

HEE



Hardwood Ecosystem Experiment

THE
HARDWOOD ECOSYSTEM EXPERIMENT

SUMMARY OF OUTPUTS

FOR THE CONTRACT PERIOD
MAY 1, 2012 – APRIL 30, 2014
AND PRECEDING CONTRACTS

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Introduction

The Hardwood Ecosystem Experiment (HEE) is a collaborative project between the Indiana Department of Natural Resources, Division of Forestry (DoF) and researchers from Purdue University, Indiana State University, Ball State University, Drake University (Iowa) and Indiana University.

The main goal of HEE is to understand the ecological and social impacts of long-term forest management on public and private lands in Indiana and the Central Hardwoods Region. Our primary objectives include:

1. Develop even-aged and uneven-aged silvicultural systems that maintain oak-dominated forest communities and landscapes;
2. Determine both the positive and negative impacts of these systems on communities of herbaceous, avian and terrestrial amphibian species groups;
3. Determine the social and economic ramifications of these systems in both the local and regional communities; and
4. Provide demonstration sites and develop novel educational materials and techniques to engage the public concerning forest management.

The HEE is designed as a long-term field experiment to study forest management and its impacts. In collaboration with DoF, we created a replicated series of study areas at Morgan-Monroe and Yellowwood State Forests, on which the most common approaches to forest management will be implemented and monitored. This framework of study sites will be used to study the long-term response of selected species both in the treated areas themselves and the surrounding forest. Simultaneously, we will conduct surveys of the landowners and general public in the immediate vicinity of the study areas to assess their attitudes towards active land management.

The purpose of this document is to provide a quick summary of HEE research products from project initiation to the present. It provides metrics of total project productivity as well as a comprehensive listing of research, technical and extension publications by author, year and title.

HEE Summary through August 2013

The HEE has completed nearly eight years of data collection, analysis and dissemination related to the impacts of forest management on forest ecosystems and human communities in southern Indiana. The project to date has involved nearly 20 principle investigators from 7 different universities and state agencies (Table 1). The project has trained more than 130 undergraduate and post-baccalaureate students as field technicians and undergraduate researchers. A total of 22 graduate students have conducted graduate research on the HEE; the large majority of these have been focused entirely on the HEE (Table 1).

Table 1. Principle investigators and university participation on the HEE from 2006-13.

| Principle Investigator | Project(s) | Institution | Start date | Finish date | Grad students¹ |
|-------------------------------|------------------------------------|------------------------------------|-------------------|--------------------|----------------------------------|
| 2012-14 | | | | | |
| Carter, Tim | Bats, fawn dispersal | Ball State University | 5/1/12 | | 3 |
| Chapman, Rob | Salamanders | Purdue University | 5/1/11 | | 0 |
| DuChamp, Joe | Bats | Indiana University of Pennsylvania | 5/1/10 | 2/28/13 | 1 |
| Dunning, John | Birds, owls | Purdue University | 5/1/06 | | 1 |
| Haulton, Scott | Deer exclosures, ruffed grouse | Indiana DNR - Division of Forestry | 5/1/08 | | 0 |
| Holland, Jeff | Wood-boring beetles | Purdue University | 5/1/06 | | 0 |
| Hoover, Bill | Human dimensions | Purdue University | 5/1/06 | | 1 |
| Islam, Kamal | Cerulean warblers | Ball State University | 5/1/07 | | 7 |
| Jenkins, Mike | Vegetation, deer exclosures | Purdue University | 5/1/08 | | 0 |
| O'Keefe, Joy | Bats | Indiana State University | 5/1/12 | | 1 |
| Saunders, Mike | Vegetation, deer exclosures | Purdue University | 5/1/08 | | 1 |
| Shelton, Angie | Spring ephemerals, deer exclosures | Indiana University | 5/1/11 | | 0 |
| Summerville, Keith | Lepidoptera | Drake University | 5/1/07 | | 0 |

| Principle Investigator | Project(s) | Institution | Start date | Finish date | Grad students¹ |
|-------------------------------|--|--------------------------|-------------------|--------------------|----------------------------------|
| Swihart, Rob | Small mammals, mast, owls | Purdue University | 5/1/06 | | 2 ² |
| 2006 –12 | | | | | |
| Amberg, Shannon | Human dimensions | Purdue University | 5/1/09 | 4/30/10 | 0 |
| MacGowan, Brian | Box turtles, rattlesnakes | Purdue University | 5/1/07 | 4/30/11 | 0 |
| Whitaker, John | Bats | Indiana State University | 5/1/06 | 4/30/11 | 2 |
| Williams, Rod | Salamanders, box turtles, rattlesnakes | Purdue University | 5/1/07 | 4/30/11 | 3 |

¹ This column includes current graduate students who have not completed their projects. Therefore, the total number of students in this column is greater than the number of theses/dissertations listed below.

