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Effects of Timber Harvesting Practices on Peaks Of Otter Salamander *(Plethodon hubrichti)* Populations

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Abstract

The Peaks of Otter salamander (Plethodon hubrichti) *is endemic to a small portion of the Blue Ridge Mountains in Virginia. Much of its range lies within a high timber producing area owned by the National Forest Service. Comparisons of salamander abundance on replicated transects in recent clearcuts, older clearcuts, recent shelterwood sites, and mature sites revealed no significant differences. However, recent clearcuts, supported consistently fewer salamanders than other sites. Salamanders in mature sites consumed significantly more soft-bodied prey than in other sites. Numbers of hard-bodied prey did not differ among sites. Timber harvesting practices do not eliminate this species but may diminish population size and diet quality.*

Key words

Plethodon hubrichti, *timber harvesting, populations, Peaks of Otter salamander, conservation, ecology, natural history, Virginia*

Introduction

The entire range of the Peaks of Otter salamander *(Plethodon hubrichti)* is limited to an approximately 19 kilometers (km) long portion of the Blue Ridge Mountains in Bedford and Botetourt Counties, Virginia (Highton 1986; Pague and Mitchell 1991). Its habitat is limited to elevations above 443 meters (m) in deciduous forest and densities are highest in areas containing mature hardwoods. Logging impact on terrestrial salamanders has resulted in complete extirpation of local populations of other terrestrial plethodontids and in population fragmentation with probable genetic and demographic consequences (Ash 1988; Buhlmann, *et al.* 1988; Dodd 1989, 1991; Petranka, *et al.* 1993, 1994). If long-term conservation of the Peaks of Otter salamander is to prevail it will require that populations not be severely impacted by timbering practices that lead to local extinctions.

Several kinds of timber operations (clearcuts, shelterwood cuts, group selection cuts) and potential, defoliation by gypsy moths may affect the salamander's forest floor habitat. Drying of leaf litter and humus layers due to canopy removal (Pough, *et al.* 1987; Dodd 1991; Dupuis, *et al.* 1995) limits salamander movements and the ability to forage. Jaeger (1990) and Jaeger and Barnard (1981) clearly show that Red-backed salamanders *(Plethodon cinereus)* foraged less and consumed fewer prey in dry periods than in wet periods. If the canopy in a logged site is eliminated and the forest floor becomes relatively drier (as compared to a forested site), then we would expect salamanders to be able to forage less often and obtain fewer prey. Lowered prey consumption may affect other aspects of their life history. Assessments of the impact of timber harvesting practices on terrestrial salamanders such as the Peaks of Otter salamander are necessary for biologists and resource managers interested in its conservation and in the economic uses of the forest.

In this preliminary report on a multiyear study, we address the following objectives: (1) To compare the size of *P. hubrichti* populations in sites that have received four different types of timber management,

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Table 1. Average numbers (+/- one standard deviation and range) of Peaks of Otter salamanders in replicates of three types of timber management and mature forest stands in fall 1994 and spring 1995.

Treatment	No. Replicates	Fall 1994	Spring 1995
Recent clearcut	6	4.7 +/- 4.6 (0-12)	4.0 +/- 3.8 (0-8)
Older clearcut	6	8.0 +/- 9.2 (0-25)	3.7 +/- 4.0 (0-9)
Shelterwood	5	8.0 +/- 10.8 (1-27)	3.2 +/- 2.9 (0-7)
Mature	6	8.8 +/- 5.0 (1-15)	7.3 +/- 5.8 (3-17)
Overall		7.4 +/- 7.7	4.6 +/- 4.3

and (2) To elucidate prey use patterns of populations in the various treatments.

Materials and Methods

A total of 23 transects were established 16-18 June 1994 in the following treatment categories: recent (4-5 years) clear cuts (number (n) = 6), 12-18 year old clearcuts (n = 6), 2-4 year old shelterwood cuts (n = 5), and mature (>80 years old) hardwood sites (n = 6). There were too few separate shelterwood cuts in the area to obtain a sixth site.

