BIRD, PLANT, AND HERPETOFAUNAL ASSOCIATIONS IN COVE FORESTS AND PINE PLANTATIONS IN MISSISSIPPI

By

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I investigated plant and animal community characteristics on 14 forest stands in north central Mississippi. Study sites included 9 pine plantations, 3 streamside management zones, and 2 hardwood cove forests. I estimated relationships between faunal metrics and habitat characteristics. I measured vegetation characteristics within quadrant and nested plot designs to estimate understory, midstory, and overstory species composition and structure. I inventoried breeding birds using point count surveys and sampled herpetofauna diversity using area-constrained searches within belt transects during 2008 and 2009. I detected 39 species of birds in 2008, 43 species of birds in 2009, 11 species of amphibians, and 9 species of reptiles. Hardwood cove sites supported more deep forest-dwelling bird and salamander species; whereas, pine stands supported more grassland bird species. Species richness and abundance of birds was related to snag DBH. Species richness and abundance of herpetofauna was related to number of understory plant species.

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CHAPTER I

INTRODUCTION

Biodiversity often is defined as variability among living organisms from all sources, including the diversity found within a single species, and among species and the ecosystems a species will inhabit (Carnus et al. 2006). This concept may be particularly evident in forested ecosystems where climate, soil type, geographical ranges, slope and topography, population and community processes, and human and natural disturbances drive ecological processes (Carnus et al. 2006). Intensively managed forests have often been thought of as biological deserts, especially with even-aged monoculture tree plantings that are managed intensively to reduce competing vegetation (Hunter 1990). Several authors report less favorable habitat in tree plantations for a variety of species compared to naturally developing stands of mature hardwoods and pine in the southern United States (Hunter 1990, Hartley 2002). Site conversion of mature, naturally occurring forest types and other natural ecosystems to plantation forests is often not preferred from a biodiversity standpoint, especially if species that depend on the original forests are desired (Carnus et al. 2006). However, planted forests can contribute to the overall species diversity of a landscape and may be comparable to naturally regenerated stands (Clout and Gaze 1984). Research in the southeastern United States has demonstrated that pine plantations managed for wildlife through such treatments as intermediate stand thinning, selective herbicide applications, and implementation of prescribed burns can provide habitat for a diversity of organisms, especially early successional and grassland

species (Miller et al. 2009). Regardless of biological communities of natural and planted forest types, high diversity of communities and species across a landscape often is created by a diversity of habitat types ranging from early successional to climax stages (Yarrow and Yarrow 1999, Dickson and Wigley 2001, Mitchell et al. 2006).

A variety of species rely on different habitat types, and a mixture of stand age and types across a managed pine landscape can enhance a landscape's heterogeneity, promoting floral and faunal diversity (Mitchell et al. 2006). However, today's relatively dense loblolly stands differ from natural oak (*Quercus* spp.)-hickory (*Carya* spp.) and pine-hardwood forests that once occurred on the landscape of the southeastern U.S. prior to human influence and establishment of pine plantations (Dickson and Wigley 2001). Therefore, some private landowners have developed approaches to retain sensitive or rare ecosystem types on the landscape. For example, biodiversity is enhanced and promoted due to presence of natural forest patches that are retained as mixed forest stands, mature hardwood forests, protected wetland areas, and streamside management zones on managed forest landscapes (Wigley et al. 2000).

As demand for timber products grows, forest management that includes retention of mature natural forests and other environmental resource patches within managed forest matrices can help provide habitat for flora and fauna that depend on older-aged forests (Davis 1996). Within the 86.6 million ha of managed forestsin the southeast, about 17.8 million ha are managed in tree plantations or early successional forests (Dickson et al 2001, Miller et al. 2009). Less than one percent of forested lands in the Southeast are comprised of primary forest which can be defined as "mature or old growth" natural forests (Davis 1996, Dickson and Sheffield 2001). Forests categorized as mature, old growth or natural forests include Appalachian, old cove forests of the Southeast, of which

only about 78,500 ha remain (Hunter 1990, Davis 1996). Furthermore, many forested landbases described as old growth may be younger than typical old growth, due to a variety of classification types (Davis 1996).

Scientists, conservationists, and policy-makers often have applied different meanings to the term "old growth". One challenge is the high variability in classification of old growth forests. According to Davis (1996), old growth is described loosely as a forest that has existed since before pre-settlement times and has had no or minimal human disturbance. This definition is not only vague, but excludes most forest landscapes due to secondary growth. To include as much mature and old growth forest as possible, Davis (1996) developed classifications to describe various stages of old growth forests (Table 1). This categorization allowed more area of mature hardwood to be labeled as "old growth", including as much forested land as possible to foster protection of remaining forests in this classification. Protection of these older age class forests is often viewed as important for conservation of many rare species that require features of mature forest types, such as closed canopy conditions, large cavity trees, multiple canopy layers, abundant standing and downed deadwood, and moist litter conditions (Hunter 1990). Conservation of remaining mature or natural forests can be important for the recovery and protection of rare flora and fauna of riparian and bottomland hardwood forests (Walker 2001). Rare species that often inhabit mature hardwood forests include species, such as the Louisiana black bear (*Ursus americanus luteolus*), Rafinesque big-eared bat (*Coryrhynchos rafinesquii*), Webster's salamander (*Plethodon websterii)* and at least 10 plant species (Yarrow and Yarrow 1999, Gibbons and Buhlmann 2001, Harvey and Saugey 2001, Pelton 2001).

Cove forests can be important in the conservation of salamanders and rare plants (Hunter 1990, Petranka et al. 1993). Coves often are associated with mature and old growth hardwood forests, most notably in the southern Appalachian cove ecosystems (Ford et al. 2002). Cove ecosystems typically exhibit common features, such as sheltered ravines, hollows, north-facing slopes, and an interspersion of creeks, springs or seeps (Ford et al. 2002). Coves are typified by moist, fertile soils with a highly diverse vegetation component (Franzreb 2005). In the southeastern United States, cove forests are often described as deciduous forests dominated by large canopy trees attaining 0.9 m to 1.2 m in diameter [DBH] and reaching over 45 m tall. Common tree species accounting for approximately 90 % of the canopy cover in these systems include yellow poplar (*Liriodendron tulipifera*), American beech, white oak (*Q. alba*) and hickory. Other species include green ash (*Fraxinus pennsylvanica*), white ash (*F. americana*), red maple (*Acer rubrum*), bigleaf magnolia (*Magnolia acuminate*), American holly (*Ilex opaca*), and eastern hophornbeam (*Ostrya virginiana*) (Whittaker 1956, Franzreb 2005). A variety of shrub species also are associated commonly with cove forests such as oakleaf hydrangea (*Hydrangea quercifolia*), wild azalea (*Rhododendron* sp.), tree sparkleberry (*Vaccinium arboretum*), Elliott's huckleberry (*V. elliottii*) and witchhazel (*Hamamelis virginiana*; Whittaker 1956).

Cove forests also have herbaceous vegetation that is unique to these systems. A variety of forbs dominate species composition in the herbaceous layer, such as partridgeberry (*Mitchella repens*), fragrant bedstraw (*Gallium triflorum*), ticktrefoil (*Desmodium* spp.), elephant's foot (*Elephantopus tomentosus*), *Eupatorium* spp., strawberry bush (*Euonymus americana*), *Viburnum* spp. and *Impatiens* spp. (Whittaker 1956). Fern species also are common and include such species as southern lady fern

(*Anthyrium asplenioides*), christmas fern (*Polystichum acrostichoides*) and woodferns (*Dryopteris* spp.). Sedges (*Carex* spp.) and rushes (*Juncus* spp.) also may be prevalent around streams and seeps (Miller and Miller 1999).

Another important habitat feature of a cove forest is presence of coarse woody debris in various stages of decay and abundant snags (Meier et al. 1996). Multiple studies have shown positive relationships between amount of coarse woody debris and salamander abundance and species richness (Petranka et al. 1993). This condition is due to life requirements of many salamander species causing them to be "primary specialists" that inhabit specific forested ecosystems with moist forest floor conditions, large snags, older age class trees, and a water source (Meier et al. 1996). Species occurring commonly in cove habitats include pond-breeding salamanders, such as marbled salamanders (*Ambystoma opacum*), mole salamanders (*Ambystoma talpodium*), lungless salamanders [slimy salamanders (*Plethodon glutinosus*), two-lined salamanders (*Eurycea bislineata*)], and a variety of dusky salamanders (*Desmognathus* spp.; Petranka 1998, Ford et al. 2002).

Mature hardwood cove sites associated with the Appalachian Mountains are important in terms of biological diversity for many species of plants, reptiles, and amphibians (Greenburg and Waldrop 2008). Similar to Appalachian cove forests, hardwood forests of Weyerhaeuser's Old Cove property are typically greater than 70 years old and exhibit older age class overstory species comprised of hickories, oaks, and American beech. These sites are unique in central Mississippi's landscape due to their topographic relief, forest composition and age classes, structure, and associated flora and fauna (Hegwood and Miller 2004). Many conservationists share a concern about declines in population and biodiversity among herpetofauna and associated plant communities

within these ecosystems. This concern has caused hardwood coves to be considered ecologically important to conserve biodiversity in the southeastern United States (Burton and Likens 1975, Hairston 1987, Alford and Richards 1999).

Degradation and site conversion of mature hardwood forests has caused population declines in many species of amphibians that depend on deciduous forests (Greenburg et al. 1994, Gibbons et al. 2000). Site conversion of natural forests for urban development, agricultural use, and intensive extractive use has produced unfavorable habitat conditions for a variety of herpetofauna, especially amphibians (Greenburg et al. 1994). Silvicultural activities, such as removal of tree cover, intensive site preparation, and replanting with conifers, can have negative impacts to selected anurans and salamanders due to the increase in ground level temperature, loss of leaf litter, and decrease in soil moisture (Johnson et al. 1985, Ash 1995). However, improved approaches at integrating conservation of biological diversity with timber production through retention of sensitive habitat patches and corridors of mature forests can limit negative effects to amphibians and other sensitive species (Hunter 1990). For example, biodiversity of salamanders and other types of rare species on a pine-dominated forest landscape may often depend on proximity to mature hardwoods and other critical habitat types. Retention of environmental resource patches, such as wetlands, riparian forests, and mature hardwood areas, can retain source populations of organisms that depend on conditions present in mature hardwood forests (Ryan et al. 2002, Dickson and Sheffield 2001). This approach potentially can maintain source populations for surrounding landscapes as they develop desirable habitat conditions (Ryan et al. 2002). Proximity of resource patches to one another and connectivity of patches also is important in

maintenance of landscape biological diversity, especially diversity of less mobile species, such as salamanders (Hunter 1990).

Although many species of amphibians appear to depend on mature hardwood forests, the historical ecological importance of mature hardwood forests in relation to bird communities is relatively unknown throughout the southeastern United States.(Hunter et al. 1995, Davis 1996, Dellasala et al. 1996). Although the ecological importance of mature hardwoods to bird communities is difficult to assess due to habitat loss and fragmentation, Haney (1999) suggested that importance of hardwoods to bird diversity can best be determined by comparing species diversity within a landscape comprised of a variety of habitat types. Bird species, whether inhabiting managed forests or natural forests, require specific habitat conditions, and diversity of bird communities in any habitat type often is altered with changes in plant successional stages or age of forest stand (Shugart et al. 1975). Furthermore, interspersion of different habitat types and forest stand ages across the landscape can create a greater diversity of bird species across that landscape (Haney 1999, Iglay 2010). For example, densities of breeding birds in regenerating hardwoods of the southeastern United States, such as streamside management zones (SMZ's), are often similar to old-growth and mature hardwood ecosystems (Thompson and Fritzell 1990). Additionally, managed forests and mature natural forests support unique assemblages of birds, whos populations are declining at regional and national levels (Dickson et al. 2001). For example, bird species that require deep deciduous forest interiors, such as wood thrush (*Hylocichla mustelina*), may depend on older age class hardwoods and mixed hardwood forests whereas pine forests with an abundant herbaceous understory may be used by grassland birds species, such as Bachman's sparrows (*Peucaea aestivalis*; Dunning and Watts 1990.91, Plentovich et al.

1998, Dickson et al. 2001). Grassland bird species and many species of mature hardwood forests and pine-grassslands have high conservation concern scores as assigned by the American Ornithological Union (PIF Science Committee 2005). Therefore, management that creates habitat conditions for bird species of grasslands, natural pine forests, and deciduous forests is often desirable for population recovery of declining species and maintenance of avian species diversity at landscape levels.

Maintenance or enhancement of biodiversity in a managed forest landscape requires a cost-effective approach to habitat conservation (Miller et al. 2009). This approach includes integration of standard silviculture practices into protection of "Special Places". Policies developed by Weyerhaeuser Company included management of forestlands for the sustainable production of forest products while protecting water quality, fish and wildlife habitat, soil productivity, and sites of cultural, historical, and aesthetic values. This approach also included landscape level planning and management for wildlife. In addition, Weyerhaeuser Company is an active participant in the Sustainable Forestry Initiative® (SFI). Relative to biodiversity, this forest certification system contains commitments to the following: (1) enhance quality of wildlife habitat by developing and implementing measures that promote habitat diversity and the conservation of plant and animal populations, (2) contribute to biodiversity by enhancing landscape diversity and providing an array of habitats, and (3) protection of water quality (SFI, Inc., 2005). A practical approach to meeting expectations of Weyerhaeuser Company and SFI commitments regarding management of "Special Places" and recognition of landscape processes that affect wildlife populations, water quality, and intrinsic nature of "Special Places", is development of a habitat management plan for the Old Cove Area in Webster County, Mississippi. Cooperative efforts for biodiversity

assessment and conservation have been ongoing since the 1980's. These efforts have included surveys and planning by professionals from Weyerhaeuser Company, Mississippi Nature Conservancy, Mississippi Natural Heritage Program, and Mississippi State University (Hegwood and Miller 2004).

Although research has investigated faunal associations and species richness in different forested habitat types in the Southeast, limited information currently exists on assessments of cumulative species richness of amphibians, reptiles, and birds occurring on land bases that retain older age class hardwoods in cove areas and hardwood SMZ's within a matrix of managed pine forests. Furthermore, limited information exists on occurrence of rare plants and amphibians within forested hardwood coves of Mississippi.

This study has potential to address the understanding of management approaches that enhance or retain biological diversity of multiple forest types on industrial pine landscapes. Also, information on associated biological communities of various forest types in the Old Cove Area can help wildlife biologists and land managers develop sound management for maintaining and conserving biodiversity in cove forests within intensively managed pine plantations. This study also offers comparisons of herpetofaunal and bird communities in protected cove forests and retained SMZ's. This information can assist forest and land managers in monitoring effectiveness of SMZ's in retention of biological diversity on the landscape.

Community similarity indices derived from faunal data allows assessment of contribution of the different forest types to the landscape-level biological diversity of the Old Cove Area. The collective information provided by this study will be used to further refine the existing strategic conservation plan that seeks to conserve biological diversity in the Old Cove Area (Hegwood and Miller 2004). Therefore, this study is an important

component of the development of a conservation plan and public outreach program to adjacent landowners and stakeholders through a cooperative partnership between Weyerhaeuser Company, The Nature Conservancy, and Mississippi State University.

My study addresses the following objectives:

1.) Measure and report species diversity, richness and abundance of reptiles, amphibians, birds, and plants in 3 age classes of pine plantations, SMZs, and cove hardwood sites to ascertain diversity of species occurring in the Old Cove Area on Weyerhaeuser company lands in central Mississippi.

2.) Measure and compare community similarity of herpetofaunal assemblages and plant communities in 3 age classes of pine plantations, SMZs, and hardwood cove sites.

3.) Estimate and compare species richness and abundance of reptiles and amphibians in the dendritic drainages of 2 cove sites with special focus on detection of rare species.

4.) Measure species richness and abundance of breeding birds occurring in SMZs and cove sites and compare these communities using similarity indices.

5.) Estimate relationships between habitat conditions in afore listed habitat types and abundance and species richness of bird, amphibian, and reptile species.

Literature Cited

Alford, R. A. and S. J. Richards. 1999. Global amphibian declines: a problem in applied ecology. Annual Review of Ecology and Systematics 30: 133-165.

Ash, A. N. 1995. Effects of clear-cutting on litter parameters in the southern Blue Ridge Mountains. Castanea 60: 89-97.

Burton, T. M. and G. E. Likens. 1975. Salamander populations and biomass in the Hubbard Brook Experimental Forest, New Hampshire. Copeia 541-546.

Carnus, J., J. Parrotta, E. Brockerhoff, M. Arbez, H. Jactel, A. Kremer, D. Lamb, K. O'Hara, and B. Walters. 2006. Planted forests and biodiversity. Journal of Forestry 104: 65-77.

Clout, M. N. and P. D. Gaze. 1984. Effects of plantation forestry on birds in New Zealand. Journal of Applied Ecology 21: 795-815.

Davis, M. B. 1996. Extent and location. Pages 18-32 *in* M. B. Davis, editor. Eastern old-growth Forests: prospects for rediscovery and recovery, Island Press, Washington D. C., USA.

Dellasala, D. A., J. C. Hagar, K. A. Engel, W. C. McComb, R. L. Fairbanks, and E. G. Campbell. 1996. Effects of silvicultural modifications of temperate rainforest on breeding and wintering bird communities, Prince of Wales Island, southeast Alaska. Condor 98: 706-721.

Dickson, J. G. and R. M. Sheffield. 2001. Defining the forests. Pages 37-47 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Dickson, J. G. and T. B. Wigley. 2001. Managing forests for wildlife. Pages 83-94 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Dickson, J. G., W. C. Hunter, D. N. Pashley, and P. B. Hamel. 2001. Bird communities of southern Forests. Pages 322-349 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat andManagement. Hancock House Publishers, Blaine, Washington, USA.

Dunning, J. B. and B. D. Watts. 1990. Regional differences in habitat occupancy by Bachman's Sparrow. Auk 107: 463-472.

Dunning, J. B. and B. D. Watts. 1991. Habitat occupancy by Bachman's Sparrow in the Francis Marion National Forest before and after Hurricane Hugo. Auk 108: 723-725.

Ford, W. M., M. A. Menzel, and R. H. Odom. 2002. Elevation, aspect, and cove size effects on southern Appalachian salamanders. Southeastern Naturalist 1(4): 315-324.

Franzreb, K. E. 2005. The effects of timber harvesting on neotropical migrants in cove hardwood Forests in the southern Appalachian Mountains. USDA Forest Service, General Technical Report PSW-GTR-191.

Gibbons, J. W., D. E. Scott, T. J. Ryan, K. A. Buhlmann, T. D. Tuberville, B. Metts, J. L. Greene, T. M. Mills, Y. A. Leiden, S. M. Poppy, and C. T.Winne. 2000. The global decline of reptiles, deja' vu amphibians. Biological Science 50: 653-666.

Gibbons, J. W. and K. A. Buhlmann. 2001. Reptiles and Amphibians. Pages 372-390 *in* J. G. Dickson, ed. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Greenburg, C. H., D. G. Neary, and L. D. Harris. 1994. Effects of high-intensity wildlife and silvicultural treatment on reptile communities in sand-pine scrub. Conservational Biology 8: 1047-1057.

Greenburg, C. H., and T. A. Waldrop. 2008. Short term response of reptiles and amphibians to prescribed fire and mechanical fuel reduction in southern Appalachian upland hardwoodforests. Forest Ecology and Management. 255: 2883-2893.

Hairston, N. G. 1987. Community Ecology and Salamander Guilds. Cambridge University Press, Cambridge, UK, 230pp.

Haney, C. J. 1999. Hierarchical comparisons of breeding birds in old-growth conifer-hardwood forests on the Appalachian plateau. Wilson Bulletin 111: 89-99.

Hartley, M. J. 2002. Rationale and methods for conserving biodiversity in plantation forests. Forest Ecology and Management 155: 81-95.

Harvey, M. J. and D. A. Saugey. 2001. Bats. Pages 359-371 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Hegwood, R. and D. Miller. 2004. Special Plans Plan: Old/Magnolia Cove and Shelton Mountain. Mississippi/Alabama Timberlands, Weyerhaeuser Company. Bellefontaine, Mississippi.

Hunter, M. A., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice-Hall, Englewood Cliffs, New Jersey, USA.

Hunter, J. E., R. J. Gutierrez, and A.B. Franklin. 1995. Habitat configuration around Spotted Owl sites in northwestern California. Condor 97: 684-693.

Iglay, R. B., B. D. Leopold, D. A. Miller, and L. W. Burger Jr. 2010. Effect of plant community composition on plant response to fire and herbicide treatments. Forest Ecology and Management 260:543-548.

Johnson, J. E., D. W. Smith, and J. A. Burger. 1985. Effects on the forest floor of whole-tree harvesting in an Appalachian oak forest. American Midland Naturalist 114: 51-61.

Meier, A. J., S. P. Bratton, and D. C. Duffy. 1996. Biodiversity in the herbaceous layer and Salamanders in Appalachian primary forests. Pages 49-64 *in* M. B. Davis, editor.Eastern old-growth forests: prospects for rediscovery and recovery. Island Press,Washington D. C., USA.

Miller, J. H. and K. V. Miller. 1999. Forest plants of the southeast and their wildlife uses. Southern Weed Science Society, Auburn, Alabama, USA.

Miller, D. A., T. B. Wigley, and K. V. Miller. 2009. Managed forests and conservation of terrestrial Biodiversity in the southern United States. Journal of Forestry 107: 197-203.

Mitchell, M. S., S. H. Rutzmoser, T. B. Wigley, C. Loehle, J. A. Gerwin, P. D. Keyser, R. A. Lancia, R. W. Perry, C. J. Reynolds, R. E. Thill, R. Weih, D. White, and P. B. Wood. 2006. Relationships between avian richness and landscape structure at multiple scalesUsing multiple landscapes. Forest Ecology and Management 221: 155-169.

Partners in Flight Science Committee. 2005. The Partners in Flight Handbook on Species Assessment, Version 2005. Partners in Flight technical series No. 3. Rocky Mountain Bird Observatory, Brighton, CO.

Pelton, M. R. 2001. American black bear. Pages 224-233 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Petranka, J. W., M. E. Eldridge, and K. E. Haley. 1993. Effects of timber harvesting on southern Appalachian salamanders. Conservation Biology 7: 363-370.

Petranka, J. W. 1998. Salamanders of the united states and Canada. Smithsonian Institution Press, Washington.

Plentovich, S. M., J. W. Tucker, Jr., N. R. Holler, and G. E. Hill. 1998. Enhancing Bachman's Sparrow habitat via management of red-cockaded woodpeckers. Journal of Wildlife Management 62: 347-354.

Ryan, T. J., T. Philippi, Y. A. Leidden, M. E. Dorcas, T. B. Wigley, and J. W. Gibbons. 2002.Monitoring herpetofauna in a managed forest landscape: effects of habitat types and census techniques. Forest Ecology and Management. 167: 83-90.

Shugart, H. H., S. H. Anderson, and R. H. Strand. 1975. Dominant patterns in bird populations of the eastern deciduous forest biome. Pages 90-95 *in* The management of forest and range habitats for nongame birds symposium. U. S. Department of Agriculture General Technical Report. U. S. Department of Agriculture. Forest Service, Washington, DC.

Sustainable Forestry Initiative [SFI], Inc. 2005. Sustainable Forestry Initiative (SFI) Standard, 2005 – 2009 Edition. American Forest and Paper Association, Washington, DC.

Thompson, F. R., III. and E.K. Fritzell, 1990. Bird densities and diversity in clearcut and mature oak-hickory forest. U.S. Forest Service Research Paper. NC-293, St. Paul, Minnesota.

Walker, J. L. 2001. Sensitive plant communities. Pages 48-71 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Yarrow, G. K. and D. T. Yarrow. 1999. Managing forest for wildlife and timber production. Pages 49-103 *in* G. K. Yarrow and D. T. Yarrow, editors. Managing wildlife: on private lands in Alabama and the Southeast. Sweetwater Press, Birmingham, Alabama, USA.

Whittaker, R. H. 1956. Vegetation of the Great Smoky Mountains. Ecological Monographs 26: 2-80.

Wigley, T. B., W. M. Baughman, M. E. Dorcas, J. A. Gerwin, J. W. Gibbons, D. C. Guynn, Jr., R. A. Lancia, Y. A. Leiden, M. S. Mitchell, and K. R. Russell. 2000. Contributions of intensively managed forests to the sustainability of wildlife communities in the South. *in* Sustaining southern forests: the science of forest assessment. USDA Forest Service, Southern Forest Resource Assessment.

CHAPTER II

STUDY AREA AND FIELD METHODS

Study Area

Study areas were located within Weyerhaeuser's Old Cove property in northwestern Webster County, MS, Sections 1,2,11,12 of Township 20N, Range 08E (Figure 2.1). Webster County was located within the Upper Coastal Plains in north-central Mississippi (Cross 1974). This land base was comprised of oak-pine forests in the northwest and east and loblolly (*Pinus taeda*)-shortleaf (*P. echinata*) pine in the southwest and central portions of the county (Cross 1974). Soils were characterized as generally moderately acidic soils (pH 5.0-5.8) composed of sand, clay, shale, and gravel (Vanderford 1962). The Old Cove property was characterized by sloping uplands producing small runoff or drainage streams known as dendritic drainages that flowed into 8 watersheds, including 2 watersheds that intersect Weyerhaeuser's natural hardwood cove stands, Pryor Creek and South Lindsay Creek watersheds (Weyerhaeuser NR Company Unpublished Data 2007, Table 2.1).

Soil formation and vegetation communities of my study areas were influenced by mild climatic conditions categorized as the humid subtropical climatic region of North America. This region was characterized by temperate winters (0° C-15°C) and hot summers (21° C-38° C). The annual mean temperature for the northern part of Mississippi was 16.7° C and precipitation normally ranged from 127 cm to 165 cm across

the state from north to south (Mississippi State University Department of Geosciences 2010).

Old Cove was comprised of 4,997 ha with 3,150 of these hectares owned and managed by Weyerhaeuser Company, with the remainder owned by Mississippi College and non-industrial private landowners (Weyerhaeuser NR Company Unpublished Data 2007). The landscape contained a variety of habitat types, including pine plantations and natural hardwood and mixed forest stands. Pine plantations within the property were managed as 57 stands totaling approximately 2,610 ha. Pine forest stands included 39 unthinned stands (1,798 ha), 13 thinned stands (593 ha), and 5 regenerating stands (218 ha). Hardwood and natural mixed hardwood-pine stands were disaggregated into 63 stands totaling 522 ha. This estimate included 3 natural areas at Old Cove, Magnolia Cove, and Shelton Mountain and SMZs that transect managed pine stands (Figure 2.1).

Within the Old Cove property, I selected 14 forest stands based on a stratified sampling design to measure vegetation characteristics and survey plant, reptile, amphibian, and bird communities (Figure 2.1). Identification of different stand types was accomplished cooperatively with Weyerhaeuser personnel using geospatial databases. Final selection of study sites was based on proposed management schedules to minimize disturbance potentials in selected sites over the 2-year study. Stand types and numbers of each included the following: 3 young pine stands of < 5 years of age, 2 unthinned pine stands of > 5 to 15 years of age, 4 thinned pine stands of > 15 years of age, 3 SMZ stands, and 2 cove sites with mature hardwood forests: Old Cove and Magnolia Cove (Table 2.2). Each forest stand was considered an experimental unit in reporting the summaries of plant and animal community characteristics.

During my study, I obtained rainfall (cm) and temperature (°C) extremes from the National Oceanic and Atmospheric Administration (NOAA) weather station located at the Department of Geosciences, Mississippi State University (NOAA 2010). I anticipated using rainfall records if atypical weather patterns occurred during the study period. Also, this information might be of importance in ascertaining reasons for lack of animal detection or high rates of detection, particularly for amphibians, related to rainfall-induced breeding pulses, movement, or vocaliziation (Bailey et al. 2006).

Field Methods

Transect Establishment

I selected 14 stands within the Old Cove Area that represented 5 habitat types and established line transects within each stand according to methods described by Hays et al. (1981). Transects established in SMZs and hardwood coves were located along permanent streams whereas transects within pine plantations were located within stands but not along streams. This approach was used because streams located within forest stands managed by Weyerhaeuser Company were buffered by SMZs. Therefore, "unbuffered" streams within pine plantations were not available. I digitally mapped transects using Arc GIS (Esri 2009) to establish transects that were located $\geq$ 50 m to the interior of each stand to avoid potential influences from edge effect. Using Arc GIS maps, I established an initiation point which served as the beginning point for each transect. From that initial point, additional points were plotted at 50-m intervals along each transect (Hays et al. 1981; Figure 2.4). I established 10 sample points along each transect in each of the selected pine and SMZ stands, and 13 sample points in each cove site. At each sample point, I established transects and quadrats to evaluate habitat

conditions and plant community characteristics (Table 2.2). I included additional sample points within coves to account for stand size and variable topography (Anderson et al. 1979). I used a GPS unit (Garmin GPS IV) to digitally record and archive data of transect locations (Huff et al. 2000). Along each transect, I established sample points to estimate bird and herpetofaunal community characteristics (Table 2.2). Herpetofaunal surveys were conducted at sample points along each transect. Each sample point established for herpetofauna surveys also were used to establish nested plots and belt transects for habitat evaluation. At sample points that occurred at 200-m intervals, point count stations for bird surveys were established (Ralph et al. 1993, Hamel et al. 1996; Figure 2.2). Point count stations along each line transect included a center point at which observers stood and counted birds heard or observed within a 50-m distance band from the center point.

Faunal Surveys

Herpetofauna

Sampling methods included use of belt transects and anuran call counts (Heyer et al. 1994). Belt transects measuring 7 m X 40 m were established at each sample point along the main transect. Belt transects were established so that the midpoint was located on the transect. Belt transects departed the primary transect at a perpendicular angle (Figure 2.2). Each belt transect was surveyed using area-constrained searches (ACS; Heyer et al. 1994). ACS required a systematic search of the entire area, checking under all moveable logs, rocks and disturbing substrate to capture hidden animals (Welsh 1987, Bury and Corn 1991, Jaeger 1994, Jaeger and Inger 1994, Welsh et al. 1997). I used 5 survey periods from fall 2008 through summer 2009. During 2009, one study site was

omitted due to harvest of a mature pine stand. Therefore, 13 stands were surveyed. Each stand was surveyed once during each period resulting in 65 surveys (680 ACS; Table 2.2).

Anuran call counts at each herpetofaunal point were conducted prior to each ACS as described by Heyer et al. (1994). I identified calling anurans to species and estimated number of calling individuals during a 10-minute period. Identification of calling anurans was verified by referencing Elliott (2004).