² This value includes one graduate student who completed an M.S. degree and continued on to a Ph.D. degree on the same project.

This research effort has led to a large body of publication (Figure 1) and has been presented to a wide array of audiences (Figure 2). HEE researchers have begun to accumulate sufficient data to describe responses of various ecosystem components to forest management, while numerous graduate students have completed their projects and data analysis; this research is now beginning to be published in peer-reviewed academic journals. Figure 1a shows a breakdown of publications by individual HEE inventory. Figure 1b shows the breakdown by year. A major accomplishment of the 2012-14 contract cycle was the completion of USDA-Forest Service General Technical Report NRS-P-108, a 350 page document cataloguing characteristics of the research sites prior to timber harvesting (see Swihart et al. 2013 below for titles). This document is the most comprehensive assessment of landscape-level ecosystem conditions in Indiana and is one of only a handful of similar documents available for the entire eastern United States. The investment of time and energy in this document will be invaluable to future researchers as they continue to follow these species groups for the remainder of the project.

Further, data from the Hardwood Ecosystem Experiment has been presented at numerous venues, both scientific and non-scientific (Figure 2a). Substantial effort was made early in the project to provide numerous extension opportunities to the general public and to natural resources professionals in the state of Indiana (Figure 2a). As more years of data have become available, there has been a large increase in the number of presentations to scientific audiences, with a particular increase in presentations at venues with regional, national and international impact (Figure 2b).