At each site, we established a 1 x 50 m transect by flagging woody vegetation and by placing wire flagging in the ground at every 10 meters. Each transect remained permanent from season to season, except for two that were vandalized during the winter of 1994-1995. These were reestablished in the exact locations of the original transects in spring 1995. All transects were separated from each other by a different type of stand, roads, or a distance >100 meters.

Searches for Peaks of Otter salamanders were conducted in fall 1994 (12 September to 17 October) and spring 1995 (9 May to 3 June) at night during or just after rain when the forest floor was wet. Transects were selected in random order each night surveys that were conducted and each was walked slowly by 1-2 people using headlamps. All salamanders during the spring sampling season were released at their capture locations within a few minutes; in the fall sampling period they were released

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A topotype specimen of a Peaks of Otter salamander (*Plethedon hubridhti*). Bedford County, Virginia.

A Peaks of Otter Salamander (*Plethodon hubrichti*). Bedford County, Virginia.

several days later (see below).

During the fall sampling period, we obtained stomach contents by stomach flushing salamanders (Fraser 1976). Prey were preserved in alcohol in individually labeled vials for later analysis. All salamanders were released within 5 m of their original capture locations 2-4 days after collection. In the laboratory, we identified 96% of prey items to order and where possible, to family following Borrer, *et al.* (1989). Remaining prey were identified to phylum or class.

Results

Population sizes varied among stand types and between the fall and spring seasons (Table 1). Numbers of salamanders ranged from 0 at a recent clearcut site to 27 at a shelterwood site. In the fall, the average number of salamanders in recent clearcuts was nearly half that in the other stand types. However, the wide variation in numbers of salamanders within stand types, especially for shelterwood cuts, resulted in no significant differences (ANOVA, $F = 0.35$, $P = 0.792$).

The spring assessment yielded fewer salamanders compared to the previous fall season (Table 1). The spring trend in numbers per stand type was similar to that for the fall sample except for the lower counts in the shelterwood and older clearcut sites. The average number of salamanders within mature stands was higher than those in clearcuts and shelterwood cuts (Table 1). However, the variation in numbers of salamanders in stand types did not differ significantly (ANOVA, $F = 1.10$, $P = 0.372$).

We found 949 taxonomically identifiable prey items in the stomachs of 80 salamanders from 20 sites. Ants *(Hymenoptera)* and collembolans *(Collembola)* made up 54.6% of all individual prey items in salamander stomachs. Of these, ants comprised 32.2% of the sample and collembolans 67.8%. We compared the numbers of ants and collembolans separately among the four stand types with Kruskal-Wallis tests. There was no significant difference in the numbers of ants (hard-bodied prey, Jaeger 1990) consumed among the four stand types ($H = 2.102$, $df = 3$, $P = 0.552$) (Figure 1a). In contrast, there was a significant difference among the numbers of collembolans (soft-bodied prey, Jaeger 1990) consumed ($H = 16.794$, $df = 3$, $P < 0.001$) (Figure 1b). Multiple comparison tests showed that salamanders from mature stands ate more collembolans than salamanders from the old clearcuts ($z = 2.68$, $P < 0.05$) and the shelterwood cuts ($z = 3.93$, $P < 0.05$).

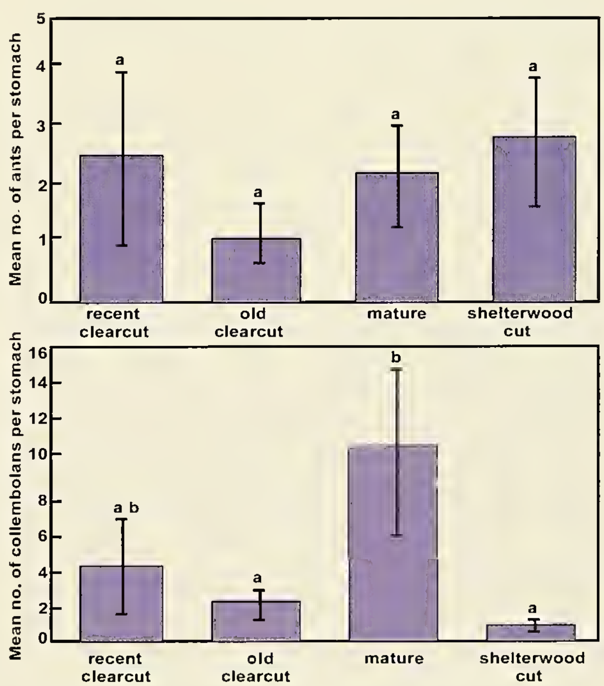

Figure 1. Average number of ants (a) and collembolans (b) per stomach in Peaks of Otter salamanders in four forest stand types. The distribution of the letters refers to statistical results (see text).