Full coverage searches were conducted in 4 dendritic drainages in Magnolia and Old Coves. Dendritic drainages were defined as contributing streams flowing along the slopes of the terrain, joining together into the main channel (Lambert 2007). Searches were conducted beneath woody debris, leaf litter, rocks and any other potential habitat structure along drainages 4 times from fall 2009 through summer 2010 to detect rare species, such as southern red salamanders (*Pseudotriton ruber vioscai*) and Webster's salamander (*Plethodon websteri*: Petranka 1998). Drainages were surveyed once each season at each site resulting in 8 surveys.

Breeding Birds

Species richness and abundance of breeding birds was measured using point count surveys within 14 stands of the Old Cove property (Boulinier et al. 1998). Surveys were conducted by recording all birds detected through visual or auditory methods by observers (Ralph et al. 1993, Hamel et al. 1996). I conducted avifauna surveys at point count stations along established transects. Surveys were completed at 3 point count stations in each of the pine and SMZ stands, and 4 stations in cove sites with assistance from a Weyerhaeuser biologist (Table 2.2). Ten-minute surveys were conducted from

sunrise until approximately 10:00 am under acceptable weather conditions (winds <20 km/h with no rainfall; Hamel et al. 1996). Identification of bird species was accomplished using Sibley (2000), and species were recorded using alpha codes described by the United States Bird Banding Laboratory (USGS 2009).

Habitat Evaluation

At each 50-m interval sample point along the transect, I established belt transects departing in a perpendicular trajectory from the line transect. Each belt transect extended 20 m on each side of the line transect yielding a belt transect length of 40 m (Hays et al. 1981). Within each belt transect, I established 5 plots with the third plot being centered on the line transect with plot centers spaced $\geq$ 10 m apart (Figure 2.3).

Within belt transect plots I recorded percent coverage and species richness of understory (herbaceous layer), midstory, and overstory canopy (Coles-Ritchie et al. 2004, Honnay et al. 2001). Species richness, percent composition, and coverage of understory vegetation (<1 m in height) was recorded within a 1.5-m^2 hoop of plastic piping over plot centers. Midstory vegetation (1-6 m in height) were surveyed within a 3.16 m X 3.16 m (10-m^2) plot surrounding each understory plot. Approximate height (m), percent composition of midstory vegetation, and species were recorded for each tree and shrub within midstory height range. Forest overstory (>6 m in height) characteristics was estimated within a 10 m X 10 m (100-m^2) plot surrounding understory and midstory plots by recording species and diameter-at-breast height (DBH) for each tree $\geq$ 10 cm DBH (Hays et al. 1981). Canopy closure was recorded using a spherical densitometer positioned at the center of each of the 5 plots (Johansson 1985). Snags were recorded within 100 m^2 plots according to methods described by Hunter (1990). Information

recorded for snags included type (hardwood or pine), DBH, and decay class (Hunter 1990). All vegetation was identified using Radford et al. (1974) and Miller and Miller (1999).

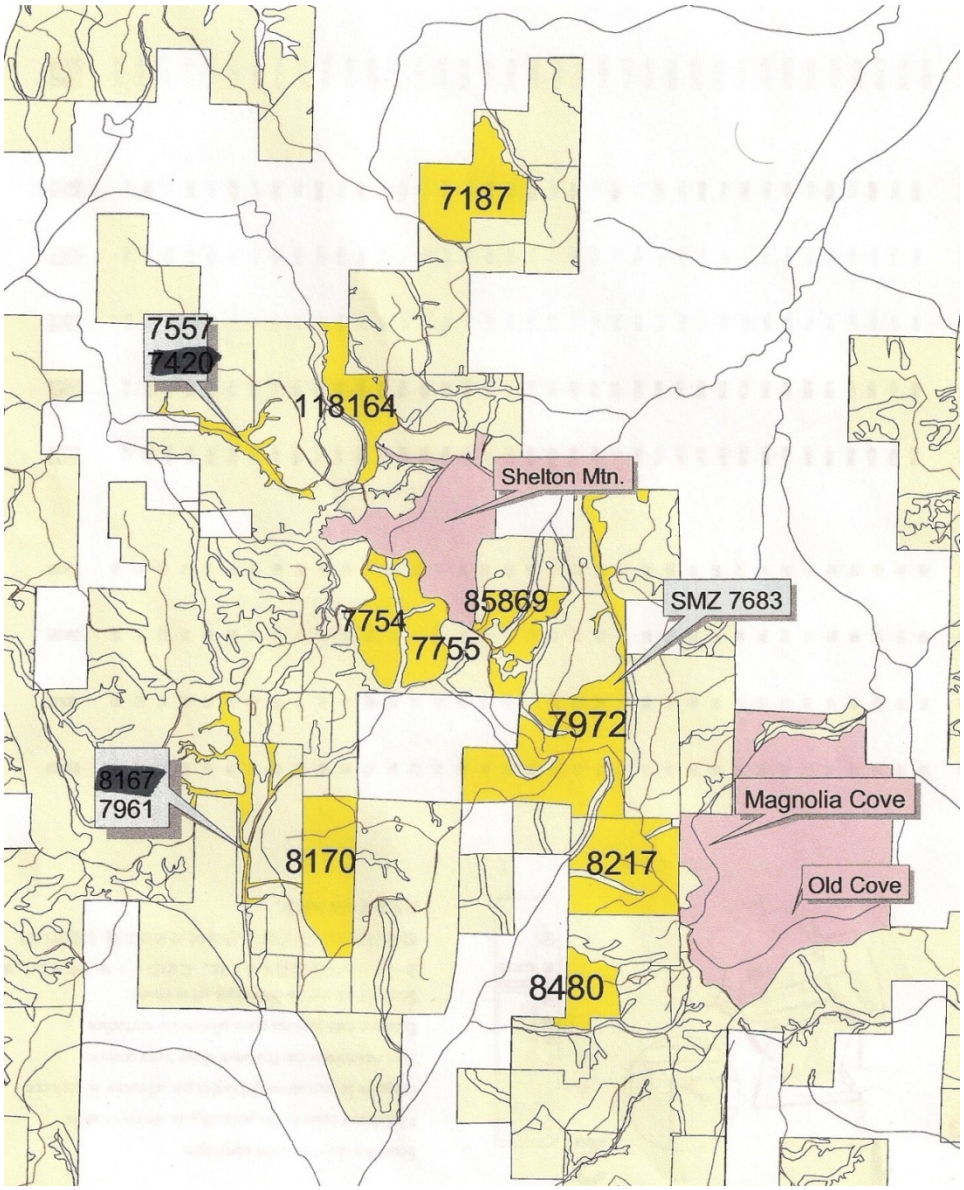

Figure 1.1 Streamside management zones, pine plantations, and cove study sites included in the biological diversity assessment within Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

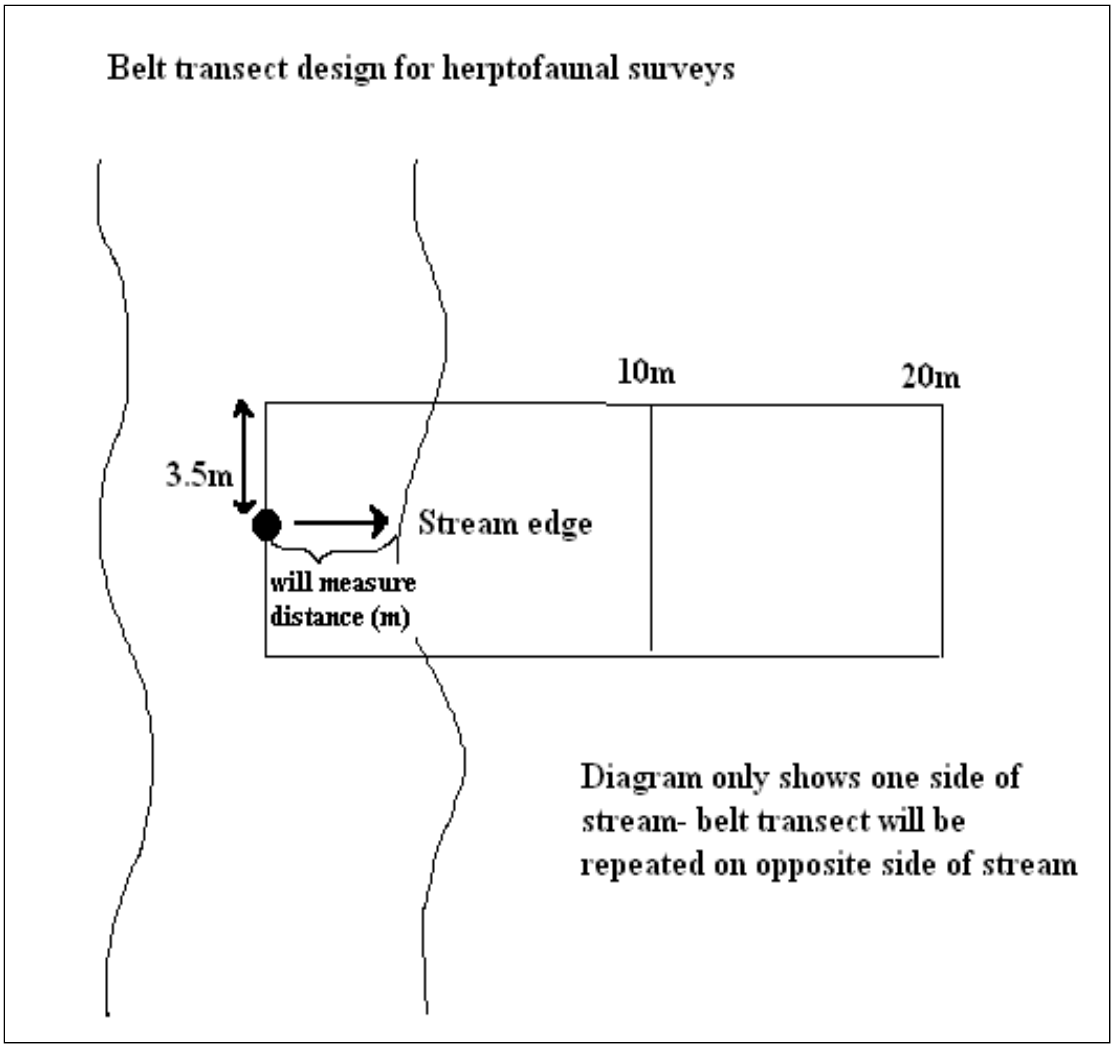

Figure 2.2 Experimental design for sampling herpetofauna communities in streamside management zones, pine plantations, and cove sites within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

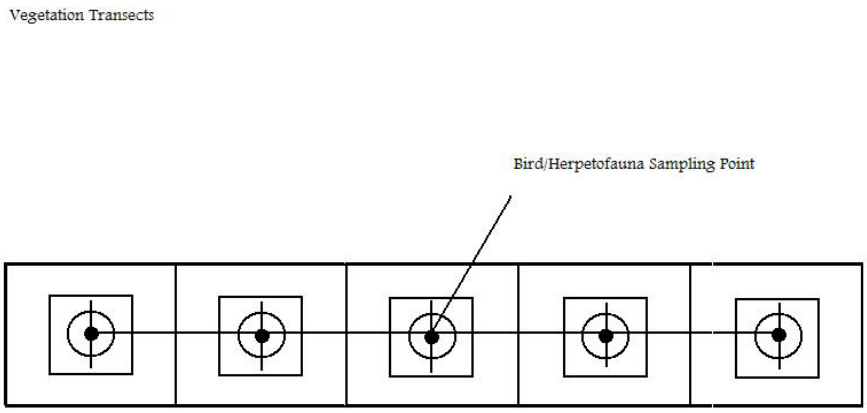

Figure 2.3 Experimental design for vegetation sampling in streamside management zones, pine plantations, and cove sites within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

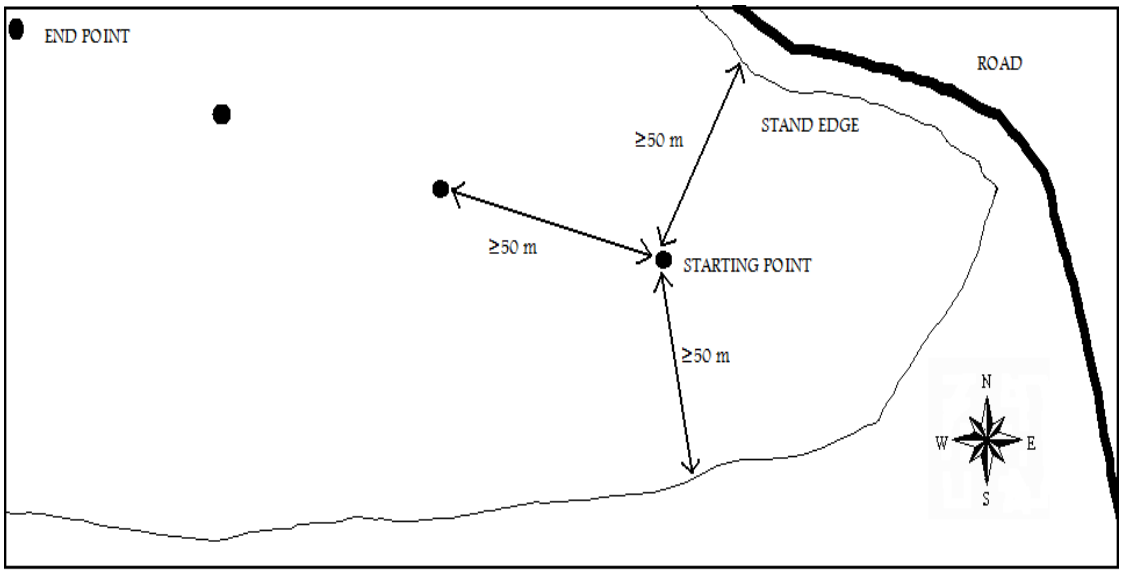

Figure 2.4 Experimental design for transect establishment in streamside management zones, pine plantations, and cove sites for measuring species richness and abundance of herpetofauna, birds, and plants within the Weyerhaeuser-owned Old Cove Area, Bellefontaine, MS 2008-2009.

Table 2.1 Habitat types and hectares of 8 watersheds found within the Weyerhaeuser-owned Old Cove Area, Bellefontaine, MS 2008-2009. (Weyerhaeuser NR Company Unpublished Data 2007).

Watershed	Total (ha)	Weyerhaeuser Owned (ha - fee or lease)	Unthinned Pine Stands (ha)	Thinned Pine Stands (ha)	SMZ Stands (ha)	Natural Stands (ha)
East Callabrella Creek	590	471	205	173	47	0
Little Bogue Creek	525	387	314	20	53	0
North Dunn Creek	366	178	13	161	5	0
North Lindsay Creek	683	145	85	40	10	0
Pryor Creek	747	471	214	70	44	62
South Dunn Creek	838	537	365	111	62	0
South Lindsay Creek	680	448	267	15	49	81
West Callabrella Creek	566	472	325	4	54	0

Table 2.2 Sampling effort in each stand type for estimation of avifauna, herpetofauna, and vegetation communities within different forest stand types of Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

		Stands (Experimental Units)		# Sample Points (Avifauna)		# Sample Points (Herpetofauna)		# Sample Points (Vegetation)		
Stand Type	# Sites	Stand Identification Numbers	# Transects/Site	Per Transect	Per Stand Type	Per Transect	Per Stand Type	Per Transect	Per Stand Type	Total Plots Per Stand Type
Planted Loblolly Pine (≤ 5 years old)	3	7754, 7755, 85869	10	3	9	10	30	10	30	150
Planted Loblolly Pine (5-15 years old)	2	8170, 7187	10	3	6	10	20	10	20	100
Planted Loblolly Pine (≥15 years old)	4	118164, 7972, 8217, 8480	10	3	12	10	40	10	40	200
Streamside Management Zone (SMZ)	3	7557, 7683, 7961	10	3	9	10	30	10	30	150
Hardwood Coves	2	Magnolia Cove, Old Cove	13	4	8	13	26	13	26	130

References

Anderson, D. R., J. L. Laake, B. R. Crain, K. P. Burnham. 1979. Guidelines for line transect sampling of biological populations. Journal of Wildlife Management 43: 70-78.

Asmus, J. 2003. Diversity of riverine turtles and pool-breeding amphibians on public lands in north-central Mississippi. Thesis, Mississippi State University, Mississippi State, Mississippi.

Boulinier, T., J. D. Nichols, J. R. Sauer, J. E. Hines, K. H. Pollock. 1998. Estimating species richness: the importance of heterogeneity in species detectability. Ecology 79: 1018-1028.

Bury, R. B. and P. S. Corn. 1991. Sampling methods for amphibians in streams in the Pacific Northwest. USDA Forest Service, Pacific Northwest Experiment Station, General Technical Report PNW-GTR-275.

Coles-Ritchie, M. C., R. C. Henderson, E. K. Archer, C. Kennedy, and J. L. Kershner. 2004. Repeatability of riparian vegetation sampling methods: how useful are these techniquesfor broad-scale, long-term monitoring? USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-138.

Conant, R. and J. T. Collins. 1998. Reptiles and amphibians of eastern/central North America. Houghton Mifflin Company, New York, NY, USA.

Cross, R. D., editor. 1974. Atlas of Mississippi. University Press of Mississippi. Jackson, USA.

Elliott, L. 2004. The calls of frogs and toads. Stackpole Books, Mechanicsburg, Pennsylvania, USA.

Esri 2009. ArcGIS Desktop. Redlands, CA: EnvironmentalSystems Research Institute, Inc.

Hamel, P. B., W. P. Smith, D. J. Twedt, J. R. Woehr, E. Morris, R. B. Hamilton, and R. J. Cooper. 1996. A land manager's guide to point counts of birds in the southeast. USDA,Forest Service, Southern Research Station. North Carolina. Pg. 1-5.

Hays, R. L. C. Summers and W. Seitz. 1981. Estimating wildlife habitat variables. Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C., USA.

Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek, and M. S. Foster. 1994. Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press, Washington, D.C.

Honnay, O., W. Verhaeghe, and M. Hermy. 2001. Plant community assembly along dendritic networks of small forest streams. Ecology 82: 1691-1702.

Huff, M. H., K. A. Bettinger, H. L. Ferguson, M. J. Brown, and B. Altman. 2000. A habitat-based point-count protocol for terrestrial birds, emphasizing Washington and Oregon.USDA, Forest Service, Pacific Northwest Experiment Station, General Technical Report PNW-GTR-501.

Hunter, M. A., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice-Hall, Englewood Cliffs, New Jersey, USA.

Jaeger, R. G. 1994. Transect sampling. Pages 103-107 *in* W. H. Heyer, M. A. Donelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster, editors. Measuring and monitoring biological Diversity. Standard methods for amphibians. Smithsonian Institution Press, Washington, D. C.

Jaeger, R. G. and R. F. Inger. 1994. Quadrat sampling. Pages 97-102 *in* W. H. Heyer, M. A. Donelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster, editors. Measuring and monitoring biological Diversity. Standard methods for amphibians. Smithsonian Institution Press, Washington, D. C.

Johansson, T. 1985. Estimating canopy density by the vertical tube method. Forest Ecology and Management 11: 139-144.

Krebs, C. J. 1989. Ecological methodology. Harper and Row, New York, New York, USA.

Lambert, D. 2007. The field guide to geology. Facts On File, Inc., New York, New York, USA.

Miller, J. H. and K. V. Miller. 1999. Forest plants of the southeast and their wildlife uses. Southern Weed Science Society, Auburn, Alabama, USA.

Mississippi State University Department of Geosciences, Office of the Mississippi State Climatologist. 2006 Aug 24. <http:www.msstate.edu/dept/geosciences/state climatologist.htm> Accessed 10 Feb 2010.

Radford, A. E., W. C. Dickison, J. R. Massey, and C. R. Bell. 1974. Vascular Plant Systematics. Harper and Row, New York, New York, USA.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. USDA Forest Service GTR RM-229. 422pp.

Sibley, D. A. 2000. The Sibley guide to birds. National Audubon Society. Alfred Knopf, New York. 544pp.

Vanderford, H. B. 1974. Soils of Mississippi. Mississippi Agricultural Experiment Station. State College, Mississippi. Mississippi State, Mississippi.

Welsh, H. H., Jr. 1987. Monitoring herpetofauna in woodland habitats of northwestern California and southwestern Oregon: a comprehensive strategy. Pages 203-213 *in* T. R. Plumb and N. H. Pillsbury, editors. Multiple-use management of California's hardwood resources. U. S. Forest Service, Pacific SoutheastExperiment Station, General Technical Report PSW-100.

Welsh, H. H., Jr., L. M. Ollivier, and D. G. Hankin. 1997. A habitat-based design for sampling and monitoring stream amphibians with an illustration form Redwood National Park.Northwestern Naturalist 78: 1-16.

United States Geological Survey [USGS]. 2009. Bird Banding Laboratory. North American Bird Banding Program. http://www.pwrc.usgs.gov/bbl/. Accessed 11 May 2009

CHAPTER III

FOREST STRUCTURE AND VEGETATION OF PINE PLANTATIONS, STREAMSIDE MANAGEMENT ZONES, AND COVE HARDWOOD FORESTS

Introduction

Mississippi is located within the Upper Coastal Plains physiographic region where approximately 54 % of the region's broad uplands and low plateaus are forested (Schoeneberger 1995, Dickson and Sheffield 2001). Forest communities in this region tend to be very diverse and productive with a variety of different forest types and stand structures (Dickson and Sheffield 2001). Plant and animal communities of southern forests are influenced by natural and anthropogenic factors (Dickson and Sheffield 2001). Some natural and human-induced changes to forest structure have happened gradually and are noticeable over a long period of time. For example, harvest of original forests that existed during European settlement occurred from the late 1800's to around 1930 (Marquis and Johnson 1989, Gilliam et al. 1995, Dickson and Sheffield 2001). Current changes in forest stand composition and structure are from a variety of events ranging from wide-scale destruction of forest stands due to catastrophic storms, such as Hurricane Katrina to human-induced deforestation, and site conversion. Therefore, natural and human-induced events have altered composition of vegetative communities in many forests of the southeastern United States (Dickson and Sheffield 2001).

Although many forest types have been modified by intensive use and site conversion, over 52% of forests in the Southeast are categorized as hardwood forests (Gilliam et al. 1995). Older age classes of these forest types are often species-rich with a low basal area of overstory trees, shade tolerant understory and midstory species, dense canopy coverage, abundant leaf litter, and woody debris (Hunter 1990, Davis 1996, Dickson and Sheffield 2001). Noss et al. (1995) reported that mature hardwood forests are critically imperiled forest types in the Southeast. Old growth forest remnants are among the most endangered hardwood forest types (Walker 2001). Most of these forests are described as surviving since pre-European settlement periods; however, many older age class forests (> 100 years of age) have been harvested at least once or twice since European settlement. Regardless, because they retain many properties of old growth forests, these forests are being considered as "old growth" due to their conservation value (Davis 1996, Walker 2001). As southern hardwood forests approach climax seral stage, compositional and structural characteristics become increasingly similar to those exhibited by old growth forests (Hunter 1990, Davis 1996, Walker 2001). These conditions include forest floor conditions with well developed litter and humic layers, abundant standing and downed deadwood, and specific plant composition shaped by successional changes over time and plant adaptations, such as shade tolerance, in climax associations. Forest composition typically includes large, older hardwood trees such as beech (*Fagus americanus*), oaks and hickories. Aging trees create an abundance of snags and downed logs, and fallen decomposing trees create forest floor topographies characterized by pits and mounds. Advanced height, plant species diversity, and tree mortality generally results in a multilayered canopy with canopy gaps and a mosaic of different aged trees. (Davis 1996). Well-developed herbaceous layers are comprised

typically of shade tolerant species, including many species of ferns (Filicales), orchids (Orchidaceae), and lilies (Liliaceae; Davis 1996).

Standing and downed deadwood in climax stage forests contribute to community diversity through deposition of organic matter to the humus layer, provision of structural cover for fauna, and creation of foraging substrate for detritivores, such as insect larvae, and vertebrate and invertebrate insectivores. Forest floor conditions also vary among forest types. Undisturbed deciduous hardwood forests in the southeastern U.S. build up leaf litter layers over time that typically create moist conditions from litter and detrital structure, shade of the overstory canopy, and evapotransporation rates of deciduous trees (Smith and Smith 2001). This leaf layer is comprised of 2 organic horizons, the unincorporated detrital layer (O_a) and the incorporated humic layer (O_i) and without flood scour, erosion, or fire creates an soil horizon that is rich in organic matter (>5% organic matter content). Within these layers exists a complex community of decomposers and detritivores, many of which are foods for vertebrates that occupy the forest floor (Smith and Smith 2001). Although upland pine and mixed pine forests also create leaf litter layers, fire dependent pines produce resinous flammable needles that create an overlapping structure on soil and herbaceous vegetation. This deposition and arrangement of linear needles allows air circulation and drying that is conducive to the transport of fire (DeBerry and Pashley 2008).

Streamside management zones that are protected from timber harvest often develop characteristics similar to older age class forests (Hunter 1990). Streamside management zones are generally protected as part of forestry management practices to protect water quality, and occur as linear buffer strips of minimally disturbed forests along streams for protection of water quality (Yarrow and Yarrow 1999). Forest

composition of SMZs may contain a variety of hardwood species including sycamore (*Platanus occidentalis*), oaks, hickories, hackberry (*Celtis laveagata*), gums (*Nyssa* spp.), and sweetgum (*Liquidambar styraciflua*) in the overstory. Black cherry (*Prunus serotina*), maples (*Acer* spp.), witchhazel (*Hamamelis virginiana*), sassafras (*Sassafras albidum*), and switchcane (*Arundinaria gigantea*) may be found in the midstory. Understory vegetation composition may include a variety of ferns, sedges (Cyperaceae), rushes (Juncaceae), grasses (Poaceae), and forbs (Miller and Miller 1999). The linear configuration of SMZs may allow sunlight exposure into forested edges if vegetation cover of adjacent land is comprised of young age class forests. This enhanced sunlight exposure may produce an ecotone that is characterized by shrubs and woody vines, such as blueberry (*Vaccinium* spp.), American beauty-berry (*Callicarpa americana*), blackberry (*Rubus* spp.) and greenbriar (*Smilax* spp; Miller and Miller 1999, Dickson et al. 2001).

In the Southeast, uplands with well-drained soils historically supported pine and mixed pine-hardwood forests (Quarterman and Keever 1962). Planted and natural pine forests comprise approximately 33% of total forest coverage. Pine plantations comprise approximately 45 % of pine timberlands and 15 % of the overall forested landbase (Gilliam et al. 1995, Dickson and Sheffield 2001). A variety of habitat conditions occur in pine plantations depending on site preparation, intermediate stand management, and targeted wood product commodities. Initial site preparation, stand management, such as burning and thinning of trees, fertilization, invasive plant control, and rotation length are factors that influence stand structure and vegetative communities within pine stands. Forest stand conditions are often created through silvicultural methods to manage for a desired wood product (Miller et al. 2009). Use of herbicide treatments in newly

established pine stands may be used to control non-native plants, manage vegetative competition, and create favorable wildlife habitat conditions (Miller and Miller 1999, Miller et al. 2009, Campbell 2010, Iglay 2010). As overstory canopy closure progresses, vegetative communities shift to shade-tolerant species (Miller and Miller 1999, Jones et al. 2009, Campbell et al. 2010, Iglay 2010). Thinning of trees prior to final harvest can then enhance a stand's understory in terms of wildlife food and cover plants (Wigley et al. 2000, Miller et al. 2009).

Older age class pine stands can exhibit different vegetative structures and composition depending on intermediate management approaches. Densely planted pine forests in a midrotation stage > 7 to 20 years will generally have limited understory and midstory vegetation as overstory canopy develops (Campbell et al. 2010). Thinning, along with herbicide applications and prescribed fire management, can subsequently increase diversity of mid-rotation pine (Jones et al. 2009, Mixon et al. 2009, Iglay et al. 2010). These forest types typically have vegetative communities dominated by greenbriar, Japanese honeysuckle and a variety of grasses and forbs (Miller and Miller 1999, Jones et al. 2009, Campbell et al. 2010, Iglay 2010). If managed for wildlife habitat diversity, mature pine stands can exhibit midstory and understory vegetation consisting of soft-mast producing trees, shrubs, and vines and abundant herbaceous food and cover plants (Yarrow and Yarrow 1999, Edwards et al. 2004, Miller et al. 2009, Mixon et al. 2009, Iglay et al. 2010). In open canopy pine forests that are maintained by fire, understory structure may be comprised of native legumes (*Lespedeza* and *Desmodium* spp.), panicgrasses (*Dichanthelium* and *Panicum* spp.), bluestems (*Andropogon* spp. and *Schizachyrium scoparium*) and many forbs of the Families Asteraceae, Euphorbiaceae, and Asclepiaceae (Hunter 1990, Miller and Miller 1999, Dickson and Sheffield 2001).

Despite the forest type present in a given landscape, stand structures are constantly changing through succession and a variety of disturbance factors. High diversity of communities and species across a landscape is often created by a diversity of habitat types ranging from early successional to climax stages (Yarrow and Yarrow 1999, and Dickson and Wigley 2001, Mitchell et al. 2006). A variety of species rely on different habitat types and a mixture of stand age and types across a pine plantation can enhance a landscape's heterogeneity, promoting flora and fauna diversity (Mitchell et al. 2006). However, today's dense loblolly stands differ from natural open pine stands and mature hardwoods that once occurred on the landscape of the southeastern U.S. prior to establishment of pine plantations (Dickson and Wigley 2001). Therefore, some timber companies have developed approaches that enhance pine plantation diversity and retain sensitive or rare ecosystem types on the landscape. For example, to retain biodiversity while providing a timber resource, selected plantations have retained areas of natural forest patches that often include mixed forest stands, mature hardwood forests, protected wetland areas, and streamside management zones (Wigley et al. 2000). This management strategy of mixed stand types can retain and enhance biodiversity of the landscape (Wigley et al. 2000). On the Old Cove Area in Webster County, MS, coves of mature hardwood forests are located within managed pine plantations. Previous surveys had reported occurrence of state-listed plants within cove sites, and they were designated as unique protected areas (Hegwood and Miller 2004). In their plan, Hegwood and Miller (2004) indicated a need for future studies that would assess the biological diversity of coves. Also, increased information was needed concerning cumulative floristic diversity and habitat composition occurring on landscapes that support different age classes of tree plantations and protected areas, such as SMZs and hardwood cove forests. This study was

conducted to assess species richness of selected animal communities within different habitat types and to investigate relationships between featured fauna and vegetation community parameters.

Specific objectives of this chapter include the following:

1.) To estimate and report plant species richness and plant coverage characteristics in pine plantations, SMZs, and cove sites.

