Within the following Conservation Assessment, under the “Management 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. Management of the species covered in this Conservation Assessment follows Forest Service 2670 Manual policy and BLM 6840 Manual direction. (Additional information, including species specific maps, is available on the Interagency Special Status and Sensitive Species website.)

EXECUTIVE SUMMARY

Species: *Vertigo* n. sp., the Hoko Vertigo

Taxonomic Group: Mollusks (Phylum Mollusca: Class Gastropoda, Order Pulmonata, Family: Pupilladae, Subfamily Vertigininae)

Management Status: This unnamed species is on the Washington State Monitor Species List, is a Tracking Species for WA BLM, and a Forest Service Region 6 Sensitive Species. The Washington Natural Heritage Program gives this species Global ranking G1, State ranking S1, “critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation”.

Range: This species is only known from 2 sites on the Hoko River in the northwestern part of the Olympic Mountains. These locations are on non-Federal lands, but are within 10 km (6 mi) of the Soleduck Ranger District (Olympic National Forest), and 20 km (12 mi) from parcels of Bureau of Land Management land along the Soleduck River in Clallam County. This species is suspected to occur in Clallam County in the Olympic National Forest. Its range may also extend into Vancouver Island, British Columbia and other islands in the region.

Specific Habitat: The Hoko Vertigo seems to be an old growth riparian associate. The 2 known locations are on bases of wooded slopes near streams at low elevations of roughly 12 and 90 meters (40 and 300 feet). It is unknown if the species could occur at considerably higher elevations. The habitat seems to be characterized by old trees, riparian hardwoods, and mesic conditions. This species is arboreal and has been found on trunks and lower limbs of deciduous trees, mainly alders. They are most easily detected on the undersides of limbs and leaning trunks of young alders that have relatively smooth bark.

Threats: When a species is known from only a few locations, any modification of the environment could be a potential threat to its survival. Habitat factors that seem to be vulnerable include late-successional stands of riparian hardwoods and the associated microclimate, the stream stability, and the diverse community of native plants and animals. Threats to these habitats include silvicultural treatments (especially hardwood conversion for fish habitat improvement) and timber harvest in riparian areas, special forest product harvesting, recreation, and road construction.

Management Considerations: If this rare species were to be found on Federal lands, the long-term survival of any newly discovered colonies should be favored by managing for late-successional riparian conifer-hardwood forest stand heterogeneity to provide the interior microclimate needs of the species. Within identified Species Habitat Areas, consider avoiding the use of fire or chemicals, as well as concentrated recreation, road construction or other activities that could compact the ground or mechanically injure old hardwood trees.

Research, Inventory and Monitoring Opportunities: The range and relative abundance of this apparently rare species need to be explored. More information on its habitat needs to be collected. Its ecology and tolerance to disturbance are largely unknown. The only known sites are on State land, which suggests that discovery of additional managed sites on federal land would greatly improve the chances of species persistence.

I. NATURAL HISTORY

A. Taxonomic/Nomenclatural History

The genus *Vertigo* is in the subfamily Vertigininae (e.g., Pilsbry, 1948, page 943), in the family Pupillidae (e.g., Burch and Pearce, 1990, page 241), and in the superfamily Pupilloidea, order Pulmonata, and class Mollusca (e.g., Smith et al. 1990).

The genus *Vertigo* was named by Müller (1774), who described a European species, *Vertigo pusilla* Müller, as the type species of this genus. According to Pilsbry (1948), this genus is known from most of the Holarctic realm from near sea level to 10,000 feet elevation, and it includes about 80 species. Pilsbry (1948) recognized 3 subgenera: *Angustula*, *Vertillaria*, and *Vertigo* (sensu stricto). Within the subgenus *Vertigo*, Pilsbry (1948) recognized 7 species groups. Frest and Johannes (1996b) placed the Hoko *Vertigo* into the *Vertigo californica* group. Sterki (1892) gave this group a subgeneric name, *Nearctula*, which was regarded as a synonym of the genus *Vertigo* by Pilsbry (1948). Recently *Nearctula* has been used by some authors as the valid genus for this species group (Smith et al. 1990; Turgeon et al. 1998).