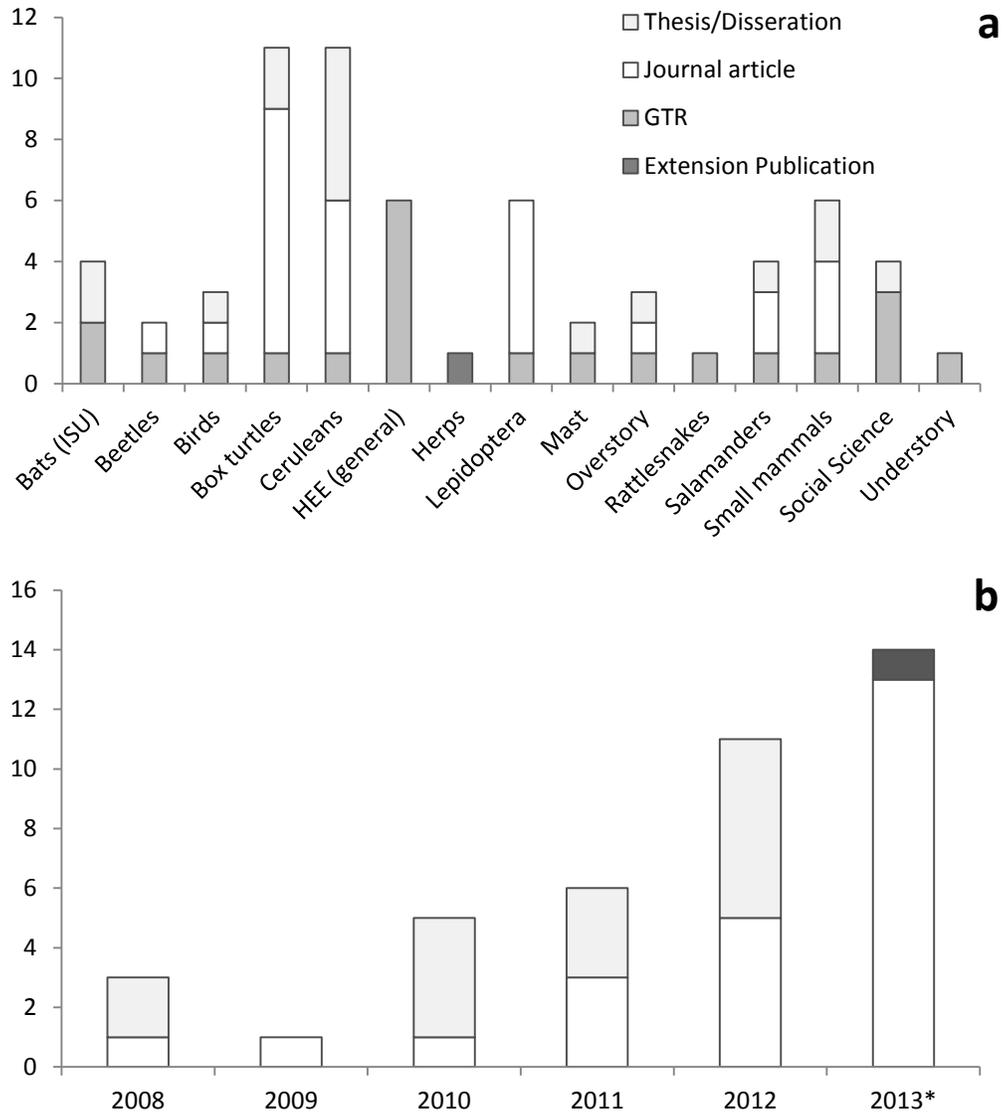


Figure 1. Hardwood Ecosystem Experiment publications by publication type for a) individual inventories and b) year. GTR refers to the HEE General Technical Report

*Eight of the publications listed for 2013 are either in press or in review and have not yet been published. Additionally, this Figure 2b does not include the 22 articles that were published by the USDA-Forest Service as part of the HEE General Technical Report (see Swihart et al. 2013 below).

