Cover objects can mitigate the effects of timbering on the Peaks of Otter Salamander: A survival story

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Abstract

Plethodontid salamanders inhabit cool, moist, mature forests with cover objects on the forest floor, such as logs and rocks. Altering the forest environment through management practices like timbering may make some areas uninhabitable. Understanding which features make areas uninhabitable may aid in modifying management practices so that salamanders can still occupy these altered areas.

In 2020, using a cover board study design, we began comparing the habitability of three adjacent sites in the Peaks of Otter mountains: mature forest, immature forest, and grass. In spring, summer, and fall of 2021, the number of Peaks of Otter salamanders under each board in all three sites was counted and measurements to determine body condition were taken. Throughout 2021, there were no significant differences in body condition across the sites, but there were significantly fewer salamanders in the immature forest and grass sites than in the mature forest. However, the number of salamanders within each site remained constant throughout the year which differs from data found in 2020. This may be due to higher maximum temperatures in 2020 than in 2021.

Knowing the minimal set of factors needed to make an area habitable for a salamander can aid in managing areas where timbering is permitted. This study shows that the Peaks of Otter salamander can occupy a less than optimal habitat if cover objects are provided. Leaving portions of downed trees after timbering would provide cover objects, which may make the area minimally habitable to salamanders as the forest regenerates.

Introduction

Plethodontid salamanders inhabit cool, moist woodlands with cover objects, like logs and rocks, on the forest floor (Petranka, 1998). Moist conditions are critical for salamanders to be able to breathe through their skin and to prevent desiccation while foraging at the surface (Petranka, 1998). Knowing the environmental parameters necessary for salamanders to inhabit a particular area is essential when forest management practices, such as timbering, alter the typical forest environment. What are the parameters necessary for an area to be habitable to a salamander (temperature, moisture, cover objects, etc.) and is there a minimum set of conditions needed in order to make an area habitable?

To help answer this question, we chose a study area at the base of Onion Mountain in the Peaks of Otter Mountains. This area, which is part of the Blue Ridge National Park, had been mowed since around 1990. In 2005, mowing ceased and natural, vegetative succession began. This area is occupied by the Peaks of Otter salamander (*Plethodon hubrichti;* **Fig. 1**), which has one of the most limited ranges for any salamander (Petranka, 1998). The Peaks of Otter Salamander is a montane species found primarily in mature, deciduous forests at elevations greater than 442 m within only a 117 km^2 area of the Blue Ridge Mountains in central Virginia (Pague & Mitchell, 1990). Because of its limited range, understanding how environmental factors alter the habitability of a site to this species is crucial for guiding forest management practices.

In 2021 we continued our cover board study, which we began in 2020, to compare the habitability of three adjacent sites in this previously mowed area at the base of Onion Mountain: mature forest **(Fig. 2),** immature forest **(Fig. 3),** and grass **(Fig. 4).** Number and condition of salamanders were measured in each site to assess habitability.

Methods & Materials

- In March of 2020, 26 square pine boards measuring 961 cm^2 were placed in each of the three sites: mature forest, immature forest, and grass.
- The three sites were visited in spring, fall, and summer in 2021, and the number of salamanders under each board was counted during every visit.
- In spring and fall of 2021, every adult salamander found was sexed using a non-destructive candling method with an LED light (Gillette & Peterson, 2001), weighed using an electronic balance, and snout-vent length (SVL) was measured using the salamander-stick method with calipers (Walston and Mullin, 2005).
- Salamanders were kept in dampened plastic bags while being processed and then returned to the board under which they were found.
- Residual condition index values were calculated for all salamanders by regressing mass against SVL (Jakob, et al. 1996).
- Temperature data was collected by randomly assigning and placing Thermochron iButtons (Model DS1921G, Maxim Integrated, San Jose, California) under three boards in each site.

Results and Discussion

Contrary to what was expected, the condition of the salamanders in 2021 did not change across the three sites **(Fig. 5)**.

- There was no significant difference in mean salamander condition between mature (mean=-1.83x10^{-5}) and immature forest (mean=-0.01) (t=2.1, d.f.=19, P=0.96).
- There was no significant difference between mature forest (mean= -1.83x10^{-5}) and grass (mean= 0.01) (t=2.1, d.f.=18, P=0.96).
- It is possible that there may truly be a difference between the sites but the small sample sizes in the immature forest (n=3) and grass (n=2), resulting in large variances, precluded our ability to detect differences.

Figure 1. Peaks of Otter salamander, *Plethodon hubrichti.*

Figure 2. Mature forest site (October) noting tall trees, leaf litter, and many cover objects.

Figure 3. Immature forest site (October) noting small, thin trees and ground vegetation.

Figure 4. Grass site noting lack of tees and ground vegetation.

