Assessing multi-scale habitat relationships and responses to forest management for cryptic herpetofauna in the Missouri Ozarks

Shelby R. Timm[1*], Alexander J. Wolf[1], Sherry Gao[1], & Kenneth F. Kellner[2]

[1]Missouri Department of Conservation; [2]Division of Forestry and Natural Resources, West Virginia University. *Corresponding author: Shelby.Timm@mdc.mo.gov

Missouri Ozark Forest Ecosystem Project (MOFEP)

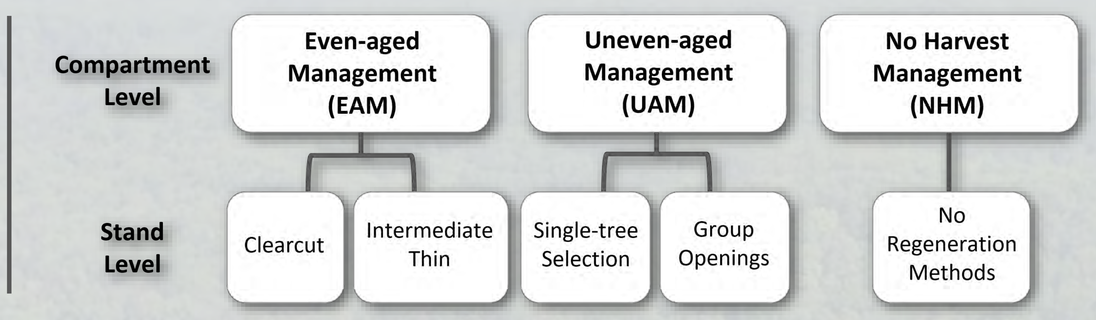
Objective:

- Determine the impacts of multiple forest management strategies on the Ozark forest ecosystem.

Background:

- Began in 1990
- Landscape-level experiment (Fig. 1)
  - At least 100 years in duration
  - Randomized complete-block design
  - 9 Compartments (~1000 acres each)
    - Compartments have 44-82 stands
- 15 year harvest re-entry

MOFEP
Missouri Ozark Forest Ecosystem Project



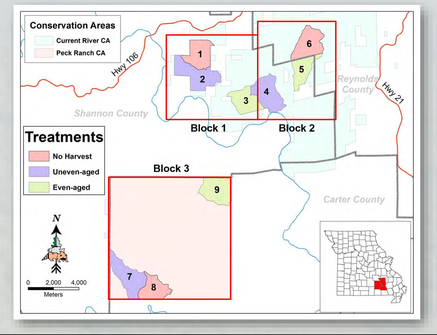


Figure 1. Map of MOFEP Compartments & randomized complete-block design

Introduction

Objective: Determine habitat relationships and responses to forest management for cryptic or uncommon herpetofauna.

Using capture histories collected on MOFEP over 23 years (1992-2014) we examined the cumulative effects of two harvest entries (1996 and 2011) at both the local- (stand-level) and landscape-scale (compartment-level) for eight uncommon herpetofauna species, including one toad, two salamanders, one skink, and four snakes.

Methods

- 12 drift fence arrays/compartment = 108 arrays (Fig. 2)
- Capture data from 14 sampling years (1992-2014; Fig. 3)
  - Includes pre-harvest and post-harvest data
  - Two harvest entries: 1996 & 2011
- Generalized linear mixed models (GLMMs)
  - Dependent Variable = Capture/No Capture
  - Fixed effects (Table 1)
  - Random effects (Array, Compartment, Block, and Year)
- Selected 8 uncommon species for analysis
  - Cave Salamander
  - Four-toed Salamander
  - Eastern Narrowmouth Toad
  - Rough Earth Snake
  - Eastern Hognose Snake
  - Rough Green Snake
  - Ribbon Snake
  - Coal Skink

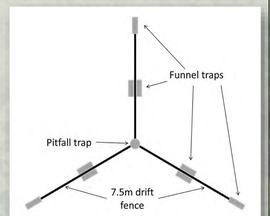


Figure 2. Herpetofauna sampling array design.

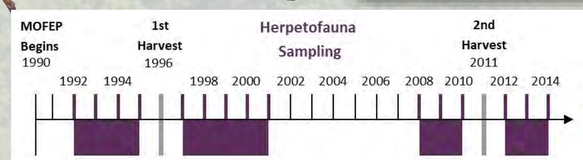


Figure 3. Timeline of herpetofauna sampling

Results

Table 1. Covariate descriptions used in species models.

Habitat covariates	
NEness	NE=1; SW=-1. Cosine(aspect - 45°). Measured using the aspect from array center.
Slope	Measured in degrees. Low values have flatter terrain than high values.
Flow Accumulation	Relates to hydrology. Low values are topographically higher (e.g. ridge top), whereas high values are areas of concentrated flow (e.g. valleys).
Pond / Stream Distance	Distance (m) to nearest pond or stream segment.
Basal Area (BA)	Measured at half acre plots using all trees >4.5 inches DBH. Calculated in m2/ha. Higher BAs correspond to greater cross-sectional tree area
Harvest related covariates	
Time Period	
Pre-harvest	Years 1992-1995
Post-harvest	Years 1998-2014 (Cumulative effects of both harvest entries)
Stand-Level Harvest Methods	
Leave	Stands that have not received harvest within NHM, UAM, or EAM compartments. Pre- and Post- harvest.
Single-tree selection	UAM harvest method. Post-harvest only.
Group Opening	UAM harvest method (1996). Post-harvest only.
Clearcut	EAM harvest method. Post-harvest only.
Intermediate thin	EAM harvest method. Post-harvest only.
Compartment-Level Treatment	
NHM	Experimental unit. Compartments 1, 6, and 8. Control
UAM	Experimental unit. Compartments 2, 4, and 7
EAM	Experimental unit. Compartments 3, 5, and 9

