ENSATINA ESCHSCHOLTZII NESTS AT A MANAGED FOREST SITE IN OREGON

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ABSTRACT—We sampled terrestrial salamanders in riparian and upland areas within a 40-y-old managed forest site in western Oregon. We found 303 ensatinas (0.015 animals/m^2) and 14 nests (0.0007 nests/m^2, 0.05 nests/ensatina) within 20,280 m^2 of forested habitat surveyed. Clutch size averaged 8.3 eggs (range 3 to 11), comparable to previous reports from Washington but lower than reported for California. Of 14 nests found, 11 were in upland forest, >30 m from streams. Nests were typically on or under downed wood. Limited downed wood recruitment was apparent from decay class distributions. Managed wood recruitment may be necessary in such young stands to maintain critical life history functions of the ensatina and other terrestrial salamanders.

Key words: ensatina, *Ensatina eschscholtzii*, Plethodontidae, nests, reproduction, relative abundance, downed wood, Oregon

Published accounts of terrestrial salamander nests are limited. Although ensatina (*Ensatina eschscholtzii*) is 1 of the more common terrestrial salamanders in the Pacific Northwest and is described as both widespread and ubiquitous (Leonard and others 1993), few nests have been reported. Published descriptions of nests are available mainly from California ($n = 12$, clutch sizes 3 to 25; Van Denburgh 1898; Storer 1925, 1929; Howard 1950; Stebbins 1954) and Washington ($n = 5$, clutch sizes 8 to 10; Norman and Norman 1980; Jones and Aubry 1985; Norman 1986). One nest has been described in Oregon (12 eggs with female in attendance; Maser and Trappe 1984). We present descriptions of ensatina nests that were detected at a site in western Oregon before and after a density management timber harvest of a young forest stand. We report nest detections relative to search effort, salamander detection rates, and downed wood availability.

STUDY AREA AND METHODS

The study site was a 146-ha managed forest stand, about 40 y old, that was naturally regenerated subsequent to clearcut timber harvest (Keel Mountain, Bureau of Land Management [BLM], Salem District; Linn Co., OR; 44°31′41″N, 122°37′55″W). Vegetation consisted of an overstory of Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*) and an understory of bryophytes, sword fern (*Polystichum munitum*), Oregon grape (*Berberis nervosa*), and huckleberry (*Vaccinium parvifolium*). In 1998, the stand was thinned from a pre-harvest tree density of about 121 trees/ha to a mosaic of tree-retention densities ranging from 16 to 49 trees/ha. Interspersed within the harvest units were clearcut and forest "islands" of 1 to 3 ha and unharvested buffer zones of 4 widths ranging from 6 to 146 m wide, along each side of stream channels.

Before and after harvest, we oriented amphibian surveys both perpendicular (upslope transects) and parallel (bank searches) to headwater stream channels. Upslope transects were 2 m wide and 59 to 197 m long, with length differing with riparian buffer width. During the spring wet season (June to July) prior to harvest in 1997, we sampled 9 stream reach locations by using 4 parallel uphill transects (4 m apart) per stream reach location. After harvest and during the spring wet-season in 1999, we surveyed 4 adjacent parallel transects, each offset from a 1997 transect by 2 m. These transects were placed near the center of thinning treatments mid-way along stream reaches buffered by alternative buffer widths, avoiding harvested gaps or patch reserves. After harvest, these upslope transects extended from unharvested riparian buffer zones into the thinned forest. For example, the 59-m-long transect extended through the 9-m-wide buffer into a 50-m thinned upslope area, and the 197 m transect extended through the 146-m-wide buffer into about a 50-m thinned upslope.

Bank searches were time-constrained with the search area (m^2) visually estimated at each location (10 locations/reach, 5 min search on each bank/location, 14 reaches); 5 more reaches were sampled than those with upland transects. Bank locations were determined by a stratified, random, systematic approach (Hankin and Reeves 1988). Strata corresponded to in-stream habitat units, pools, and riffles, based on in-channel surveys not reported here. We conducted pre-harvest bank searches in the spring and summer of 1995 and in the spring of 1997, and post-harvest searches in the spring of 1999. Both upslope and bank surveys involved comparable search effort and moderate levels of disturbance. We lifted and replaced cover objects, opened decayed logs in layers by hand or with a hand tool, and raked litter. We minimized disturbance whenever a nest was detected. We captured all amphibians encountered for identification and then released them. We estimated the number of eggs and approximate size of the attending adult (snout-vent length, SVL, or total length, TL, as possible from the animal's position) and recorded microhabitat cover. In 1999 only, we recorded the diameter of logs where nests were found.