2.) To estimate and compare habitat conditions in hardwood coves and SMZs.

3.) To report habitat and vegetation characteristics that were used to estimate relationships of these habitat conditions and herpetofauna and bird communities within the different forest stand types.

Study Area

I conducted field experiments in 14 forest stands located within Weyerhaeuser's Old Cove property in Webster county, north-central Mississippi. These 14 stands consisted of 3 young pine stands < 5 years of age (7755, 7754, 85869), 2 unthinned pine stands 5 to 15 years of age (7187, 8170), 4 thinned pine stands > 15 years of age (7972, 118164, 8217, 8480), 3 SMZ stands (7557, 7683, 7961) and 2 of the special interest areas comprised of natural cove hardwoods, Old Cove and Magnolia Cove (Table 2.2). All pine stands were planted and the mature mesic hardwood stands had been set aside and labeled "special place" by Weyerhaeuser NR Company for ecological research and conservation purposes. Additional details regarding study site location and habitat description are provided in Chapter II.

Field Methods and Statistical Analysis

Habitat variables were collected from late spring to late summer 2008 using a nested plot design positioned perpendicular to a line transect intersecting each research stand. Points at which herpetofauna were sampled served as the center of each plot. This design created 5 plots per point (Jaegar 1994; Figure 2.3). Understory (1.5 m^2 hoop), midstory (10 m^2 plot), and overstory (100 m^2 plot) data were obtained during surveys (Anderson et al. 1979, Johansson 1985, Hunter 1990, Jaeger and Inger 1994). Specifics on field methods are described in Chapter II.

I used Principle Component Analysis (PCA) to determine variation of understory, midstory and overstory plant composition in each habitat type (McCune and Grace 2002). Analysis of variance (ANOVA; PROC GLM, SAS 9.2) was used to compare plant species richness and coverage characteristics in pine plantations, SMZs, and cove sites (SAS Institute 1999). Data were examined for normality using the Shapiro-Wilk test prior to analyses (Royston 1992; PROC UNIVARIATE, SAS 9.2). All tests were considered significant at $P \leq 0.05$. If significant results were found, a least-square means (LSD) procedure was used to determine multiple comparisons between sites (Freund and Wilson 2003). Habitat variables were used to develop models to evaluate faunal responses to habitat conditions within all study stands. (Table 3.7).

Vegetation Results

I detected 204 plant species across habitat types with 87 species detected in coves, 137 species in SMZs, 92 species in pine stands < 5 years old, 83 in pine stands 5 to 15 years old, and 137 in pine stands >15 years old. Overall, 177 plant species were detected in the understory, 96 plant species in the midstory and 45 plant species in the overstory (Tables 3.1, 3.2, and 3.3).

Ground cover of pine plantations of < 5 years of age was 36.8% pine needle litter (± 0.4), 24.3% woody vine (± 0.4), 6.7% legumes (± 0.3), 8.5% grasses and grass-like species (± 0.3), and 7.3% shrub (±0.3); Tables 3.1 and 3.4). Midstory species composition was 15.5 % vine, 32.7 % shrub, and 37.4 % tree; Table 3.2). Overstory consisted of 17 species of trees with a mean DBH of 13.6 mm (± 0.1) for all stands of < 5 year old pine. Of the total tree composition, loblolly pine comprised 72.4 % of 756 trees detected (Table 3.3). The most common woody and semi-woody plants included eastern baccharis (*Baccharis halimifolia*), bicolor lespedeza (*Lespedeza bicolor*), American pokeweed (*Phytolacca americana*), loblolly pine (*P. taeda*), winged sumac (*R. copallinum*), muscadine grape (*Vitis rotundifolia*), and greenbriar. A mean of 0.01 snags/100m^2 (± 0.01) was detected in all pine stands < 5 year old with a mean DBH of 21.6 mm (± 1.0) and mean decay class of 3.5 (± 0.6). Mean number of downed logs constituted 1.9% (± 0.4) of the understory coverage with a mean count of 0.2 logs/1.5 m^2 (± 0.1) and a mean decay class of 3.5 (± 0.1; Table 3.4).

Ground cover of pine plantations 5 to 15 years of age was 65.8 % pine needle litter (± 0.5; Table 3.4). Pine plantations 5 to 15 years old had understory comprised of 2.2 % legume species (± 0.2), 3.9 % grass, sedges, and rush species (± 0.3), 1.2 % fern species (± 0.2), 10.0 % vine species (± 0.3), 4.2 % shrub species (± 0.3), and 3.0 % tree species (± 0.2; Table 3.1). Midstory species composition was 15.0 % vine, 26.5 % shrub, 54.9 % tree, and 1.0 % giant cane (*Arundinaria gigantean*); Table 3.2). Overstory contained 21 species of trees with a mean DBH of 14.2 mm (± 0.1). Of total tree composition, loblolly pine comprised 77.6 % of 1,456 trees detected (Table 3.3). Commonly detected species included loblolly pine, winged sumac, winged elm (*Ulmus alata*), eastern redbud (*Cercis canadensis*), devil's walking stick (*Aralia spinosa*), and

woodoats (*Chasmanthium sessiliflorum*). A mean of 0.2 snags/100m^2 ($\pm$ 0.1) was detected with a mean DBH of 13.6 mm ($\pm$ 0.6) and mean decay class of 3.99 ($\pm$ 0.29). Mean number of downed logs constituted 1.4 % ($\pm$ 0.4) of the understory coverage with a mean count of 0.2 logs/1.5 m^2 ($\pm$ 0.1) and a mean decay class of 3.5 ($\pm$ 0.2; Table 3.4).

Ground cover of pine plantations > 15 years of age was 50 % pine needle litter ($\pm$ 0.4; Table 3.4)}. Pine habitat >15 years old had understory comprised of 4.3% legume species ($\pm$ 0.2), 15.9% grass, sedge, rush species ($\pm$ 0.3), 1.4 % fern species ($\pm$ 0.2), 19.6 vine species ($\pm$ 0.3)}, 4.8 % shrub species ($\pm$ 0.2), and 3.1 % tree species ($\pm$ 0.2; Table 3.1)}. Midstory species composition was 13.5 % vines, 31.7 % shrubs, and 46.3 % trees: Table 3.2). Overstory contained 31 species of trees with a mean DBH of 20.5 mm ($\pm$ 0.1). Of the total tree composition, loblolly pine comprised 67.4 % of 2,744 trees detected (Table 3.3). Commonly detected species included loblolly pine, red mulberry (*Morus rubra*), sweetgum, several oak species, American beautyberry, partridge pea (*Chamaecrista fasciculata*) and several species of panicgrass. Mean of 0.3 snags/100m^2 ($\pm$ 0.1) were detected in all stands of pine > 15 years old. Standing snags had a mean DBH of 16.9 mm ($\pm$ 0.5) and mean decay class of 3.5 ($\pm$ 0.2). Mean number of downed logs constituted 1.90 % ($\pm$ 0.14) with a mean count of 0.1 logs/1.5 m^2 ($\pm$ 0.1) and a mean decay class of 3.4 ($\pm$ 0.2; Table 3.4).

Ground cover of SMZs was 51.2 % leaf litter ($\pm$ 0.5; Table 3.4). SMZs had understory comprised of 3.9 % legume species ($\pm$ 0.2), 4.4 % grass, sedge, rush species ($\pm$ 0.3), 1.4 % fern species ($\pm$ 0.2), 6.4 % vine species ($\pm$ 0.3), 2.4 % shrub species ($\pm$ 0.2), 6.0 % tree species ($\pm$ 0.2), and 0.2 % giant cane ($\pm$ 0.1; Table 3.1). Midstory species composition was 14.4 % vine, 7.9 % shrubs, 63.0 % tree, and 7.2 % giant cane (Table 3.2). Overstory contained 34 species of trees with a mean DBH of 20.2 mm ($\pm$ 0.1).

Loblolly pine comprised 17.0 % of tree composition (Table 3.3); the remainder of tree species consisted of sweetgum, yellow poplar, southern red oak (*Q. falcata*), and red maple. Commonly detected species in ground and midstory included witchhazel, sassafras, Eastern hophornbeam, red maple, giant cane, Christmas fern (*Polystichum acrostichoides*), and St. Johnswort (*Hypericum* spp.). A mean of 0.4 snags/100m^2 ($\pm$ 0.1) were detected in SMZs. Standing snags exhibited a mean DBH of 18.5 mm ($\pm$ 0.5) and mean decay class of 3.4 ($\pm$ 0.2). Mean number of downed logs constituted 1.6 % ($\pm$ 0.2) with a mean count of 0.2 logs/1.5 m^2 ($\pm$ 0.1) and a mean decay class of 3.1 ($\pm$ 0.2; Table 3.4).

Ground cover of coves was 48.7 % leaf litter ($\pm$ 0.0; Table 3.4). Coves had an understory comprised of 6.9 % legume species ($\pm$ 0.3), 1.6 % grass, sedge, rush species ($\pm$ 0.2), 3.0 % fern species ($\pm$ 0.2), 3.6 % vine species ($\pm$ 0.2), 0.7 % shrub species ($\pm$ 0.1), 7.8 % tree species ($\pm$ 0.3), and 0.2 % giant cane ($\pm$ 0.1; Table 3.1). Midstory species composition was 6.2 % vine, 17.5 % shrub, 62.2 % tree, and 3.4 % giant cane (Table 3.2). Overstory contained 29 species of trees with a mean DBH of 24.1 mm ($\pm$ 0.2). Overstory tree composition was dominated by hardwoods (95% composition) with 5% being comprised of loblolly and shortleaf pines of a total of 635 trees detected (Table 3.3). Commonly detected species included elephantsfoot (*Elephantopus tomentosus*), partridgeberry (*Mitchella repens*), wild iris (*Dietes* spp.), oakleaf hydrangea (*Hydrangea quercifolia*), azalea (*Rhododendron* spp.), bigleaf magnolia (*Magnolia macrophylla*), beech, and several species of oaks and hickories. Forbs and ferns that were more prevalent in coves consisted of smooth trefoil (*Desmodium laevigatum*), elephants foot (*Elephantopus tomentosus*), royal fern (*Osmunda regali*s), cinnamon fern (*O. cinnamomea*), and netted-chain fern (*Woodwardia areolata*) were more abundant in

coves compared to other habitat types. A mean of 0.3 snags/100m^2 ($\pm$ 0.04) were detected with a mean DBH of 21.3 mm ($\pm$ 0.6) and mean decay class of 3.9 ($\pm$ 0.2). Mean number of downed logs constituted 2.3 % ($\pm$ 0.2) of the understory coverage with a mean count of 0.3 logs/1.5 m^2 ($\pm$ 0.1) and a mean decay class of 3.5 ($\pm$ 0.2; (Table 3.4).

Principle Component Analysis

PCA of 38 habitat variables yielded 9 significant axes (eigenvalues >1) that explained 95.76 % of variation among habitat variables. On these axes, 26 variables had eigenvector loadings with absolute values >0.27 (Table 3.5). Variables that tended to have a strong relationship (i.e., have elements in the eigenvector larger in absolute value than others) with the first principal component were mean log decay class (LDC) and mean percent coverage of understory tree species/1.5 m^2 (UTC). The second principle component showed a strong relationship with mean number of overstory trees (OT) and percent composition of pine snags/100 m^2 (PPS). The third principle component showed a strong relationship with mean log count/1.5 m^2 (LC) and mean percent hardwood logs/1.5 m^2 (HL). The fourth principle component showed a strong relationship with LC, LDC, mean number of pine snags/100 m^2 (PS), and mean number of standing snags/100 m^2 (SC). The fifth principle component showed a strong relationship with percent composition of midstory vine species/10 m^2 (MV), mean midstory tree/shrub height (MH), mean percent coverage of understory forb species/1.5 m^2 (FC), and mean percent coverage of understory moss species/1.5 m^2 (MC). The sixth principle component showed a strong relationship with mean snag decay class (SD) and mean percent coverage of understory sedge and rush species/1.5 m^2 (SRC; Table 3.6).

Comparisons among Habitat Types

Understory Vegetation

Of 10 habitat variables evaluated, 4 were significantly differed among stand types. These included UTC, mean percent coverage of understory giant cane (UGCC), mean percent coverage of understory fern species (UFC), and mean percent coverage of understory vine species (UVC). Coverage of giant cane was greatest in SMZs and coves and differed significantly from pine stands ($F_{4,8}$ = 5.95, P = 0.02). Coverage of fern species was greatest in coves and differed significantly from SMZs and pine stands ($F_{4,8}$ = 10.25, P = 0.01). Coverage of understory tree species was greatest in coves and was similar to that of SMZs ($F_{4,8}$ = 4.67, P = 0.03). Coverage of understory vines was greatest in <5 year pine stands and was similar to >15 year pine stands. Vine coverage was similar among pine stands ($F_{4,8}$ = 5.75, P = 0.02; Tables 3.8 and 3.9).

Midstory Vegetation

Variables representing midstory included percent composition of midstory shrub species/10 m^2 (MS), MV, and mean midstory tree/shrub height (MH). Of these variables, MS differed among stand types at $P \leq 0.05$ ($F_{4,8}$ = 4.05, P = 0.04; Tables 3.8 and 3.9).

Overstory Vegetation

Eight habitat variables were used to quantify overstory vegetation characteristics. Mean snag diameter at breast height (SDBH), SC, and SD were not significant. Significant differences were detected among number overstory pine trees/100 m^2 (>6 m height, > 10 cm DBH; OP), SC, and PPS. OP ($F_{4,8}$ = 8.54, P = 0.01) was greater in 5 to 15 year pine stands and similar to >15 and <5 year pine stands. OP in SMZs and coves differed from the 3 age classes of pine stands. OT was greatest in 5 to 15 year pine stands

and was similar to SMZs and >15 year pine stands ($F_{4,8}$ = 6.67, P = 0.01). OT in coves and <5 year pine stands did not differ significantly, but differed significantly from 5 to 15 year pine stands, SMZs, and >15 year pine stands. PS was greatest in >15 year pine stands. However, this number did not differ statistically from 5 to 15 year pine stands, SMZs, and coves ($F_{4,8}$ = 2.91, P = 0.09). OT (F4,8 = 6.67, P = 0.01). OT in cove and <5 year pine stands did not differ significantly, but differed significantly from 5 to 15 year pine stands, SMZs, and >15 year pine stands. PS was greatest in >15 year pine habitat; however, did not differ statistically from 5 to 15 year pine, SMZ, and cove habitat types ($F_{4,8}$ = 2.91, P = 0.09). PPS ($F_{4,8}$ = 7.19, P = 0.01). PPS was greatest in 5 to 15 year pine habitat, and differed significantly from cove and <5 year pine habitat.

Discussion

Plant communities within Old Cove varied greatly among habitat types. Not unexpectedly, forest types dominated by hardwoods (coves and SMZs) had different plant communities than forest types dominated by planted loblolly pines. Plant diversity varied with forest stand age and composition, and these conditions were due primarily to land use, silvicultural practices, and edaphic conditions (Thomas et al. 1999). Presence, abundance, and type of downed woody debris were an important structural component of understory habitat, especially for invertebrate and vertebrates of the forest floor community (Bartels et al. 1985, Edmonds and Eglitis 1989). Log counts/1.5 m^2, average decay class, and presence of hardwood debris were greatest in coves and SMZs and least in >15 year old pine stands. These findings were similar to those reported by Hunter (1990). Advanced decay classes and amounts of downed logs in cove habitat were potentially due to older age class of the hardwood forests in coves (Davis 1996). High

occurrence of downed hardwood debris in coves and SMZs originated from hardwood-dominated overstory. Cove and riparian zones forests were almost exclusively comprised of hardwoods, and planted pine forest generally exhibited less hardwood trees due to management strategies including site preparation and vegetation control to reduce amount of hardwood competition (Perry et al. 2011). This management approach along with rotation length of planted pines likely influenced downed woody debris during stand development stages (Marquis and Johnson 1989).

Abundance of understory plants was similar across all habitat types; however, species composition of understory plant species were dissimilar among habitat types. The habitat type with the greatest species richness of understory plants was SMZs. Because this habitat type is generally narrow, influenced by riparian conditions and close to pine plantations, the transition from pine to hardwood ecotone in these forest types created an opportunity for plant species that typically occur in both habitats (Brinson and Verhoeven 1999). Different types of understory plants of each habitat type were influenced by overstory canopy development, forest floor microclimate conditions, presence of surface water, and active forest management (Hunter 1990). Sedges, rushes, ferns, and a variety of moss species occurred mostly in coves and SMZs where there was a permanent to semi-permanent water source (Conant and Collins 1998, Ross et al. 2000). Presence of water and moist forest floor conditions along with leaf litter conditions potentially created more desirable growing conditions for shade tolerant forbs, ferns, sedges, rushes and bryophytes (Radford et al. 1968). These species are shade tolerant and adapted to thick layers of rich organic matter layers. Therefore, moist conditions and ample shade probably influenced abundance and richness of these plant species in coves and SMZs (Miller and Miller 1999).

Presence and coverage of switchcane differed among the 5 habitat types and was most abundant in coves and SMZs. The other stand type where switchcane was recorded was <5 year pine stands adjacent to SMZs. Switchcane generally occurs in moist sites along stream banks and around seeps, but this plant also occurs in established colonies of upland forests with a hardwood component (Miller and Miller 1999). Switchcane colonizes following disturbances in areas of flood water scour, abandoned farmland, or old fields (Walker 2001). Greater abundance of switchcane in SMZs was due, in part, to site hydrology, moisture availability, landscape position, and linear SMZ structure that allow sunlight penetration at the SMZ-plantation interface (Miller and Miller 1999).

As with the understory component, composition of midstory shrub, tree, and vine species reflected management strategies and site conditions. Habitat features of midstory showed a greater percent composition of shrubs in the 3 pine types compared to the coves and SMZs, with <5 year old pine having the greatest composition of shrubs. Stand age and management strategies hindered the growth of hardwoods in pine plantations (Miller and Miller 1999, Miller et al. 2009), and as pines begin to dominate the overstory structure, the canopy begins to close, reducing vegetative growth in the understory and midstory (Halls and Alcaniz 1968, Campbell 2010, Iglay et al. 2010). High percent composition of midstory trees was detected in the cove, SMZ, and 5-15 year old pine habitat types. High percent composition is from natural hardwood regeneration in the cove and SMZ stands (Runkle 1981) and management strategies in the 5-15 year old pine stands. As the 5-15 year old pine stands were unthinned, many of pine trees were not tall enough to be categorized as overstory (>1 m height, <6 m height), therefore increasing the midstory tree percentage. Presence and coverage of midstory vine species differed among the 5 habitat types and was most abundant in <5 year old pine habitat. Reduced

canopy coverage providing increased sunlight penetration allowed for vines in <5 year old pine to reach the height requirement for inclusion into the midstory category (Dickson et al. 2001).

Species richness of overstory trees was similar among pine habitat types, which were comprised mainly of loblolly pine. However, >15 year old pine did have a lesser percent pine composition. Stands representing >15 year old pine had been thinned to lesser basal areas compared to <5 and 5-15 year old pine. Due to management of these mature pine stands, hardwood trees grew to a height that was considered overstory. Species richness and composition of overstory associated within coves and SMZs depended primarily on successional stage, silvicultural management, and associated habitat structure and composition. Retention of cove forests on the Old Cove Area was partially a product of the cove's steep and varying topography that inhibited its use as a viable location for planted pine. Its unique topographic relief provided site conditions unique in central Mississippi including older age class of hardwoods, dense canopy coverage, high mean snag DBH, and presence of a permanent water source that make the cove sites comparable to forest stands labeled as "old growth", such as forests of the Appalachian Mountains (Davis 1996, Walker 2001, Hegwood and Miller 2004). Although SMZs exhibited canopy and forest stand composition characteristics similar to those of coves, including high composition of hardwood trees and a water source, they were generally younger, and had greater occurrence and coverage of disturbance dependent species due to their linear nature. SMZs were surrounded by pine forests of various age classes under intensive management which influenced the overstory composition. Species such as loblolly pine and sweetgum were more common within the

overstory of SMZs than in coves, but both habitat types had a greater number of hardwoods compared to pine habitat types.

Table 3.1 Mean percent coverage and species numbers of understory plants detected in 5 stand types of Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS spring and summer 2008.

	Cove			SMZ			Pine (<5 years)			Pine (5-15 years)			Pine (>15 years)			
Plant Growth Form	**Percent Coverage**	**Species Number**	**SE**	**Percent Coverage**	**Species Number**	**SE**	**Percent Coverage**	**Species Number**	**SE**	**Percent Coverage**	**Species Number**	**SE**	**Percent Coverage**	**Species Number**	**SE**	**Total Species Detected**
Understory Herbaceous Plants																
Legumes and Forbs	6.9	18	0.3	3.9	42	0.2	6.7	22	0.3	2.2	13	0.2	4.3	42	0.2	80
Grasses, Sedges, Rushes	1.6	9	0.2	4.4	18	0.3	8.5	10	0.3	4.0	6	0.3	5.9	16	0.3	28
Fern	3.0	3	0.2	1.4	3	0.2	0.4	2	0.01	1.2	4	0.2	1.4	5	0.2	7
Understory Woody Plants																
Vines	3.6	11	0.2	6.4	15	0.3	24.3	9	0.4	10.0	10	0.3	19.6	12	0.3	20
Shrubs	0.7	7	0.1	2.4	11	0.2	7.3	6	0.3	4.2	5	0.3	4.8	11	0.2	18
Trees	7.8	28	0.3	6.0	25	0.2	0.9	13	0.1	3.0	25	0.1	3.1	26	0.2	41
Rivercane	0.2	1	0.1	0.2	1	0.1	0.1	1	0.1	0.0	0	0.2	0.0	0	0.0	1

Table 3.2 Midstory percent composition habitat measurements detected in 5 stand types of Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS spring and summer 2008.

	Cove		SMZ		Pine (<5 years)		Pine (5-15 years)		Pine (>15 years)		
Plant Growth Forms	**Percent Composition**	**Species Counts**	**Percent Composition**	**Species Counts**	**Percent Composition**	**Species Counts**	**Percent Composition**	**Species Counts**	**Percent Composition**	**Species Counts**	**Total Species Detected**
Vine	6.2	8	14.4	9	15.5	10	15.0	9	13.5	14	21
Shrub	17.5	7	8.0	14	32.7	8	26.5	9	31.7	13	25
Tree	62.2	28	63.0	34	37.4	35	54.9	34	46.3	40	60
Rivercane	3.4	1	7.2	1	1.6	1	1.0	1	0.0	0	1

Table 3.3 Overstory habitat measurements detected in 5 stand types of Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS spring and summer 2008.

Overstory Habitat Features	**Cove**	**SMZ**	**Pine (<5 years)**	**Pine (5-15 years)**	**Pine (>15 years)**	**Total**
Overstory Species	29	34	17	21	31	58
Percent Overstory Pine	5.0	17.0	72.4	77.6	67.4	46.8

	Mean DBH (mm)	SE	Mean DBH (mm)	SE	Mean DBH (mm)	SE	Mean DBH (mm)	SE	Mean DBH (mm)	SE
Mean DBH (mm) of Overstory Trees	24.1	0.2	20.2	0.1	13.6	0.1	14.2	0.1	20.5	0.1

Table 3.4 Mean measurements of habitat features detected in 5 stand types of Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS spring and summer 2008.

Habitat Features	Cove		SMZ		Pine (<5 years)		Pine (5-15 years)		Pine (>15 years)	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Bare Ground/Leaf Littler										
Mean Percent Bare Ground	2.5	0.3	5.6	0.3	4.4	0.3	0.8	0.2	2.1	0.2
Mean Percent Leaf Litter	48.7	0.5	51.2	0.5	36.8	0.4	65.8	0.5	50.0	0.4
Snags										
Mean Number of Standing Snags ($100m^2$)	0.2	0.04	0.2	0.1	0.01	0.01	0.1	0.1	0.2	0.1
Mean Number of Standing Hardwood Snags ($100m^2$)	0.2	0.04	0.1	0.04	0.01	0.01	0.03	0.02	0.1	0.02
Mean Number of Standing Pine Snags ($100m^2$)	0.02	0.01	0.1	0.03	0.00	0.00	0.1	0.05	0.2	0.04
Mean Snag DBH (cm)	21.3	0.6	18.5	0.53	21.6	1.0	13.6	0.6	16.9	0.5
Mean Snag Decay Class	3.9	0.2	3.4	0.2	3.5	0.6	4.0	0.3	3.5	0.2
Downed Logs										
Mean Log Count ($1.5\ m^2$)	0.3	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1
Mean Log Decay Class	3.5	0.2	3.1	0.2	3.5	0.1	3.5	0.2	3.4	0.2
Mean Percent Coverage of Downed Logs	2.3	0.2	1.6	0.2	1.9	0.4	1.4	0.4	1.9	0.1

Table 3.5 Eigenvectors of 6 principle components from PCA on 26 habitat variables of 5 stand types within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS from 2008.

Variable	Prin 1	Prin 2	Prin 3	Prin 4	Prin 5	Prin 6
BG	0.0072	-0.2501	0.2673	0.075	0.0938	0.0136
LL	0.1057	0.2534	-0.1324	-0.0583	0.1356	-0.1388
LCPP	0.0586	0.0332	-0.1601	0.4695	0.2876	0.0739
LC	0.1094	-0.0416	-0.2978	0.3274	-0.0653	-0.0388
LDC	-0.2759	0.0435	-0.0295	0.3759	0.0338	0.0617
HL	0.1076	-0.1857	-0.3439	0.154	0.0358	-0.0247
MS	-0.2134	0.095	-0.0426	-0.0462	-0.1703	0.1972
MV	-0.0923	0.0343	0.0756	0.0735	0.3308	0.272
MH	0.1173	0.1572	-0.1263	-0.0051	0.3336	-0.0934
OP	-0.2185	0.1915	-0.0247	-0.0541	0.0276	-0.1209
OT	0.0839	0.3353	0.0582	-0.0043	0.162	-0.1338
SDBH	0.1506	0.0245	0.1856	-0.245	0.0023	0.2896
PS	0.0093	0.2241	0.254	0.3225	-0.0338	0.0511
SC	0.1746	0.1113	0.1611	0.3105	0.0916	0.0442
SD	0.1684	0.1151	0.1956	-0.0831	-0.0626	0.3045
PPS	0.022	0.3472	0.1614	-0.027	-0.0526	-0.0626
UGCC	0.1941	-0.2006	-0.0225	0.053	0.1343	0.0889
UFC	0.1686	0.0304	-0.0409	-0.0088	-0.2676	0.1396
FC	-0.0997	-0.2233	0.1534	0.0917	-0.3143	-0.0999
MC	0.0992	0.0168	-0.0752	0.0874	-0.3925	0.0952
SRC	0.0166	-0.1249	0.281	0.1185	0.1389	-0.3553
USC	-0.193	0.0165	0.0626	0.0919	0.1315	0.3593
UTC	0.2431	-0.1258	0.0616	-0.0481	-0.0649	-0.0232
UVC	-0.1952	0.01	0.014	0.0487	0.1762	0.3787
UCT	0.0031	-0.2288	0.1959	0.0787	0.084	0.1194
USR	0.1404	-0.1479	0.3247	0.0701	0.0477	-0.1146

Table 3.6 Eigenvalues of the covariance matrix from PCA on 26 habitat variables from 5 stand types within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS from 2008.

Eigenvector	Eigenvalue	Proportion	Cumulative
1	12.365	0.325	0.325
2	6.573	0.173	0.498
3	4.184	0.110	0.609
4	3.556	0.094	0.702
5	3.038	0.080	0.782
6	2.180	0.057	0.839
7	1.934	0.051	0.890
8	1.334	0.035	0.925
9	1.223	0.032	0.958

Table 3.7 Principal components analysis of 38 habitat variables yielding 9 significant axes (eigenvalues >1) explaining 95.76 % of the total variation in habitat conditions among study sites from 5 stand types within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS from 2008. From these 9 axes, 26 environmental variables had eigenvector loadings of >0.27 and < - 0.27.

Variables	Measurements
BG	Mean percent coverage of bare ground
LL	Mean percent coverage of leaf litter
LCPP	Mean log count per sample point
LC	Mean log count
LDC	Mean log decay class
HL	Mean percent hardwood logs
MS	Total percent composition of midstory shrub species
MV	Total percent composition of midstory vine species
MH	Mean midstory tree/shrub height (>1 m, <6 m height)
OP	Total number overstory pine trees (>6 m height, >10 m DBH)
OT	Mean number overstory trees (>6 m height, >10 cm DBH)
SDBH	Mean snag diameter at breast height
PS	Mean number of pine snags
SC	Total number of standing snags
SD	Mean snag decay class
PPS	Percent composition of pine snags
UGCC	Mean percent coverage of understory rivercane
UFC	Mean percent coverage of understory fern species
FC	Mean percent coverage of understory forb species
MC	Mean percent coverage of understory moss species
SRC	Mean percent coverage of understory sedge and rush species
USC	Mean percent coverage of understory shrub species
UTC	Mean percent coverage of understory tree species
UVC	Mean percent coverage of understory vine species
UCT	Mean percent understory count
USR	Total count of understory species abundance (<1 m)

Table 3.8 PROC GLM ANOVA results for differences in habitat variables among 5 stand types: cove, streamside management zone, pine plantation <5 years of age, pine plantation 5-15 years of age, and pine plantation >15 years of age within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008.

	Habitat Type		
Habitat Variable	*F*	df	*P*
BG	1.14	4	0.40
LL	2.98	4	0.09
LCPP	0.37	4	0.82
LC	3.28	4	0.07
LDC	0.48	4	0.75
HL	3.02	4	0.09
MS	4.05	4	0.04
MV	2.25	4	0.15
MH	0.80	4	0.56
OP	8.54	4	0.01
OT	6.67	4	0.01
SDBH	1.38	4	0.32
PS	2.91	4	0.09
SC	1.44	4	0.30
SD	3.05	4	0.08
PPS	7.19	4	0.01
UGCC	5.95	4	0.01
UFC	10.25	4	0.01
FC	1.65	4	0.25
MC	1.41	4	0.31
SRC	2.44	4	0.13
USC	3.21	4	0.08
UTC	4.67	4	0.03
UVC	5.75	4	0.02
UCT	0.50	4	0.74
USR	2.21	4	0.16

Table 3.9 LS Means for habitat variables for each stand type within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS from 2008.