Discussion

Population sizes of terrestrial salamanders are variable and depend on a wide range of factors. These include soil depth, soil temperature, soil moisture, aspect, slope angle, underground shelter availability, nest site availability, number of surface cover sites for territories, prey quality and abundance, predator abundance, and presence of known competitors *(Plethodon cinereus)* (Buhlmann, *et al.* 1988; Dodd 1991; Wicknick 1995). Clearing of the canopy vegetation and the majority of understory trees, a common result from clearcutting, changes the physical environmental characteristics (*e.g.*, soil and log moisture) of the area (Heatwole 1962; Blymyer and McGinnes 1977; Dodd 1989, 1991; Dupuis, *et al.* 1995). Loss of individual salamanders occurs directly from logging operations that include road building, the use of skidders and other heavy equipment, and mechanical site preparation (Dodd 1991). Individuals not directly impacted by the immediate logging operation are probably subjected to stresses associated with reduced or altered prey resources and changes in the physical characteristics of the soil/litter ecosystem. We would thus expect to find reduced numbers of Peaks of Otter salamanders in such areas.

Shelterwood cuts allow a possible solution to the problems attached to clearcutting. Unfortunately, shelterwood operations that leave a small basal area (*i.e.*, as few canopy trees) act identically to clearcuts and they produce similar effects on salamanders. Our data show that the numbers of Peaks of Otter salamanders in shelterwood cuts ranged from one to 27, the largest range of variation in any of the stand types. The numbers of Peaks of Otter salamanders in shelterwood sites were, on average, 10-66% lower than in adjacent mature sites. The wide variation may be related to the number of standing trees remaining. Thus, different levels of shelterwood cuts may have dramatically different effects on Peaks of Otter salamanders because of the interaction between the amount of basal area remaining and the quality of the habitat present before and after the operation takes place.

Population sizes in our study were, on average, consistently higher in mature sites that had not been logged in 80 or more years when compared to recent and older clearcuts and shelterwood cuts. The high variation in number of salamanders within stand types complicates the interpretation of these data. The lack of statistical significance does not mean that there are no detrimental effects caused by these logging practices. Such effects may not be detectable at the population level because of historical factors (*e.g.*, past logging history and habitat quality), and differences in relative abundances due to slope angle and aspect. The size of the impacted area and its proximity to mature stands containing large populations may influence the length of time for *P. hubrichti* populations to achieve prelogging levels.

The effects of logging may be more clearly elucidated by analysis of diet quality. The quantity of collembolans consumed by Peaks of Otter salamanders was significantly higher in mature stands than in recent clearcuts and shelterwood cuts. Collembolans are soft-bodied prey (Jaeger 1990) which presumably pass through *P. hubrichti* digestive tracts quickly and with high assimilation efficiency, as do other soft-bodied prey such as termites in the congener *P. cinereus* (Gabor and Jaeger 1995). Differences in diet quality among stand types suggests that there may also be differences in salamander growth and reproduction. Mature sites, therefore, appear to offer a higher quality habitat to Peaks of Otter salamanders than timbered sites because they presumably have a more intact and functional soil/litter ecosystem due to the types and quality of downed woody debris, canopy shelter that affects the thermal and moisture regime, and higher prey quality. Results from our forthcoming analyses of data on prey quality and availability in wet and dry years will provide a detailed assessment of differential affects of stand types at the individual level.