In 1997, prior to harvest, we measured downed wood cover within 140 circular plots (6-m diameter, 28.3 m^2) arrayed along additional transects parallel to our animal sampling transects, 1 wood transect per stream location and set of 4 animal transects (n = 9 wood transects total). We recorded percent cover of downed wood for 3 diameter categories, <0.05 m, 0.05 to 0.30 m, and >0.30 m. Decay class was recorded for wood in the largest size category (>0.30 m, Maser and others 1979). We compared downed wood availability at the Keel Mountain site with a companion study site at Green Peak, which also is a riparian area with forest age about 40 y (BLM Salem District; Benton Co., OR; 44°22'00"N, 123°27'30"W). At Green Peak we used similar methods to sample downed wood (n = 133 plots) and amphibians.

Results and Discussion

The total survey area from combined upslope and bank searches at Keel Mountain was 20,280 m^2, where we found 303 ensatinas (0.015 ensatinas/m^2) and 14 ensatina nests (0.0007 nests/m^2, 0.05 nests/ensatina). Clutch sizes ranged from 3 to 11 ($\bar{x}$ = 8.3 eggs, s = 2.2 eggs; Table 1; in 3 cases clutch size was estimated in order to avoid further disturbing the nest). In each case, an adult was coiled around or on top of the eggs, as reported previously (Jones and Aubry 1985). In addition to the ensatina, only 1 other salamander species, the Oregon slender salamander (*Batrachoseps wrighti*), was regularly encountered on upslope transects (252 captures total, 0.012 captures/m^2, no nest detections). Bank captures included the Dunn's salamander (*Plethodon dunni*; 0.02 captures/m^2, 1 nest detected; Nauman and others 1999).

Ensatina nest detection rates (nests/m^2 searched) were extremely low (Table 2). It is unlikely that the timing of our surveys missed the nesting period because only 1 gravid female was noted among all captures and the timing of our surveys coincided with the reported incubation period (Nussbaum and others 1983). Our survey efforts near the ground surface likely failed to detect a larger subsurface population of ensatinas and nests. Nussbaum and others (1983) reported ensatina nests up to 0.8 m below the surface in underground cavities.

Ensatina nests were primarily found in upland forest areas (see distance from stream in Table 1); 10 of the 14 were found within upslope transects, 2 during bank searches, and 2 during haphazard, opportunistic sampling in an upslope area. These observations suggest that nests may not usually occur at the ground surface in near-riparian areas. However, it is possible that subsurface nests went undetected.

An apparent clustering of nests was apparent in 2 cases: we found 3 nests about 40 m from a small wetland on a relatively flattened topographic bench and 2 nests 20 cm apart in a rodent tunnel under a single log (diameter about 30 cm).

Thirteen of the 14 nests were associated with downed wood and 10 of those were associated with logs (Table 1). Although we did not routinely collect log diameter information, in 1999, 4 log diameters with nests were ≥0.4 m (Table

TABLE 1. *Ensatina eschscholtzii* nests found at Keel Mountain in western Oregon. NA = not applicable.

Date	Number of eggs	Female size[1] (mm)	Microhabitat	Log decay class (log diameter, m)	Distance from stream (m)
3 June 1999	10	80 TL	hole in soil[2]	NA	161 (91 m from ephemeral stream)
3 June 1999		55 SVL 100 TL	in log	5 (0.4)	38
4 June 1999	11	100 TL	under soil on log	4 (0.5)	62
4 June 1999	10	100 TL	under bark on soil[2]	NA	91
9 June 1999	≥3[3]	40 SVL 86 TL	under bark in log	3 (0.48)	32
9 June 1999	≥5[3]	90 TL	under bark on log	3 (0.6)	50 (9 m from ephemeral pond)
9 June 1999	8–10	80 TL	in bark on soil[2]	NA	69 (46 m from ephemeral pond)
4 June 1997	8	48 SVL	under log on soil	1	No data
4 June 1997	8	55 SVL	under log on soil	1	No data
4 June 1997	8	62 SVL 93 TL	in log	4	23
3 July 1997	8	48 SVL 94 TL	in log	4	14
17 July 1997	11	50 TL	under bark on log	4	50
18 July 1997	8	60 TL	under bark on log	3	114
2 August 1995	7	90 TL	under bark on soil	NA	27

[1] Depending upon female position and visibility, reliable estimates of both TL and SVL could not be obtained.
[2] Nest found post-harvest; all others found prior to experimental treatment.
[3] In some cases, the number of eggs was estimated to reduce disturbance to the nest.

