Short-term small mammal responses to silviculture in the Central Hardwoods

Kenneth Kellner*, Natasha Urban*†, and Robert Swihart*

***Forestry and Natural Resources, Purdue University; †Biological Sciences, University of Cincinnati**

Abstract

Identifying the effects of land management on plant and animal communities is important for managers seeking to preserve ecosystem function. For example, silviculture (timber harvesting) impacts many forest species, including small mammals, a key component of forest food webs. We studied short-term responses of several common small mammal species to silviculture in hardwood forests of southern Indiana. Small mammals were trapped at 32 stands over a 5-year period; 2 years of trapping occurred before harvest. Each stand received a silvicultural treatment: clearcutting (4 ha openings), shelterwood harvest (4 ha), patch cutting (≤2 ha) or no harvest. Following harvest, small mammals were trapped for 3 additional years. We used an *N*-mixture model fit in a Bayesian framework to estimate abundance from capture data and compared estimates before and after harvests. The eastern chipmunk (*Tamius striatus*) increased in abundance clearcuts and patch cuts. The short-tailed shrew (*Blarina brevicauda*) and pine vole (*Microtus pinetorum*) declined following clearcuts. The white-footed mouse (*Peromyscus leucopus*), did not respond numerically to most harvest treatments. Abundance of all species was unchanged following the first phase of shelterwood harvests. This study provides evidence of changes in small mammal communities following silviculture and identifies species sensitive to conditions following harvest. It also presents a method for estimating abundance that is less labor-intensive and offers greater utility than traditional mark-release-recapture approaches when populations are small.

Introduction

- Small mammals: important role in forests
  - Predator, prey, herbivore[1]
  - Dispersal agents[2]
  - Influence insect/disease life cycles[3]
- Silviculture can greatly alter habitat for small mammals(Fig. 1)
- Varying, **inconclusive** effects of silviculture on small mammals reported[4] (Fig. 2)
- Past studies have ignored **imperfect detection** and temporal changes in **food availability** (e.g. mast[5])

Figure 1. Forest stand before and after a clearcut harvest

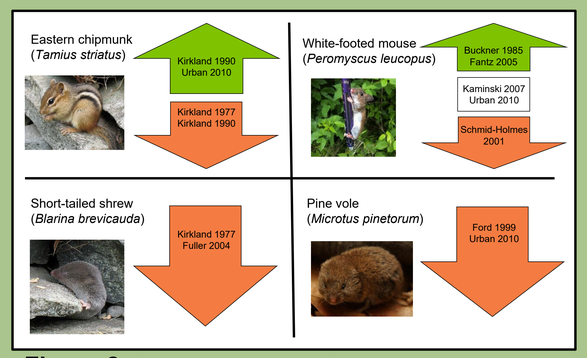

Figure 2. Reported responses of small mammals (positive, negative, or neutral) to silvicultural disturbance of forest.

Objective

Measure the effects of silviculture on the abundance of common small mammals in the Central Hardwoods, accounting for imperfect detection and changes in food (mast) availability

Predictions

1. Populations of granivores linked to mast abundance[5]
2. Increase in Eastern chipmunk abundance following harvest[7]
3. Decrease in short-tailed shrew and pine vole abundance[7]
4. Minimal small mammal response to the first stage of shelterwood harvests (only midstory trees removed)

Methods

- Part of the **Hardwood Ecosystem Experiment (HEE)**: study of responses to silviculture
- 3 silvicultural treatments (Fig. 3)
  - **Even-aged**: clearcuts and shelterwood harvests (4 ha)
  - **Uneven-aged**: patch cuts (0.4-2 ha)
  - **Control**: unharvested
- 32 trapping grids
  - Divided between treatments
  - Trapped 1 week/year for 5 years: 2 pre-, 3 post-harvest
- Microhabitat, mast data collected at each grid

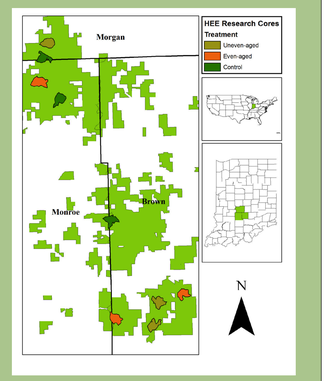

Figure 3. Map of HEE study sites in Morgan-Monroe and Yellowwood State Forests, Indiana, USA

Analysis

- ***N*-mixture model**[15] (Fig. 4)
  - Allows abundance estimates from repeat count data (no marks)
  - Incorporates imperfect detection
- **GLMMs** connect detection (*p*) and abundance (λ) to covariates
- Fit in **Bayesian framework**

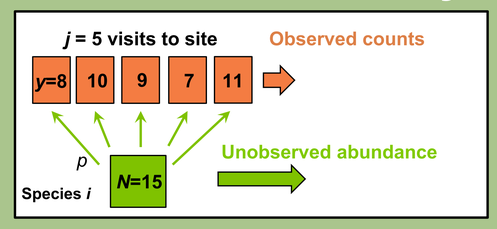

Figure 4. *N*-mixture model structure, with example observations. The model contains observed (Binomial) and unobserved (Poisson) units, accounting for imperfect detection.

