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Relative importance of timber harvest and habitat for reptiles in experimental forestry plots

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A B S T R A C T

Forestry practices affect various habitat characteristics that influence wildlife populations. Understanding the relative importance of the broad effects of forestry practices versus specific habitat variables for wildlife may help managers balance multiple forest management objectives and potentially adjust forestry practices to better conserve biodiversity. We compared the relative importance of experimental timber harvest treatments (clearcutting, thinning to remove undesirable tree species) to habitat variables (coarse down wood, herbaceous vegetation, leaf litter) for captures of reptiles in central Missouri, USA for two years post-harvest. We also used drift fences along the edges between uncut control forest and clearcut to detect changes in movements between treatments after timber harvest, which is one potential mechanism for differences in captures among timber harvest treatments. We found that habitat variables best predicted captures of small snakes, while both habitat and timber harvest treatment predicted lizard captures. Two lizard taxa (*Plestiodon* spp., *Sceloporus undulatus*) had higher captures in clearcuts than in the no harvest control, which is consistent with studies across the southeastern United States. *Plestiodon* spp. showed significantly more movements into clearcuts from control forest than in the opposite direction, demonstrating that higher captures in clearcuts were at least in part due to immigration from adjacent forested areas. Small snakes and *Sceloporus undulatus* captures were higher in areas with more coarse down wood and higher herbaceous vegetation cover, which were associated with the clearcut plots. These results for small snakes are consistent with another study in Missouri, but in contrast to two from South Carolina, indicating that there may be regional differences in the response of small snakes to forestry practices. Further work on the effects of forestry management on reptiles should examine regional differences and seek to understand underlying mechanisms.

1. Introduction

Forest management goals often include balancing economic interests with the conservation of natural resources. Empirical information on the effects of different forest management techniques on different species of wildlife and the habitat that they depend on is needed for making informed land management decisions that meet multi-objective management goals. This type of information is especially useful when the importance of different habitat variables versus broader forest management techniques are ranked relative to each other (Sutton et al., 2014; Earl and Semlitsch, 2015). Particularly, if certain taxa respond primarily to habitat variables, then forestry practices may be adjusted to provide suitable habitat conditions for these taxa and better balance several different objectives for forest management (Earl et al., 2016).

Studies have compared the relative importance of habitat variables and broader forestry practices across multiple vertebrate taxa. Habitat variables, including microclimate, have higher predictive power than forestry practices for captures of three out of four small mammal species (Earl et al., 2016) and the survival and growth of three amphibian species (Earl and Semlitsch,

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2015) in Missouri hardwood forests. Lizards appear to respond to both habitat and forestry practices, as shown in Alabama pine-hardwood forest (Sutton et al., 2014). However, all of these studies demonstrated species-specific responses with different combinations of habitat variables selected in the best models. Despite these specific responses, trends with particular habitat variables tend to be consistent within taxa. For example, captures of three species of lizards all had positive relationships with coarse down wood and the presence of woody stems (Sutton et al., 2014). Unfortunately, these comparisons have only been performed on one site per taxa, making it unclear if any of these responses are similar in different regions, forest types, or species assemblages.

The response of reptiles to forestry practices is variable, though the number of studies is more limited than for other vertebrate taxa (Riffell et al., 2011; Verschuyl et al., 2011). Captures of common lizard species tend to increase with canopy reduction from clearcutting or shelterwood harvest in hardwood and pine forest in the southeastern and central US (e.g., Perison et al., 1997; Greenberg et al., 2016; Rota et al., 2017). Small snakes exhibit more mixed responses to both even and uneven-aged stand management (Perison et al., 1997; Todd and Andrews, 2008; Rota et al., 2017), which may be attributable to either different species assemblages and/or different forest types. Further, in southeastern US pine forests, lizards are unaffected by changes in the quantity of coarse down wood, but snakes have higher abundance and diversity with the removal of coarse down wood (Davis et al., 2010).

Reptiles are important components of the ecosystem, acting as predators and prey for a variety of wildlife with subsequent effects on ecosystem properties and trophic dynamics (Valencia-Aguilar et al., 2013). Because of these roles, snakes have been proposed as indicators of various ecosystem properties and quality (Beaupre and Douglas, 2009), and lizard abundance can alter the dynamics of vector transmitted pathogens, such as Lyme disease (Swei et al., 2011). Unfortunately, reptiles are in global decline with habitat destruction and alteration as a major contributor (Gibbons et al., 2000; Reading et al., 2010; Bohm et al., 2013). As such, greater information about the effects of different types of land use and habitat variables is important for reptile conservation.