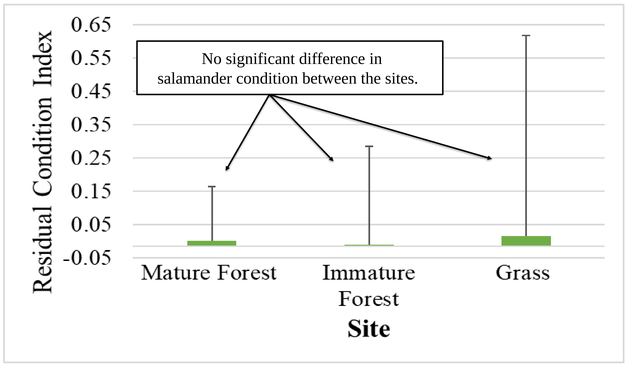

Figure 5. Mean salamander condition indices across sites in 2021.

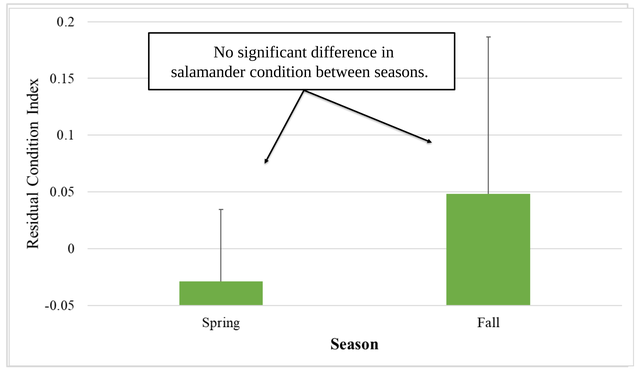

Figure 6. Mean salamander condition indices of all three sites for Spring and Fall seasons in 2021.

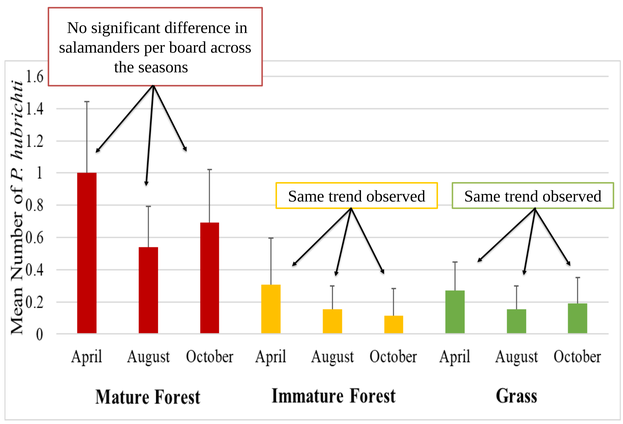

Figure 7. Mean number of salamanders per board in each site for April, August, and October of 2021.

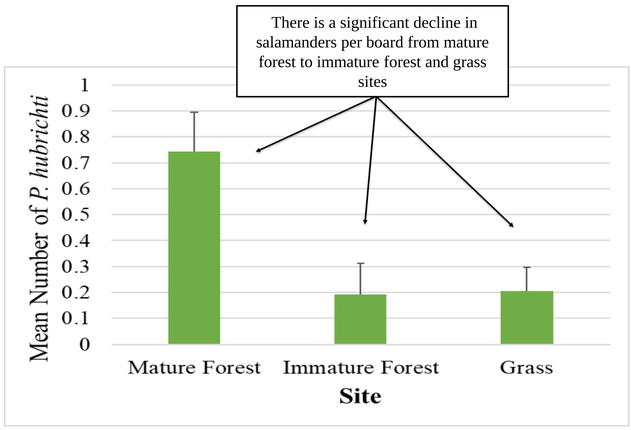

Figure 8. Mean number of salamanders per board in each site for 2021.

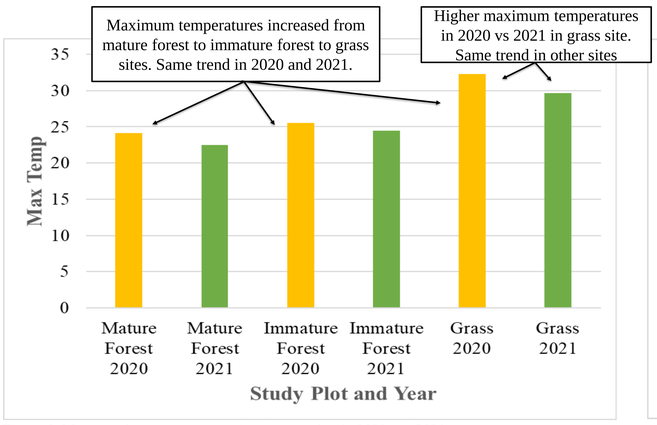

Figure 9. Mean maximum temperature for all three sites in 2020 and 2021.