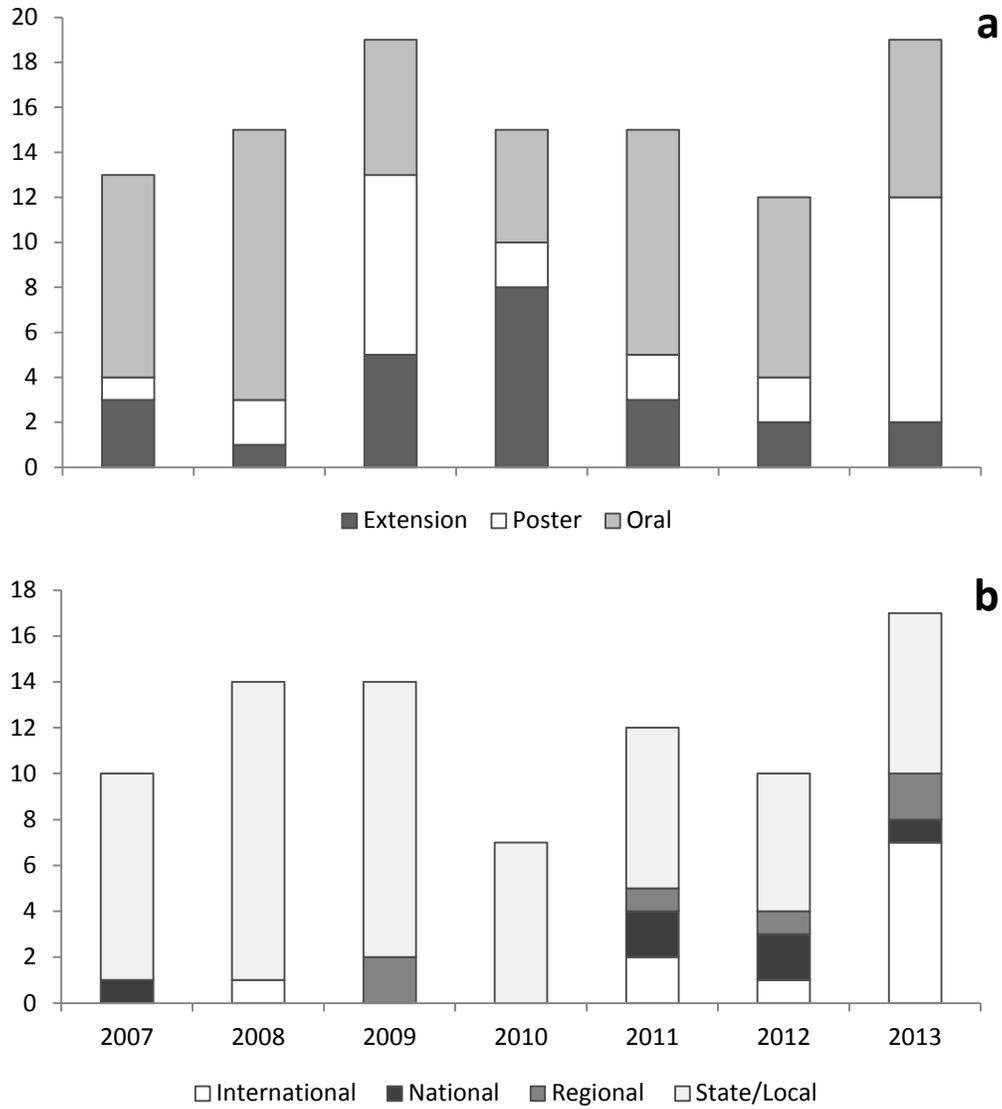


Figure 2. Hardwood Ecosystem Experiment presentations by a) presentation type and by b) presentation scope. Extension presentations are not included in 2b resulting in lower total numbers.

2012-14 HEE Publications

Journal articles

- Currylow, A.F., B.J.MacGowan and R.N.Williams. 2013. Hibernial thermal ecology of eastern box turtles within a managed forest landscape. *Journal of Wildlife Management* 77(2): 326-335.
- Currylow, A.F., M.S.Tift, J.L.Meyer, D.E.Crocker and Williams. 2013. Seasonal variations in plasma vitellogenin and sex steroids in male and female eastern box turtles (*Terrapene c. carolina*). *General and Comparative Endocrinology* 180:48-55.
- Kaminski, K.J. and K.Islam. 2013. Effects of forest treatments on abundance and spatial characteristics of cerulean warbler territories. *American Midland Naturalist* 170:111 – 120.
- Currylow, A.F., B.J.MacGowan and R.N.Willa. 2012. Short-term forest management effects on a long-lived ectotherm. *PLoS ONE* 7(7):e40473.
- Kimble, S.J.A. and R.N.Williams. 2012. Temporal variance in hematologic and plasma biochemical reference intervals for free-ranging eastern box turtles (*Terrapene carolina carolina*). *Journal of Wildlife Diseases*
- Summerville, K.S. 2013. Forest lepidopteran communities are more resilient to shelterwood harvest compared to more intensive logging regimes. *Ecological Applications*. [<http://dx.doi.org/10.1890/12-0639.1>]
- Islam, K., J.Wagner, R.Dibala, M.M.MacNeil, K.J.Kaminski and L.P.Young. 2012. Cerulean Warbler (*Setophaga cerulea*) response to changes in forest structure in Indiana *Ornitologia Neotropical* 23: 335-341.
- Summerville, K.S., J.L.Lane and D.Courard-Hauri. 2012. Stability in forest Lepidopteran communities: how sensitive are pest species to experimental forest management. *Insect Conservation and Diversity*. [<http://dx.doi.org/10.1111/j.1752-4598.2012.00213.x>]
- Urban, N.A., R.K.Swihart, M.C.Malloy and J.B.Dunning. 2012. Improving selection of indicator species when detection is imperfect. *Ecological Indicators* 15: 188-197.
- Currylow, A.F., A.J.Johnson and R.N.Williams. In press. Ranavirus infections among sympatric populations of larval amphibians and Eastern Box Turtles (*Terrapene carolina carolina*). *Journal of Herpetology*.
- MacNeil, J.E. and R.N.Williams. In press. Effectiveness of two artificial cover objects in sampling terrestrial salamanders. *Herpetological Conservation and Biology*.

Kimble, S.J.A., O.E.Rhodes, Jr. and R.N.Williams. In review. Unexpectedly low rangewide population genetic structure of the imperiled eastern box turtles. *PLoS ONE*.

Kimble, S.J.A., O.E.Rhodes, Jr. and R.N.Williams. In review. Relatedness and other finescale genetic processes in the box turtle. *Herpetologica*.

MacNeil, J.E. and R.N.Williams. In review. Effects of timber harvests and silvicultural edges on terrestrial salamanders. *PLoS ONE*.

Kellner, K.F., N.A.Urban and R.K.Swihart. In revision. Short-term responses of small mammals to timber harvest in the Central Hardwoods. *Journal of Wildlife Management*.

Meier, A.R. and M.R.Saunders. In prep. Factors affecting epicormic branching of mature oak trees that border forest openings. *Canadian Journal of Forest Research*.

General Technical Report NRS-P-108

Swihart, R.K., M.R.Saunders, R.A.Kalb, G.S.Haulton and C.H.Michler. 2013. The Hardwood Ecosystem Experiment: a framework for studying responses to forest management. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] 350 p.