This is a biological species that, as of September 2005, has not been formally named or described. Hence there is no type specimen or type locality. Instead there is a morphologically distinct population of snails first recognized by Frest and Johannes that is informally known as the Hoko *Vertigo*, *Vertigo* n. sp. 1 (Frest and Johannes 1993). It is unknown if this taxon will be determined to be a distinct species, or a subspecies or variety of another taxon.

B. Species Description

1. Morphology

The Hoko *Vertigo* is a tiny snail. Adults have a shell that is about 2.5 mm (0.1 inch) in length, which is the greatest dimension. The shell is pupilliform or shaped like an insect pupa, vaguely cylindrical with rounded ends. As one of these snails grows, progressively more of the growth is downward (from the apex) and this results in a lengthening of the cylinder formed by the dextral spiraling of the shell (see illustrations of the *Vertigo californica* group on page 997 of Pilsbry, 1948). Burke (1994) noted that snails in the genus *Vertigo* usually have shells that are a brownish, dark amber to cinnamon brown. This description is consistent with a photograph by Thomas E. Burke of 2 shells of this species, which appear closer to amber brown than cinnamon brown.

The shell of the Hoko *Vertigo* was described by Frest and Johannes (1996b). They noted the shell to be relatively smooth and glossy. Because it has growth ribs that are low and irregular, it resembles *Vertigo rowellii* and is unlike *Vertigo californica* that has strongly pronounced ribbing. The single parietal lamella (or “parietal tooth”) is fairly prominent, as in *Vertigo rowellii*. The columellar lamella is vestigial and higher on the columella than in *Vertigo rowellii*. In subadult shells the palatal and basal lamellae are short and multiple, and in fully adult specimens the basal lamellae are fused laterally into a blade-like tooth (a

key feature of this species). As with other members of the *Nearctula* group, there is no sinus, crest, or depression over the palatal lamella. The umbilicus is open and relatively large for a *Vertigo*. The aperture is distinctly flared, more so than in other members of this group, and barely reflected. The middle whorls of the shell are broader than the final whorl. A glossary of terms is in Frest and Johannes (1996b) and Furnish et al. (1997). In Pilsbry (1948, page 869; redrawn in Burch and Pearce, 1990, page 243) there is a labeled diagram of the lamellae of a pupillid snail (family Pupillidae).

2. Reproductive Biology

Land snails, including pupillid snails, are hermaphroditic and exchange gametes with other conspecific individuals when conditions are favorable. Pilsbry (1948, page 926) speculated that probably all pupillid snails are viviparous (ovoviviparous), and his figure 500 (on page 927) illustrates a pupillid uterus that is distended with at least 3 snail embryos. This suggests that the Hoko *Vertigo* does not lay eggs but instead retains the fertilized eggs and gives birth to small numbers of live young. The Hoko *Vertigo* is thought to be a short-lived species with a potential life span of less than 2 years. At any given time of year, the individuals in a colony of pupillid snails all seem to be at about the same stage of development. Captive maintenance, as was done by Walton (1963, 1970) for a variety of snails in other families, has not been done for this species or for any other pupillid snail in order to determine potential longevity.

3. Ecology

Little is known about the ecology of the Hoko *Vertigo*, other than the available habitat descriptions and the observation that virtually all of individuals are arboreal. The distinctly arboreal lifestyle and mouthparts of this group of snails suggests a foraging strategy of harvesting microorganisms growing on the surfaces of smooth barked trees and shrubs or epiphytic lichens. Very few have been found within leaf litter samples that were collected from under occupied trees, and those that were in the litter samples may have fallen from arboreal sites. In Northwest forests, pupillid snails overwinter on tree limbs, so presumably they are not killed by freezing temperatures. Wrens feed mainly on insects, but the Winter Wren (*Troglodytes troglodytes*) may also predate on pupillid snails. Andrus (1897) reported that while collecting another species, *Pupa rowelli* [= *Vertigo rowelli*] in Douglas County, Oregon, he observed a Winter Wren “at work on a small myrtle” and when he went to that tree he found no examples of that snail although “there were plenty on adjoining trees.”