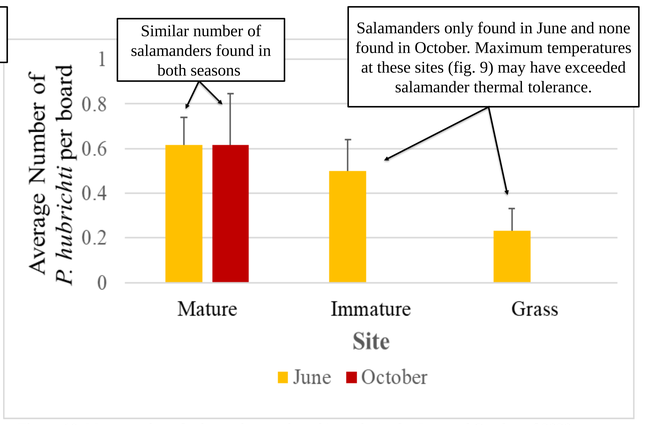

Figure 10. Mean number of salamanders per board in each site for June and October of 2020.

Results and Discussion Continued

Salamander condition was expected to be higher in fall versus spring because spring salamanders recently emerged from brumation as compared to the fall salamanders that had been foraging throughout the active season **(Fig. 6)**.

- The mean condition is higher in fall (mean = 0.05) than in spring (mean = -0.03) but the difference is not significant (t=2.04, d.f.=31, P=0.32).

Throughout the study period from April to October of 2021, the mean number of salamanders per board found within each treatment site remained similar **(Fig. 7)**.

- There was no significant difference from April (mean=1.00) to August (mean=0.54) (t=1.81, d.f.=40. P=0.07) or from April (mean=1.0) to October (mean=0.69) (t=1.11, d.f.=50, P=0.27) for the mature forest.
- This same trend was observed for the immature forest and the grass sites (P>0.05; **Fig. 7**).
- This is encouraging because it shows that Peaks of Otter salamanders are able to maintain their numbers in a site across their entire active season.

In 2021, the mean number of salamanders found in the immature forest and grass sites was less than those in the mature forest **(Fig. 8; figure uses compiled data across three samplings – April, August, and October)**.

- A comparison of the mean number of salamanders per board yielded significantly lower numbers in the immature forest (mean=0.19) compared to the mature forest (mean=0.74) for each of the three sampling periods (April (t=2.64, d.f.=43, P=0.01), August (t=2.64, d.f.=40, P=0.01), and October (t=3.12, d.f.=37, P=0.003)).
- The same trend was found in the comparison between the mature forest (mean=0.74) and the grass sites (mean=0.21) (P<0.05).
- Salamanders could persist in all three treatment sites with no significant decrease in condition, but the next step was to determine why the immature forest and grass sites were inhabited by a smaller number of salamanders than in the mature forest.

The immature forest and the grass sites had higher maximum temperatures than the mature forest in 2021 **(Fig. 9)**.

- Cool temperatures are required by the montane-adapted Peaks of Otter salamander to inhabit an area.
- The higher maximum temperatures in the immature forest (24.5°C) and grass sites (29.7°C) in 2021 could be an explanatory factor as to why there was a decrease in the number of salamanders from the mature forest (22.5°C) to the other sites.
- Temperature is only one environmental variable, and other factors affect whether a site is occupiable.

While salamanders were found in all three treatment sites in June of 2020, they were only found in the mature forest in October 2020 **(Fig. 10)**. This may be due to the greater maximum temperatures in 2020 than those observed in 2021 **(Fig. 9)**.

- Thus, if environmental conditions are favorable, the Peaks of Otter Salamander is able to inhabit less preferred sites, such as the immature forest and grass sites, across the entire season.

Conclusions & Future Work

Forest management practices such as timbering may negatively alter the Peaks of Otter salamanders' natural habitat, which is a cause for concern due to the salamanders' extremely limited geographic range. As shown in our study, when cover objects are provided, salamanders with the same body condition as those in their preferred habitat can live in sites that are generally considered uninhabitable. Additionally, they are found in these less optimal sites throughout their entire active season. By simply leaving portions of downed trees on the ground to act as cover objects, the negative impacts of forest management practices, like timbering, on the Peaks of Otter salamander can be reduced. Future research involves individually marking salamanders found within each site. This will allow us to determine if the same salamanders are inhabiting the same site throughout their active season, and if salamanders from the mature forest are migrating to the immature forest and grass sites. Finally, another year of counting the salamanders within each site during the spring, summer, and fall months would be helpful in determining which year of data, 2020 or 2021, reflects the norm.

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