Taxa	Cove	SMZ	Pine <5yr	Pine 5-15yr	Pine >15yr
BG	2.45	5.55	4.41	0.75	2.74
LL	44.18	51.17	36.81	65.78	52.21
LCPP	2.31	1.63	1.91	2.26	1.63
LC	1.50	0.80	0.93	1.20	0.60
LDC	3.48	3.10	3.46	3.34	3.46
HL	1.39	0.63	0.90	0.75	0.30
MS	3.75	2.81	5.71	5.04	5.86
MV	6.24	14.41	15.48	14.96	14.31
MH	2.34	2.64	2.34	2.75	2.44
OP	5.02	17.01	62.71	81.99	69.39
OT	19.81	44.47	13.73	55.20	43.27
SDBH	19.23	19.48	7.20	13.69	20.41
PS	0.34	0.64	0.00	0.71	0.83
SC	1.04	1.25	0.07	0.65	1.23
SD	1.93	1.85	0.62	1.72	2.00
PPS	15.00	45.92	0.00	87.50	62.32
UGCC	0.04	0.05	0.02	0.00	0.00
UFC	2.99	1.37	0.43	1.21	0.60
FC	6.92	3.93	6.73	2.17	4.54
MC	0.13	0.05	0.05	0.11	0.06
SRC	0.04	0.11	0.06	0.00	0.05
USC	0.68	2.43	7.32	4.15	4.17
UTC	7.82	6.03	0.87	3.00	3.03
UVC	3.61	6.44	24.27	10.02	19.17
UCT	28.42	26.90	28.47	24.40	29.00
USR	17.31	18.77	14.70	14.25	16.87

References

Anderson, D. R., J. L. Laake, B. R. Crain, K. P. Burnham. 1979. Guidelines for line transect sampling of biological populations. Journal of Wildlife Management 43: 70-78.

Bartels, R., J. D. Dell, R. L. Knight, and G. Schaefer. 1985. Dead and down woody material. Pages 171-186 *in* Brown, E.R., editor. Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington. R6-F&WL-192-1985, USDA Forest Service, Portland, OR.

Brinson, M. M. and J. Verhoeven. 1999. Riparian forests. Pages 265-299 *in* M. L. Hunter Jr., editor. Maintaining biodiversity in forest ecosystems. Cambridge University Press. Cambridge, UK.

Campbell, T. 2010. Wildlife habitat quality in Southern Mississippi 8 years after intensive pine plantation establishment. Thesis, Mississippi State University, Mississippi State, USA.

Conant, R. and J. T. Collins. 1998. Reptiles and amphibians of eastern/central North America. Houghton Mifflin Company, New York, NY, USA.

Davis, M. B. 1996. Extent and location. Pages 18-32 *in* M. B. Davis, editor. Eastern old-growth Forests: prospects for rediscovery and recovery, Island Press, Washington D. C., USA.

DeBerry, D. and D. Pashley. 2008. Pine ecosystem conservation handbook for the gopher tortoise in Georgia. American Forest Foundation, Washington, D.C. 96pp.

Dickson, J. G. and R. M. Sheffield. 2001. Defining the forests. Pages 37-47 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Dickson, J. G. and T. B. Wigley. 2001. Managing forests for wildlife. Pages 83-94 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Edmonds, R.L. and A. Eglitis. 1989. The role of the Douglas-fir beetle and wood borers in the decomposition of and nutrient release from Douglas-fir logs. Canadian Journal Forest Research 19: 853-859.

Edwards, S. L., S. Demarais, B. Watkins, and B. K. Strickland. 2004. White-tailed deer forage production in managed and unmanaged pine stands and summer food plots in Mississippi. Wildlife Society Bulletin 32: 739-745.

Freund, R. J. and W. J. Wilson. 2003. Nonparametric methods. Pages 590-596 *in* B. Holland, editor. Statistical methods. Academic Press, San Diego, California, USA.

Gilliam, F. S., N. L. Turrill, and M. B. Adams. 1995. Herbaceous-layer and overstory species in clear-cut and mature central Appalachian hardwood forests. Ecological Application 5(4): 947-955.

Halls, L. K. and R. Alcaniz. 1968. Browse plants yield best in forest openings. Journal of Wildlife Management 32(1): 185-186

Hays, R. L. C. Summers and W. Seitz. 1981. Estimating wildlife habitat variables. Office of Biological Services, Fish and Wildlife Service, U.S.D.I., Washington, D.C., USA.

Hegwood, R. and D. Miller. 2004. Special Plans Plan: Old/Magnolia Cove and Shelton Mountain. Mississippi/Alabama Timberlands, Weyerhaeuser Company. Bellefontaine, Mississippi.

Herndon, A. and D. Taylor. 1985. Litterfall in pinelands of Everglades National Park. South Florida Research Center Report SFRC-85/01. 41p.

Hunter, M. A., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice-Hall, Englewood Cliffs, New Jersey, USA.

Iglay, R. B., B. D. Leopold, D. A. Miller, and L. W. Burger Jr. 2010. Effect of plant community composition on plant response to fire and herbicide treatments. Forest Ecology and Management 260:543-548.

Jaeger, R. G. and R. F. Inger. 1994. Quadrat sampling. Pages 97-102 *in* W. H. Heyer, M. A. Donelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster, editors. Measuring and monitoring biological Diversity. Standard methods for amphibians. Smithsonian Institution Press, Washington, D. C.

Johansson, T. 1985. Estimating canopy density by the vertical tube method. Forest Ecology and Management 11: 139-144.

Jones, P. D., S. L. Edwards, S. Demarais, and A. W. Ezell. 2009. Vegetation community response to different establishment regimes in loblolly pine (*Pinus taeda*) plantations in southern Mississippi, USA. Forest Ecology and Management 257: 553-560.

Marquis, D. A. and R. L. Johnson. 1989. Silviculture of eastern hardwoods. Pages 9-17 *in* R. M. Burns, ed. The scientific basis for silviculture and management decisions in the National forest System. USDA Forest Service General Technical Report WO-55.

McCune, B. and J.B. Grace. 2002. Analysis of ecological communities. MjM Software Design, 97 Gleneden Beach, Oregon, USA.

Miller, J. H. and K. V. Miller. 1999. Forest plants of the southeast and their wildlife uses. Southern Weed Science Society, Auburn, Alabama, USA.

Miller, J. H. 2003. Nonnative invasive plants of southern forests: A field guide for identification and control. General Technical Report SRS-62. United States Forest Service, Washington, D.C., USA

Miller, D. A., T. B. Wigley, K. V. Miller. 2009. Managed forests and conservation of terrestrial Biodiversity in the southern United States. Journal of Forestry 107: 197-203.

Mitchell, M. S., S. H. Rutzmoser, T. B. Wigley, C. Loehle, J. A. Gerwin, P. D. Keyser, R. A. Lancia, R. W. Perry, C. J. Reynolds, R. E. Thill, R. Weih, D. White, and P. B. Wood. 2006. Relationships between avian richness and landscape structure at multiple scales using multiple landscapes. Forest Ecology and Management 221: 155-169.

Mixon, M. R., S. Demarais, P. D. Jones, B. J. Rude. 2009. Deer forage response to herbicide and fire in mid-rotation pine plantations. Journal of Wildlife Management 73:663 – 668.

Noss, R. F., E. T. LaRoe III, and J. M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. National Biological Service, Biological Report 28. 58p.

Perry, R. W., T. B. Wigley, M. A. Melchoirs, R. E. Thrill, P. A. Tappe, and D. A. Miller. 2011. Width of riparian buffer and structure of adjacent plantations influence occupancy of conservation priority birds. Biodiversity Conservation: 20: 625-642.

Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the vascular flora of the Carolinas. University of North Carolina Press, Chapel Hill, North Carolina, USA.

Ross, B., T. Fredericksen, E. Ross, W. Hoffman, M. L. Morrison, J. Beyea, M. B. Lester, B. N. Johnson, and N. J. Fredericksen. 2000. Relative abundance and species richness of herpetofauna in forest stands in Pennsylvania. Forest Science 46(1): 139-146.

Royston, P. 1992. Approximating the Shapiro-Wilk W-test for non-normality. Statistics and Computing 2: 117-119.

Runkle, J. R. 1981. Gap regeneration in some old-growth forests of the eastern United States. Ecology 62(4): 1041-1051.

Schoeneberger, P. 1995. Soils, geomorphology, and land use of the southeastern United States. Pages 58-82 *in* S. Fox and R. A. Mickler, editors. Impact of air pollutants on southern pine forests. Springer-Verlag, New York, NY.

SAS Institute. 1999. SAS/STAT User's Guide. Version 9. SAS Institute, Cary, North Carolina, USA.

Smith, R.L. and T. M. Smith. 2001. Ecology and Field Biology. 6th Edition, Benjamin Cummins Addison Wesley Longman, Inc. New York, NY. 57-77. Smith, R. L. and T. M. Smith. 2003. Elements of ecology. 5th Edition, Benjamin Cummins Pearson Education, Inc. San Francisco, CA. 123-135.

Thomas, S. C., C. B. Halpern, D. A. Falk, D. A. Liguori, and K. A. Austin. 1999. Plant diversity in managed forests: understory response to thinning and fertilization. Ecological Applications 9(3): 864-879.

Walker, J. L. 2001. Sensitive plant communities. Pages 48-71 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Wear, D. N. and J. G. Greis. 2002. The southern forest resource assessment: Summary report. General Technical Report SRS-54. United States Forest Service, Washington, D.C., USA.

Wigley, T. B., W. M. Baughman, M. E. Dorcas, J. A. Gerwin, J. W. Gibbons, D. C. Guynn, Jr., R. A. Lancia, Y. A. Leiden, M. S. Mitchell, and K. R. Russell. 2000. Contributions of intensively managed forests to the sustainability of wildlife communities in the South. *in* Sustaining southern forests: the science of forest assessment. USDA Forest Service, Southern Forest Resource Assessment.

Yarrow, G. K. and D. T. Yarrow. 1999. Managing forest for wildlife and timber production. Pages 49-103 *in* G. K. Yarrow and D. T. Yarrow, editors. Managing wildlife: on private lands in Alabama and the Southeast. Sweetwater Press, Birmingham, Alabama, USA.

CHAPTER IV

BREEDING BIRDS AND HABITAT ASSOCIATIONS OF BIRDS WITHIN COVE HARDWOOD FORESTS, PINE PLANTATIONS, AND STREAMSIDE MANAGEMENT ZONES IN MISSISSIPPI

Introduction

Bird communities in the southern U.S. have been shaped by natural and human-induced changes in ecosystems at forest stand and landscape levels (Shugart and James 1973, Dickson and Segelquist 1979). Human-induced habitat alterations have caused changes in forest stand structure and age classes, habitat successional stages, and habitat patch size and fragmentation (MacArther and MacArther 1961, Wilson 1974 Roth 1976). Changes in forest types and stand structure that modify successional stages of forests are primary influences in occurrence and relative abundance of bird species (Dickson et al. 1993).

A single type of forested habitat, natural or managed, cannot typically maximize potential biodiversity of a physiographic region (Allen et al. 1996). A diversity of habitat types interspersed across a landscape generally supports a variety of avian species with each species occupying specific habitats and niches that meet its specific life requirements (Allen et al. 1996). However, site conversion of natural forests for urban, agricultural, and commercial forestry uses often results in a reduction of plant and animal diversity (Hunter 1990). For example, intensive plantation forestry can create monocultures with limited vegetation diversity and lesser habitat suitability, especially

for species that depend on natural mixed and hardwood forests (Johnston and Odum 1956, Dickson and Segelquist 1979). However, management of planted forests can result in a diversity of habitat types if management actions are implemented to integrate production of forest commodities with wildlife habitat management and water quality protection (Wigley and Melchiors 1994, Miller et al. 2009). Depending on management actions, tree plantations can contain natural areas, such as cove hardwoods, mixed mesic hardwood, and riparian forests (streamside management zones; Miller et al. 2009). Interspersion of different stand types allows for habitat structure that can create habitat heterogeneity for many different species of plants and animals (Mitchell et al. 2006). Consequently, integrative forest management that creates a diversity of habitat types and successional stages often results in diverse avian communities (MacArthur and MacArthur 1961, Willson 1974, Balda 1975, Niemi and Hanowski 1984). For example, early successional species, such as grassland birds, typically inhabit young age class pine plantations due to their life requirements for nesting and foraging. Therefore, harvest of mature forest stands and creation of early successional forest stand shifts species composition from forest-dwelling species to grassland and thicket-nesting species (Childers et al. 1986, Miller et al. 2009).

In the Southern U.S., young age class loblolly pine (*Pinus taeda*) stands (<5 years old) with a dense understory and lack of canopy can support bird species that depend on thickets and herbaceous understory vegetation. For example, Childers et al. (1986) reported that species richness and diversity in breeding birds was greatest in 2-5 year old loblolly pine stands compared to all other age class of pine plantations, but populations of many species associated with shrub and grassland habitats have exhibited regional declines (Dickson et al. 2001). Habitat management that retains herbaceous and shrub

cover within managed pine forests can prevent degradation of habitat for declining species, such as prairie warbler (*Setophaga discolor*), field sparrow (*Spizella pusilla*), and northern bobwhite (*Colinus virginianus*; Capel et al. 1994). For example, Nolan (1978) reported that prairie warblers have exhibited increases in populations within their geographic range compared to numbers at the turn of the 20th century, and this increase may be related to availability of early successional habitat in managed forests.

As young pine forests mature and the canopy closes, plant diversity in the understory decreases causing a reduction in abundance of birds (Johnston and Odum 1956, Shugart and James 1973). Dickson et al. (2001) suggests that this decrease in avian populations, especially vulnerable forest-dwelling birds, is a result of mid-successional pine monoculture characterized by closed overstory canopies and sparse understory vegetation. Silvicultural practices, including thinning, stimulate development of understory vegetation layers by creating gaps in the canopy. Thinning allows sunlight penetration into the forest floor and stimulates an increase in understory vegetation which, in turn, increases food and cover for more diverse bird communities (Johnston and Odum 1956, Shugart and James 1973, Shugart et al. 1975, Iglay 2010). For example, Wilson and Watts (1999) reported that birds with regionally declining populations, such as brown-headed nuthatches (*Sitta pusilla*), red-headed woodpeckers (*Melanerpes erythrocephalus*), and Bachman's sparrows (*Peucaea aestivalis*), reached high abundance levels in loblolly pine plantations in the first year after thinning and declined in subsequent years as overstory canopy closure progressed.

Although pine plantations offer habitat conditions that are conducive to supporting a variety of avian species, mature hardwood forests (60-120 years old; Dickson et al. 1995) are ecologically important to sustaining bird diversity across a

landscape (Haney 1999). Older hardwood forests tend to have many large decaying or dead standing snags that can provide habitat for cavity-nesting bird species, such as red-headed woodpeckers and great-crested flycatchers (*Myiarchus crinitus*; Stauffer and Best 1982, Dickson et al. 1995). These forests typically exhibit well developed, multiple canopy layers, little understory growth, and dense leaf litter. As a result, mature hardwoods harbor many common canopy nesting species, such as wood pewees (*Contopus virens;* Dickson et al. 1995). Other species rely on the moist leaf litter of mature hardwood forests for foraging such as wood thrushes (*Hylocichla mustelina*), veeries (*Catharus fuscenscens*), and hermit thrushes (*Catharus guttatus*; Yarrow and Yarrow 1999). These species and other deep-forest birds are sensitive to increases in forest edge, and many of these species associated with mature hardwood forests have declined with increases in habitat fragmentation (Dickson et al. 2001).This situation has resulted in the American Ornithological Union assigning high conservation concern scores to many species dependent on older age class hardwoods and mixed mesophytic hardwood forests (Partners in Flight Science Committee. 2005).

Densities of breeding birds in regenerating hardwoods of the southeastern United States are often similar to old-growth and mature hardwood ecosystems (Thompson and Fritzell 1990). Furthermore, riparian and wetland buffers, such as SMZs, often exhibit hardwood or mixed pine-hardwood forests of older age classes. SMZs are retained primarily for protection of water quality and often comprise < 1% percent of forest management lands. However, SMZs provide important habitat for a variety of bird species (Stevens et al. 1977, Knopf 1985, Knopf et al. 1988, Perry et al. 2011). Riparian buffers function as aquatic and terrestrial habitat types, often having high species diversity compared to the surrounding forest matrix (Gregory et al. 1991, Naiman et al.

1993, LaRue et al. 1995). Additionally, SMZs may shelter species adversely affected by loss of overstory while providing travel corridors between suitable habitats. (Perry et al. 2011). SMZs of at least 45 – 90 m in width can be important for neartic-neotropical birds (Dickson et al. 1995) Birds associated with adequate width, hardwood SMZs may include species associated with mature forests, such as yellow-throated vireos (*Vireo flavifrons*), hooded warblers (*Setophaga citrina*), and Louisiana waterthrushes (*Parkesia motacilla*; Tassone 1981,Tappe et al. 1994, Dickson et al. 1995). Other species, such as Acadian flycatchers (*Empidonax virescens*), may often utilize SMZs due to this species' tendency to nest in riparian areas and other hardwood dominated sites close to surface water (Wilson and Cooper 1998, Olendorf and Robinson 2000). Brinson et al. (1981) stated that SMZs support up to twice the avian diversity as surrounding uplands, making riparian areas an important component of managed landscapes.

Bird species, whether inhabiting managed forests or natural forests, require specific habitat conditions. Therefore, diversity of bird communities in any habitat type usually shifts in composition as changes in plant successional stages or age of forest stand occur (Shugart et al. 1975). Interspersion of different habitat types and stand ages can create a greater diversity of bird species across a landscape (Haney 1999). Additionally, managed forests and mature natural forests support unique assemblages of birds, many of which are exhibiting population declines at regional and national levels (Dickson et al. 2001). As loblolly plantations continue to expand along with industrial development and increases in human population s, integrated approaches will be required to apply habitat management that promotes food and cover in managed forests and protection of environmental resource areas, such as forested wetlands and cove and riparian forests (Hunter 1990). These integrative approaches can potentially provide habitat for many

species of breeding, wintering, and migratory birds across southern forest landscapes (Wilson et al. 1995, Dickson et al. 2001).

Protection of unique habitat types, such as forested wetlands and hardwood coves, is an approach used to help retain native biological diversity on public and private industrial lands. An example of this effort exists on forest lands owned by Weyerhaeuser Company on the Old Cove Area in Webster County, Mississippi. Protection and designation of mature hardwood forests of coves occurred in 2004, and sites were recognized for their uniqueness and contributions to landscape level biological diversity (Hegwood and Miller 2004). Hegwood and Miller (2004) also reported that additional surveys and studies were needed to identify fauna and flora that occurred in mature hardwood forests of coves. This study was conducted to increase knowledge of bird communities inhabiting cove hardwood forests, SMZs, and pine plantations of the Old Cove Area.

Primary objectives included the following:

1.) Estimation of species richness and abundance of birds occurring in mature hardwood forest of coves, mixed hardwood forests of SMZs, and 3 age classes of pine plantation in central Mississippi.

2.) Estimation of relationships between bird community characteristics and habitat conditions within afore listed habitat.

3.) Development of community similarity indices for breeding birds to estimate degree of community overlap among these habitat types.

4.) Report cumulative conservation scores using Partners in Flight scores for detected birds in the different habitat types.

Study Area

I conducted field experiments in 14 forest stands located within Weyerhaeuser's Old Cove property in Webster county, north-central Mississippi. These 14 stands consisted of 3 young pine stands < 5 years of age (7755, 7754, 85869), 2 unthinned pine stands 5 to 15 years of age (7187, 8170), 4 thinned pine stands > 15 years of age (7972, 118164, 8217, 8480), 3 SMZ stands (7557, 7683, 7961) and 2 of the special interest areas comprised of natural cove hardwoods, Old Cove and Magnolia Cove (Table 2.2). All pine stands were planted, and mature mesic hardwood stands had been set aside and labeled "special place" by Weyerhaeuser for ecological research and conservation purposes. Additional details regarding study site location and habitat description are provided in Chapter II.

Methods

Field data was collected June 2008 and June 2009 using point call counts at each bird point as described by Ralph et al. (1993). I conducted surveys at each point count station for a ten-minute period during dawn hours to 10:00 am on days of favorable weather conditions as described by Ralph et al. (1993). Surveys were conducted once in each stand of each habitat type during each year by the same 2 to 3 observers over the two-year period (Table 4.1 and 4.2). All data were obtained from 44 bird points within the selected stands, and 440 minutes (10 minutes per point) of point count surveys per year. Specifics on field methods are described in Chapter II.

Statistical Analysis

Species richness, occurrence of selected species, or abundance (detection per unit effort) were my response variables. Forest stand types and metrics on habitat

characteristics were considered independent explanatory variables (Chapter III). Sampling effort remained consistent between each point within each stand (10 min survey period), but sampling effort varied among habitat types due to unequal number of stands representing each habitat type (Table 4.1). Sampling effort varied by site due to an unequal number of stands representative of the age classification requirements, weather-related disturbances, and ongoing management practices which restricted sampling and site access (i.e., timber harvest, flooding). Counts of birds were standardized according to Fogarty (2005) and Edwards (2009) using detection-per-unit effort (DPUE) to adjust for differences in sampling intensity among sites using the following formula:

$$\text{DPUE} = \frac{\text{Total number of detected individuals per site}}{\text{Adjusted number of sample days}} \tag{4.1}$$

The following hypotheses were investigated at a significance level of $\alpha = 0.05$:

1. H_0: Bird abundance (DPUE) and species numbers will be similar between different habitat types.

   H_1: Bird abundance (DPUE) and species numbers will different in the different habitat types.

2. H_0: Species richness of breeding birds will not be related to habitat conditions measured in different habitat types.

   H_1: Species richness of breeding birds will be related to habitat conditions in different habitat types.

3. H_0: Abundance of all birds and selected species based on DPUE will not be related to habitat conditions measured in different habitat types.

H_1: Abundance of all birds and selected species based on DPUE will be related to habitat conditions in different habitat types.

Differences Among Habitat Types

I conducted an analysis of variance (PROC GLM, SAS 9.2) to compare bird species richness and abundance based on DPUE among pine plantations, SMZs, and cove sites (Freund and Wilson 2003, SAS Institute Inc. 2004). Data were tested for normality using the Shapiro-Wilk test prior to analysis (PROC UNIVARIATE, SAS 9.2; Freund and Wilson 2003, SAS Institute Inc. 2004). All tests were considered significant at $P \leq 0.05$. If significant results were found, least-square means procedure was used to determine multiple comparisons among sites (Freund and Wilson 2003).

Community Similarity

I derived avian community similarity indices using Renkonen's Index to quantify similarity of avian communities among 5 habitat types in 2008 and 2009 (Table 4.4; Krebs 1989). The index is a percentage similarity index defined as $P = \sum \text{minimum}\ (p_{1i}, p_{2i})$; where, P = percentage similarity between habitat 1 and habitat 2; p_{1i} = percentage of species i in habitat 1; p_{2i} = percentage of species i in habitat 2 (Krebs (1989). Renkonen's Index can be viewed as a scale from 0 (no similarity between habitat types) to 100 (complete similarity between habitat types; Krebs 1989). Similarity indices were derived using taxonomic class of fauna and separately using species pooled across all avian species. Similarity indices derived for the class or grouping were reported and compared qualitatively and quantitatively through comparisons of percentage of similarity or difference of communities among habitat types (Krebs 1989).

Avian Conservation Values

Cumulative conservation scores were computed according to methods described by Nuttle et al. (2003) for avian communities by type for each year (Table 4.3). Breeding scores were obtained from Partners-in-Flight's (PIF) Species Assessment Database for species occurring within Region 27 (Southeast Gulf Coastal Plains; Ruth 2006; Appendix A.3.). Breeding scores for each species were then multiplied by mean abundance of each species (DPUE) detected within each of the 5 habitat types during each study year (Nuttle et al. 2003). All species detected were included in the analysis of the cumulative conservation values.

Multiple Linear Regression

For regression analyses, stand was the experimental unit yielding an experimental sample size of 13. Faunal response variables included species richness and abundance of birds (DPUE) and individual species abundance (DPUE). Regression analysis for individual species abundance DPUE was conducted on bird species with $\geq$20 observations across study sites during both study years (Edwards 2009). Included 26 of 38 habitat variables as independent variables in analyses. Mean or sum values of habitat variables were derived by site based upon vegetation data collected during summers 2008 and 2009 (Chapter III, Table 3.1).

Determination of potential relationships between habitat conditions and bird community metrics was a multiple-step process. I used data reduction techniques to eliminate environmental variables exhibiting little variation among study sites and variables that were correlated (Johnson 1998). First, data were examined for normality using the Shapiro-Wilk test (PROC UNIVARIATE, SAS 9.2) and transformed when necessary using square-root transformations for count data and arcsine square-root

transformations for percentage data. Then, principal components analysis (PCA) was used to reduce the habitat data set to a smaller number of variables that limited amount of redundancy among variables and represented most of the variation in habitat characteristics among study sites (PROC PRINCOMP, SAS 9.1; McCune and Grace 2002). PCA is a basic eigenvector analysis that requires one data matrix, in this case, habitat variables by study site, and determines which variables contribute most to the overall variance of the data set relative to one another (Johnson 1998). Each component that is extracted is represented by an eigenvalue that represents amount of variance accounted for by a given component. Every variable then has a loading on each axis indicating its significance within each principal component with the square of the loading equaling percentage of variation in the variable explained by that axis (McGarigal et al. 2000). Significant axes were determined by Kaiser's criterion where components with an eigenvalue >1 were retained and interpreted (Hatcher 1994; McCune and Grace 2002; Edwards 2009). Within each component, variables with eigenvector loadings >0.27 and <-0.27 were considered meaningful. This method allowed for selection of variables that represent approximately 10% of the variance explained by that axis (Hair et al. 1987; McGarigal et al. 2000).

Variables were examined for collinearity using Pearson correlation coefficients which evaluated relationships among explanatory variables (Myers 1990). If 2 variables had a coefficient >0.75, they were evaluated as candidates for exclusion from the data set. Based on current knowledge and literature, the variable with the greatest biological significance for the specified taxonomic group was retained for inclusion in regression analyses (Table 4.5). Next, I used the habitat variables reduced by PCA and collinearity

diagnostics to develop models for avian species richness and abundance (DPUE) using multiple linear regression (PROC REG, SAS Institute 1999).

Breeding Bird Results

Point Call Counts

Forty-four point call count surveys in 2008 (Table 4.1) yielded 25 species (89 individuals) in the coves, 28 species (127 individuals) in the SMZs, 25 species (151 individuals) in the <5 year pine stands, 17 species (74 individuals) in the 5-15 year pine stands, and 23 species (152 individuals) in the > 15 year pine stands accounting for 39 species and 604 individuals (Appendix A.1). In 2009, one of the stands representing >15 year pine (Stand ID: 8480) was harvested; consequently, bird surveys were not conducted in this stand in 2009. Therefore, 41 surveys in 2009 (Table 4.1) yielded 43 species and 594 individuals. Twenty-four species and 107 individuals in coves, 37 species and 156 individuals in SMZs, 15 species and 127 individuals in <5 year pine stands, 19 species and 80 individuals in 5-15 year pine stands, and 18 species and 124 individuals in >15 year pine stands (Appendix A.2).

Comparisons of Bird Community Metrics among Habitat Types

Species richness of birds did not differ among vegetation community types (P = 0.11; Table 4.6). However, bird abundance (DPUE) differed among cove, SMZ, and pine categories ($F_{4,8}$ = 3.95, P = 0.05; Table 4.6). Cove forests species abundance of breeding birds was similar to abundance in SMZs. Three categories of pine stands and SMZs were similar but differed from coves (Tables 4.7).

Avian Conservation Values

Cumulative conservation values derived using breeding bird scores assigned to each species obtained from PIF's Species Assessment Database were totaled, resulting in a PIF conservation score of 646 for cove habitat type, 624 for SMZ habitat type, 632 for <5 year pine habitat type, 508 for 5-15 pine habitat type, and 535 for >15 year pine habitat type (Table 4.3).

Community Similarity Index

Approximately 57% to 68% of bird communities were similar among the 3 categories of pine, 55% to 64% were similar among SMZ and pine, and 46% were similar between cove and SMZs (Table 4.4). Thirty-one percent to 38% were similar among cove and pine.

Multiple Linear Regression and Stepwise Model Reduction

Variables included in stepwise linear regression as independent variables for evaluating relationships to bird community metrics were number of understory plant species (USR), LDC, SC, MS, mean percent coverage of leaf litter/1.5 m^2 (LL), OP, MV, mean percent coverage of understory shrub species/1.5 m^2 (USC), LC, and SDBH; Table 3.6).

Bird Richness. The model contained one variable, SDBH (R^2 = 0.53). SDBH had a positive association with bird species richness (β-hat = 0.11, SE = 0.03, F = 12.43, df = 1,11, P = <0.01; Table 4.5).

Bird DPUE. The model contained 2 variables, USR and SDBH (R^2 = 0.81; Table 4.5). Bird species richness was associated positively with USR (β-hat = 0.02, SE = 0.01,

F = 13.46, df = 2,10, P = <0.01) and SDBH (β-hat =0.01, SE = <0.01, F = 7.49, df = 2,10, P = 0.02).

Abundance of Individual Species. For abundance of species relationships between habitat variables and abundance of individual species significant models were not derived for 3 species of birds, including Carolina wren (*Thryothorus ludivicianus*), hooded warbler, and worm-eating warbler (*Helmitheros vermivorum*). Significant models were developed for 15 bird species as follows:

Acadian Flycatcher (Empidonax virescens). Abundance was associated with 3 explanatory variables, LC, MV, and OP (R^2 = 0.96). DPUE had a negative relationships between MV (β-hat = -0.06, SE = 0.01, F = 56.03, df = 3,9, P = <0.01) and OP (β-hat = -0.01, SE = <0.01, F = 42.74, df = 3,9, P = <0.01), and a positive association with LC (β-hat = 0.26, SE = 0.09, F = 8.83, df = 3,9, P = 0.02; Table 4.5).

American Crow (Corvus brachyrhynchos). Abundance was related positively to one explanatory variable, OP (R^2 = 0.34, β-hat = 0.01, SE = <0.01, F = 5.56, df = 1,11, P = 0.04; Table 4.5).

Blue Jay (Cyanocitta cristata). Abundance was associated positively with one explanatory variable, SDBH (R^2 = 0.5, β-hat = 0.03, SE = 0.01, F = 9.93, df = 1,11, P = 0.01; Table 4.5).

Eastern Towhee (Pipilo erythropthalmus). Abundance was related positively to one explanatory variable, USC (R^2 = 0.40, β-hat = 0.08, SE = 0.03, F = 7.22, df = 1,11, P = 0.02; Table 4.5).

Indigo Bunting (Passerina cyanea). Abundance was associated positively with one explanatory variable, MV (R^2 = 0.34, β-hat = 0.09, SE = 0.04, F = 5.69, df = 1,11, P = 0.04; Table 4.5).