GTR-NRS-P-108 Contents:

Historical and Current Perspectives on Forest Management

Jenkins, M.A. 2013. The history of disturbance in forest ecosystems of southern Indiana. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 2-11.

Carman, S.F. 2013. Indiana forest management history. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 12-23.

Witter, D.J., S.M.Amberg, D.J.Case and P.T.Seng. 2013. Indiana residents' perceptions of woodland management. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 24-34.

Introduction to the Hardwood Ecosystem Experiment

Kalb, R.A. and C.J.Mycroft. 2013. The Hardwood Ecosystem Experiment: Goals, Design and Implementation. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 36-59.

Targeted Wildlife Species

Islam, K., K.J.Kaminski, M.M.MacNeil and L.P.Young. 2013. The cerulean warbler in Morgan-Monroe and Yellowwood State Forests, Indiana: pre-treatment data on abundance and spatial characteristics of territories. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 61-77.

Currylow, A.F., B.J.MacGowan and R.N.Williams. 2013. Spatial ecology and behavior of eastern box turtles on the Hardwood Ecosystem Experiment: pre-treatment results. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 78-85.

MacGowan, B.J. and Z.J.Walker. 2013. Spatial ecology of timber rattlesnakes on the Hardwood Ecosystem Experiment: pre-treatment results. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 86-94.

Targeted Wildlife and Plant Communities

Saunders, M.R. and J.E.Arsenault. 2013. Pre-treatment analysis of woody vegetation composition and structure on the Hardwood Ecosystem Experiment research units. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 96-125.

Malloy, M.C. and J.B.Dunning. 2013. Breeding bird communities of the Hardwood Ecosystem Experiment. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 126-141.

MacNeil, J.E. and R.N.Williams. 2013. Relative abundance and species richness of terrestrial salamanders on Hardwood Ecosystem Experiment sites before harvesting. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 142-150.

Urban, N.A. and R.K.Swihart. 2013. A pre-treatment assessment of small mammals in the Hardwood Ecosystem Experiment. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 151-175.

Kellner, K.F., J.K.Riegel, N.I.Lichti and R.K.Swihart. 2013. Oak mast production and animal impacts on acorn survival in the Central Hardwoods. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 176-190.

Sheets, J.J., J.O.Whitaker, Jr., V.Brack, Jr. and D.W.Sparks. 2013. Bats of the Hardwood Ecosystem Experiment before timber harvest: assessment and prognosis. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 191-202.

Sheets, J.J., J.E.Duchamp, M.C.Caylor, L.D'Acunto, J.O.Whitaker, Jr. and V.Brack, Jr., D.W.Sparks. 2013. Habitat use by bats in two Indiana Forest prior to silvicultural treatments for oak regeneration. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 203-217.

Holland, J.D., J.T.Shukle, H.E.M.Abdel Moniem, T.W.Mager, K.R.Raje and K.Schnepp, S.Yang. 2013. Pre-treatment assemblages of wood-boring beetles (Coleoptera: Buprestidae, Cerambycidae) of the Hardwood Ecosystem Experiment. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 218-236.

Summerville, K.S., M.R.Saunders and J.L.Lane. 2013. The Lepidoptera as predictable communities of herbivores: a test of niche assembly using the moth communities of Morgan-Monroe State Forest. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 237-252.

Socio-economic Implications of Forest Management

Rogers, S.C., W.L.Hoover and S.B.Allred. 2013. Public acceptability of management practices on the Morgan-Monroe State Forest: Examining the influence of information, values, and visual characteristics. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 254-286.

Hoover, W.L. 2013. Value of the Morgan-Monroe-Yellowwood State Forest Complex. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 287-313.

Concluding Synthesis and Looking Forward

Saunders, M.R. and R.K.Swihart. 2013. Science in the Hardwood Ecosystem Experiment: accomplishments and the road ahead. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 315-332.

MacGowan, B.J., L.D.Farlee and R.N.Chapman. 2013. The Hardwood Ecosystem Experiment: extension and outreach. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 333-338.

Haulton, G.S. 2013. Past is prologue: a synthesis of state forest management activities and Hardwood Ecosystem Experiment pre-treatment results. *Gen. Tech. Rep. NRS-P-108. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.* [CD ROM] pp. 339-349.