C. Range, Known Sites

The known range of the Hoko *Vertigo* consists of only two sites, which are located along the east side of the Hoko River in Clallam County in the northwestern part of the Olympic Peninsula of Washington State. One site is in the mouth of Blue Canyon about 4.8 miles SW of the Washington route 112 turnoff and in the SE quarter of section 32, T. 32 N, R. 13 W, Willamette Meridian. The USGS topographic map for Hoko Falls, Washington suggests this location is more likely to be in the SW quarter of the same

section. The other site is along the Ozette Lake Road roughly 2 miles to the NE of Blue Canyon, and is in the SW quarter of section 22 close to the section line, T. 32 N, R. 13 W. The land ownership of both locations is non-Federal (apparently both are owned by the State of Washington).

The elevational range of this species is not known. The two available records are from relatively low elevations, roughly 12 and 90 meters (40 and 300 feet). Although this snail is apparently dependent on riparian hardwoods, there is no reason to anticipate that this species does not occur in otherwise suitable situations that are at considerably higher elevations.

D. Habitat Characteristics and Species Abundance

Both known sites for the Hoko Vertigo are in riparian forests on the east side of the Hoko River. The habitat at one of the two known sites consists of second-growth Douglas-fir forest with a sizable component of bigleaf maple. This site is near a stream and is at the base of a steep northwest-facing slope with seeps. Local vegetation includes liverworts, large sword fern, and maidenhair fern. The substrate is sedimentary rock, possibly of Oligocene age. The habitat at the other site is at the foot of a slope next to the Hoko River and is characterized by the presence of old hardwood trees, mostly alder. The presence of old riparian hardwood trees, seems to be important because searches for this species at other locations along the Hoko River where there were only young riparian hardwoods failed to detect this species.

This tiny snail, like most pupillid snails, is arboreal and is most easily observed on the relatively smooth bark of small alders and other hardwood trees and bushes but occasionally is found on the trunks of mossy mature alders. Snails of this genus are often found on the underside of limbs, leaning trunks, and root sprouts. This preference for the underside of limbs may have a number of benefits such as avoiding the impact of raindrops, being shaded from sunbeams that come through the canopy, being less accessible to avian predators, and possibly finding more to eat on the dampest surface of each limb. Their appearance *in situ*, leaning at a small angle on the stem, is remarkably similar to a small bud, and may also be an adaptive mechanism to avoid predation.

The snails of this species are reported to be rare where they are present (Frest and Johannes 1996a). To some extent this apparent rarity could be a result of changes to the structural habitat and microclimate. The USGS topographic map shows an abundance of logging roads in this area (section 32), and the area is reported to have been extensively logged in the past. In samples of leaf litter collected from under inhabited trees, Frest and Johannes found this species to be very rare and speculated it was probably present on the ground only by accident.

In general, as noted by Andrus (1897) and Frest and Johannes (1996a), arboreal pupillid snails seem to be naturally patchy in their distribution, with small to large numbers being found in some trees and none in nearby trees of the same species, age, and situation. This tendency of pupillid snails to have a patchy distribution may make it difficult to make estimates of population size and population trends in the Hoko Vertigo.

Approximately 300 acres have been surveyed for this species within the Olympic

National Forest without any new detections. 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.