Northern Bobwhite (Colinus virginianus). Abundance was related positively to one explanatory variable, MV (R^2 = 0.38, β-hat = 0.07, SE = 0.02, *F* = 6.85, df = 1,11, *P* = 0.02; Table 4.5).

Northern Cardinal (Cardinalis cardinalis). Abundance was related positively to one explanatory variable, MV (R^2 = 0.41, β-hat = 0.09, SE = 0.03, *F* = 7.73, df = 1,11, *P* = 0.02; Table 4.5).

Pine Warbler (Setophaga pinus). Abundance was related to 2 explanatory variables, LC and SC (R^2 = 0.69). Pine warbler DPUE had a negative association with LC (β-hat = -0.89, SE = 0.20, *F* = 20.29, df = 2,10, *P* = <0.01), and a positive association with SC (β-hat = 0.27, SE = 0.10, *F* = 6.64, df = 2,10, *P* = 0.03; Table 4.5).

Prairie Warbler (Setophaga discolor). Abundance was related to 2 explanatory variables, MV and SC (R^2 = 0.63). Prairie warbler DPUE had a positive association with MV (β-hat = 0.05, SE = 0.02, *F* = 5.85, df = 2,10, *P* = 0.04), and a negative association with SC (β-hat = -0.41, SE = 0.12, *F* = 11.39, df = 2,10, *P* = 0.01; Table 4.5).

Red-eyed Vireo (Vireo olivaceus). Abundance was associated negatively with one explanatory variable, MV (R^2 = 0.43, β-hat = -0.09, SE = 0.03, *F* = 8.19, df = 1,11, *P* = 0.02; Table 4.5).

Tufted Titmouse (Baeolophus bicolor). Abundance was related to 3 variables, USC, LL, and SDBH (R^2 = 0.81). Tufted titmouse DPUE had a negative association with USC (β-hat = -0.12, SE = 0.03, *F* = 20.36, df = 3,9, *P* = <0.01) and LL (β-hat = -0.02, SE = 0.01, *F* = 8.34, df = 3,9, *P* = 0.02), and a positive association with SDBH (β-hat = 0.03, SE = 0.01, *F* = 10.32, df = 3,9, *P* = 0.01; Table 4.5).

White-eyed Vireo (Vireo griseus). Abundance was related to 2 explanatory variables, USC and OP (R^2 = 0.84). White-eyed vireo DPUE had a positive association

with USC (β-hat = 0.05, SE = 0.02, F = 6.48, df = 2,10, P = 0.03) and OP (β-hat = 0.01, SE = <0.01, F = 29.20, df = 2,10, P = <0.01; Table 4.5).

Wood Thrush (Hylocichla mustelina). Abundance was associated with 4 explanatory variables, LDC, MS, MV, and OP (R^2 = 0.94). Wood thrush DPUE had a positive association with LDC (β-hat = 0.34, SE = 0.07, F = 23.79, df = 4,8, P = <0.01) and MS (β-hat = 0.05, SE = 0.02, F = 6.34, df = 4,8, P = 0.04), and a negative association with MV (β-hat = -0.03, SE = 0.01, F = 37.61, df = 4,8, P = <0.01) and OP (β-hat = -0.01, SE = <0.01, F = 34.78, df = 4,8, P = <0.01; Table 4.5).

Yellow-billed Cuckoo (Coccyzus americanus). Abundance was associated with 2 explanatory variables, USR and LDC (R^2 = 0.74). Yellow-billed cuckoo DPUE had a positive association with USR (β-hat = 0.08, SE = 0.02, F = 13.35, df = 2,10, P = <0.01), and a negative association with LDC (β-hat = -0.56, SE = 0.14, F = 15.78, df = 2,10, P = <0.01; Table 4.5).

Yellow-breasted Chat (Icteria virens). Abundance was associated positively with one explanatory variable, USC (R^2 = 0.60, β-hat = 0.29, SE = 0.07, F = 16.49, df = 1,11, P = <0.01; Table 4.5).

Discussion

Species found in SMZs and coves typically inhabit deciduous forests that exhibit gaps or openings and have high availability of cavity trees and standing snags (Dickson et al. 1995, Fischer 2000). Three bird species detected only in SMZs included cavity nesters, brown-headed nuthatch and eastern bluebird (*Sialia sialis*), and one species that is found often in forest-field ecotones, red-shoulder hawk (*Buteo lineatus*). Perry et al. (2011) reported that effects of SMZ widths on birds of high conservation concern

generally depended on the specific life requirements of species. Habitat conditions of SMZs that potentially influenced presence of these species were ecotone structure and plant community composition, availability of nesting cavities, and adjacent habitat types (Perry et al. 2011). Although SMZs supported some of the same bird species found in coves, coves represented a habitat of larger size with non-linear habitat patches of hardwood forests compared to linear SMZs. I did not conduct productivity studies, such as estimation of nesting success rates. Therefore, I cannot report contributions of coves and SMZs in terms of bird population recruitment or source-sink dynamics. However, due to size and configuration, coves may be more important to forest dependent species that are area sensitive or susceptible to nest parasitism and depredation (Smith 1977, Smith 1999).

Coves typically supported a greater abundance of deep-forest dwelling species including woodpeckers, flycatchers, thrushes, and forest-dwelling warblers. Also, 4 species of birds including ovenbird (*Seiurus aurocapilla*), American robin (*Turdus migratorius*), white-breasted nuthatch (*Sitta carolinensis*), red-headed woodpecker, were detected only in coves. Similar findings have been reported by other studies (Smith 1977, Wilson and Cooper 1998). Woodpeckers and thrushes have been reported to inhabit coves and other hardwood dominated habitat types due to an abundance of standing snags, forest floor conditions, closed overstory canopy structure, and a diversity of hard and soft mast producing trees (Dickson et al. 1995). Density of standing snags (>2 snags/ha) and suitable nesting cavities may have influenced presence of cavity nesters and excavators in cove and SMZs. In my study, size (DBH) of standing snags was related positively to bird species richness, abundance, and abundance of tufted titmice. Cavity nesters of high conservation concern detected in coves and SMZs included brown-headed

and white-breasted nuthatches. Wilson and Watts (1999) reported that nuthatches were associated positively with standing snag densities, and I submit that snags may have influenced presence of these species. However, I did not detect enough individuals of these species for analyses. Acadian flycatchers which were most numerous in coves and were related positively to forest stand conditions of mature hardwood forests, but this species could have been attracted to riparian habitats of coves due to their tendency to nest in tree canopies over surface water (Wilson and Cooper 1998).

Conservation of hardwood forests in coves and within SMZs is important in maintaining species diversity of breeding birds across a landscape (Perry et al. 2011, Smith 1999). Although bird response to width of SMZs may vary depending on the species in question and surrounding habitat conditions (Perry et al. 2011), riparian, cove, and SMZ forests can provide habitat for many sensitive bird species that would otherwise be found in smaller or reduced populations in upland hardwood and fragmented ecosystems (Smith 1977). Because increased size and availability of protected riparian forests could increase suitability for many forest dwelling species, Dickson and Warren (1994) suggested that SMZ widths be increased on managed landscapes. Furthermore, Kilgo et al. (1998) and Perry et al. (2011) found that most species experienced peak densities in wider riparian forests such as Acadian flycatcher and Louisiana waterthrush that typically nest over a water source. In addition to riparian forests, upland hardwood and mesic cove hardwood forests provided important breeding and wintering habitat for many species of birds, including many warblers (Family Parulidae), tanagers (*Piranga spp.*), thrushes, flycatchers, and nuthatches (Franzeb 2005, Haney 1999). Additionally, detection of species with high conservation concern scores ($\geq$ 16) within the coves and SMZs including brown-headed nuthatch, eastern towhee, northern bobwhite, and summer

tanager (*Piranga rubra*; Partners in Flight Science Committee 2005) demonstrates e importance of conserving riparian habitat types.

Significant relationships were found between selected habitat variables of 5 habitat types and bird community metrics. Snag DBH was an influential variable in species richness and abundance of birds. Cavity nesters, such as tufted titmice, also were associated positively with mean snag DBH and had their greatest detection in coves and SMZs where mean snag DBH was greatest. Snag DBH ranged in size from 19 – 21 cm in all habitat types except for 5-15 year old pine plantations which exhibited the least mean DBH of standing snags (14 cm). Although snags exhibited positive relationship with some bird metrics, abundance of some species, such as prairie warblers, had negative associations with mean snag DBH. Conversely, this species and northern cardinals were associated positively with percent composition of midstory vine species, which was greatest in < 5 year old pine, the habitat type where northern cardinal and prairie warbler abundance was high. Other shrub nesting species, such as yellow breasted chats, were associated positively with percent coverage of understory shrub species. Yellow breasted chat had the greatest detection in < 5 year old and >15 year old pine where mean percent coverage of understory shrub species was detected. This vegetation structure probably provided nesting habitat that occurred within 3 m of the ground surface (Halkin and Linville 1999, Nolan et al. 1999). In contrast, percent composition of midstory vine species, a habitat variable that was greatest in < 5 year old and 5-15 year old pine had negative associations with 2 species of breeding birds, red-eyed vireo and wood thrush, 2 species that had the least detection in these habitat types. These species prefer mature hardwood and pine-hardwood forests which typically have closed canopy and reduced understory and midstory structure (Dickson et al. 2001). My analyses supported findings

of other studies concerning use of different habitat types by bird species depending to the species' life requirements (Dickson 2001).

SMZs exhibited greatest species numbers and abundance of birds during each study year. I did not measure productivity in terms of nesting success or recruitment; therefore, I cannot provide information on contribution of SMZs to bird populations or address source-sink dynamics. However, SMZs of the Old Cove Area supported a mixture of species that often inhabit early successional forest stands (< 5 year old pine plantations), forests with midstory shrubs and vines, and mature forests, such as hardwood forests of coves. Bird communities of SMZs were comprised of several nesting and feeding guilds of birds including shrub species (i.e., eastern towhee and indigo buntings), grassland species (i.e., northern bobwhite), and forest-dwelling species (i.e., wood thrushes and Acadian flycatchers; Capel et al. 1994, Dickson et al. 1995, Olendorf and Robinson 2000). Indigo buntings, northern bobwhites, and prairie warblers were often the most numerous high priority species detected in SMZs. Species of forest-dwelling birds that inhabited SMZs included summer tanagers, yellow-billed cuckoos, Kentucky warblers (*Geothlypis formosa*), and wood thrushes. Most numerous bird species in SMZs and other habitat types included northern cardinals, Carolina wrens, and red-eyed vireos. I submit that response of bird communities to width of SMZs is not well understood (Perry et al. 2011). Selected species, such as northern bobwhite, have exhibited negative associations with SMZ widths; whereas, deep forest-dwelling birds often exhibited positive associations (Perry et al. 2011). Northern bobwhites were detected in SMZs. I submit that contributions of SMZ habitat to bird productivity and recruitment may be influenced by linear configuration, edge effects, and subsequent exposure of nesting birds to nest parasitism and depredation (Smith 1977); however,

because of SMZs retention for water quality protection on intensely managed forest lands, they also may contribute to landscape level conservation of biological diversity, including bird community diversity (Wigley et al. 2009).

Habitat characteristics that influenced bird communities in my study included mean snag DBH, number of standing snags, forest overstory conditions, understory plant coverage and species numbers, and total percent composition of midstory vine species. Associations of these habitat features with abundance of specific bird species depended on the species and its life history requirements. Bird species richness was influenced by size (DBH) of standing snags, and bird abundance was related positively to number of plant species in the understory. Potential relationships to standing snag size may have been due to foraging, perching, and nesting requirements of cavity-nesting species, such as tufted titmice, woodpeckers, Carolina wrens, Carolina chickadees (*Poecile carolinensis*), and nuthatches. Total number of understory plant species potentially influenced plant and invertebrate food availability and foraging cover for many species of birds (Balda 1975). Associations of abundance of selected bird species with midstory and understory vegetation characteristics indicated relationships between abundance of these birds and conditions of nesting, foraging and escape cover substrates. For example, thicket-nesting birds tended to be more highly associated with understory and midstory shrub and vine characteristics of young pine plantations and edges of SMZ habitats.

Based on community similarity indices derived from bird surveys, each habitat type contributed to total species richness of the Old Cove property. Cove forests exhibited greatest number of species that depend on conditions of mature deciduous forests with a high conservation concern value including Acadian flycatcher and summer tanager, causing the greatest score in coves. However, relatively high conservation score

in young pine stands was caused by abundance of grassland and thicket-nesting birds including Carolina chickadee and prairie warbler. Similarities in bird communities between coves and SMZs indicated that SMZs can provide habitat for almost half of the forest-dwelling bird species present in mature forests of coves. Because I did not assess productivity, I cannot provide information on nesting success or recruitment. However, cove habitats were larger in size and may provide better habitat for interior forest birds that are sensitive to edge effects. I believe that retention of SMZs, protections of existing cove forests, and management of pine plantations can provide for the greatest diversity of bird species on the Old Cove property. I concur with Wigley et al. (2009) who proposed protection of unique habitats and retention of natural forests in SMZs can advance conservation efforts for forest dwelling bird species. In my study, conservation approaches within the Old Cove property created interspersion of mature forests, forested SMZs, and pine-grassland habitats that supported over 40 bird species during springs and early summers, 2008, 2009. At least 15 species were of high conservation concern that depend on mature deciduous forests and grassland-shrub habitats (Partners in Flight Science Committee 2005).

Sampling of breeding bird populations is an important management strategy for determining presence of species within the landscape and determining distribution and population trends over time (Bibby et al. 2000). In my study, breeding birds were sampled one time in each stand representing each habitat type once a year during spring. Additionally, one experienced observer and 2 observers that were in training were used to complete the point call count survey in 2008, whereas in 2009, 2 experienced and 2 trained observers conducted the surveys. A greater number of bird species was detected in 2009, and I submit that observer experience probably influenced numbers of birds and

bird species detected during this study year. For a better understanding of what species are present throughout the year, I recommend that sampling periods encompass all seasons to detect species present throughout the year. The same observers should be used throughout the study if feasible to reduce any observer bias. Also, surveys for birds should be repeated multiple times during each sampling season to increase the probability of detection (Ralph et al.1993).

Table 4.1 Sampling effort and duration of point count surveys for breeding birds at Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS during spring-early summer 2008 and 2009.

Habitat Type	Number of Bird Points		Survey Time/Stand (minutes)		Survey Time/Habitat Type (minutes)	
Stand Identification	2008	2009	2008	2009	2008	2009
Hardwood Coves						
Old Cove	4	4	40	40	80	80
Magnolia Cove	4	4	40	40		
Streamside Management Zones						
Stand No. 7557	3	3	30	30		
Stand No. 7683	3	3	30	30	90	90
Stand No. 7961	3	3	30	30		
Pine Plantations (>15 years)						
Stand No. 7972						
Stand No. 118164	3	3	30	30		
Stand No. 8217	3	3	30	30		
Stand No. 8480[a]	3	-	30	-		
Pine Plantations (5-15 years)						
Stand No. 7187	3	3	30	30	60	60
Stand No. 8170	3	3	30	30		
Pine Plantations (<5 years)						
Stand No. 7754	3	3	30	30		
Stand No. 7755	3	3	30	30	90	90
Stand No. 85869	3	3	30	30		

[a] Stand not surveyed during spring 2009 due to tree harvest activities.

Table 4.2 Bird species numbers and abundance of bird/point count stations in 5 stand types on the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS in spring-early summer 2008 and 2009.

	Habitat Types									
	Cove Hardwoods		Streamside Management Zones		Pine Plantations <5 yrs of age		Pine Plantations 5-15 yrs of age		Pine Plantations >15 yrs of age	
Bird Community Metrics	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Number of Species Detected	25	24	28	37	25	15	17	19	23	18
Number of Birds Detected	89	107	127	156	151	127	74	80	152	124
Mean Number of Birds Detected[a]	11.1	13.4	14.1	17.3	16.8	14.1	12.3	13.3	12.7	13.8

[a] Mean Number of Birds Detected = Total number of birds detected ÷ number of point count stations in each habitat type.

Table 4.3 Cumulative conservation scores of breeding birds detected in each stand type within Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS during spring 2008 and 2009.

Habitat Type	Cove Sites (N=2)	SMZ Sites (N=3)	Pine (<5 years) Sites (N=3)	Pine (5-15 years) Sites (N=2)	Pine (>15 years) Sites (N=4)
Survey Years (Spring)	2008, 2009	2008, 2009	2008, 2009	2008, 2009	2008, *2009
PIF Conservation Score [a]	646	624	632	508	535

[a] Partners in Flight (PIF) Conservation Value for each habitat type using breeding bird scores from PIF Science Committee (2005) and derived according to methods described by Nuttle et al. (2003). Cumulative Conservation Score = Breeding bird score (obtained from PIF for a particular species) X Mean abundance detected in the habitat type of that species. All species scores for the particular habitat type of interest where then added together to obtain a cumulative conservation score

Table 4.4 Renkonen Similarity Indices of breeding birds of 5 stand types within Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

Habitat Comparison	Community Similarity Index (2008)	Community Similarity Index (2009)	Community Similarity Index (Years Combined)
Pine (<5 years) Sites; Pine (5-15 years) Sites	0.522	0.558	0.572
Pine (<5 years) Sites; Pine (>15 years) Sites	0.517	0.654	0.604
Pine (<5 years) Sites; SMZ Sites	0.604	0.530	0.640
Pine (<5 years) Sites; Cove Sites	0.327	0.256	0.312
Pine (5-15 years) Sites; Pine (>15 years) Sites	0.601	0.650	0.677
Pine (5-15 years) Sites; SMZ Sites	0.514	0.535	0.553
Pine (5-15 years) Sites; Cove Sites	0.375	0.284	0.333
Pine (>15 years) Sites; SMZ Sites	0.556	0.576	0.627
Pine (>15 years) Sites; Cove Sites	0.418	0.318	0.381
SMZ Sites; Cove Sites	0.509	0.377	0.458

Table 4.5 Significant associations among breeding bird species richness, mean abundance of birds, and mean abundance of selected bird species and selected habitat variables in 5 stand types during spring 2008 and 2009 at Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS.

Bird Community Metric	
Dependent Response Variable (Y)	**Significant Influential Models**
Total Bird Species Richness	Y= 1.02 + 0.12 (SDBH)
Total Bird Abundance DPUE[b]	Y = - 0.35 + 0.03 (USR) + 0.01 (SDBH)
Selected Bird Species with Adequate Detection Numbers for Model Development ($R^2 > 0.50$)	
Baeolophus bicolor DPUE[b]	Y= 1.38 - 0.12 (USC) - 0.02 (LL) + 0.03 (SDBH)
Cardinalis cardinalis DPUE	Y= - 0.34 + 0.09 (MV)
Coccyzus americanus DPUE	Y = 0.97 + 0.08 (USR) – 0.56 (LDC)
Dendroica pinus DPUE	Y= 1.11 - 0.89 (LC) + 0.27 (SC)
Dendroica discolor DPUE	Y= 0.18 + 0.05 (MV) – 0.41 (SC)
Empidonax virescens DPUE	Y= 1.06 + 0.26 (LC) – 0.06 (MV) - 0.01 (OP)
Hylocichla mustelina DPUE	Y= - 0.38 + 0.35 (LDC) + 0.06 (MS) - 0.04 (MV) - 0.01 (OP)
Icteria virens virens DPUE	Y= 0.57 + 0.29 (USC)
Pipilo erythrophthalmus DPUE	Y= 0.09 + 0.08 (USC)
Vireo griseus DPUE	Y= 0.28 + 0.05 (USC) + 0.01 (OP)
Bird Species with Adequate Numbers for Model Development ($R^2 < 0.50$)	
Colinus virginianus DPUE	Y= - 0.50 + 0.07 (MV)
Corvus brachyrhynchos DPUE	Y= 0.46 + 0.01 (OP)
Cyanocitta cristata DPUE	Y= 0.04+ 0.03 (SDBH)
Passerina cyanea DPUE	Y= - 0.38 + 0.09 (MV)
Vireo olivaceus DPUE	Y= 2.13 - 0.10 (MV)

Legend for Habitat Acronyms: USR - Total number of understory plant species (< 1m); LDC- Mean log decay class according to Hunter (1990); SC– Total number of standing snags; MS - Total percent composition of midstory shrub species; LL - Mean percent coverage of leaf litter; OP – Total number of overstory pine trees (> 6m in height; > 10 cm DBH); MV – Total percent composition of midstory vine species; USC – Mean percent coverage of understory shrub species; LC – Total mean log count; SDBH– Mean snag diameter at breast height (DBH)

[b]DPUE = Total number of detected individuals per site ÷ Adjusted number of sample days

Table 4.6 PROC GLM ANOVA results for differences in breeding bird species richness and detection -per-unit effort among 5 stand types: cove, streamside management zone, pine <5 years of age, pine 5-15 years of age, and pine >15 years of age within Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

Taxa	**Habitat Type**		
	F	Df	*P*
Total Breeding Bird Species Richness	2.73	4	0.11
Total Breeding Bird DPUE	3.95	4	0.05
Empidonax virescens DPUE	0.88	4	0.52
Corvus brachyrhynchos DPUE	0.08	4	0.99
Cyanocitta cristata DPUE	0.8	4	0.56
Thryothorus ludovicianus DPUE	2.16	4	0.16
Pipilo erythrophthalmus DPUE	4.33	4	0.04
Contopus virens DPUE	1.43	4	0.31
Baeolophus bicolor DPUE	1.93	4	0.20
Wilsonia citrina DPUE	6.28	4	0.01
Passerina cyanea DPUE	1.51	4	0.29
Colinus virginianus DPUE	1.7	4	0.24
Cardinalis cardinalis DPUE	21.51	4	< 0.01
Dendroica pinus DPUE	57.09	4	< 0.01
Dendroica discolor DPUE	0.86	4	0.53
Vireo olivaceus DPUE	13.15	4	< 0.01
Vireo griseus DPUE	2.92	4	0.09
Helmitheros vermivorus DPUE	1.23	4	0.37
Hylocichla mustelina DPUE	4.35	4	0.04
Icteria virens virens DPUE	1.74	4	0.25

Table 4.7 P-values from differences in LS Means for breeding bird species richness and DPUE by stand type within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

Total Breeding Bird Richness

	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.159	0.019	0.54	0.443
SMZ	0.159	-	0.159	0.418	0.428
Pine <5 yr	0.019	0.159	-	0.055	0.044
Pine 5-15 yr	0.54	0.418	0.055	-	0.918
Pine >15 yr	0.443	0.428	0.044	0.918	-

Total Breeding Bird DPUE

	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.061	0.01	0.015	0.01
SMZ	0.061	-	0.216	0.263	0.216
Pine <5 yr	0.01	0.216	-	1	1
Pine 5-15 yr	0.015	0.263	1	-	1
Pine >15 yr	0.01	0.216	1	1	-

***Empidonax virescens* DPUE**

	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.588	0.325	0.403	0.697
SMZ	0.588	-	0.603	0.697	0.311
Pine <5 yr	0.325	0.603	-	0.938	0.143
Pine 5-15 yr	0.403	0.697	0.938	-	0.208
Pine >15 yr	0.697	0.311	0.143	0.208	-

***Corvus brachyrhynchos* DPUE**

	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.747	0.94	0.946	0.94
SMZ	0.747	-	0.658	0.692	0.658
Pine <5 yr	0.94	0.658	-	1	1
Pine 5-15 yr	0.946	0.692	1	-	1
Pine >15 yr	0.94	0.658	1	1	-

Table 4.7 (Continued)

***Cyanocitta cristata* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.401	0.864	0.64	0.609
SMZ	0.401	-	0.45	0.193	0.151
Pine <5 yr	0.864	0.45	-	0.498	0.45
Pine 5-15 yr	0.64	0.193	0.498	-	1
Pine >15 yr	0.609	0.151	0.45	1	-

***Thryothorus ludovicianus* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.85	0.087	0.065	0.458
SMZ	0.85	-	0.085	0.064	0.531
Pine <5 yr	0.087	0.085	-	0.707	0.227
Pine 5-15 yr	0.065	0.064	0.707	-	0.157
Pine >15 yr	0.458	0.531	0.227	0.157	-

***Pipilo erythrophthalmus* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.036	0.007	0.011	0.007
SMZ	0.036	-	0.27	0.32	0.27
Pine <5 yr	0.007	0.27	-	1	1
Pine 5-15 yr	0.011	0.32	1	-	1
Pine >15 yr	0.007	0.27	1	1	-

***Contopus virens* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.204	0.051	0.113	0.204
SMZ	0.204	-	0.342	0.587	1
Pine <5 yr	0.051	0.342	-	0.743	0.342
Pine 5-15 yr	0.113	0.587	0.743	-	0.587
Pine >15 yr	0.204	1	0.342	0.587	-

Table 4.7 (Continued)

***Baeolophus bicolor* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.507	0.725	0.071	0.507
SMZ	0.507	-	0.27	0.151	1
Pine <5 yr	0.725	0.27	-	0.029	0.27
Pine 5-15 yr	0.071	0.151	0.029	-	0.151
Pine >15 yr	0.507	1	0.27	0.151	-

***Wilsonia citrina* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.006	0.004	0.545	0.102
SMZ	0.006	-	0.803	0.017	0.073
Pine <5 yr	0.004	0.803	-	0.012	0.049
Pine 5-15 yr	0.545	0.017	0.012	-	0.282
Pine >15 yr	0.102	0.073	0.049	0.282	-

***Passerina cyanea* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.095	0.372	0.802	1
SMZ	0.095	-	0.321	0.147	0.067
Pine <5 yr	0.372	0.321	-	0.527	0.321
Pine 5-15 yr	0.802	0.147	0.527	-	0.784
Pine >15 yr	1	0.067	0.321	0.784	-

***Colinus virginianus* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.291	0.291	0.078	0.05
SMZ	0.291	-	1	0.311	0.224
Pine <5 yr	0.291	1	-	0.311	0.224
Pine 5-15 yr	0.078	0.311	0.311	-	0.924
Pine >15 yr	0.05	0.224	0.224	0.924	-

Table 4.7 (Continued)

***Cardinalis cardinalis* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.558	0.647	0.592	0
SMZ	0.558	-	0.259	1	<.0001
Pine <5 yr	0.647	0.259	-	0.309	0
Pine 5-15 yr	0.592	1	0.309	-	0
Pine >15 yr	0	<.0001	0	0	-

***Dendroica pinus* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	1	<.0001	1	0.035
SMZ	1	-	<.0001	1	0.022
Pine <5 yr	<.0001	<.0001	-	<.0001	<.0001
Pine 5-15 yr	1	1	<.0001	-	0.035
Pine >15 yr	0.035	0.022	<.0001	0.035	-

***Dendroica discolor* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.22	0.131	0.184	0.17
SMZ	0.22	-	0.702	0.797	0.848
Pine <5 yr	0.131	0.702	-	0.932	0.848
Pine 5-15 yr	0.184	0.797	0.932	-	0.932
Pine >15 yr	0.17	0.848	0.848	0.932	-

***Vireo olivaceus* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.346	0.002	0	0.003
SMZ	0.346	-	0.005	0.001	0.008
Pine <5 yr	0.002	0.005	-	0.092	0.707
Pine 5-15 yr	0	0.001	0.092	-	0.053
Pine >15 yr	0.008	0.707	0.053	0.003	-

Table 4.7 (Continued)

***Vireo griseus* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.227	0.077	0.554	0.077
SMZ	0.227	-	0.443	0.083	0.443
Pine <5 yr	0.077	0.443	-	0.027	1
Pine 5-15 yr	0.554	0.083	0.027	-	0.027
Pine >15 yr	0.077	0.443	1	0.027	-

***Helmitheros vermivorus* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.109	0.616	0.138	0.278
SMZ	0.109	-	0.189	1	0.494
Pine <5 yr	0.616	0.189	-	0.235	0.494
Pine 5-15 yr	0.138	1	0.235	-	0.539
Pine >15 yr	0.278	0.494	0.494	0.539	-

***Hylocichla mustelina* DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.151	0.005	0.464	0.114
SMZ	0.151	-	0.036	0.476	0.84
Pine <5 yr	0.005	0.036	-	0.017	0.051
Pine 5-15 yr	0.464	0.476	0.017	-	0.377
Pine >15 yr	0.114	0.84	0.051	0.377	-

Icteria virens virens **DPUE**	Cove	SMZ	Pine <5 yr	Pine 5-15yr	Pine >15 yr
Cove	-	0.529	0.211	0.451	0.806
SMZ	0.529	-	0.057	0.757	0.662
Pine <5 yr	0.211	0.057	-	0.094	0.111
Pine 5-15 yr	0.451	0.757	0.094	-	0.54
Pine >15 yr	0.806	0.662	0.111	0.54	-

References

Allen, A. W., Y. K. Bernal, and R. J. Moulton. 1996. Pine plantations and wildlife in the southeastern United States: An assessment of impacts and opportunities. Information andTechnology Report 3, January 1996. U. S. Department of the Interior, National Biological Service, Washington, D. C. 32pp.

Balda, R. P. 1975. Vegetation structure and breeding bird diversity. *In*: pages 59-80 D. R. Smith, technical coordinator. Symposium on management of forest and range habitats for nongame birds. General Technical Report, WO-GTR-1. U. S. Forest Service, U. S. Department of Agriculture.

Barber, D. R., T. E. Martin, M. A. Melchiors, R. E. Thill, and T. B. Wigley. 2001. Nesting success of birds in different silvicultural treatments in southeastern U. S. pine forests. Conservation Biology 15: 196-207.

Bibby, C. J., N. D. Burgess, D. A. Hill, and S. H. Mustoe. 2000. Bird census techniques, second edition. Elsevier. Oxford, UK

Brinson, M. M., B. L. Swift, R. C. Plantico, and L. S. Barclay. 1981. Riparian ecosystems: their ecology and status. FWS/OBS-81/17. Office of Biological Services, U. S. Fish and Wildlife Service, Washington, DC.

Capel, S., B. Carmichael, M. Gudlin, and D. Long. 1994. Wildlife needs assessment: Southeast Region. A report for the Wildlife Management Institute, Washington, D. C. 16pp.

Childers, E. L., T. L. Sharik, and C. S. Adkisson. 1986. Effects of loblolly pine plantations on songbird dynamics in the Virginia Piedmont. Journal of Wildlife Management 50: 406-413.

Conner, R. N. and C. S. Adkisson. 1975. Effects of clearcutting on the diversity of breeding birds. Journal of Foresty 73: 781-785.

Dickson, J. G. and C. A. Segelquist. 1979. Breeding bird populations in pine and pine-hardwood forests in Texas. Journal of Wildlife Management 43: 549-555.

Dickson, J. G., R. N. Conner, J. H. Williamson. 1993. Breeding bird community changes in a developing pine plantation. Bird Populations 1: 28-35.

