

## Contrasting Effects of Prescribed Fire and Wildfire on Terrestrial Salamanders

Terrestrial salamanders in the family Plethodontidae (lungless salamanders) are abundant in eastern forests. Estimating the abundance of salamander populations has been notoriously difficult, because they are nocturnal and spend a majority of time in soil burrows up to a foot deep, only coming to the surface during wetter periods. Recent advances in modeling, coupled with standardized monitoring methods are providing better estimates of salamander abundance. For example, a new study conducted across the range of red-backed salamander found average densities of more than 4,000 per acre, with a biomass comparable to white-tailed deer and mice within forest ecosystems (Grant and others 2024). Terrestrial salamanders require moist conditions for respiration through their skin. They are carnivorous, consuming numerous soil and litter invertebrates, and thus play a significant role in slowing leaf litter decomposition and affecting soil nutrient cycling. They also are an important prey source for other animals including birds, mammals, snakes, turtles, and frogs (Davic and Welch 2004).

Because fire consumes leaf litter and can alter the microclimate of the forest floor, there has been concern that prescribed burning may have negative impacts on terrestrial salamander populations. In response, a number of studies have examined the effects of prescribed fire on salamander populations in the eastern U.S. Most research has concluded that low-intensity prescribed fire has relatively little impact on salamander populations in the short-term, but due to the difficulties of estimating abundance, there remains need for further study. Much less research has been conducted on the effects of wildfire on salamanders in the eastern region. Here we summarize the findings from two recently published papers on the effects of fire on terrestrial salamanders; the first focuses on low-intensity prescribed fire and second on moderate- to high-severity wildfire.

### Prescribed Fire Effects in Southern Indiana Hardwood Forests

**Ochs, A.E., Swihart, R.K. and Saunders, M.R., 2024. Population-level effects of prescribed fires on terrestrial salamanders. *Forest Ecology and Management*, 560, p.121842.**

This study estimated the abundance of red-backed (*Plethodon cinereus*) and zigzag (*Plethodon dorsalis*) salamanders together over a four-year period spanning before and after prescribed fire, and compared those estimates to those found in nearby unburned sites. The research team also estimated fire intensity and measured key environmental factors for salamander habitat. The authors predicted that prescribed fire would result in some decrease in salamander abundance due to potential negative impacts on their forest floor and soil habitat (reduced litter, lower soil moisture, higher soil temperatures).

#### Study site and Methods:

- The study was conducted in two State Forests (Morgan-Monroe and Yellowwood), in stands within the Hardwood Ecosystem Experiment (HEE). For both burned and unburned treatments, study plots were located on both xeric (oak-hickory) and mesic (tulip poplar, beech, maples) slopes. No recent harvesting had occurred on these sites.
- Sampling grids, each consisting of 45 untreated poplar cover boards were established in 2019 and were checked for salamanders multiple times in spring and fall of each year 2019-2022. Leaf litter depth and soil moisture were also quantified within the sampling grids.
- Salamanders found beneath the cover boards were marked with visual implant elastomer marks to provide mark-recapture data.
- During the study, one low-intensity dormant-season prescribed fire (target flame lengths 1-3') was conducted at each burn site in spring or fall, in either 2020 or 2021 (each grid thus included pre- and post-burn monitoring). In addition, these units had been burned once prior to this study, between 2015 and 2017. Fire intensity was estimated with temperature-sensitive paint tags and the height of bark char.
- Models were used to estimate the effects of fire and environmental conditions on salamander populations.



*Alison Ochs conducting field work. Photo by Alison Ochs*

### Key Findings:

- Litter depth was reduced more where fire intensity was greater but soil moisture was not affected by fire.
- Throughout the study, each grid was checked 63 times, and a total of 4922 salamanders were found (2923 red-backed; 1947 zigzag), of which 1939 were re-captures. Total captures were similar between unburned (216-613) and burned (149-524) grids. Throughout the study, more salamanders were generally captured when litter depth and soil moisture were greater.
- The models did show some variable fire effects on estimates of post-burn survival and emigration, but estimates of abundance did not indicate a significant fire impact.
- The authors concluded that annual and seasonal factors (e.g., soil moisture) had a much greater effect on salamander captures than did prescribed fire.



Poplar cover boards used to monitor salamander populations. Photo by Alison Ochs



Zigzag salamander on cover board. Photo by Alison Ochs

### Take – Home Points:

- Two quotes from the paper provide the take home points:
  - “Overall, we found few and small effects of prescribed fire on terrestrial salamanders.”
  - “Prescribed fires for oak regeneration in the Midwest may have little effect on salamander populations over times frames comparable to our study.”
- However, the authors also caution that more research is needed to examine the response of salamander populations to repeated prescribed fires over longer time periods.

[Alison Ochs](#) conducted this study for her PhD dissertation at Purdue University. She is currently a postdoctoral fellow at Carlton University in Ottawa, Canada. Robert Swihart and Mike Saunders were advisors and are faculty members in the [Department of Forestry at Purdue](#).