1), suggesting that large logs might be preferred; large logs were only about 10% of those available (Fig. 1). Aubry and others (1988) thought that large, moderately decayed downed wood might be necessary for ensatina persistence; our small sample size of nests in large logs supports their contention.

Published accounts of ensatina nest locations include: on soil under logs (n = 4; Van Denburgh 1898; Storer 1925; Stebbins 1954); under loose bark on top of logs (n = 3; Howard 1950; Stebbins 1954); within logs (n = 6; Stebbins 1954; Maser and Trappe 1984; Jones and Aubry 1985; Norman 1986); under moss on top of logs (n = 2; Norman and Norman 1980); between fissured rock in a seepage area (n = 2; Stebbins 1954); and inside a mountain beaver (*Aplodontia rufa*) nest chamber (n = 1; Storer 1925).

Disturbance accompanying timber harvest activities may negatively affect salamander populations (deMaynadier and Hunter 1995; Ash 1997; Herbeck and Larsen 1999; Welsh and Droege 2001). Harvest impacts such as site xerification, ground compaction, and microhabitat cover disturbance may result in both direct mortality and indirect effects on survival and reproduction through habitat degradation (deMaynadier and Hunter 1995; Welsh and

TABLE 2. Area searched for salamanders by 2 different methods, and ensatina and nest detections. NA = not applicable.

Year	Method	Area searched (m^2)	Ensatina captures	Ensatina density[1]	Number of nests[2]	Nest density[1,2]
1995	bank	3046	38	0.012	1	0.0003
1997	bank	1343	32	0.024	1	0.0007
1999	bank	1993	13	0.006	0	NA
1997	upslope	6949	119	0.017	3	0.0004
1999	upslope	6949	101	0.014	7	0.0010
Total		20,280	303	0.015	12	0.0006

[1] Relative abundance (number detected/m^2 searched).
[2] Does not include 2 nests discovered outside of bank searches and upslope transects.

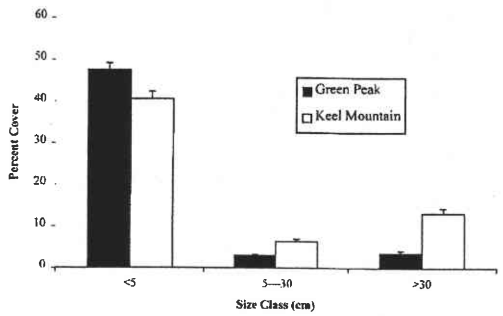

FIGURE 1. Percent ground cover ($\bar{x}$, $s_{\bar{x}}$) of woody material in 3 size in survey plots at 2 managed stands in western Oregon.

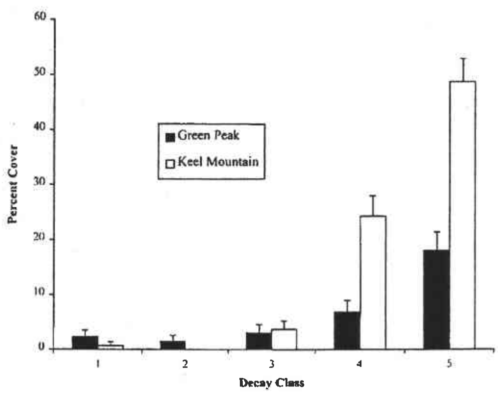

FIGURE 2. Percent ground cover ($\bar{x}$, $s_{\bar{x}}$) of large woody material by decay class in survey plots at 2 managed stands in western Oregon. Decay class 1 indicates the least decayed down wood, such as a recently fallen tree (see Maser and others 1979).

Droege 2001). Ensatina is thought to be the most resilient of Pacific Northwest terrestrial-breeding salamanders relative to forest management: the salamanders range broadly across the region, occur in multiple forest types and stand ages, and can be found in relatively dry conditions (Blaustein and others 1995; Kuchta and Parks 2005; Kuchta and Wake 2005).