Dickson, J. G. and M. L. Warren, Jr. 1994. Wildlife and fish communities of eastern riparian forests. Pages 1-31 *in* Riparian Ecosystems in the Humid U. S.: Functions, Values, and Management. National Association of Conservation Districts, Washington, DC.

Dickson, J. G., F. R. Thompson, III, R. N. Conner, and K. E. Franzreb. 1995. Silviculture in central and southeastern oak-pine forests. Pages 245-268 *in* T. E. Martin and D. M. Finch, editors. Ecology and management of neotropical migratory birds. Oxford University Press, New York, NY.

Dickson, J. G. 2001. Wild turkey. Pages 108-121 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Dickson, J. G., W. C. Hunter, D. N. Pashley, P. B. Hamel. 2001. Bird communities of southern forests. Pages 322-349 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Edwards, K.E. 2009. Faunal communities of temporary wetlands of upland and floodplain forests in north Mississippi. Dissertation, Mississippi State University, Mississippi State, Mississippi, USA.

Fisher, R. A. 2000. Width of riparian zones for birds. EMRRP Technical Notes Collection (TN EMRRP-SI-09). U. S. Army Engineer Research and Development Center, Vicksburg, MS.

Franzreb, K. E. 2005. The effects of timber harvesting on neotropical migrants in cove hardwood Forests in the southern Appalachian Mountains. USDA Forest Service, General Technical Report PSW-GTR-191.

Freund, R. J. and W. J. Wilson. 2003. Nonparametric methods. Pages 590-596 *in* B. Holland, editor. Statistical methods. Academic Press, San Diego, California, USA.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience 41: 540-551.

Hair, J.F., Jr., R.E. Anderson, and R.L. Tatham. 1987. Mulitvariate data analysis, second edition. Macmillian, New York, New York, USA.

Halkin, S. L. and S. U. Linville. 1999. Northern Cardinal (*Cardinalis cardinalis*), The Birds of North America Online. Ithaca: Cornell Lab of Ornithology http://bna.birds.cornell.edu.proxy.library.cornell.edu/bna/species/440. Accessed 30 July 2011.

Haney, C. J., 1999. Hierarchical comparisons of breeding birds in old-growth conifer-hardwood forests on the Appalachian plateau. Wilson Bulletin 111: 89-99.

Harmon, M. E. 1982. Decomposition of standing dead trees in the Southern Appalachian Mountains. Oecologia 52: 214-215.

Hatcher, L. 1994. A step-by-step approach to using the SAS® System for factor analysis and structural equation modeling. SAS Institute Inc., Cary, North Carolina, USA.

Hunter, M. A., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice-Hall, Englewood Cliffs, New Jersey, USA

James, F. C. 1971. Ordinations of habitat relationships among breeding birds. The Wilson Bulletin 83(3): 215-236.

Johnston, D. W. and E. P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology 37: 50-62.

Johnson, R. R., L. T. Haight, and J. M. Simpson. 1977. Endangered species vs. endangered habitats: a concept. Pages 68-79 *in* R. R. Johnson and D. A. Jones, editors. Importance, preservation, and management of riparian habitat: a symposium. U. S. Forest Service General Technical Report RM-43.

Johnson, D.E. 1998. Applied Multivariate Methods for Data Analysts. Duxbury Press.

Kilgo, J. C., R. A. Sargent, B. R. Chapman, and K. V. Miller. 1998. Effect of stand width and adjacent habitat on breeding bird communities in bottomland hardwoods. Journal of Wildlife Management 62: 72-83.

Knopf, F. L. 1985. Significance of riparian vegetation to breeding birds across an altitudinal cline. In: R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliot, and R. H. Hamre, technical coordinators. Riparian Ecosystems and their Management: Reconciling Conflict Uses. Technical Report, RM-120. U. S. Forest Service, Ft. Collins, CO 105-111.

Knopf, F. L., R. R. Johnson, T. Rich, F. B. Samson, R. C. Szaro. 1988. Conservation of riparian ecosystems in the United States. Wilson Bulletin 100: 272-284.

Krebs, C. J. 1989. Ecological methodology. Harper and Row, New York, New York, USA.

LaRue, P., L. Belanger, and L. Huot. 1995. Riparian edge effects on boreal balsam fir bird communities. Canadian Journal of Forest Research 25: 555-566.

MacArthur, R H. and J. W. MacArthur. 1961. On bird species diversity. Ecology 42: 594-598.

McCune, B. and J.B. Grace. 2002. Analysis of ecological communities. MjM Software Design, Gleneden Beach, Oregon, USA.

McGarigal, K., S. A. Cushman, and S. Stafford 2000. Multivariate Statistics for Wildlife and Ecology Research. Springer Verlag, New York, New York, USA.

Miller, D. A., T. B. Wigley, K. V. Miller. 2009. Managed forests and conservation of terrestrial biodiversity in the southern United States. Journal of Forestry 107: 197-203.

Mitchell, M. S., S. H. Rutzmoser, T. B. Wigley, C. Loehle, J. A. Gerwin, P. D. Keyser, R. A. Lancia, R. W. Perry, C. J. Reynolds, R. E. Thill, R. Weih, D. White, and P. B. Wood. 2006. Relationships between avian richness and landscape structure at multiple scales using multiple landscapes. Forest Ecology and Management 221: 155-169.

Myers, R.H.. 1990. Classical and modern regression with applications. PWS-KENT, Boston, Massachusetts, USA.

Naiman, R. J., H. Decamps, and M. Pollock. 1993. The role of riaparian corridors in maintaining regional biodiversity. Ecological Applications 3: 209-212.

Niemi, G. J. and J. M. Hanowski. 1984. Relationship of breeding birds to habitat characteristics in logged areas. Journal of Wildlife Management 48: 438-443.

Nolan, V., Jr. 1978. Ecology and behavior of the Prairie Warbler, *Dendroica discolor*. Ornithological Monograph No. 26.

Nolan, V., Jr., E. D. Ketterson, and C. A. Buerkle. 1999. Prairie Warbler, *Dendroica discolor*. No. 455 *in* A. Poole and F. Gill, editors. The Birds of North America. The Birds of North America, Inc., Philadelphia, PA.

Nuttle, T., A. Leisdolf, and L. W. Burger. 2003. Assessing the conservation value of bird communities with Partners in Flight-based ranks. Auk 120:541-549.

Olendorf, R. and S. K. Robinson. 2000. Effectiveness of nest defense in the Acadian Flycatcher *Empidonax virescens*. Ibis 144: 365-371.

Pagen, R. W., F. R. Thompson III, and D. E. Burhans. 2000. Breeding and post-breeding habitat use by forest migrant songbirds in the Missouri Ozarks. The Condor 102: 738747.

Partners in Flight Science Committee. 2005. The Partners in Flight Handbook on Species Assessment, Version 2005. Partners in Flight technical series No. 3. Rocky Mountain Bird Observatory, Brighton, CO.

Perry, R. W., T. B. Wigley, M. A. Melchoirs, R. E. Thrill, P. A. Tappe, and D. A. Miller. 2011. Width of riparian buffer and structure of adjacent plantations influence occupancy of conservation priority birds. Biodiversity Conservation: 20: 625-642.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. USDA Forest Service GTR RM-229. 422pp.

Robbins, C. S., D. K. Dawson, and B. A. Dowell. 1989. Habitat area requirements of breeding birds of the Middle Atlantic states. Wildlife Monograph 103: 1-34.

Roth, R. R. 1976. Spatial heterogeneity and bird species diversity. Ecology 57: 773-782.

Rudnicky, T. C. and M. L. Hunter, Jr. 1993. Reversing the fragmentation perspective: effects of clearcut size and bird species richness in Maine. Ecological Applications 3: 357-366.

Ruth, J. M. 2006. Partners in Flight – U.S. Website. Served by the USGS Patuxent Wildlife Research Center, Laurel, MD, USA. http://www.partnersinflight.org

Samson, F. and F. L. Knopf. 1994. Prairie conservation in North America. BioScience 44(6): 418-421.

SAS Institute Inc. 2004. Base SAS 9.1 Procedures Guide. Version 9.1.2. SAS Institute Inc., Cary, North Carolina, USA.

Shugart, H. H., Jr. and D. James. 1973. Ecological succession of breeding bird populations in northwest Arkansas. Auk 90: 62-77.

Shugart, H. H., S. H. Anderson, and R. H. Strand. 1975. Dominant patterns in bird populations of the eastern deciduous forest biome. Pages 90-95 *in* The management of forest and range habitats for nongame birds symposium. U. S. Department of Agriculture General Technical Report. U. S. Department of Agriculture. U. S. Forest Service, Washington, DC.

Smith, K. G. 1977. Distribution of summer birds along a forest moisture gradient in an Ozark watershed. Ecology 58: 810-819.

Stauffer, D. F. and L. B. Best. 1982. Nest-site selection by cavity-nesting birds of riparian habitats in Iowa. Wilson Bulletin 94: 329-337.

Stevens, L. E., B. T. Brown, J. M. Simpson, and R. R. Johnson. 1977. The importance of riparian habitat to migrating birds. In: R. R. Johnson and D.A. Jones, technical coordinators. Importance, Preservation and Management of Riparian Habitat: A Symposium. General Technical Report, RM-43. U. S. Forest Service. Tucson, AZ 156-164.

Tappe, P. A., R. E. Thill, M. A. Melchoirs, and T. B. Wigley. 1994. Wildlife values of streamside management zones in the Ouachita Mountains, Arkansas. Pages 122-138 *in* Riparian ecosystems in the humid U.S.: functions, values, and management. National Association of Conservation Districts, Washington, DC.

Tassone, J. F. 1981. Utility of hardwood leave strips for breeding birds in Virginia's central Piedmont. M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg. 83pp.

Thompson, F. R., III. and E. K. Fritzell. 1990. Bird densities and diversity in clearcut and mature oak-hickory forest. Research Paper, NC-293. U. S. Forest Service. St. Paul, MN.

Thompson, F. R., III. and D. R. Dessecker. 1997. Management of early-successional communities in central hardwood forests: with special emphasis on the ecology and management of oaks, ruffed grouse, and forest songbirds. USDA Forest Service General Technical Report NC-195.

Thurmond, D. P., K. V. Miller, and T. G. Harris. 1995. Effect of streamside management zone width on avifauna communities. Southern Journal of Applied Forestry 19(4): 166-169.

Walk, J. W. and R. E. Warner. 1999. Effects of habitat area on the occurrence of grassland birds in Illinois. American Midland Naturalist 141: 339-344.

Wigley, T. B. and M. A. Melchiors. 1994. Wildlife habitat and communities in streamside management zones: a literature review for the eastern United States. Pages 100-121 *in* Riparian ecosystems in the humid U.S.: functions, values, and management. National Association of Conservation Districts, Washington, DC.

Wilson, M. F. 1974. Avian community organization and habitat structure. Ecology 55: 1017-1029.

Wilson, C. W., R. E. Masters, and G. A. Bukenhofer. 1995. Breeding bird response to pine-grassland community restoration for red-cockaded woodpeckers. Journal of Wildlife Management 59: 56-67.

Wilson, R. R. and R. J. Cooper. 1998. Acadian flycatcher nest placement: Does placement influence reproductive success? The Condor 100:673-679.

Wilson, M. D. and B. D. Watts. 1999. Response of brown-headed nuthatches to thinning of pine Plantations. Wilson Bulletin 111: 56-60.

Yarrow, G. K. and D. T. Yarrow. 1999. Managing for non-game wildlife. Pages 255-283 *in* G. K. Yarrow and D. T. Yarrow, editors. Managing wildlife: on private lands in Alabama and the Southeast. Sweetwater Press, Birmingham, Alabama, USA.

CHAPTER V

HERPETOFAUNA OF COVE HARDWOOD FORESTS, STEAMSIDE MANAGEMENT ZONES, AND MANAGED PINE FORESTS IN MISSISSIPPI

Introduction

In the southeastern United States, regional populations of many species of amphibians and reptiles are in decline due to loss of natural ecosystems (Gibbons et al. 2000). With expansion of human populations and associated land uses, fragmentation and alteration of natural forests has occurred (Alig and Wear 1992). Intensive land uses, such as urbanization, agriculture, and site conversion associated with production of forest products, can have negative effects on vulnerable wildlife populations, especially species that are sensitive to cover type modifications and increased amounts of edges (Yahner 1988, Murcia 1995). Land uses, such as intensive agriculture and urbanization, cause habitat losses that are typically long term impacts to most native wildlife species; whereas lands dedicated to production of forest products can be managed in a manner that retains habitat quality for many native species of fauna and flora (Wigley et al. 2000). With integrated approaches that consider conservation along with timber production, managed forest lands can provide opportunities for retention and protection of native biological diversity that includes herpetofaunal communities (Wigley et al. 2000). This type of forest management is especially important when considering retention of naturally occurring habitat types and rare biological communities (Ryan et al. 2002).

On industrial forestlands where negative impacts to sensitive habitat are minimized or avoided and a variety of different age classes of forest types are retained, a diversity of habitat types can exist for many wildlife species, including reptiles and amphibians (Seymour et al. 2002, Fox et al. 2004, Shipman et al. 2004, Loehle et al. 2005). Wigley et al. (2000) reported that high species richness can occur within a managed forest landscapes if a variety of habitat conditions exists. However, silvicultural practices can have varying effects on reptiles and amphibians depending on the practices and the adaptations of the species in question. Interspersion of forest types and forest age classes across the landscape can retain refugia for selected amphibian species, such as bufonids and hylids (Bailey et al. 2006). For example, de Maynadier and Hunter (1995) found that managed forested lands proximal to recent clearcut activity supported an abundance of amphibians which was 3.5 times greater within forested stands than clearcut stands.

Intensity of pine plantation management has potential to influence amount and age of forested ecosystems that support biodiversity of climax ecosystems, and this impact is often reported for species that depend on natural, older age class forests (Kramer et al. 1993, de Maynadier and Hunter 1998). Within managed pine landscapes, natural forest types will often harbor threatened or endangered floral and/or faunal communities. Consequently, these habitats are often protected from harvest activity to protect indigenous rare species (Taylor et al. 2005). Such habitat includes riparian forests known as streamside management zones (SMZs), which are retained along rivers and streams within managed pine forests. These forested buffers may be retained with minimal harvest as part of a management strategy to protect water quality from sedimentation and nutrient loads (Martin and Pierce 1980, Hornbeck et al. 1986, Gregory et al. 1991, Castelle et al. 1994). Because riparian areas are often the most biologically

diverse habitat within a landscape, these areas are often characterized by high wildlife abundance and diversity and are important in sustaining ecosystem integrity (Stauffer and Best 1980, Budd et al. 1987, Gregory et al. 1991, Naiman et al. 1993). Specifically, SMZs can be very important in habitat retention for many amphibian species, especially woodland, spring, and streambank salamanders (Hunter 1990, Petranka 1998, Seymour et al. 2002).

A large portion of amphibian and reptile communities of the Southeast are known to be specific to certain ecosystems including mesic coves, bottomland and upland hardwood forest, and naturally occurring pine ecosystems (Gibbons and Buhlmann 2001, Baxley and Qualls 2009). Certain species of amphibians including dusky salamanders (*Desmognathus auriculatus*), southern red salamanders (*Pseudotriton ruber*), three lined salamanders (*Eurycea guttolineata*), and Webster's salamanders (*Plethodon websterii*), and some species of reptiles including ringneck snake (*Diadophis punctatus*, *Lampropeltis triangulum*), and broad-headed skink (*Plestiodon laticeps*), occur in mature and older age class hardwood forests that exhibit standing snags, downed logs and woody debris, rock outcroppings, rich topsoil with a thick leaf litter component, and natural surface water sources (Conant and Collins 1998, Ross et al. 1999). Shaffer and McCoy (1991) reported that loss of these habitat features within natural forest ecosystems can impact populations of forest-dependent, habitat specialists through reduction of forest canopy, changes in forest composition and structure, and changes in microsite conditions of the forest floor (Hunter 1990, Petranka 1998).

Losses of many species of herpetofauna can cause impacts to their species associates and ecosystem structure and function (Burton and Likens 1975). For example, amphibians are among the most plentiful vertebrates in forested ecosystems, and

therefore, occupy important niches in forest communities in terms of biomass and contribution to ecological food webs (Burton and Likens 1975, Hairston 1987, Pough et al. 1987). For example, salamanders, particularly plethodontids, exhibit cutaneous respiration and depend on moist forest floor conditions to retain cutaneous moisture for adequate oxygen transport. These species typically exhibit small home ranges, limited dispersal and movement capabilities and depend on hardwood forests that are characterized by dense overstory canopies, abundant, overlapping leaf litter, and moist substrate conditions (Feder 1983, Hairston 1987, de Maynadier and Hunter 1995).

As with amphibians, reptiles comprise a large proportion of the vertebrate fauna of forests of the southeastern United States. Over 240 species of lizards, snakes, and turtles inhabit forested ecosystems of this region (Conant and Collins 1999). Because of this great diversity, the southeastern United States are important in conservation of these fauna (Lydread and Mayden 1995, Gibbons and Buhlmann 2001). Gibbons et al. (2000) showed that reptile populations, especially habitat specialists, are exhibiting population declines similar to those of amphibians. In contrast to amphibians, reptiles of upland habitats of the southeastern United States are often more adapted to xeric forest types than amphibians (Conant and Collins 1999). Creation of early successional habitat by clearcutting may benefit some species (Campbell and Christman 1982, Greenburg et al. 1994). Ross et al. (2000) showed that snake species diversity increased with decreased basal area, a silvicultural practice commonly achieved through thinning or prescribed burning of mid-rotational pine (Barrett 1995). Other studies showed that a managed forest landscape could support rare species, such as gopher tortoises (*Gopherus polyphemus*), bog turtles (*Glyptemys muhlenbergii*), black pine snakes (*Pituophis*

melanoleucus lodingi), and scarlet kingsnakes (*Lampropeltis triangulum elapsoides*; Conant and Collins 1999, Leiden et al. 1999, Dorcas 2005).

Reptiles and amphibians may exhibit a variety of responses to different forest management practices (Leiden et al. 1999). These responses depend, in part, on factors such as scale, intensity, and types of forest management and the adaptations and life requirements of the specific species or taxonomic group. Furthermore, Renken et al. (2004) reported that timber harvest activities generally affected herpetofauna communities at a local scale, and that effects were not evident over an entire landbase. Plantation forestry that creates an interspersion of forest age classes and retains natural forests in streamside management zones, wetlands, and unique areas can support a diversity of amphibians and reptiles (Wigley et al. 2000). To date, few studies have examined the cumulative herpetofaunal diversity that may be supported by unique areas, such forested coves, SMZs, and multiple age classes of pine plantations on the same landscape. Furthermore, few studies have estimated community similarities between these habitat types within the same study period. This information can enhance our understanding of species occurrence and diversity within and among these different habitats. Greater understanding of uniqueness and contributions of these different habitat types to landscape level biodiversity can be important in integration of commercial forest management with conservation of herpetofauna on timber industry lands. To advance our knowledge of these topics, I investigated herpetofaunal diversity in different habitat types of the Old Cove Area in Webster County, MS.

Specific objectives of this chapter include the following:

1.) Measure and report species richness, abundance, and community similarity of herpetofaunal communities in coves, SMZs, and 3 age classes of managed

pine plantations to ascertain total diversity of herpetofaunal communities of the Old Cove Area on Weyerhaeuser Company lands in central Mississippi.

2.) Estimate and compare species richness and abundance of amphibians and reptiles between cove and SMZ habitats and 3 age classes of pine plantations.

3.) Estimate species richness and abundance of reptiles and amphibians in the dendritic drainages of Magnolia and Old Coves.

4.) Estimate relationships between species richness and abundance of amphibians and reptiles and habitat conditions in 5 different habitat types.

Study Area

I conducted field experiments on 14 forest stands located within Weyerhaeuser's Old Cove property in Webster county, north-central Mississippi. These 14 stands consisted of 3 young pine stands < 5 years of age (7755, 7754, 85869), 2 unthinned pine stands 5 to 15 years of age (7187, 8170), 5 thinned pine stands > 15 years of age (7972, 118164, 8217, 8480), 3 SMZ stands (7557, 7683, 7961) and 2 of the special interest areas, Old Cove and Magnolia Cove (Table 2.2). All pine stands were planted pine plantation and the mature mesic hardwood stands had been set aside and labeled "special place" by Weyerhaeuser for ecological research and conservation purposes. Additional details regarding study site location and habitat description are provided in Chapter II.

Methods

Amphibian and reptile data were collected from fall 2008 through summer 2009 using area-constrained searches (ACS) within designated belt transects positioned perpendicular to line transects intersecting each research stand (Figure 2.2). All data were collected obtained within the perimeter of each belt transect using methods described by

Welsh (1987) and Jaeger and Inger (1994). Data were obtained from 5 survey periods (146 surveys per period) on all stands (Table 2.2). Additional information on field methods is described in Chapter II.

Statistical Analysis

Analyses focused on comparisons of herpetofaunal communities among forest types and estimation of relationships between faunal responses and independent explanatory variables associated with habitat conditions measured in each forest type. Faunal response variables included species richness and abundance of amphibians and reptiles and individual species abundance based on catch per unit effort (CPUE). Species richness was calculated as total number of species at each study site detected by area searches along established transects for herpetofauna. Sampling effort varied by site due to an unequal number of stands representative of the age classification requirements, weather-related disturbances and management practices which restricted sampling and variable site access (i.e., forest management activities, flooding), numbers of animals counted were standardized using CPUE (Fogarty 2005, Edwards 2009) to adjust for differences in sampling intensity among sites as follows:

$$\text{CPUE} = \frac{\text{Total number of captured individuals per habitat type}}{\text{Number of sites representing the habitat type}} \tag{5.1}$$

All hypotheses were investigated at a significance level of $\alpha = 0.05$:

1. H_0: Species richness and abundance (CPUE) of herpetofauna will be similar between SMZs and coves and 3 age classes of pine plantations.

   H_1: Species richness and abundance (CPUE) of herpetofauna will differ between SMZ and cove habitat types and 3 age classes of pine plantations.

2. H_0: Species richness and abundance (CPUE) of herpetofauna will be similar for dendritic drainages of the selected cove sites.

   H_1: Species richness and abundance (CPUE) of herpetofauna will differ for dendritic drainages of the selected cove sites.

3. H_0: Species richness of amphibians and/or reptiles will not be influenced by habitat conditions measured in different habitat types.

   H_1: Species richness of amphibians and/or reptiles will be influenced by habitat conditions measured in different habitat types.

4. H_0: Abundance of herpetofauna (CPUE) and abundance (CPUE) of selected species of herpetofauna will not be related to habitat conditions measured in the different forest types.

   H_1: Abundance of herpetofauna (CPUE) and abundance (CPUE) of selected species of herpetofauna will be related to habitat conditions measured in the different habitat types.

Comparisons among Habitat Types

I conducted an analysis of variance (PROC GLM, SAS 9.2) to determine differences in species richness and detection rates of herpetofauna among SMZ and cove sites (Freund and Wilson 2003). Herpetofaunal communities of dendritic drainages within cove sites was compared using Kruskal-Wallis test (PROC NPAR1WAY, SAS 9.1) to determine if abundance of individuals varied significantly between cove sites (Conover 1980). Data was examined for normality using Shapiro-Wilk tests prior to analysis (PROC UNIVARIATE, SAS 9.2; Royston 1992). All tests were considered significant at $P \leq 0.05$. If significant results were found, the Least-square means/PDIFF

procedure was used to determine multiple comparisons between sites (Freund and Wilson 2003).

Community Similarity

Renkonen's Index was used to quantify similarity of herpetofaunal communities among pine plantations, SMZs, and coves (Krebs 1989). The index is a percentage similarity index defined as $P = \sum \text{minimum}\ (p_{1i}, p_{2i})$; where, P = percentage similarity between habitat 1 and habitat 2; p_{1i} = percentage of species i in habitat 1; p_{2i} = percentage of species i in habitat 2. Renkonen's Index can be viewed as a scale from 0 (no similarity between habitat types) to 100 (complete similarity between habitat types; Krebs 1989). Similarity indices were derived using taxonomic class of fauna separately using species pooled across 2 taxonomic classes: Reptilia and Amphibia. Community similarity indices derived for each class were reported and compared qualitatively and quantitatively through comparisons of percentage of similarity or difference of communities among habitat types (Krebs 1989).

Multiple Linear Regression

For modeling, study sites of each habitat type were considered experimental units (n=13). Faunal response variables included species richness and abundance of amphibians and reptiles and individual species abundance standardized by CPUE. Individual species with <20 individuals detected across all study sites were not evaluated in regression analyses (Edwards 2009). Included 26 of the 38 habitat variables as reported in Chapter 3 analyses that were averaged or summed by site based upon vegetation data collected during summer, 2008 (Table 3.1). All data were examined for normality using the Shapiro-Wilk test (PROC UNIVARIATE, SAS 9.2) and transformed when necessary

using square-root transformations for count data and arcsine square-root transformations for percentage data (Royston 1992).

Estimation of relationships between independent habitat variables and dependent response variables, herpetofauna species richness and abundance, was a multiple-step process. I used data reduction techniques to eliminate explanatory variables that were similar among study sites or highly correlated with one another (Johnson 1998). First, I used Principal Components Analysis (PCA) to reduce the habitat data set to a smaller number of variables that limited amount of redundancy among variables and represented most of the variation in habitat characteristics among study sites (PROC PRINCOMP, SAS 9.1; McCune and Grace 2002). Significant axes were determined by Kaiser's criterion where components with an eigenvalue >1 were retained and interpreted (Hatcher 1994; McCune and Grace 2002). Within each component, variables with eigenvector loadings >0.27 and <-0.27 were considered meaningful. This method allowed for selection of variables that represent approximately 10% of the variance explained by that axis (Hair et al. 1987, McGarigal et al. 2000).

Next, I used habitat variables reduced by PCA to develop models for amphibian and reptile species richness and abundance CPUE using multiple linear regression (PROC REG, SAS Institute 1999, McCune and Grace 2002). Prior to regression analysis, habitat variables were examined for collinearity using Pearson correlation coefficients, and variables with coefficients of > 0.75 were evaluated as candidates for exclusion from analysis. If 2 variables exhibited collinearity, final variable inclusion involved determination of variables of greatest biological significance for the specified taxonomic group as reported by Conant and Collins (1998), Bailey et al. (2006) and Petranka (1998). I then used stepwise linear regression (to identify variables that were

related to amphibian and reptile species richness and abundance (SAS Institute 1999, McCune and Grace 2002).

Herpetofauna Results

Area-Constrained Searches (ACS)

Surveys resulted in detection of 20 species comprised of 278 individuals over all study sites including 40 anurans (7 species), 132 salamanders (4 species), 16 snakes (4 species), 87 lizards (4 species), and 3 turtles (one species). Amphibians accounted for 172 individuals (62% of detections) and reptiles accounted for 106 individuals (38% of detections). Of the detected herpetofauna, 8 amphibians were not identified to species due to life stage or premature escape. Un-identified species included 2 ranids (*Rana* spp.) in SMZ, and 2 streamside salamanders (*Eurycea* spp.) and 4 larvae in the hardwood coves (Table 5.1 and 5.2).

Hardwood coves resulted in 13 species comprised of 124 individuals. Amphibians (8 species) accounted for 104 individuals (84% of detections) and reptiles (5 species) accounted for 20 individuals (16 % of detections). SMZs resulted in 13 species comprised of 90 individual. Amphibians (9 species) accounted for 57 individuals (63 % of detections) and reptiles (5 species) accounted for 33 individuals (37 % of detections). Pine stands of <5 years of age resulted in 3 species comprised of 5 individuals, all of which were reptiles. Pine stands >5-15 years of age resulted in 6 species comprised of 10 individuals. Amphibians (2 species) accounted for 2 individuals (20% of detections) and reptiles (4 species) accounted for 8 individuals (80% of detections). Pine stands >15 years of age resulted in 12 species comprised of 49 individuals. Amphibians (5 species)

accounted for 9 individuals (18% of capture) and reptiles (7 species) accounted for 40 individuals (82% of detections, Table 5.3).

Coves and Streamside Management Zones

Species richness of amphibians was similar between coves and SMZs ($F_{1,23}$ = 0.21, P = 0.65; Appendix B.1). Although species richness was similar between coves and SMZs, coves supported a greater abundance of amphibians than SMZ habitats ($F_{1,23}$ = 8.15, P = 0.09; Appendix B.1).

Species richness of reptiles was similar between coves and SMZs ($F_{1,23}$ = 0.06, P = 0.81; Appendix B.2). Reptile abundance also was similar between habitat types ($F_{1,23}$ = 0.58, P = 0.456; Appendix B.2).

Pine Plantation Habitats

Species richness of amphibians differed among the pine stands ($F_{1,23}$ = 3.54, P = 0.04; Appendix B.3). Pine stands >15 years had the greatest number of amphibian species. However, species richness of amphibians was similar to that of pine 5-15 years. Pine stands <5 years exhibited fewer species than >15 year and 5-15 year pine stands. Amphibian abundance differed significantly among the pine stands ($F_{1,23}$ = 3.38, P = 0.045; Appendix B.3). Pine stands >15 years had the greatest abundance of amphibians, and was similar to that of 5-15 year pine stands.

Species richness of reptiles differed among the pine stands ($F_{1,23}$ = 6.24, P = 0.01; Appendix B.4). Species richness of reptiles in pine plantations <5 years differed significantly from pine plantations of >15 years and 5-15 years of age. Reptile abundance differed among the pine stands. Pine plantations >15 years exhibited the greatest

abundance of reptiles ($F_{1,23}$ = 10.57, P = <0.001; Appendix B.4). Reptile abundance was similar in pine stands 5-15 years and <5 years of age.

Dendritic Drainages of Coves

ACS within dendritic drainage of coves resulted in 13 species of herpetofauna comprised of 99 individuals. Amphibians (8 species) accounted for 75 individuals (75.80 % of detections) and reptiles (4 species) accounting for 24 individuals (24.20 % of detections). Dendritic drainages yielded 8 species of amphibians and 2 species of reptiles totaling 53 individuals. Amphibians accounted for 46 individuals (86.80 % of detections) with reptiles accounting for 7 individuals (13.20 % of detections). Dendritic drainages of the Magnolia Cove resulted in 5 amphibian and 3 reptile species totaling 46 individuals. Sixty-three percent of the detections were amphibians and 37% were reptiles (Table 5.5).

Comparisons of numbers of detected reptiles and amphibians in the 2 coves indicated Magnolia Cove supported greater abundance of 2 species: Spotted dusky salamanders (*Desmognathus auriculatus;* χ^2= 4, df=1, P = 0.045), and Mississippi ringneck snakes (*Diadophis punctatus stictogenys;* χ^2= 4, df=1, P = 0.045).