Conclusions

The preliminary results of our study allow several tentative conclusions. Peaks of Otter salamander populations are not always completely eliminated from a site within their range by timber operations of clearcutting and shelterwood cutting. They are reduced 45-47% by clearcutting and 10-66% by shelterwood cutting, as compared to populations in adjacent mature sites. Salamanders in mature sites may obtain a higher quality diet than those in sites treated by some form of timber management. Peaks of Otter salamander populations remain at varying levels of risk from timber management depending on the type of harvesting practice used. Such practices undoubtedly cause small scale geographic variation in growth, diet, reproduction, and population recruitment.

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References

Ash, A.N. 1988. Disappearance of salamanders from clearcut plots. *Journal of the Elisha Mitchell Scientific Society* 104: 116-122.

Blymyer, M.J. and McGinnes, B.S. 1977. Observations on possible detrimental effects of clearcutting on terrestrial amphibians. *Bulletin of the Maryland Herpetological Society* 13: 79-83.

Borrer, D.J., Triplehorn, C.A., and Johnson, N.F. 1989. *An Introduction to the Study of Insects, 6th edition.* Saunders College Publishing, Philadelphia, Pennsylvania. 875 pp.

Buhlmann, K.A., Pague, C.A., Mitchell, J.C., and Glasgow, R.B. 1988. Forestry operations and terrestrial salamanders: Techniques in a study of the Cow Knob salamander, *Plethodon punctatus*, pp. 38-44 in Szaro, R.C. *et al.* (editors). *Management of Amphibians, Reptiles, and Small Mammals in North America.* USDA Forest Service General Technical Report RM-166. 458 pp.

Dodd, C.K., Jr. 1989. Status of the Red Hills salamander is reassessed. *Endangered Species Technical Bulletin* 24: 10-11.

Dodd, C.K., Jr. 1991. The status of the Red Hills salamander, *Phaeognathus hubrichti*, Alabama, USA, 1976-1988. *Biological Conservation* 55: 57-75.

Dupuis, L.A., Smith, J.N.M., and Bunnell, F. 1995. Relation of terrestrial-breeding amphibian abundance to tree-stand age. *Conservation Biology* 9: 645-653.

Fraser, D.F. 1976. Empirical evaluation of the hypothesis of food competition in salamanders of the genus *Plethodon*. *Ecology* 57: 458-471.

Gabor, C.R. and Jaeger, R.G. 1995. Resource quality affects the agonistic behaviour of territorial salamanders. *Animal Behaviour* 49: 71-79.

Heatwole, H. 1962. Environmental factors influencing local distribution and activity of the salamander, *Plethodon cinereus*. *Ecology* 43: 460-472.

Highton, R. 1986. *Plethodon hubrichti. Catalogue of American Amphibians and Reptiles.* 393.1-393.2.

Jaeger, R.G. 1990. Territorial salamanders evaluate size and chitinous content of arthropod prey, pp. 111-126 in Hughes, R.N. (editor). *Behavourial Mechanisms of Food Selection.* Springer-Verlag, Heidelberg. 886 pp.

Jaeger, R.G. and Barnard, D.E. 1981. Foraging tactics of a terrestrial salamander: Choice of diet in structurally simple environments. *American Naturalist* 117: 639-664.

Pague, C.A. and Mitchell, J.C. 1991. *Plethodon hubrichti* Thurow, Peaks of Otter Salamander, pp. 436-437 in Terwilliger, K. (coordinator). *Virginia's Endangered Species.* McDonald and Woodward Publication Co., Blacksburg, Virgina. 672 pp.

Petranka, J.W., Brannon, M.P., Hopey, M.E., and Smith, C.K. 1994. Effects of timber harvesting on low elevation populations of southern Appalachian salamanders. *Forest Ecology and Management* 67: 135-147.

Petranka, J.W., Eldridge, M.E., and Haley, K.E. 1993. Effects of timber harvesting on southern Appalachian salamanders. *Conservation Biology* 7: 363-370.

Pough, F.H., Smith, E.M., Rhodes, D.H., and Callazo, A. 1987. The abundance of salamanders in forest stands with different histories of disturbance. *Forest Ecology and Management* 20: 1-9.

Wicknick, J.A. 1995. Interspecific competition and territoriality between a widespread species of salamander and a species with a limited range. *Ph.D. Dissertation, University of Southwestern Louisiana, Lafayatte, Louisiana.* 152 pp.

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