### **Wildfire Effects in the Southern Appalachians**

**Wilk, A.J. and Peterman, W.E., 2024. Impacts of wildfire burn severity on plethodontid salamander populations of Great Smoky Mountains National Park. *Herpetologica*, 80(2), pp.199-208.**

The southern Appalachians support an exceptionally high diversity of terrestrial salamanders. This study was conducted in and adjacent to the nearly 15,000 acre Chimney Tops Two wildfire that occurred in Great Smoky Mountains National Park in 2016. This wildfire and others in 2016 exhibited a range of fire severities and delayed tree mortality occurred where fires burned deep into the duff layer, consuming fine roots (Carpenter and others 2021). Here, salamander abundances were estimated five years after the wildfire across a variety of elevations and burn

severities, as well as in similar sites in adjacent unburned areas. The authors predicted 1) fewer salamanders within the burn boundary, 2) high severity burned sites would support fewer salamanders than low severity burn sites, 3) salamanders would tend to be larger on burned sites, because smaller salamanders are more susceptible to desiccation, and 4) within the burn boundary, salamander abundance would be greater near the burn perimeter than in the interior, due to some immigration from adjacent unburned habitat.



High-severity burn site, Chimney Tops 2. Photo by Bill Peterman

### Study Site and Methods:

- Sampling sites were located within the burn boundary (35 sites) and also in a 4.6 mile buffer zone of unburned forest around the burned area (30 sites). Sites were balanced across five elevation classes and five burn severity

classes (based on satellite imagery). Primary forest types were chestnut oak, northern hardwood, oak-hickory, and yellow pine.

- At each site in the summer of 2021, three nocturnal visual encounter surveys were conducted to record salamanders (species, size). Twelve species were recorded but analyses focused on five: red-cheeked (Plethodon jordani), northern slimy (Plethodon glutinosus), pygmy (Desmognathus wrighti), imitator (Desmognathus imitator), and the Blue Ridge two-lined (Eurycea wilderae).
- Data analyses: Topographic data and weather conditions during the surveys were used in data analyses to incorporate the probability of detection. Models were fit to estimate the abundance of each of the five species, based on detection probabilities, burn status (in or out of burn boundary), and burn severity class.

### **Key Findings:**

- Among the five species, 1,718 individuals were recorded in the surveys; the most common was the red-cheeked salamander (991).
- All five species were much less abundant on sites within the burned area compared to sites outside the burned area. Also, within the burn, all five species tended to have decreased abundance with increasing burn severity.
- For three of the five species, individuals trended toward larger sizes on burned sites, as predicted, due to greater desiccation risk to smaller individuals.
- The imitator salamander was more abundant closer to the burn boundary, suggesting post-burn immigration from unburned habitat, but results were less clear for the other species, suggesting limited immigration.

### **Take-Home Points:**

- Salamander populations were severely impacted throughout the Chimney Tops Two wildfire boundary, which generally burned at moderate to high severity. This contrasts with previous work showing that salamander populations can recover quickly after low severity wildfire.
- The degree to which fire impacts were caused by direct mortality during the fire or due to indirect effects on their habitat (e.g., forest floor consumption, changes in microclimate, reduced prey populations) is unknown. However, because the fire occurred in November when salamanders are typically inactive (in torpor) and towards the end of a severe several-month drought, it's likely that salamanders were relatively deep in soil burrows and thus possibly escaped direct mortality.

The authors note that:

“These results emphasize that moderate- to high-severity burns impact plethodontid populations more severely than prescribed fire or low-severity wildfire. Using prescribed fire to mitigate the chance of high-severity wildfires is justified despite the potential negative effects on plethodontid populations”

This project was a component of Andrew Wilk's M.S. degree in Wildlife Science at Ohio State University. Andrew is currently a Data Manger at the [Renewable Energy Wildlife Institute](#). [Bill Peterman](#) served as Andrew's advisor and is an Associate Professor in Wildlife Ecology and Management at Ohio State University.

Red-cheeked salamander, Great Smoky Mountains NP. Photo by Bill Peterman



Blue Ridge two-lined salamander, Great Smoky Mountains NP. Photo by Bill Peterman

## **References:**

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## **Links to Papers:**

Alison E. Ochs, Robert K. Swihart, Mike R. Saunders., 2024. Population-level effects of prescribed fires on terrestrial salamanders. *Forest Ecology and Management*, Volume 560, 121842.

<https://doi.org/10.1016/j.foreco.2024.121842>

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Andrew J. Wilk, William E. Peterman; Impacts of Wildfire Burn Severity on Plethodontid Salamander Populations of Great Smoky Mountains National Park. *Herpetologica* 30 June 2024; 80 (2): 199–208. doi:

<https://doi.org/10.1655/Herpetologica-D-23-00050>

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## **Related Research:**

<http://www.appalachianfire.org/amphibians/reptiles>