Anuran Call Counts

Although data from anuran call count surveys were not included in statistical analyses, 2 species were heard vocalizing within coves, 4 species within SMZs, one within <5 year pine stands, 2 species within 5-15 year pine stands, and 2 species within >15 year pine stands. Two additional treefrog species, green treefrog (*Hyla cinerea*) and bird-voiced treefrog (*H. avivoca*), were detected using anuran call counts but were not detected during ACS (Table 5.6).

Community Similarity Indices

Renkonen Index values showed that 54 % to 60 % of the herpetofaunal communities were similar between pine stands of < 5 years of age and older age class pine. Communities of 5-15 year old and > 15 year old pine stands were most similar among pine communities with 78 % of species occurring in both stand types. Herpetofaunal communities of SMZs and coves exhibited a similarity of 53 % (Table 5.7).

Stepwise Linear Regression and Model Reduction

Amphibian Models

Response variables included in stepwise linear regression for amphibian species richness, amphibian abundance, and individual abundance were SRC, USR, mean percent coverage of bare ground/1.5 m^2 (BG), LDC, SC, UVC, MS, LL, HL, OP, and mean snag decay class (SD; Table 3.6).

Amphibian Species Richness. The model contained 4 variables, UVC, USR, SD, and LL (R^2 = 0.97; Table 5.8). Amphibian species richness was associated negatively with UVC (β-hat = -0.08, SE = 0.01, F = 79.46, df = 4,8, P = <0.01) and LL (β-hat =-0.02, SE = 0.07, F = 8.63, df = 4,8, P = 0.02), and associated positively with USR (β-hat =0.14, SE = 0.04, F = 15.78, df = 4,8, P = <0.01) and SD (β-hat =0.51, SE = 0.11, F = 23.12, df = 4,8, P = <0.01).

Amphibian CPUE. The model contained 2 variables, UVC and OP (R^2 = 0.89; Table 5.8). Abundance was associated negatively with UVC (β-hat = -0.02, SE = <0.01, F = 23.50, df = 2,10, P = <0.01) and OP (β-hat = -0.01, SE = <0.01, F = 26.41, df = 2,10, P = <0.01).

Relationships between abundance of selected amphibian species and habitat variables were evaluated, and significant models were derived for 2 species, three-lined salamander *(Eurycea guttolineata)* and Mississippi slimy salamander *(Plethodon mississippi*; Table 5.9). Model contained one variable, OP, which had a negative association with abundance (R^2 = 0.67; β-hat = <-0.01, SE = <0.01, *F* = 21.99, df = 1,11, *P* = <0.01). Significant model for slimy salamander contained 5 variables: MS, OP, UVC, SC, and LDC (R^2 = 0.98; Table 5.8). Abundance had a negative association with MS (β-hat = -0.03, SE = 0.01, *F* = 6.25, df = 5,7, *P* = 0.04), OP (β-hat = <-0.01, SE = <0.01, *F* = 42.56, df = 5,7, *P* = <0.01), and UVC (β-hat = -0.01, SE = <0.01, *F* = 24.21, df = 5,7, *P* = <0.01). Abundance had a significant positive association with SC (β-hat = 0.07, SE = 0.02, *F* = 10.76, df = 5,7, *P* = 0.01) and LDC (β-hat = 0.14, SE = 0.04, *F* = 9.76, df = 5,7, *P* = 0.02).

Reptiles Models

Explanatory variables included in the full model for stepwise linear regression of reptile species richness, reptile abundance, and individual species capture rates were USR, BG, LDC, SC, MS, LL, HL, SD, MV, and mean midstory tree/shrub height (>1 m height, <6 m height; MH; Table 3.6).

Two significant models were developed for reptile abundance and abundance of ground skinks (*Scincella lateralis*; Table 5.8). The model contained one variable, USR, which was associated positively with reptile abundance (CPUE; R^2 = 0.67, β-hat = 0.03, SE = 0.01, *F* = 22.59, df = 1,11, *P* = <0.01). Abundance of ground skinks was positively related to USR (R^2 = 0.63, β-hat = 0.02, SE = 0.01, *F* = 19.03, df = 1,11, *P* = <0.01).

Discussion

Habitats of coves and SMZs supported the greatest species richness and abundance of herpetofauna. Although species richness was similar between the 2 habitat types, abundance of animals differed. Of these habitat types, amphibian abundance was greatest in hardwood coves whereas reptile abundance was greater in SMZs. Greater richness and numbers of salamander species were detected in cove habitats. According to my models, variation in herpetofaunal communities among the different habitat types of the Old Cove Property was potentially influenced by characteristics, including standing and downed deadwood, forest floor conditions, and forest composition and structure. However, presence of surface water and moist soil conditions associated with streams was probably a primary influence on presence of amphibians and aquatic reptiles in these habitats. Transects of coves and SMZs were associated with surface water of streams that provided habitat for aquatic reptile species and moist microsite conditions for amphibians. My findings are in concurrence with Taylor et al. (2005) who reported importance of riparian habitat protection through establishment of SMZs. Similarities in species richness between cove and SMZ habitats indicated that herpetofaunal species richness conservation can occur within SMZs, and this richness can enhance landscape-level biodiversity on timber industry or other multiple use lands (Taylor et al. 2005). Although SMZs are generally retained as part of a management strategy to protect water quality from sedimentation and nutrient loading, these areas can be very important due to their biologically diverse communities (Castelle et al. 1994, Gregory et al. 1991, Hornbeck et al. 1986, Martin and Pierce 1980). My findings indicated that these habitats were especially important for salamanders and many frog species. Others have reported importance of forested buffers associated with wetlands, springs, and streams as refugia

for amphibians and many reptiles within managed forest landscapes (Greenberg 2002, Iglay 2010, Seymour et al. 2002).

Although herpetofaunal species richness was similar between coves and SMZs, abundance of selected amphibians was greater in cove habitats. Cove habitats exhibited specific habitat conditions that fulfill life requirements of many amphibian species. Closed canopy hardwood forests, permanent surface water of streams and springs, and in channel stream features, such as bottom substrates with abundant rocks, leaf litter, and woody debris, were features present in coves that have been reported to favor amphibians, especially salamanders (Petranka 1998). Other studies have reported streams of hardwood forests to be important habitat for woodland salamanders, dusky salamanders, and streambank salamanders (Petranka 1998, Ryan et al. 2002, Seymour et al. 2002). I detected greatest abundance of two-lined and three-lined salamanders (*E. bislineata*, *E. longicauda guttolineata*) in cove habitats, and in streams of coves, I recorded evidence of reproduction, including larvae and egg masses of two-lined salamanders. I suggest that streams of coves are important breeding areas for two-lined salamanders and may be important in retaining populations of this species on the Old Cove property. Presence of streams with sandy or rocky bottom substrates could explain presence of adult, larvae, and egg masses of northern two-lined salamander in cove streams, because this species requires constant slow flowing water with rock and stone substrate that provides oxygenated waters, escape cover, ample invertebrate foods, and substrate for egg attachment (Minshall 1984, Barr and Babbitt 2002).

Although other salamander species, such as slimy salamanders, were detected in SMZs and older pine forests, recorded numbers of this salamander species were greatest in cove hardwood forests. Coves exhibited wider corridors of riparian deciduous forests

that provided more interior forest conditions, such as moist microsites on the forest floor and undisturbed streams and seepages. According to Petranka (1998), these conditions are requirements of these species. Furthermore, these larger forest corridors with adequate habitat conditions may be important in maintaining the current species richness of salamanders on the Old Cove Area (Petranka 1998, Ross et al. 1999). Similar findings were reported by Gibbons and Buhlmann (2001) who reported that certain species of salamanders, lizards, and snakes depended on mature and older age classes of hardwood forests. Also, I detected spotted dusky salamanders associated with seepages and drainages of coves. Spotted dusky salamanders were detected in dendritic drainages of Magnolia Coves and found nowhere else on the Old Cove property. Seepages and springs embedded with mature deciduous forests are considered important features for dusky salamanders (Conant and Collins 1998, Gibbons and Buhlmann 2001, Ross et al. 1999). Detection of dusky salamanders is significant from a herpetofaunal diversity standpoint because of the limited numbers of documented detections in this region of Mississippi (Fogary and Jones 2005). Although within the distributional range of dusky salamanders, studies of herpetofaunal communities on public forest lands in Winston, Noxubee, and Choctaw counties, Mississippi have failed to detect dusky salamanders in recent years despite presence of adequate habitat conditions (Conant and Collins 1990, Edwards 2009, Fogarty and Jones 2005). Other conditions of coves that are important for salamanders and selected frog species included abundant snags and downed woody debris, rich topsoil with a thick leaf litter component, and rock outcroppings. Shaffer and McCoy (1991) reported that loss of these habitat characteristics within forests can impact populations of forest-dependent, habitat specialists through reduction of forest canopy, changes in forest composition and structure, and changes in microsite conditions of the forest floor.

Pine plantations exhibited a greater abundance of reptiles than amphibians. This trend could have been due to the lack of surface water sources and presence of xeric soil conditions related to topographic position and forest stand conditions. In contrast to most amphibians, reptiles of upland habitats of the Southeast are more adapted to xeric habitat types (Conant and Collins 1990, Bailey et al. 2006). Because reptiles depend less on water sources and moist microsite conditions, open canopy conditions of pine plantations may stimulate conditions which provide more basking sites for thermal regulation, sun exposure and warmth for egg incubation, and greater coverage of plants that support more invertebrate and vertebrate food sources (Bailey et al. 2006). In my study, forest floor conditions of SMZs, coves, and pine plantations supported good litter conditions for support of reptiles that forage in leaf litter and woody debris. Hardwood leaf litter was most predominant in cove and SMZ forests. However, leaf litter comprised primarily of pine needles was present in older age class pine plantations. Coniferous and deciduous leaf litter appeared to support ground skinks which were the most abundant reptile in most habitat types. My findings were similar to other studies that have reported that reptiles are better adapted for exploiting early successional habitats, including pine plantations and SMZs interspersed within managed pine plantations (Campbell and Christman 1982, Greenburg et al. 1994). For example, studies have indicated that snake species diversity may increase in areas where thinning or prescribed burning of mid rotational pine was implemented (Barrett 1995, Iglay 2010). However, other studies documented some reptile species, such as broad headed skinks and ring neck snakes, depend on conditions present in mature, deciduous forests (Fitch 1975). Renken et al. (2004) reported that timber harvest activities typically affected reptile and amphibian

communities at a local scale with responses by specific species and groups depending on life requirements of the affected species.

Results from Renkonen's Index indicated high herpetofaunal community similarity btween the 2 older age class pine plantation types. Greatest similarity occurred between 5-15 year pine and >15 year pine, with a herpetofaunal community similarity of 78.6%. Comparisons between <5 year pine and 5-15 year pine plantations exhibited community similarities of 60% and 54.3%, respectively. In addition, comparison between cove and SMZ herpetofaunal communities had a relatively high community similarity of 53.5%. High similarity of herpetofauna communities among thinned pine stand types can be accredited to similarity of reptile species captured in these habitats. Among the pine habitat types, 3 species of reptiles, ground skink, five-lined skink, and green anole (*Anolis carolinensis*), were detected frequently in older age class pine plantations. Iglay (2010) reported similar reptile communities among pine plantations in a central Mississippi study that addressed fire and herbicide management within planted pine forests. Differences in community similarity between cove and other habitat types can be attributed primarily to the differences in species and abundance of salamander species and selected anuran species. Bronze frogs (*Lithobates clamitans*), spring peepers (*Pseudacris crucifer*), narrow mouth toads (*Grastrophryne carolinensis*), and northern cricket frogs (*Acris crepitans*) were anurans that were detected in coves in greater numbers than in other habitat types. In SMZs, 5 frog species were detected including bronze frogs, southern leopard frogs (*L. utricularia*), eastern narrowmouth toads, Cope's gray tree frogs (*Hyla chrysoscelis*), and Fowler's toads (*Anaxyrus fowleri*). Anuran species, such as Fowler's toads, which are adapted to dryer site conditions, were detected more commonly in SMZs and older age class pine plantations. Fowler's toads, northern

cricket frogs, leopard frogs, and spring peepers were detected in > 15 year old pine plantations. Of the habitat types investigated, pine plantations of < 5 years and > 5 – 15 years of age supported the fewest species of amphibians. Forest stand conditions and lack of pooled surface water as well as other habitat conditions may have influenced presence of amphibian species in these habitat types.

According to Wigley et al. (2000), plantation forestry that creates an interspersion of forest age classes and retains natural forests in SMZs, wetlands, and unique areas, can support a diversity of amphibians and reptiles, and results of my study support these conclusions. Of the 2 classes of herpetofauna, reptiles were more widely distributed in 4 habitat types. Aquatic reptile species were more abundant in coves and SMZs, and this trend was probably due to presence of surface water in these habitat types. Amphibians were detected more commonly in cove and SMZ habitats and these habitat had the greatest species richness and abundance of amphibians. Presence of water in streams and drainages and forest cover conditions were primary reasons for more diverse amphibian communities in these habitat types (de Maynadier and Hunter 1995, Feder 1983, Hairston 1987). Of the habitat types studied, coves supported greatest number of species and abundance of amphibians. Abundance of amphibians was greatest in cove habitats compared to SMZs. However, species richness was similar between the 2 site types. This information is important from a biological perspective as it relates to conservation of biological diversity of amphibians (Gibbons and Buhlmann 2001, Schaffer and McCoy 1991). Although some anuran species occurred in cove, SMZ, and > 15 year pine plantations, salamanders and selected frog species were detected in greater numbers in hardwood-dominated cove forests, and drainages and seepages along slopes of coves supported dusky salamanders which are rarely detected in central Mississippi.

My findings are similar to those reported by Gibbons and Buhlmann (2001) and Petranka (1998). For example, according to Petranka (1998), interspersion of seepages, springs, moist drainages, and streams within cove forests created high quality habitat for amphibians that require moist microsite conditions of mature closed canopy forests of riparian areas. Salamanders detected in our study were usually associated with deciduous leaf litter and downed woody debris of edges and channels of springs, seepages, or streams. Because of size of cove forests and their association with undisturbed seepages, springs, and streams, I believe that these habitats are very important to retention of streambank and woodland salamanders on the Old Cove property. Because larvae of *Eurycea* spp. were detected in streams of coves, I also believe that cove habitats are important in the reproduction cycles of these salamanders. Of the salamanders detected, Mississippi slimy salamanders were most widely distributed across cove, SMZ, and older pine types. However, abundance of slimy salamanders were greater in sites with moist microsites even within older age class pine plantations, so practices that favor retention of undisturbed drainages that support moist forest floor conditions could benefit this salamander species (Bailey et al. 2006). I submit that SMZs within pine plantation habitats may be especially important for anurans and salamander species that have more general habitat requirements than forest interior species (Bailey et al. 2006).

Presence of pooled surface water potentially influenced presence of and my ability to detect amphibians in all habitat types. However, other habitat features that created xeric habitat conditions cannot be excluded in terms of importance to amphibians. I submit that most amphibians detected in my study benefitted from shady conditions of midstory and overstory vegetation, moist forest floor microsite conditions, abundant woody debris and downed logs, and presence of unpolluted surface water (Bailey et al

2004). In my study, at least one salamander species was influenced negatively by number of pines in the overstory. I believe that this association is related to availability of moist soil conditions and perhaps other soil chemistry parameters that I did not measured.

I submit that retention and protection of SMZs and hardwood forests of coves can help support a greater biological diversity of amphibians and selected reptile species on the Old Cove property. Habitat for many species of herpetofauna can be preserved or enhanced by meeting or exceeding state recommended best management practices (BMPs) developed by Mississippi. Expansion of SMZ widths, limiting forest disturbance, and protection of streambanks from disturbance that can lead to erosion and destabilization are measures which could benefit herpetofauna of the Old Cove property (Bailey et al. 2006). Increasing connectivity between SMZs and coves that result in creation and maintenance of corridors for movement and dispersal also could benefit genetic and species diversity of herpetofauna on the Old Cove property (Bailey et al. 2004). Based on my findings, retention of cove forests and SMZs is important for amphibian conservation, especially salamander species that used these habitats for reproduction on Old Cove Area. Magnolia and Old Coves were transected by streams, seepages, and dendritic drainages, embedded within closed canopy deciduous forests that provide quality forest floor conditions for these species (Bailey et al. 2004, Petranka 1998). These habitat conditions also are present on lower slopes of Shelton Mountain near Pryor Creek drainage.

Recommendations for Future Studies

Survey methods used in my study were designed to capture herpetofauna during a timeframe when they were active. Use of ACS at 2-month intervals increased probability

that each site was inspected during each season. This approach allowed for possibility of capturing species that were active during a specific season. Due to the fossorial life habits of many reptile and amphibian species, year round surveys are necessary to detect species of the herpetofauna community (Conant and Collins 1998). Use of multiple technicians during ACS allowed for the potential to find most active amphibians and reptiles for that particular season. Some bias associated with ACS was evident in my study with low capture rates occurring in areas that were difficult to search. For example, lesser detection rates of some animals within <5 year pine plantations may have been due to the ability to effectively search within established belt transects. Dense understory dominated by blackberry thickets and greenbriar prevented time effective detection of some herpetofaunal species due to proximity of abundant escape cover. Seasonal migration or high mobility of many herpetofauna species could have made them harder to detect, possibly attributing to low capture rates (Smith and Petranka 2000). Additionally, the inability to move and search under large logs could have inhibited my ability to effectively detect all individuals present. Species that were commonly detected tended to be species that exhibited secrecy with little movement. Use of a drift fence array with pitfall traps would have potentially allowed for greater capture rates of mobile species such as snakes, frogs, and toads (Fogarty and Jones 2003). For future studies, I would recommend use of multiple survey methods including area searches, drift fence arrays with pitfall traps, and some form of anuran call counts to detect multiple species that could be present across habitat types. This approach would potentially allow for capture of species that exhibit breeding pulses and weather-dependent activity or movement patterns (Edwards 2009). Burrowing anurans, such as Spadefoot toads (Scaphiopus sp.) and narrowmouth toads (Gastrophryne sp.) would be more readily detected using a

multiple method approach to sampling (Edwards 2009). Although multiple sampling methods can often detect more species within the community, pit fall trapping may result in high mortality of captured animals. Therefore, special within trap structures and inspection of traps twice daily is recommended for reduction of mortality in captured amphibians, reptiles, and small mammals (Edwards 2009)

Table 5.1 Amphibian species and mean numbers of individuals detected in 5 stand types of the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

		Sample Periods											
Site	**Species**	**Jan-Feb**		**March-April**		**May-June**		**July-Aug**		**Nov-Dec**		**Total Amphibians**	
Coves	**Frogs/Toads**	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean
	Bronze Frog *Lithobates clamitans clamitans*	0	0	0	0	4	0.15	0	0	1	0.04	5	0.038
	Eastern Narrowmouth Toad *Gastrophryne carolinensis*	0	0	0	0	1	0.04	0	0	0	0	1	0.008
	Northern Cricket Frog *Acris crepitans*	0	0	0	0	0	0	1	0.04	0	0	1	0.008
	Spring Peeper *Pseudacris crucifer*	0	0	1	0.04	0	0	0	0	0	0	1	0.008

Table 5.1 (Continued)

Site	Species	Sample Periods											
		Jan-Feb		March-April		May-June		July-Aug		Nov-Dec		Total Amphibians	
Cove	**Salamanders**												
	Central Newt *Notophthalmus viridescens louisianensis*	0	0	0	0	0	0	1	0.04	0	0	1	0.04
	Mississippi Slimy Salamander *Plethodon mississippi*	6	0.23	6	0.23	5	0.19	11	0.42	4	0.15	32	0.246
	Northern Two-lined Salamander Eurycea bislineata	10	0.38	3	0.12	6	0.23	10	0.38	7	0.27	36	0.277
	Stream Salamander *Eurycea* spp.	0	0	0	0	0	0	2	0.08	0	0	2	0.08
	Three-lined Salamander *Eurycea guttolineata*	3	0.12	0	0	1	0.04	13	0.5	4	0.15	21	0.162
	Unknown Larvae	0	0	0	0	0	0	4	0.15	0	0	4	0.031
	Total Amphibians	19	0.73	10	0.38	17	0.65	42	1.61	16	0.7	104	

Table 5.1 (Continued)

		Sample Periods											
Site	**Species**	**Jan-Feb**		**March-April**		**May-June**		**July-Aug**		**Nov-Dec**		**Total Amphibians**	
Streamside Management Zone	**Frogs/Toads**	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean
	Bronze Frog *Lithobates clamitans clamitans*	0	0	2	0.07	4	0.13	4	0.13	0	0	10	0.067
	Cope's Grey Treefrog *Hyla chrysoscelis*	0	0	0	0	0	0	1	0.03	0	0	1	0.007
	Fowler's Toad *Anaxyrus fowleri*	0	0	2	0.07	3	0.12	1	0.03	0	0	6	0.027
	Northern Cricket Frog *Acris crepitans*	0	0	1	0.03	1	0.03	0	0	1	0.03	3	0.02
	Southern Leopard Frog *Rana utricularia*	0	0	0	0	0	0	0	0	1	0.03	1	0.007
	Spring Peeper *Pseudacris crucifer*	0	0	0	0	0	0	1	0.03	1	0.03	2	0.013
	True Frog *Lithobates* spp.	0	0	0	0	0	0	0	0	2	0.07	2	0.013
	Salamanders												
	Mississippi Slimy Salamander *Plethodon mississippi*	5	0.17	6	0.2	3	0.1	9	0.3	3	0.1	26	0.173
	Three-lined Salamander *Eurycea guttolineata*	0	0	3	0.1	2	0.07	0	0	1	0.03	6	0.04
	Total Amphibians	5	0.17	14	0.47	13	0.43	16	0.53	9	0.3	57	

Table 5.1 (Continued)

		Sample Periods											
Site	**Species**	**Jan-Feb**		**March-April**		**May-June**		**July-Aug**		**Nov-Dec**		**Total Amphibians**	
Pine Plantation (5-15 years)	**Frogs/Toads**	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean
	Spring Peeper *Pseudacris crucifer*	0	0	0	0	0	0	0	0	1	0.05	1	0.01
	Salamander												
	Mississippi Slimy Salamander *Plethodon mississippi*	0	0	0	0	0	0	0	0	1	0.05	1	0.01
	Total Amphibians	0	0	0	0	0	0	0	0	2	0.1	2	
Pine Plantations (>15 years)	**Frogs/Toads**												
	Fowler's Toad *Anaxyrus fowleri*	0	0	0	0	0	0	1	0.03	0	0	1	0.005
	Northern Cricket Frog *Acris crepitans*	1	0.03	1	0.03	0	0	0	0	0	0	2	0.011
	Southern Leopard Frog *Rana utricularia*	0	0	0	0	0	0	1	0.03	0	0	1	0.005
	Spring Peeper Pseudacris crucifer	1	0.03	1	0.03	0	0	0	0	0	0	2	0.011
	Salamander												
	Mississippi Slimy Salamander *Plethodon mississippi*	1	0.03	2	0.07	0	0	0	0	0	0	3	0.017
	Total Amphibians	3	0.08	4	0.13	0	0	2	0.05	0	0	9	

Table 5.2 Reptile species and mean numbers of individuals detected in 5 stand types of the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

		Sample Periods											
Site	**Species**	**Jan-Feb**		**March-April**		**May-June**		**July-Aug**		**Nov-Dec**		**Total reptiles**	
Coves	**Snakes**	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean
	Black Racer *Coluber constrictor constrictor*	0	0	0	0	0	0	1	0.04	0	0	1	0.008
	Cottonmouth *Agkistrodon picivorus*	0	0	2	0.08	1	0.04	1	0.04	0	0	4	0.031
	Lizards/Skinks												
	Five-lined Skink *Plestiodon fasciatus*	0	0	0	0	2	0.08	0	0	0	0	2	0.015
	Green Anole *Anolis carolinensis*	1	0.04	2	0.08	0	0	0	0	0	0	3	0.023
	Ground Skink *Scincella lateralis*	1	0.04	3	0.12	3	0.12	2	0.08	1	0.04	10	0.077
	Total Reptiles	2	0.08	7	0.27	6	0.23	4	0.03	1	0.04	20	

Table 5.2 (Continued)

		Sample Periods											
Site	**Species**	**Jan-Feb**		**March-April**		**May-June**		**July-Aug**		**Nov-Dec**		**Total reptiles**	
Streamside Management Zone	**Snakes**	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean
	Cottonmouth *Agkistrodon piscivorus*	0	0	3	0.1	1	0.03	2	0.07	0	0	6	0.04
	Turtles												
	Eastern Box Turtle *Terrapene carolina carolina*	0	0	0	0	2	0.07	0	0	0	0	2	0.013
	Lizards/Skinks												
	Five-lined Skink *Plestiodon fasciatus*	1	0.03	0	0	0	0	1	0.03	0	0	2	0.013
	Green Anole *Anolis carolinensis*	0	0	0	0	0	0	3	0.1	0	0	3	0.02
	Ground Skink *Scincella lateralis*	2	0.07	5	0.17	1	0.03	7	0.23	4	0.13	19	0.127
	Unknown lizard	0	0	0	0	0	0	1	0.03	0	0	1	0.007
	Total Reptiles	3	0.1	8	0.06	4	0.13	14	0.47	4	0.13	33	

Table 5.2 (Continued)

Site	Species	Sample Periods											
		Jan-Feb		March-April		May-June		July-Aug		Nov-Dec		Total reptiles	
Pine Plantation (<5 years)	**Lizards/Skinks**	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean
	Five-lined Skink *Plestiodon fasciatus*	0	0	2	0.07	0	0	0	0	0	0	2	0.013
	Green Anole *Anolis carolinensis*	0	0	0	0	0	0	0	0	1	0.03	1	0.007
	Ground Skink *Scincella lateralis*	0	0	1	0.03	0	0	0	0	1	0.03	2	0.013
	Total Reptiles	0	0	3	0.1	0	0	0	0	2	0.07	5	
Pine Plantation (5-15 years)	**Snakes**												
	Copperhead *Agkistrodon contortrix*	0	0	0	0	0	0	1	0.05	0	0	1	0.01
	Lizards/Skinks												
	Five-lined Skink *Plestiodon fasciatus*	0	0	1	0.05	0	0	0	0	0	0	1	0.01
	Green Anole *Anolis carolinensis*	0	0	0	0	1	0.05	0	0	0	0	1	0.01
	Ground Skink *Scincella lateralis*	1	0.05	1	0.05	1	0.05	2	0.1	0	0	5	0.05
	Total Reptiles	1	0.05	2	0.1	2	0.1	3	0.03	0	0	8	

Table 5.2 (Continued)

Site	Species	Sample Periods											
		Jan-Feb		March-April		May-June		July-Aug		Nov-Dec		Total reptiles	
Pine Plantation (>15 years)	**Snakes**	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean	Total	Mean
	Copperhead *Agkistrodon contortrix*	0	0	0	0	0	0	2	0.05	0	0	2	0.011
	Southern Ringneck Snake *Diadophis punctatus punctatus*	0	0	1	0.03	0	0	0	0	0	0	1	0.006
	Turtles												
	Eastern Box Turtle *Terrapene carolina carolina*	0	0	0	0	0	0	1	0.03	0	0	1	0.006
	Lizards/Skinks												
	Fence Lizard *Sceloporus undulatus*	0	0	0	0	0	0	0	0	1	0.03	1	0.006
	Five-lined Skink *Plestiodon fasciatus*	0	0	0	0	0	0	0	0	3	0.03	3	0.017
	Green Anole *Anolis carolinensis*	2	0.05	1	0.03	0	0	0	0	1	0.03	4	0.022
	Ground Skink *Scincella lateralis*	1	0.03	5	0.17	6	0.2	9	0.23	7	0.18	28	0.156
	Total Reptiles	3	0.06	7	0.23	6	0.2	12	0.3	12	0.3	40	

Table 5.3 Number of individual amphibians and reptiles detected or captured during area-constrained searches (ACS) among 5 stand types within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS from 2008-2009.

Habitat Type	Reptile Species	Reptiles Detected	Amphibian Species	Amphibians Detected	% of Total Captures/Detections (Reptiles)	% of Total Captures/Detections (Amphibians)
Cove	5	20	8	104	16.13	83.87
SMZ	5	33	9	57	36.67	63.33
<5 year pine	3	5	0	0	100.00	0.00
5-15 year pine	4	8	2	2	80.00	20.00
>15 year pine	7	40	5	9	81.63	18.37

Table 5.4 Number of individual amphibians and reptiles detected during area-constrained searches of dendritic drainages of Magnolia Cove and Old Cove within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS from 2009-2010.

Cove Drainages	Reptile Species	Reptiles Detected	Amphibian Species	Amphibians Detected	% of Total Captures/Detections (Reptiles)	% of Total Captures/Detections (Amphibians)
Old Cove	2	7	8	46	13.21	86.79
Magnolia Cove	3	17	6	29	36.96	63.04

Table 5.5 Herpetofaunal counts resulting from area-constrained searches (ACS) of dendritic drainages of Magnolia Cove and Old Cove within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS from 2009-2010.

Taxon	Old Cove	CPUE	SE	Magnolia Cove	CPUE	SE
Order Anura						
Northern Cricket Frog *Acris crepitans crepitans*	1	0.06	0.06	0	0.00	0.00
Spring Peeper *Pseudacris crucifer*	3	0.19	0.10	0	0.00	0.00
Bronze Frog *Lithobates clamitans clamitans*	1	0.63	0.06	0	0.00	0.00
True Frog *Lithobates* spp.	2	0.13	0.09	0	0.00	0.00
Subtotal	7	0.44	0.20	0	0.00	0.00
Species Richness	4			0		
Order Caudata						
Spotted Dusky Salamander *Desmognathus fuscus conanti*	0	0.00	0.00	15	0.94	0.51
Northern Two-lined Salamander *Eurycea bislineata*	11	0.69	0.25	5	0.31	0.18
Three-lined Salamander *Eurycea guttolineata*	2	0.13	0.09	2	0.13	0.09
Streamside Salamander *Eurycea* spp.	3	0.19	0.14	2	0.13	0.09
Mississippi Slimy Salamander *Plethodon mississippi*	23	1.44	0.85	5	0.31	0.12
Subtotal	39	2.44	0.92	29	1.81	0.69
Species Richness	4			5		

Table 5.5 (Continued)

Taxon		Old Cove	CPUE	SE	Magnolia Cove	CPUE	SE
Order Squamata							
Suborder Serpentes							
Eastern Cottonmouth *piscivorus*	*Agkistrodon*	2	0.13	0.13	0	0	0
Southern Ringneck Snake *punctatus punctatus*	*Diadophis*	0	0.00	0.00	4	0.25	0.11
	Subtotal	2	0.13	0.13	4	0.25	0.11
	Species Richness	1			1		
Order Squamata							
Suborder Lacertilia							
Green Anole *carolinensis*	*Anolis*	0	0	0	2	0.13	0.09
Ground Skink *lateralis*	*Scincella*	5	0.31	0.25	11	0.69	0.34
	Subtotal	5	0.31	0.25	13	0.81	0.33
	Species Richness	1			2		
	Total	53	3.31	1.19	46	2.88	0.95
	Species Richness	10			8		

Table 5.6 Anuran species detected during anuran call counts among 5 stand types within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS from 2008-2009.