II. CURRENT SPECIES SITUATION

A. Status History

Findings under the FEMAT assessment implied that, under the preferred alternative (Option 9) there was a 35% chance of being well distributed across Federal lands, a 25% chance of being locally restricted (i.e., with significant gaps between populations), a 25% chance of being restricted to refugia, and a 15 percent chance of this species becoming extirpated (USDA, 1994a). This mollusk seems to have a very limited distribution, so activities that alter habitat features or microclimate at occupied sites should be viewed as threats to its survival. If additional surviving populations are discovered, as seems likely, the probability of a more favorable outcome might increase.

Appendix J2 of the Forest Plan EIS "Summary" states, "The rating reflects uncertainty about the number of species locations that would be protected by riparian reserves or LSRs under the proposed action or any other alternative. Given this uncertainty, there is some likelihood that the species may be extirpated from some parts of its range." (USDA,1994b)

This species was listed under Table C-3, Survey Strategies 1 and 2 of the Survey and Manage Standard and Guidelines (USDA, 1994c). It was considered to be a rare species, based on the low number of occurrences, its low detection rate in suitable habitat and its limited range. This species was placed in Survey and Manage Category A. The Washington Natural Heritage Program gives the species a Global ranking G1, State ranking S1 (Critically imperiled globally and within the state because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation). In 2004, Region 6 of the Forest Service classified this species as a Sensitive Species. It is listed as a tracking species by WA BLM, due to the unlikely occurrence of the species on BLM lands in Washington. Tracking species are not considered Special Status Species for management purposes.

B. Major Habitat and Viability Considerations

The number and distribution of population sites required to maintain species viability is unknown. However, it can be assumed that the likelihood of species viability increases with the number of populations. The extreme rarity of this species puts it at high risk of extirpation. The preeminent habitat and viability consideration for this very rare species is the conservation of existing populations by maintaining hardwood tree and shrub species, structural habitat and associated microclimate at those sites and the location and management of additional occupied sites which would increase the distribution and viability of the species. It should also be recognized that this species depends on the health of the local ecosystem, which in turn depends on connectivity with adjacent communities, both terrestrial and aquatic.

C. Threats to the Species

Because the Hoko Vertigo seems to have a very limited distribution and habitat tolerances are unknown, any environmental alteration should be viewed as a possible threat. Most of the area surrounding the known sites has been recently logged, so the most serious threat seems to be the possibility that the remaining inhabited patches of older trees could be lost to timber harvest. Adjacent areas have young alders but they are not inhabited by this species. The present community of plants and animals, including arboreal lichens, may be stressed by being more exposed to wind and relatively dry air than would have been the case before the adjacent areas were logged. In addition to logging, presumably these islands of older riparian forest are also vulnerable to fire and damaging floods. Chemicals spilled or applied near inhabited areas could contribute to extirpation. Other possible threats could come from the disruption of the local ecosystem by nonnative species, such as predation by exotic birds, competition and disease from exotic mollusks, and degradation of arboreal substrates by exotic plants that will climb hardwood tree trunks. Special forest products activities such as collection of mosses and/or lichens from hardwood branches within occupied habitats also have the potential to adversely impact this species. Loss of riparian hardwoods due to conversion to conifers for enhancement of aquatic habitat or road construction could also pose risks to this species.

D. Distribution Relative to Land Allocations

There are no known sites for the Hoko Vertigo on Federal forest lands. The two known sites are on State lands. The nearest part of the Olympic National Forest is the Soleduck Ranger District, which is about 10 airline km (6 miles) to the southeast. This District contains both Late Successional Reserves (LSR) and Adaptive Management Areas within Clallam County and the suspected range of this species. The Clallam County part of the Quilcene Ranger District is also within the suspected range of this species, and is mostly LSR. There are small parcels of Bureau of Land Management land along the Soleduck River, roughly 20 airline km (12 miles) to the south, which are congressionally withdrawn lands managed for recreation and scenic quality.