Interestingly, this study showed that ensatina continued to occur and reproduce in the spring following forest density management. The harvest design included a mosaic of reserve areas, such that about 106 ha of the 146 ha site was disturbed by a partial harvest and, in harvested areas, 10 to 40% of the trees were retained. Not all nests and captures occurred in the undisturbed portion of the site in 1999. Post-harvest detection rates were nearly identical in thinned (0.011 ensatina/m^2, upslope transect sampling) and untreated areas (0.013 ensatina/m^2). Additionally, 3 of 7 post-harvest nests were found in the thinned areas (Table 1; total area sampled = 2775 m^2: 31 ensatina captured, 0.001 nests/m^2, 0.10 nests/ensatina), whereas the other 4 were found in untreated reserved areas (6167 m^2 sampled: 83 ensatina captured, 0.0006 nests/m^2, 0.05 nests/ensatina).

Although the harvest seemed to have little impact on ensatina initially, a longer-term response to management is possible. Our post-harvest sampling was conducted in the 1st spring after harvest and prior to the disturbed areas experiencing the summer dry season. The potential site xerification during summer dry seasons after timber harvest may have a greater impact on terrestrial salamanders than the mechanical disturbance of the harvest.

An important cumulative effect of multiple timber harvests over time at a site is the change in the downed wood component (for example, Spies and others 1988; Rose and others 2001). Managed recruitment of downed wood from current stands may be necessary to maintain critical life history functions of terrestrial salamanders. The Keel Mountain site exhibited an abundance of large down logs relative to the other study areas (pers. obs.; Fig. 1), a legacy of past harvest (D. Sneadecor, pers. comm.; Spies and others 1988; Rose and others 2001) and had relatively much smaller levels of wood in the early decay classes (Fig. 2). These results are consistent with U-shaped frequency distributions of decaying wood inputs to managed stands (y-axis) over time (x-axis; Spies and others 1988), where the bottom of the U, low wood inputs, is reached as legacy large wood deteriorates and is not replaced. The legacy large wood may have been a boon to salamanders in this managed stand. This site contains about 3 to 4 times more large wood than occurs in similarly aged stands that we have studied in western Oregon (see Fig. 1 for a comparison with wood cover at the Green Peak site, a 40-y-old stand in the Oregon Coast Range where we found >100 ensatina found in upslope transects but no ensatina nests. These Green Peak data (Fig. 1) also indicate limited large downed wood recruitment. While we did not conduct tallies post-treatment, we did not observe downed wood to have been removed or destroyed at the site due to harvest activities. Conversely, additional recruitment of new downed logs was not noticeable post-treatment in 1999, although subsequent blow-down or ice-damaged down trees have been seen in some areas. Further study of ensatina densities in association with downed wood abundance and character in managed forest stands are warranted. Downed wood management at young stands may be necessary for the maintenance of life history functions of terrestrial salamanders on the forest floor.

ACKNOWLEDGMENTS

We appreciate the field assistance and-or data management provided by C Jacobson, D Campbell, L Campbell, D DeGross, S Eden, I Emmons, E Goodwin, H Hoekstra, K Hychka, D Kelly, M Knapp, K Koch, J Lumianski, D Moore, K Ronnenberg, D Rundio, E Rynerson, and R Thompson. We thank J Hall for comments on a previous draft of the manuscript and 2 anonymous reviewers for comments on the current draft. Funding was provided to DHO by the USDA Forest Service, National Forest System, and the Pacific Northwest Research Station. For assistance in study implementation and coordination, we are grateful to C Thompson (BLM, Portland, OR), J Tappeiner (Biological Resources Division, US Geological Survey, Corvallis, OR), K Murphy and F Freeman (BLM, Salem District, Salem, OR), and P Redlinger (BLM, Eugene District, Eugene, OR).

LITERATURE CITED

ASH AN. 1997. Disappearance and return of plethodontid salamanders to clearcut plots in the southern Blue Ridge Mountains. Conservation Biology 11:983–989.

AUBRY KB, JONES LLC, HALL PA. 1988. Use of woody debris by Plethodontid salamanders in Douglas-fir forests in Washington. In: Szaro RC, Severson KE, Patton DR, technical coordinators. Management of amphibians, reptiles and small mammals in North America. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Research Station, General Technical Report RM-GTR-166. p 32–37.