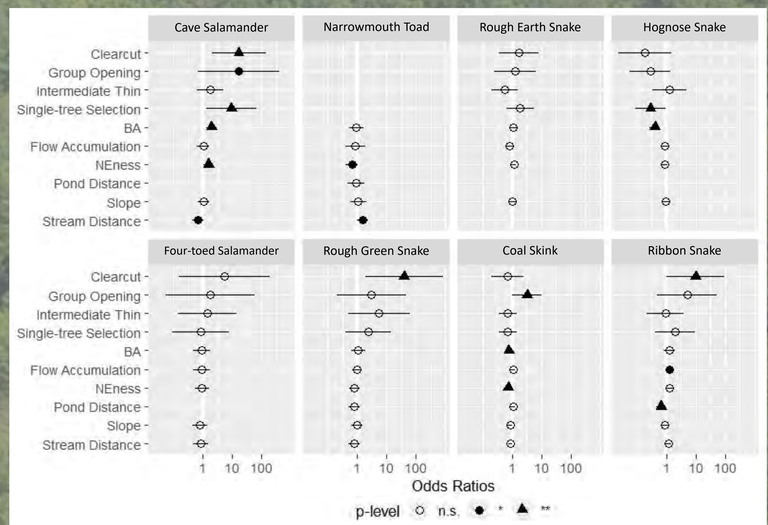


Figure 4. Odds ratios and 90% CI for each species. Fixed effects included covariates hypothesized to be associated with species capture probability based on life history strategies. Stand-level harvest methods could not be analyzed for narrowmouth toads due to convergence issues. Significant effects are indicated by black symbols (p<0.1*; p<0.05**).

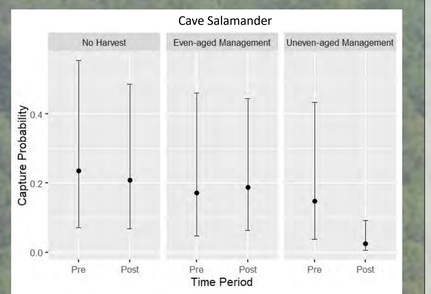


Figure 5. Capture probability and 90% CI for cave salamanders by compartment-level treatment (NHM, EAM, and UAM) and time period (Pre/Post Treatment). Cave salamanders exhibited a significant decline (p=0.046) from pre-treatment UAM to post-treatment UAM.

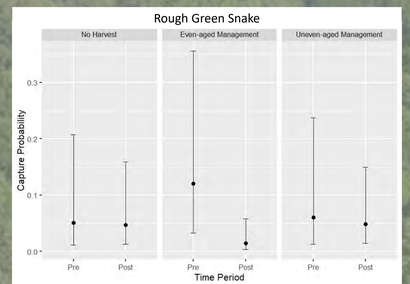


Figure 6. Capture probability and 90% CI for rough green snakes by compartment-level treatment (NHM, EAM, and UAM) and time period (Pre/Post Treatment). Rough green snakes exhibited a significant decline (p=0.045) from pre-treatment EAM to post-treatment EAM.

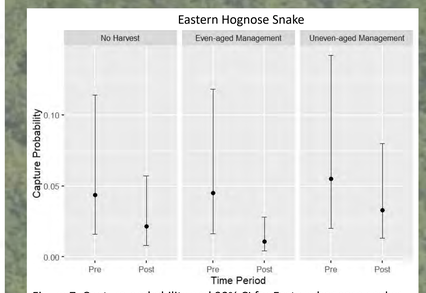


Figure 7. Capture probability and 90% CI for Eastern hognose snakes by compartment-level treatment (NHM, EAM, and UAM) and time period (Pre/Post Treatment). Eastern hognose snakes exhibited a significant decline (p=0.013) from pre-treatment EAM to post-treatment EAM, as well as in the NHM compartment (p=0.064).

- Stand-level responses (Fig. 4)
  - 5 of 7 species considered had stand-level responses
  - Contrasting effects to the compartment-level responses.
- Habitat associations (Fig. 4)
  - 5 of 8 species had increased capture probability at arrays:
    - Cave salamanders
      - ⇧ BA, NE slopes, & proximity to streams.
    - Eastern narrowmouth toads
      - SW slopes & greater distance to streams.
    - Eastern hognose snakes
      - ⇩ BA
    - Coal skinks
      - ⇩ BA & SW slopes
    - Ribbon snakes
      - proximity to ponds & higher flow accumulation
- Compartment-level responses
  - Cave salamanders: ⇩ in UAM (Fig. 5)
  - Rough green snakes: ⇩ in EAM (Fig.6)
  - Eastern hognose snakes: ⇩ across all treatments, including the control. Indicates the cause is not due to treatment, but likely an environmental factor (Fig. 7)

Conclusions

- Distinguishing responses to forest management at multiple management scales and determining habitat relationships that can be used to inform management activities can be especially important for uncommon or behaviorally cryptic species.
  - Local observations my not be indicative of what is occurring at the population level.
- The silvicultural systems on MOFEP appear to promote a range of habitat structures that can maintain biodiversity across taxa.

Additional Resources

Poster PDF

Publication link

MOFEP Website