III. MANAGEMENT GOALS AND OBJECTIVES

Management for this species follows Forest Service Region 6 Sensitive Species (SS) policy. For Region 6 of the Forest Service, SS policy requires the agency to maintain viable populations of all native and desired non-native wildlife, fish, and plant species in habitats distributed throughout their geographic range on National Forest System lands. Management “must not result in a loss of species viability or create significant trends toward federal listing” for any identified SS (Forest Service Manual 2670.32).

IV. HABITAT MANAGEMENT

A. Lessons from History

There seem to be no reports on any populations of snails in the genus *Vertigo* that have been observed over a range of time, or even over a range of environmental conditions, that provide any circumstantial evidence of a response to forest management activities.

B. Identification of Species Habitat Areas for Management

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

This document addresses management at two spatial scales. At the local population scale, a species habitat area is designed to support a functional population of interacting individuals. The size of such areas is based on estimates of dispersal distances in similar-sized terrestrial mollusks and estimates of genetic neighborhood, or deme, size. Based on the small size and limited dispersal ability of this species, the habitat area needed to sustain a population of interacting individuals may be only a few acres, depending on the extent of contiguous riparian habitat and the amount of surrounding habitat needed to maintain suitable moisture conditions. For species that are known to be extremely rare, as this one seems to be, larger areas may be considered in order to fully account for the unknown variables in habitat that may limit the suitability of the area for the species. Chen et al. (1995) found that edge effects on air humidity and wind speed (measured at 2 meters above the ground) can extend over 240 meters (787 feet) into the forest. As new data is compiled, consideration should also be given to daily and annual movements within the life cycles of the organisms.

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

At the smallest scale, within each habitat area, habitat elements, such as hardwood trees and shrubs, should be protected from disturbance to provide for the critical periods in the animals' life history (aestivation, hibernation, reproduction).

C. Management Within Species Habitat Areas

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

In general management within identified Species Habitat Areas should focus on conservation or attainment of late-successional riparian hardwood forest conditions. Consider the following:

- In spite of the fact that alders are shade-intolerant trees, and the observation that

suitable habitat seems to include both young and old alder trees, maintain the existing canopy closure and age class composition to reduce exposure of these snails and arboreal lichens to the drying effects of sun and wind, and to provide future habitat. In particular, retain hardwood root sprouts and young trees and shrubs.

- Avoid the removal or harvesting of mosses, lichens, or boughs within Species Habitat Areas.
- Although these snails are arboreal, activities that could substantially disturb or compact the soil may adversely affect the health of the riparian hardwoods. Consider avoiding concentrations of recreational activities in Species Habitat Areas.
- Once old alder trees are mechanically injured, decay causing organisms can rapidly invade (Harrington 1990). Consider avoiding actions which may result in damage to mature trees (eg. harvest of maple burls).
- Avoid the use of chemicals in Species Habitat Areas, especially aerial spraying of herbicides and fire retardants. Consider the control of non-native plants and animals by mechanical or biological means, as needed.
- As an arboreal species, the Hoko Vertigo is especially vulnerable to extirpation by fire. Avoid prescribed fire for fuels treatments within Species Habitat Areas, however manage the threat from wildfire by the reduction of hazardous fuels in adjacent areas if there is adequate protection of Species Habitat Areas.

D. Other Management Issues and Considerations

Watersheds that are inhabited by the Hoko Vertigo should be managed to conserve and promote the relative stability of stream flow and to avoid damaging floods and debris torrents. Because it is known from very few sites, limit disturbance to occupied habitats for surveys or monitoring to no more than 5% of the area or strictly regulate surveys to prevent inadvertent extirpation.

V. RESEARCH, INVENTORY, AND MONITORING OPPORTUNITIES

The objective of this section is to identify opportunities for additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. While the research, inventory, and monitoring information is not required, these recommendations should be addressed by a coordinating body at the Regional level.

Due to its extreme rarity, care should be used when studying this taxon to ensure that sampling does not result in the loss of individuals to the extent that the persistence of the local population may be threatened.

A. Data Gaps and Information Needs

In order for this taxon to be recognized and managed appropriately, a formal description and name must be published. Genetic and morphologic analysis may be needed.