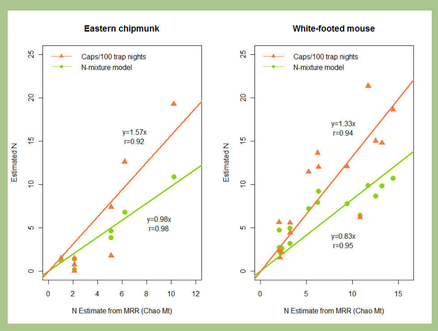

Figure 5. Comparison of relative abundance estimates (*N*-mixture model and captures/100 trap nights; Y-axis) with estimates from mark-release-recapture (Chao M_t estimator; X-axis) at a subset of sites. *N*-mixture estimates were more closely correlated with the MRR estimate.

Results

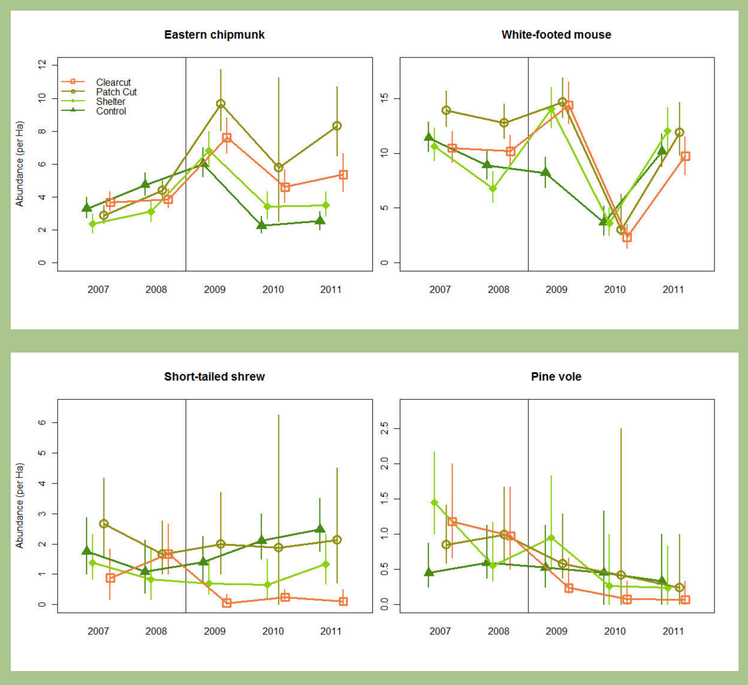

Figure 6. Mean (with 95% credible interval) small mammal abundance by harvest type and year. The vertical lines in each graph separate the pre- and post-harvest periods. Only 20 of the 32 sites were sampled in 2010, resulting in larger credible intervals.

	Chipmunk		Mouse		Shrew		Vole	
Total Captures	2515		1886		127		76	
Covariate	β_j	SE	β_j	SE	β_j	SE	β_j	SE
***p* (detection)**								
Temperature	**-0.12**	0.05	**-0.13**	0.03	-0.06	0.09	-0.20	0.14
Julian Day	-0.05	0.06	0.09	0.05	**-0.50**	0.13	0.27	0.17
Trap Effort	-0.03	0.10	**1.03**	0.34	-0.15	0.19	-0.06	0.43
***λ* (abundance)**								
Mast	0.05	0.04	**0.10**	0.03	**0.27**	0.10	-0.12	0.16
Aspect	-0.05	0.09	0.10	0.06	**0.41**	0.23	0.42	0.29
Clearcut (4 ha)	**0.51**	0.13	-0.06	0.11	**-2.41**	0.87	**-1.96**	0.89
Patch cut (0.4-2 ha)	**0.36**	0.13	-0.12	0.09	-0.24	0.35	**-0.96**	0.59
Shelterwood (4 ha)	0.22	0.14	0.09	0.10	-0.24	0.34	-0.28	0.46

Table 1. Total captures (first row) and estimated parameters from the *N*-mixture model for each small mammal species. Effects of covariates on probability of detection are listed first followed by covariates associated with abundance. Highlighted values are statistically different from 0.

Results

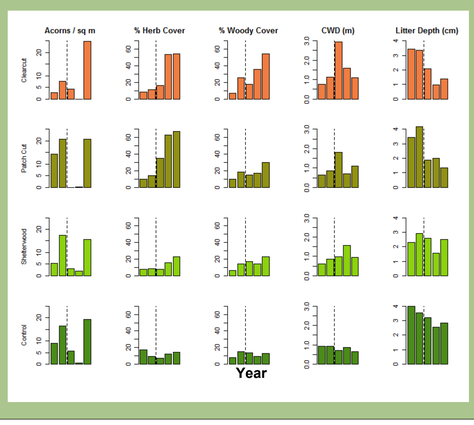

Figure 7. Mean values for total acorn production (acorns / m^2 of trap area) and microhabitat variables by treatment and study year. Vertical lines separate the pre- and post-harvest periods.