To better understand the relative importance of timber harvest treatment and habitat variables, we examined the capture rates and species richness of reptiles in experimental forestry plots in central Missouri, USA. We used an information-theoretic approach to determine the best model of reptile captures for each taxa. The experimental timber harvest treatments included partial cut forest and clearcuts with high and low coarse down wood, which were compared to an unharvested control. Habitat variables included leaf litter depth, amount of coarse down wood, and herbaceous cover. We predicted that some species would respond primarily to timber harvest treatment, while others would respond to habitat variables, as found for previous studies (Sutton et al., 2014; Earl et al., 2016). Also, we expected lizard captures to increase in clearcuts (Greenberg et al., 2016; Rota et al., 2017). We further examined reptile movements into and out of control forest from clearcuts to investigate changes in movement patterns before and after timber harvest. This allowed us to investigate one possible mechanism for changes in captures under different timber harvest treatments (Semlitsch et al., 2008).

2. Material and methods

2.1. Study system

This experiment was conducted as part of the Landuse Effects on Amphibian Populations (LEAP) project, a NSF collaborative project. We designed the experimental arrays from the LEAP project to examine the effects of forestry management practices on amphibians (e.g. Semlitsch et al., 2009), but captures of other vertebrate groups allowed us to additionally examine the effects timber harvest on reptiles (this paper) and small mammals (Earl et al., 2016). Four replicate experimental arrays were located in Daniel Boone Conservation Area in the upper Ozark Plateau in Warren County, Missouri consisting of mature (80–100 years old) oak (*Quercus* spp.) and hickory (*Carya* spp.) forest. Each array was a circular plot 164 m in radius centered on a constructed wildlife pond (28–48 years old). We divided these plots into equal quadrants (~2.11 ha each) receiving one of four experimental forestry treatments: control (uncut forest), a partial cut (thinned forest), a clearcut with high coarse down wood (high-wood) and a clearcut with low coarse down wood (low-wood; Semlitsch et al., 2009). We thinned the experimental partial cut to approximately 60% of stocking level by girdling and felling poor quality trees and undesirable species (primarily *Acer saccharum* and *Juniperus virginia*). This thinning method is not common across the US but is used in Missouri Conservation Areas to promote oak regeneration and control *Acer saccharum* (Osbourn and Earl, personal observation). We implemented the clearcut treatments by removing all marketable timber greater than 25 cm diameter at breast height (DBH) for sale. In the high-wood clearcut, we felled the remaining trees (<25 cm DBH) and left them on the ground. In the low-wood clearcut, we girdled the remaining trees and left them standing, so they did not provide ground cover for small vertebrates. In each experimental array, we randomly assigned the control to a quadrant and the clearcut treatments to the quadrants adjacent to the control with the partial cut treatment fixed across from the control. We implemented all experimental forestry treatments between March 2004 and January 2005.

2.2. Reptile sampling

In order to assess capture rates of reptiles in each experimental forestry treatment, we installed six drift fences per quadrant (hereafter called treatment fences) in a concentric circular configuration around the central pond in each plot (illustrated in Earl et al., 2016). These fences covered approximately 7% of the circumference at 50, 100 and 150 m from the central pond. We made each fence 5.4 m long from aluminum flashing buried ~30 cm below ground and extending 60 cm above ground. We placed six pitfall traps in pairs on either side of the fence at each end and approximately in the middle. We made pitfall traps from plastic plant pots (23 cm diameter, 48 cm deep) that we buried so that the top was flush with the ground against the fence.

We installed six additional drift fences along the edges between the control and each clearcut treatment (constructed as above; hereafter called edge fences) to examine movement into and out of the control quadrants in each experimental array (Semlitsch et al., 2009). We placed these fences 1–2 m inside the control treatment parallel to the clearcut edge on either side of the control (total of 46.2 m or 28.2% of the total length on each side).

We checked all pitfall traps for animals every 1–3 days from mid-February through early November (though only data from completely sampled months were used for analysis, i.e. March through October) in 2005 and 2006 for treatment fences and 2004 (pre-harvest), 2005 and 2006 for edge fences. At each pitfall trap, we recorded date, species, age class (juvenile or adult), and direction of movement for all individuals captured in traps and released on the opposite side of the fence, the presumed direction of travel. We grouped individuals of the species *Plestiodon fasciatus*, *P. laticeps*, and *P. anthracinus* as *Plestiodon* spp. due to difficulty accurately distinguishing between the three in the field.