The most urgent need is for surveys that explore the range and relative abundance of the Hoko Vertigo. Its range may be limited to a few sites along the Hoko River, or this species could prove to be fairly widespread in the mountains of the Olympic Peninsula. Surveys may also gain information about the elevational and ecological distribution of this tiny snail. Hopefully surveys will also gain information about canopy composition, age, closure, and other habitat conditions required by the species. Although the current suspected range of this species is limited to Clallam County, exploration for this species on non-Federal lands in other parts of the Olympic Peninsula, Vancouver Island and other islands in the vicinity could also make important contributions to the conservation of this species.

B. Research Questions

How tolerant is the Hoko Vertigo to habitat disturbance from forestry activities?

How tolerant is this snail to disturbance by mollusk survey activities?

Which plants are important as arboreal substrates for this species?

What are the best seasons and weather conditions for finding this species?

Can this species be distinguished from local similar species in the field?

What does this snail eat, and what predators eat this snail?

How does this arboreal snail disperse to other trees and other areas?

C. Monitoring Opportunities

At this time there are no known sites for the Hoko Vertigo on Federal forest lands. When and if populations of the Hoko Vertigo are found on Federal lands, those populations should be monitored (1) to evaluate the habitat impacts of activities and events in and near these locations, and (2) to document the continued existence and demographics of this species within Species Habitat Areas. As noted in section I-D (above), because of the tendency of pupillid snails (in the family Pupillidae) to have patchy distributions, it may be difficult to estimate population size and trends for colonies of this species. It is suggested that monitoring be limited to periodic tests to detect continued presence at each known location. Because this is an annual species, its population responses to environmental changes could be too rapid to detect let alone reverse locally, but the loss of the species at some sites could serve to indicate a need for modification of management at other sites where this species is still surviving.

VI. REFERENCES

- Andrus, Fred H. 1897. Notes on the land shells of Douglas Co., Ore. The Oregon Naturalist (Palestine, Oregon), volume 4, number 8, pages 53-54, December.
- Burch, J(ohn) B(ayard), and Timothy A(llen) Pearce. 1990. Terrestrial Gastropoda. Chapter 9 (pages 201-309) in Daniel L(ee) Dindal (editor). Soil biology guide. John Wiley and Sons (New York, NY), xviii + 1349 pages.
- Burke, Thomas E(dmond). 1994. Mollusk species from the Record of Decision (ROD), President's Forest Plan Supplement, Table C-3 Survey and Manage. Notes on molluscan species from Washington. Unpublished review, Cle Elum Ranger District, Wenatchee National Forest, 17 pages, September 27.
- Chen, JiQuan, Jerry F(orest) Franklin, and Thomas A(llen) Spies. 1995. Growing-season microclimate gradients from clearcut edges into old-growth Douglas-fir forests. Ecological Applications, volume 5, number 1, pages 74-86, February.
- Frest, Terrence J(ames), and Edward J(ames) Johannes. 1993. Mollusc species of special concern within the range of the Northern Spotted Owl, with an addendum addressing new management options proposed in June 1993. Report by Deixis Consultants (Seattle, WA) to the Forest Ecosystem Management Working Group, USDA Forest Service (Portland, OR), vi+98 pages (May 1) and addendum of ii+39 pages (June 13).
- Frest, Terrence J(ames), and Edward J(ames) Johannes. 1996a. Comments on and additions to Appendix J2. Report by Deixis Consultants (Seattle, WA) to USDI Bureau of Land Management (Oregon State Office and Salem District Office), contract order number 1422H952-P5-4298, ii + 78 pages, March 3.
- Frest, Terrence J(ames), and Edward J(ames) Johannes. 1996b. Taxonomic report for ROD mollusk species. Report by Deixis Consultants (Seattle, WA) to USDI Bureau of Land Management [Oregon State Office and Salem District Office], contract order number 1422H952-P5-4298, 55 pages.
- Furnish, Joseph, Tom Burke, Ted Weasma, John Applegarth, Nancy Duncan, Roger Monthey, and Darryl Gowan. 1997. Survey protocol for terrestrial mollusk species from the Northwest Forest Plan, draft version 2.0. USDA Forest Service Regions 5 and 6, and USDI Bureau of Land Management in Oregon, Washington, and California, vi+79 pages, October 29.
- Harrington, Constance A. 1990. *Alnus rubra* Bong., Red Alder, Betulaceae, birch family. Pages 116-123 in Russell M. Burns and Barbara H. Honkala. Silvics of North America. Volume 2, Hardwoods. USDA Forest Service, Agriculture Handbook 654, viii+877 pages, December.