BLAUSTEIN AR, BEATTY JJ, OLSON DH, STORM RM. 1995. The biology of amphibians and reptiles in old-growth forests in the Pacific Northwest. Portland, OR: USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-337. 98 p.

DEMAYNADIER PG, HUNTER ML JR 1995. The relationship between forest management and amphibian ecology; a review of the North American literature. Environmental Reviews 3:230–261.

HANKIN DG, REEVES GH. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:834–844.

HERBECK LA, LARSEN DR. 1999. Plethodontid salamander response to silvicultural practices in Missouri Ozark forests. Conservation Biology 13: 623–632.

HOWARD WE. 1950. Eggs of the salamander *Ensatina eschscholtzii platensis.* Copeia 1950:236.

JONES LLC, AUBRY KB. 1985. *Ensatina escscholtzii oregonensis* (Oregon ensatina). Reproduction. Herpetological Review 16:26.

KUCHTA SR, PARKS D. 2005. *Ensatina escscholtzii* Gray, 1850: Ensatina. In: Lannoo M, editor. Amphibian declines: the conservation status of United States species. Berkeley, CA: University of California Press. p 732–734.

KUCHTA SR, WAKE DB. 2005. Ensatina: *Ensatina eschscholtzii* Gray. In: Jones LLC, Leonard WP, Olson DH, editors. Amphibians of the Pacific Northwest. Seattle, WA: Seattle Audubon Society. p 110–113.

LEONARD WP, BROWN HA, JONES LLC, MCALLISTER KR, STORM RM. 1993. Amphibians of Washington and Oregon. Seattle, WA: Seattle Audubon Society. 168 p.

MASER C, ANDERSON RG, CROMACK K JR, WILLIAMS JT, MARTIN RE. 1979. Dead and down woody material. In: Thomas JW, technical editor. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. Washington DC: USDA Forest Service, Agriculture Handbook Number 553. p 78–95.

MASER C, TRAPPE JM, Technical Editors. 1984. The seen and unseen world of the fallen tree. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. Gen. Tech. Rep. PNW-164. 56 p.

NAUMAN RS, OLSON DH, ELLENBURG LL, HANSEN BP. 1999. *Plethodon dunni* (Dunn's salamander). Reproduction. Herpetological Review 30:89–90.

NORMAN BR. 1986. *Ensatina escscholtzii oregonensis* (Oregon ensatina). Reproduction. Herpetological Review 17:89.

NORMAN CE, NORMAN BR. 1980. Notes on the egg clusters and hatchlings of *Ensatina eschscholtzi oregonensis.* Bulletin of the Chicago Herpetological Society 15:99–100.

NUSSBAUM RA, BRODIE ED JR, STORM RM. 1983. Amphibians and reptiles of the Pacific Northwest. Moscow, ID: University of Idaho Press. 332 p.

ROSE CL, MARCOT BG, MELLEN TK, OHMANN JL, WADDELL KL, LINDLEY DL, SCHREIBER B. 2001. Decaying wood in Pacific Northwst forests: concepts and tools for habitat management. In: Johnson DH, O'Neil TA, managing directors. Wildlife–habitat relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press. p 580–623.

SPIES TA, FRANKLIN JF, THOMAS TB. 1988. Coarse woody debris in Douglas-fir forests of western Oregon and Washington. Ecology 69:1689–1702.

STEBBINS RC. 1954. Natural history of the salamanders of the plethodontid genus *Ensatina*. University of California Publications in Zoology 54:47–24.

STORER TI. 1925. A synopsis of the amphibia of California. University of California Publications in Zoology 27:1–342.

STORER TI. 1929. Notes on the genus *Ensatina* in California, with description of a new species from the Sierra Nevada. University of California Publications in Zoology 30:443–452.

VAN DENBURGH J. 1898. Herpetological notes. Proceedings of the American Philosophical Society 37:139.

WELSH HH JR, DROEGE S. 2001. A case for using plethodontid salamanders for monitoring biodiversity and ecosystem integrity on North American forests. Conservation Biology 15: 558–569.

Submitted 25 July 2005, accepted 18 April 2006. Corresponding Editor: K Ovaska.