Discussion

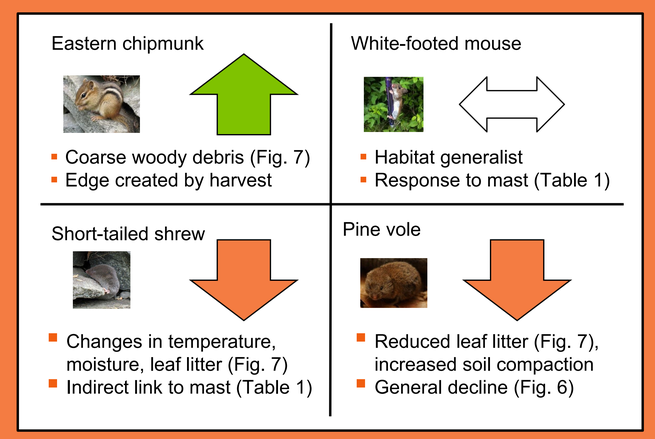

Figure 8. General direction of response to clearcut and patch cut harvests for each species, and potential explanations for the changes

- No effects of 1st stage of shelterwood harvest (Table 1)
- Advantages of *N*-mixture model
  - No marks necessary (reduces time and cost)
  - Accurate abundance estimates (Fig. 5)
  - Caveat: validation is necessary

Acknowledgments

Harmony Dalgleish, Mike Saunders, Mike Steele, and Pat Zollner provided feedback on this poster. Rebecca Kalb, Jeff Riegel , and numerous field technicians helped with data collection and logistics. Funding was provided by the Purdue Department of Forestry and Natural Resources, the Purdue Graduate School, and the Division of Forestry, Indiana DNR.

Hardwood Ecosystem Experiment

Literature Cited

1. Whitaker, J.O.; Hamilton, W.J. 1998. Mammals of Eastern United States. Ithaca, NY: Cornell University Press. 583 p.
2. Moore, J.E.; McEuen, A.B.; Swihart, R.K.; Contreras, T.A.; Steele, M.A. 2007. Determinants of seed removal distance by scatter-hoarding rodents in deciduous forests. Ecology. 88: 2529-2540.
3. Page, L.K.; Swihart, R.K.; Kazacos, K.R. 2001. Seed preferences and foraging by granivores at raccoon latrines in the transmission dynamics of the raccoon roundworm. Canadian Journal of Zoology. 79: 616-622.
4. Zwolak, R. 2009. A meta-analysis of the effects of wildfire, clearcutting, and partial harvest on the abundance of North American small mammals. Forest Ecology and Management 258: 539-545.
5. Wolff, J.O. 1996. Population fluctuations of mast-eating rodents are correlated with production of acorns. Journal of Mammalogy 77: 850-856.
6. Kirkland, G.L. 1990. Patterns of initial small mammal community change after clearcutting of temperate North American forests. Oikos. 59:313-320.
7. Urban, N.A.; Swihart, R.K. 2010. Small mammal responses to forest management for oak regeneration in southern Indiana. Forest Ecology and Management. 261: 353-361.
8. Kirkland, G.L. 1977. Responses of small mammals to the clearcutting of northern Appalachian forests. Journal of Mammalogy. 58: 600-609.
9. Fuller, A.K.; Harrison, D.J.; Lachowski, H.J. 2004. Stand scale effects of partial harvesting and clearcutting on small mammals and forest structure. Forest Ecology and Management. 191: 373-386.
10. Buckner, C.A.; Shure, D.J. 1985. The response of Peromyscus to forest opening size in the southern Appalachian mountains. Journal of Mammalogy. 66: 299-307.
11. Fantz, D.K.; Renken, R.B. 2005. Short-term landscape-scale effects of forest management on Peromyscus spp. mice within Missouri Ozark forests. Wildlife Society Bulletin. 33: 293-301.
12. Kaminski, J.A.; Davis, M.L.; Kelly, M.; Keyser, P.D. 2007. Disturbance effects on small mammal species in a managed Appalachian forest. American Midland Naturalist. 157: 385-397.
13. Schmid-Holmes, S.; Drickamer, L.C. 2001. Impact of forest patch characteristics on small mammal communities: a multivariate approach. Biological Conservation. 99: 293-305.
14. Ford, W.M.; Menzel, M.A.; McGill, D.W.; Laerm, J.; McCay, T.S. 1999. Effects of a community restoration fire on small mammals and herpetofauna in the southern Appalachians. Forest Ecology and Management 114: 233-243.
15. Royle, J.A. 2004. N-mixture models for estimating population size from spatially replicated counts. Biometrics 60: 108-115.