- Müller, Otto Frederik. 1774. *Vermium terrestrium et fluviatilium, seu animalium Infusoriorum, Helminthicorum et Testaceorum, non marinorum, succincta Historia*. Faber/Schubotho (*Hafniae et Lipsiae* = Copenhagen and Leipzig), 2 volumes. [The genus *Vertigo* is named on page 124 of volume 2.]
- Pilsbry, Henry Augustus. 1948. Land Mollusca of North America (north of Mexico). Academy of Natural Sciences (Philadelphia, PA), Monograph number 3, volume 2, part 2, pages i-xlvi and 521-1113, March 19.
- Roth, Barry. 1993. Critical review of terrestrial mollusks associated with late-successional and old-growth forests in the range of the Northern Spotted Owl. Report prepared for the Forest Ecosystem Management Working Group, USDA Forest Service (Portland, OR), ii+42 pages, April 28.
- Smith, Allyn Goodwin, Walter B. Miller, Carl C. Christensen, and Barry Roth. 1990. Land Mollusca of Baja California, Mexico. California Academy of Sciences (San Francisco), Proceedings, volume 47, number 4, pages 95-158.
- Sterki, Victor. 1892. Preliminary list of North American Pupidae (north of Mexico). *The Nautilus*, volume 6, pages 2-8. [subgenus *Nearctula* proposed on page 5]
- Turgeon, Donna Demoranville, James F. Quinn Jr., Arthur E. Bogan, Eugene V. Coan, Frederick G. Hochberg, William G. Lyons, Paula M. Mikkelsen, Richard J. Neves, Clyde F. E. Roper, Gary Rosenberg, Barry Roth, Amelie Scheltema, Fred G. Thompson, Michael Vecchione, and James D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. Second edition. American Fisheries Society, Special Publication 26, x + 526 pages.
- USDA Forest Service and USDI Bureau of Land Management. 1993. 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. Appendix A. Forest ecosystem management: An ecological, economic, and social assessment. US Dept of Agriculture, US Dept of Commerce, US Dept of the Interior, and Environmental Protection Agency (Washington, DC), 1055 pages.
- USDA Forest Service and USDI Bureau of Land Management. 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. Appendix J2. Results of additional species analysis. USDA Forest Service and USDI Bureau of Land Management (Washington, DC), vi+476 pages, February.
- USDA Forest Service and USDI Bureau of Land Management. 1994b. Record of Decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the Northern Spotted Owl. USDA Forest Service and USDI Bureau of Land Management, ii+74 pages and Attachment A (Standards and Guidelines for management of habitat for Late-Successional and Old-Growth forest related species within the range of the Northern Spotted Owl), viii+148 pages, April.

USDI and USDA Forest Service. 2004. Final Supplemental Impact Statement to Remove or Modify the Survey and Manage Mitigation Standards and Guidelines.

Walton, Munroe L. 1963. Length of life in west American land snails. *The Nautilus*, volume 76, number 4, pages 127-131, (April 19).

Walton, Munroe L. 1970. Longevity in *Ashmunella*, *Monadenia* and *Sonorella*. *The Nautilus*, volume 83, number 3, pages 109-112, (January 23).