Extension publications

MacNeil, J.E., B.J.MacGowan, A.F.Currylow and R.N.Williams. 2013. Forest management for reptiles and amphibians: a technical guide for the Midwest. FNR-480-W, Purdue University Extension, West Lafayette, Indiana, USA.

Graduate student dissertations and theses

Kimble, S.J.A. 2012 . Population genetics of the eastern box turtle, *Terrapene c. Carolina*. Doctor of Philosophy Dissertation. Purdue University, West Lafayette, Indiana

Dibala, R. 2012. Population response of a declining songbird to silviculture: how Cerulean Warbler (*Setophaga cerulea*) territory size and settlement patterns fare in the face of forest disturbance. Master of Biology Thesis. Ball State University, Muncie, IN.

Kellner, K.F. 2012. Temporal dynamics of mast and small mammals: short-term responses to silviculture. Master of Science Thesis. Purdue University, West Lafayette, Indiana.

Malloy, M.C. 2012. Effects of forest management on breeding bird populations on mixed deciduous forests of southern Indiana. Master of Science Thesis. Purdue University, West Lafayette, Indiana.

Meier, A.R. 2012. Aspects of epicormic development in *Quercus alba* (L.) and other eastern North American oak species in relation to genetics, tree vigor and silvicultural treatments. Master of Science Thesis. Purdue University, West Lafayette, Indiana.

Wagner, J. 2012. Cerulean Warbler population and breeding response to recent silviculture and influences of prey availability on avian nesting ecology. Master of Biology Thesis. Ball State University, Muncie, Indiana

2006-12 HEE Publications

Journal articles

- Currylow, A.F., P.A.Zollner, B.J.MacGowan and R.N.Williams. 2011. A survival estimate of Midwestern adult Eastern box turtles using radio telemetry. *The American Midland Naturalist* 165(1): 143-149.
- Holland, J.D. 2010. Isolating spatial effects on beta diversity to inform forest landscape planning. *Landscape Ecology* 25(9): 1349-1362.
- Summerville, K.S. 2011. Managing the forest for more than the trees: effects of experimental timber harvest on forest Lepidoptera. *Ecological Applications* 21(3): 806-816.
- Summerville, K.S., D.Courard-Hauri and M.M.Dupont. 2009. The legacy of timber harvest: Do patterns of species dominance suggest recovery of Lepidopteran communities in managed hardwood stands? *Forest Ecology and Management* 259(1): 8-13.
- Summerville, K.S., M.M.Dupont, A.V.Johnson and R.L.Krehbiel. 2008. Spatial structure of forest Lepidopteran communities in oak hickory forests of Indiana. *Environmental Entomology* 37(5): 1224-1230.
- Urban, N.A. and R.K.Swihart. 2011. Small mammal responses to forest management for oak regeneration in southern Indiana. *Forest Ecology and Management* 261:353-361.

Graduate student dissertations and theses

- Caylor, M.K. 2011. Impacts of different forest tree-harvest methods on diets and populations of insectivorous forest bats. Master of Science Thesis. Indiana State University, Terre Haute, IN.
- Currylow, A.F. 2011. Effects of forest management on the ecology and behavior of Eastern box turtles. Master of Science Thesis. Purdue University, West Lafayette, Indiana.
- Kaminski, K.J. 2010. Cerulean Warbler initial response to silviculture treatments in southern Indiana. Master of Biology Thesis. Ball State University, Muncie, Indiana.
- MacNeil, J.E. 2011. The effects of forest management on terrestrial salamanders. Master of Science Thesis. Purdue University, West Lafayette, Indiana.
- MacNeil, M.M. 2010. Does timber harvesting affect Cerulean Warbler foraging ecology? Master of Science Thesis. Ball State University, Muncie, Indiana.
- Rogers, S.C. 2008. Public acceptability of management practices on the Morgan-Monroe State Forest: Examining the influence of information, values, and visual characteristics. M.S. Thesis. Purdue University, West Lafayette, Indiana.

Sheets, J.J. 2010. Impact of forest management techniques on bats with a focus on the endangered Indiana myotis (*Myotis sodalis*). Master of Science Thesis. Indiana State University, Terre Haute, Indiana.

Urban, N.A. 2010. Improving inferences on wildlife responses to oak-centered forest management with models that account for imperfect detection. Master of Science Thesis. Purdue University, West Lafayette, Indiana.

Young, L.P. 2008. Distribution and foraging ecology of Cerulean Warblers in southern Indiana. Ball State University, Muncie, Indiana.