Habitat Type	Anuran Call	Estimate of Calling Individuals
Hardwood Cove Forests	Bronze Frog *Lithobates clamitans clamitans*	<5
Streamside Management Zones	Bird-Voiced Treefrog *Hyla avivoca**	>20
	Bronze Frog *Rana clamitans clamitans*	<5
	Cope's Grey Treefrog *Hyla chrysoscelis*	>5-10
	Spring Peeper *Pseudacris crucifer*	>5-10
Pine Plantation (< 5 years)	Spring Peeper *Pseudacris crucifer*	>5-10
Pine Plantation (> 5-15 years)	Green Treefrog *Hyla cinerea**	>5-10
	Spring Peepers *Pseudacris crucifer*	>10-20
Pine Plantation (> 15 years)	Cope's Gray Treefrog *Hyla chrysoscelis*	<5
	Spring Peeper *Pseudacris crucifer*	>5-10

*Species detected during anuran call counts that were not detected during area constrained searches

Table 5.7 Renkonon's Community Similarity Index comparing herpetofaunal communities among 3 ages of pine plantations, and between coves and streamside management zones within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS from 2008-2009.

Habitat Comparison	Herpetofaunal Community Similarity Index
Pine (<5 years) Site; Pine (5-15 years) Site	0.60
Pine (<5 years) Site; Pine (>15 years) Site	0.54
Pine (5-15 years) Site; Pine (>15 years) Site	0.79
SMZ Site; Cove Site	0.54

Table 5.8 Significant associations between habitat variables reduced through PCA and species richness and catch-per-unit effort of amphibians and reptiles within the Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS from 2008-2009.

Herpetofaunal Response Variable (Y)		Significant Models
Amphibian Species Richness		Y= 0.243 + 0.509 (SDC) - 0.077 (UVC) + 0.140 (USR) – 0.019 (LL)
Amphibian Abundance [a]		Y= 0.894 - 0.019 (UVC) - 0.006 (OP[b])
Three-lined salamander *Eurycea longicauda guttolineata*	Abundance[a]	Y= 0.287 - 0.004 (OP[b])
Mississippi Slimy Salamander *mississippi*	*Plethodon*	Y= 0.077 - 0.008 (UVC) + 0.139 (LDC) - 0.029 (PMS) - 0.003 (OP[b]) + 0.066 (SC)
Reptile Abundance [a]		Y= - 0.422 + 0.035 (USR)
Ground Skink Abundance[a] *lateralis*	*Scincella*	Y= - 0.276 + 0.022 (USR)

[a] Abundance estimates standardized based on catch per unit effort; [b] Includes Overstory Trees - ≥ 10.2 cm diameter at breast height and > 6 m in height; [c] Understory = plants occurring at < 1 m height along transect

References

Alig, R. and Wear, D. 1992. Changes in private timberlands: Statistics and projections for 1952 to 2040. Journal of Forestry. 90(5): 31–37.

Bailey, M. A., J. N. Holmes, K. A. Buhlmann, and J. C. Mitchell. 2006. Habitat management guidelines for amphibians and reptiles of the southeastern United States. Partners in Amphibian and Reptile Conservation Technical Publication HMG-2, Montgomery, AL. 80pp.

Barbour, R. W., M. J. Harvey, and J. W. Hardin. 1969. Home range, movements, and activity of the Eastern worm snake, *Carphophis amoenus amoenus*. Ecology 50: 470–476.

Barr, G. E. and Babbitt K. J. 2002. Effects of biotic and abiotic factors on the distribution and abundance of larval two-lined salamanders, *Eurycea bislineata*, across spatial scales. Oecologia 133: 176–185.

Baxley, D. and C. Qualls. 2009. Habitat associations of reptiles and amphibian communities in longleaf pine habitats of South Mississippi. Herpetological Conservation and Biology 4(3): 295-305.

Barrett, J. W., editor. Regional Silviculture of the United States John Wiley and Sons Inc. Third edition. NY, NY 1995 pg 271-331.

Bennett, S. H., J. W. Gibbons, and J. Glanville. 1980. Terrestrial activity, abundance, and diversity of amphibians in differently-managed forest types. American Midland Naturalist 103: 412-416.

Blaustein, A. R. and D. B. Wake. 1990. Declining amphibian populations: A global phenomenon? Trends in Ecological Evolution 5:203-204.

Brinson, M. M. and J. Verhoeven. 1999. Riparian forests. Pages 265-299 *in* M. L. Hunter Jr., editor. Maintaining biodiversity in forest ecosystems. Cambridge University Press. Cambridge, UK.

Brinkley, D. 1986. Soil acidity in loblolly pine stands with interval burning. Soil Science Society of America 50: 1590-1594.

Budd, W. W., P. L. Cohen, P. R. Saunders, and F. R. Steiner. 1987. Stream corridor management in the Pacific Northwest: I. Determination of stream corridor widths. Environmental Management 11: 587–597

Burton, T. M. and G. E. Likens. 1975. Salamander populations and biomass in the Hubbard Brook Experimental Forest, New Hampshire. Copeia 541-546.

Cain, M. D. 1991. The influence of woody and herbaceous competition on early growth of naturally generated loblolly and shortleaf pines'. Southern Journal of Applied Forestry 15(4): 179-185.

Campbell, H. W. and S. P. Christman. 1982. The herpetological components of Florida sandhill and sand pine scrub associations. Pages 163–171 *in* N. J. Scott Jr., editor. Herpetological communities. Research report 13. U.S. Fish and Wildlife Service, Washington, D.C.

Castelle, A. J., A. W. Johnson, and C. Conolly. 1994. Wetland and stream buffer size requirements – a review. Journal of Environmental Quality 23: 878-882.

Conant, R., and J. T. Collins. 1998. Reptiles and amphibians of eastern/central North America. Houghton Mifflin Company, New York, NY, USA.

Conover, W.J. 1980. Practical nonparametric statistics. Second edition. John Wiley & Sons, New York, USA.

deMaynadier, P.G. and M.L. Hunter, Jr. 1995. The relationship between forest management and amphibian ecology: a review of the North American literature. Environmental Review 3: 230-261.

deMaynadier, P.G. and M.L. Hunter, Jr. 1998. Effects of silvicultural edges on the distribution and abundance of amphibians in Maine. Conservation Biology 12(2): 340-352.

Dorcas, M. E. 2005. Rare, threatened, and endangered amphibians and reptiles within the Catawaba-Wateree River System. Final Report to Duke Power Company.

Dunson, W. A., R. L.Wyman, and E. S. Corbett. 1992. A symposium on amphibian declines and habitat acidification. Journal of Herpetology 26: 349-352.

Edwards, K.E. 2009. Faunal communities of temporary wetlands of upland and floodplain forests in north Mississippi. Dissertation, Mississippi State University, Mississippi State, Mississippi, USA.

Feder, M. E. 1983. The relation of air breathing and locomotion to predation on tadpoles, Rana berlandieri, by turtles. Physiological Zoology 56(4): 522-531.

Fitch, H. S. 1975. A demographic study of the ringneck snake (*Diadophis punctatus*) in Kansas. University of Kansas Museum of Natural History Miscellaneous Publications 62: 1–53.

Fogarty, J. H. and J. C. Jones. 2003. Pitfall trap versus area searches for herpetofaunal research. Proceedings of the Southeastern Association of Fish and Wildlife Agencies Annual Conference 57: 268-279.

Fox, S. F., P. A. Shipman, R. E. Thill, J. P. Phelps, and D. M. Leslie Jr. 2004. Amphibian communities under diverse forest management in the Ouachita Mountians, Arkansas. Pages 164-173 *in* Guldin, J. M. editor. Ouachita and Ozark Mountian Symposium: Ecosystem Management Research, Hot Springs, AR, October 26-28, 1999. General Technical Report No. SRS-74. Southern Research Station, USDA Forest Service, Ashville, North Carolina.

Freund, R. J. and W. J. Wilson. 2003. Nonparametric methods. Pages 590-596 *in* B. Holland, editor. Statistical methods. Academic Press, San Diego, California, USA.

Gibbons, J. W. and Stangel, P. W. 1999. Conserving amphibians and reptiles in the new millennium. Proceedings of the Partners in Amphibian and Reptile Conservation (PARC) Conference, 2-4 June 1999, Atlanta, GA. Aiken, SC: Savannah River Ecology Laboratory. Herp Outreach Publication No. 2.

Gibbons, J. W., D.E. Scott, T.J. Ryan, K.A. Buhlmann, T.D.Tuberville, B.S. Metts, J.L Greene, T.Mills, Y. Lieden, S. Poppy, and C.T. Winne. 2000. The global decline of reptiles, déjàvu amphibians. Bioscience 50: 653-666.

Gibbons, J.W. and K.A. Buhlmann. 2001. Reptiles and amphibians. Pages 372-390 *in* J.G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Greenberg, C. H., D. G. Neary, and L. D. Harris. 1994. Effect of high intensity wildfire and silvicultural treatments on reptile communities in sand-pine scrub. Conservation Biology 8: 1047–1057.

Gregory, S. V., F. J. Swanson, and W. A. Cummins. 1991. An ecosystem perspective of riparian zones: focus on links between land and water. BioScience 41(8): 540-551.

Godley, J. S. 1980. Foraging ecology of the striped swamp snake, *Regina alleni*, in southern Florida. Ecological Monographs 50: 411–436.

Hair, J.F., Jr., R.E. Anderson, and R.L. Tatham. 1987. Mulitvariate Data Analysis, second edition. Macmillian, New York, New York, USA.

Hairston, N. G., 1987. Community Ecology and Salamander Guilds. Cambridge University Press, Cambridge, UK, 230pp.

Harmon, M. E., J. F. Franklin, F. J. Swanson, P. Sollins, S. V. Gregory, J. D. Lattin, N. H. Anderson, S. P. Cline, N. G. Aumen, J. R. Sedell, G. W. Lienkaemper, K. Cromack, Jr., and K. W. Cummins. 1986. Ecology of coarse woody debris in temperate ecosystems. Advances in Ecological Research 15: 133–302.

Hatcher, L. 1994. A step-by-step approach to using the SAS® System for factor analysis and structural equation modeling. SAS Institute Inc., Cary, North Carolina, USA.

Hornbeck, J. W., C. W. Martin, R. S. Pierce, F. H. Bormann, G. E. Likens, and J. S. Eaton. 1986. Clearcutting northern hardwoods: effects on hydrologic and nutrient ion budgets. Forest Science 32: 667–686.

Hunter, M. A., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice-Hall, Englewood Cliffs, New Jersey, USA

Jaeger, R. G. and R. F. Inger. 1994. Quadrat sampling. Pages 97-102 *in* W. H. Heyer, M. A. Donelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster, editors. Measuring and monitoring biological diversity. Standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

Johnson, D.E. 1998. Applied Multivariate Methods for Data Analysts. Duxbury Press.

Kramer, P., N. Reichenbach, M. Hayslett, and P. Sattler. 1993. Population dynamics and conservation of the Peaks of Otter salamander, *Plethodon hubrichti*. Journal of Herpetology 27: 431-435.

Krebs, C.J. 1989. Ecological methodology. Harper and Row, New York, New York, USA.

Leiden, Y. A., M. E. Dorcas, and J. W. Gibbons. 1999. Herpetofaunal diversity in coastal plain communities of South Carolina. Journal of the Elisha Mitchell Scientific Society 115: 270-280.

Loehle, C., T. B. Wigley, P. A. Shipman, S. F. Fox, S. Rutzmoser, R. E. Thill, and M. A. Melchiors. 2005. Herpetofaunal species richness responses to forest landscape structure in Arkansas. Forest Ecology and Management 209: 293-308.

Lydeard, C. and R. L. Mayden. 1995. A diverse and endangered aquatic ecosystem of the southeastern United States. Conservation Biology 9: 800-805.

Martin, C.W. and R.S. Pierce. 1980. Clearcutting patterns affect nitrate and calciumin streams of New Hampshire. Journal of Forestry 78: 268-272.

McCune, B. and J.B. Grace. 2002. Analysis of ecological communities. MjM Software Design, Gleneden Beach, Oregon, USA.

McGarigal, K., S. A. Cushman, and S. Stafford 2000. Multivariate Statistics for Wildlife and Ecology Research. Springer Verlag, New York, New York, USA.

Means, B. D. and J. Travis. 2007. Declines in ravine-inhabiting Dusky Salamanders of the Southeastern U.S. Coastal Plains. Southeastern Naturalist 6(1): 83-96

Minshall, G. W. 1984. Aquatic insect-substratum relationships. Pages 358-400 *in* Resh V. H., Rosenberg D. M. editors. The ecology of aquatic insects. Praeger, New York.

Murcia, C. 1995. Edge effects in fragmented forests: implications for conservation. Trends in Ecology and Evolution. 10: 58-62.

Naiman, R. J., H. Decamps, and M. Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications 3: 209-212.

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington D.C., USA

Pough, R. H., E. M. Smith, D. H. Rhodes, and A. Collazo. 1987. The abundance of salamanders in forest stands with different histories of disturbance. Forest Ecology and Management 20: 1-9.

Renken, R. B., W. K. Gram, D. K. Frantz, S. C. Richter, T. J. Miller, K. B. Ricke, B. Russell, and X.Wang. 2004. Effects of forest management on amphibians and reptiles in Missouri Ozark forests. Conservation Biology 18(1): 174-188.

Ross, B., T. Fredericksen, E. Ross, W. Hoffman, M. L. Morrison, J. Beyea, M. B. Lester, B. N. Johnson, and N. J. Fredericksen. 2000. Relative abundance and species richness of herpetofauna in forest stands in Pennsylvania. Forest Science 46(1): 139-146.

Royston, P. 1992. Approximating the Shapiro-Wilk W-test for non-normality. Statistics and Computing 2: 117-119.

Ryan, T. J., T. Philippi, Y. A. Leidden, M. E. Dorcas, T. B. Wigley, and J. W. Gibbons. 2002. Monitoring herpetofauna in a managed forest landscape: effects of habitat types and census techniques. Forest Ecology and Management 167: 83-90.

SAS Institute. 1999. SAS/STAT User's Guide. Version 9. SAS Institute, Cary, North Carolina, USA

Semlitsch, R. D. and J. R. Bodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Conservation Biology 17: 1219-1228.

Seymour, R. S., A. S. White, and P. G. deMaynadier. 2002. Natural disturbance regimes in northeastern North America: evaluating silvicultural systems using natural scales and frequencies. Forest Ecology and Management 155;357-367.

Shaffer, L. L. and C. J. McCoy. 1991. Pennsylvania amphibians and reptiles. Pennsylvania Fish and Boat Commission, Harrisburg, Pennsylvania.

Sinsch, U. 1990. Migration and orientation in anuran amphibians. Ethology Ecology and Evolution 2: 65-79.

Smith, C. K. and J. W. Petranka. 2000. Monitoring terrestrial salamanders: repeatability and validity of area-constrained cover object searches. Journal of Herpetology 34(4): 547–557.

Smith, W.H. 2009. *Desmognathus conanti*. Habitat. Herpetological Review 40: 66.

Stamps, J. A., M. Buechner, and V. V. Krishnan. 1987. The effects of edge permeability and habitat geometry on emigration from patches of habitat. American Naturalist 129: 533-552.

Stauffer, D. F. and L. B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. Journal of Wildlife Management 44: 1-15.

Stebbins, R. C. and N. W. Cohen. 1995. A natural history of amphibians. Princeton University Press, Princeton, New Jersey.

Shipman, P. A., S. F. Fox, R. E. Thill, J. P. Phelps, and D. M. Leslie Jr. 2004. Reptile communities under diverse forest management in the Ouachita Mountians, Arkansas. Pages 174-182 *in* Guldin, J. M. editor. Ouachita and Ozark Mountian Symposium: Ecosystem Management Research, Hot Springs, AR, October 26-28, 1999. General Technical Report No. SRS-74. Southern Research Station, USDA Forest Service, Ashville, North Carolina.

Taylor, M. F. J., K. F. Suckling, and J. J. Rachlinski. 2005. The effectiveness of the Endangered Species Act: A quantitative analysis. BioScience 55(4): 360-368.

Thorne, S., K. C. Kim, and K. C. Steiner. 1995. Conserving Pennsylvania's native biological diversity. Pennsylvania Fish and Boat Commision, Harrisburg, Pennsylvania 60 p.

Todd, B. D. and K. M. Andrews. 2007. Response of a reptile guild to forest harvesting. Conservation Biology 22(3): 753-761.

Welsh, H. H., Jr. 1987. Monitoring herpetofauna in woodland habitats of northwestern California and southwestern Oregon: a comprehensive strategy. Pages 203-213 *in* T. R. Plumb and N. H. Pillsbury, editors. Multiple-use management of California's hardwood resources. U. S. Forest Service, Pacific Southeast Experiment Station, General Technical Report PSW-100.

Whiles, M. R. and J. W. Grubaugh. 1993. Importance of course debris to southern forest herpetofauna. Proceedings of the Workshop on Coarse Woody Debris in Southern Forests: Effects on Biodiversity, 18-20 October 1993, Athens, GA.

Wigley, T.B., Baughman, W.M., Dorcas, M.E., Gerwin, J.A., Gibbons, J.W., Guynn, D.C., Lancia, R.A., Leiden, Y.A., Mitchell, M.S., Russell, K.R., 2000. Contributions of intensively managed forests to the sustainability of wildlife communities in the south. In: Sustaining southern forests: the science of forest assessment. USDA Forest Service, Southern Forest Research Assessment. Available on line at: http:// www.srs.fs.fed.us/sustain/conf/.

Willson, J. D., and M. E. Dorcas. 2004. Aspects of the ecology of small fossorial snakes in the western Piedmont of North Carolina. Southeastern Naturalist 3: 1–12.

Wyman, R. L. 1990. What's happening to the amphibians? Conservation Biology 4: 350-352.

Yahner, R. H. 1988. Changes in wildlife communities near edges. Conservation Biology 2(4): 333-339.

CHAPTER VI

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Biodiversity is often defined as variability among living organisms from all sources including diversity found within a single species, between species and the ecosystem types a species will inhabit (Carnus et al. 2006). Habitat factors, such as forest microclimate, available cover, and presence and abundance of a food source allow a species to survive and flourish in a particular habitat (Cody 1985). High diversity of communities and species across a landscape is often created by a diversity of habitat types ranging from early successional to climax stages (Mitchell et al. 2006, Yarrow and Yarrow 1999, and Dickson and Wigley 2001). A variety of species rely on different habitat types, and a mixture of stand age and types across a pine plantation can enhance a landscape's heterogeneity, promoting flora and fauna diversity (Mitchell et al. 2006). Forest plantations can provide this matrix of managed habitats that affects different species depending on their individual habitat requirements (Miller et al. 2009). To retain biodiversity while providing timber resources, managers can retain areas of non-plantation stands of natural forest patches including mature hardwood forests, protected wetlands, and SMZs within managed forest landscapes (Wigley et al. 2000). This management strategy of mixed stand types can enhance and promote biodiversity of a variety of floral and faunal types across a landscape (Wigley et al. 2000). Pine plantations, such as those found at the Old Cove Area provide a good example of a managed landscape that creates different habitats at variable successional stages

interspersed with SMZs and protected coves. This interspersion of habitat types may benefit a variety of species. Species richness and abundance of plants, herpetofauna, and birds on a landbase, such as Old Cove Area, are generally from a variety of habitat types represented across the landscape (Allen et al. 1996).

Many species of breeding birds were found only in specific habitat types where forest management practices created favorable habitat conditions. Examples of this include the brown-headed nuthatch's positive response to a first year thin of pine stands (Wilson and Watts 1999), and a greater number of cavity-nesting species found along established streamside management zones. These examples represent where management practices were related to detection of selected bird species. Studies have reported that one particular management action can positively affect a species population at the stand level, but to effectively manage breeding bird community assemblages across a landbase, habitat management should be implemented at a landscape level.

Management of breeding birds in a matrix of managed pine plantations involving conservation of mature hardwoods has allowed the opportunity for research and monitoring aimed at identifying species that occur within managed pine plantations, SMZs, and protected cove forests. Based on my study, I concur with Wigley et al. (2000) who reported that protection of unique habitats, such as hardwood cove forests, and retention of natural forests in SMZs can advance conservation efforts for forest-dwelling bird species on managed landscapes. Because these mature natural forest habitats may be rare on the landscape, conservation initiatives, such as those occurring at the Old Cove Area, are important for bird species that depend on early successional habitats, shrub habitat, and mature forests in Mississippi. For example, among the 3 pine habitat types

represented in my study, 39 bird species were detected, whereas 48 species of birds were detected among all habitat types across the landbase (Figure 6.1).

In my study, I estimated species richness and abundance of herpetofaunal communities across the Old Cove Area landscape to assess communities within different habitat types as recommended by Bailey et al. (2006; Figure 6.2). Greater numbers of amphibians found in coves, SMZs and older age class pine plantations were potentially related to factors such as forest canopy closure, leaf litter, deadwood layers, and interspersion of streams and seepages surrounded by adequate forest cover and other vegetation structure (Conant and Collins 1998, Petranka 1998). These conditions created high quality habitat for amphibians that require moist microsite conditions of mature closed canopy forests and forested riparian areas. These conditions were especially important to salamander species that were detected during the study. Also, coves and SMZs supported greatest species richness of amphibians. This trend may have been related to presence of water in streams that transected coves and SMZs. However, greater abundance and species richness of salamanders within coves was probably due to mature forest characteristics combined with forested streams and seepages (Petranka 1998). Conversely, some reptiles were detected in all habitat types, but overall, abundance of reptiles was greatest in older pine plantations. Favorable conditions existed for many terrestrial reptile species, including increased exposure of soil surface to sunlight, increased vegetation structure and ground cover composition, potential abundance of invertebrate and vertebrate prey, and increased availability of basking and egg incubation sites (Ross et al. 1999, Owens et al. 2008). Although greatest abundance was observed in older pine plantations, some species of reptiles were specialist found to be associated with specific habitat characteristics. Examples included cottonmouth (*Agkistrodon*

piscivorus), which was found only close to streams in SMZ and cove habitats where fish and aquatic amphibians prey were available (Conant and Collins 1998). Another example is the detection of the copperhead (*Agkistrodon contortrix*) in pine habitats that exhibited grassland and shrub habitat that may have supported abundant prey populations, such as voles and mice (Garton and Dimmick 1969).

Cove and streamside habitat were important to selected species of salamanders, such as dusky and two lined salamanders, which depend on habitat conditions created by mature deciduous forests and surface water sources. Other habitat specialists dependent on the same type habitat conditions included southern red salamander (*Pseudotriton rubur vioscai*) and Webster's salamander (*Plethodon websteri*). Forested riparian areas, stream, seepages, and springs can be protected by meeting or exceeding state recommended best management practices (BMPs), which includes expansion of SMZ widths, allowing for increased forest canopy along streams. Maintenance of mature forests within SMZs and coves, and retention or creation of corridors for movement and dispersal could maintain connectivity of suitable habitats and increase the overall amphibian biodiversity of the landscape. Based on my findings, I submit that retention and expansion of SMZs within the Old Cove Area and other pine dominated lands could enhance habitat quality for amphibians by providing additional invertebrate food resources, moist microsite conditions, and increased structural cover (Fitch 1954; Petranka 1998). For example, protection of dendritic drainages within Magnolia Cove could protect habitat for isolated populations of dusky salamanders which are rarely detected within the central region of Mississippi (Petranka 1998). Additionally, protection of mature cove forests is essential for conserving existing salamander communities that include a variety of streambank and Plethodontid salamanders.

Although some species were present in most habitat types, species that have specific habitat requirements only occurred where this habitat existed. Overall, management of the Old Cove Area provided different habitat across the landscape, ultimately increasing biodiversity (Figure 6.3). Detection of several species only found in one habitat type shows the potential for many rare species and ecosystems to occur across the landscape, ultimately increasing biodiversity. For continued diversity and overall health of herpetofauna and breeding bird communities in Old Cove Area and other commercially managed forest landscapes, retention of older age class hardwood stands, like mesic coves, bottomland hardwoods, and SMZs should be considered for retention within matrices of managed pine plantations. As shown in my study, these areas have the potential to contain rare habitats supporting specialist species that depend on older age class hardwood forests (Hartley 2002).

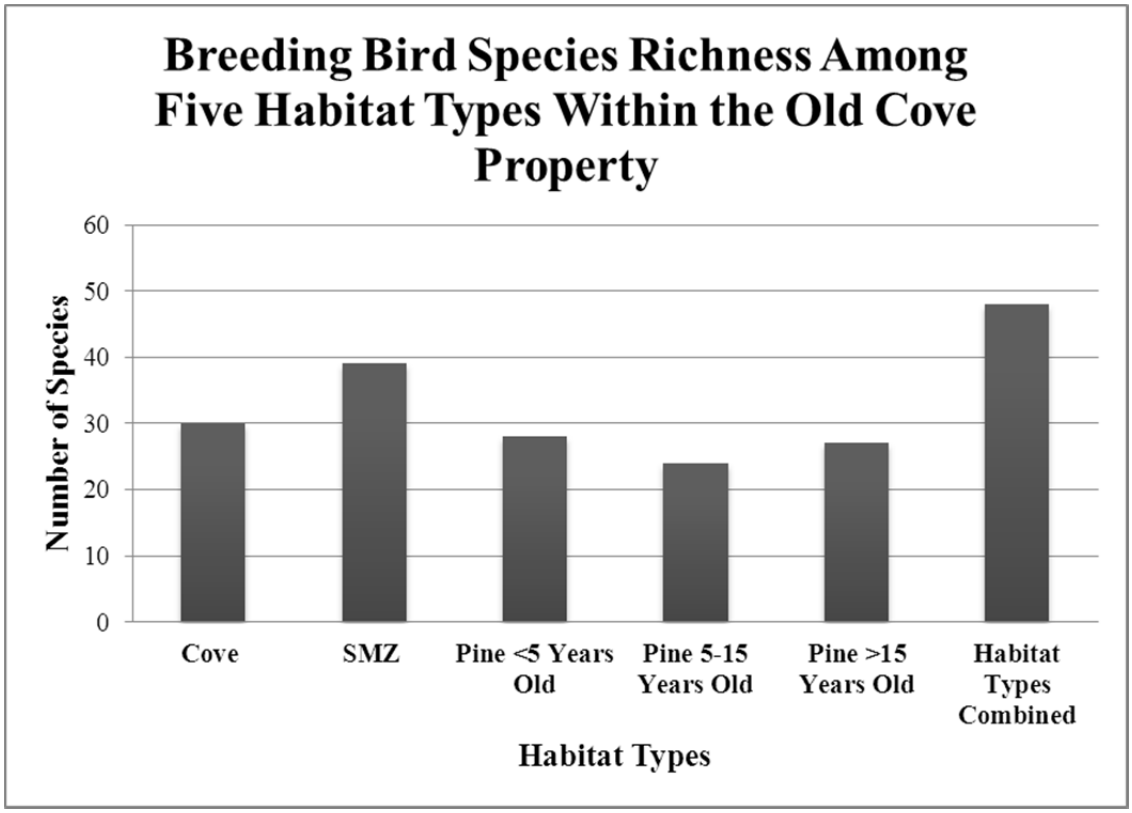

Figure 6.1 Species richness of birds detected within streamside management zones, pine plantations, cove sites, and all stands combined within Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS during spring-early summer of 2008 and 2009.

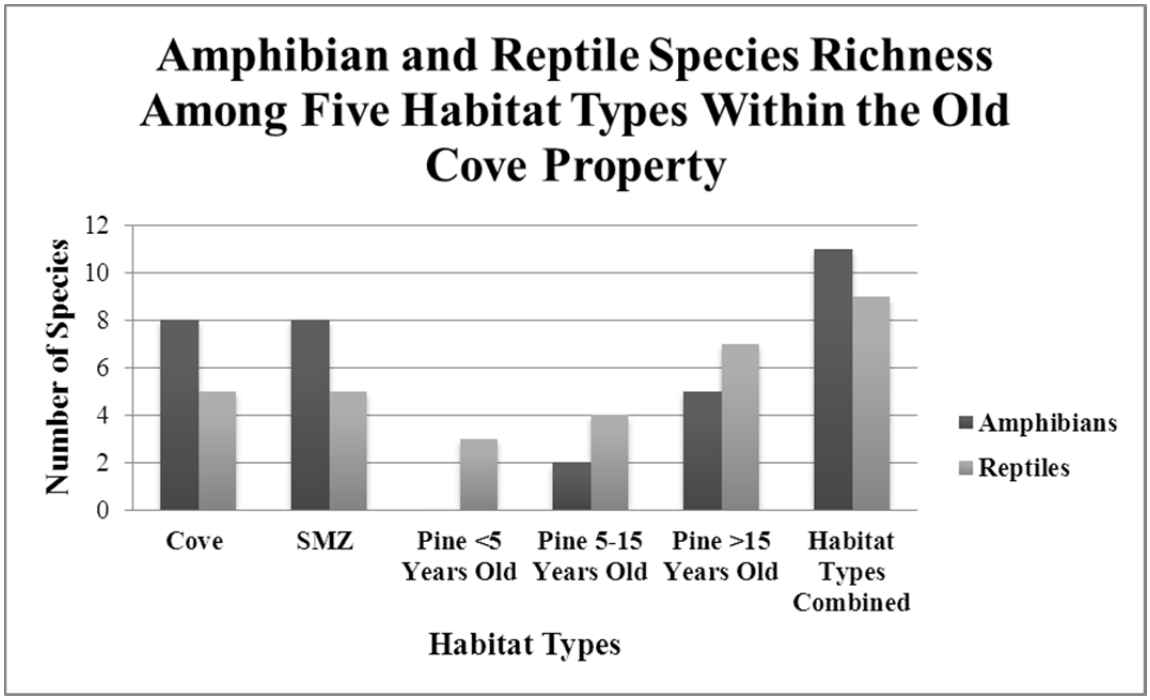

Figure 6.2 Species richness of amphibians and reptiles detected within streamside management zones, pine plantations, cove sites, and all stand types combined within Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

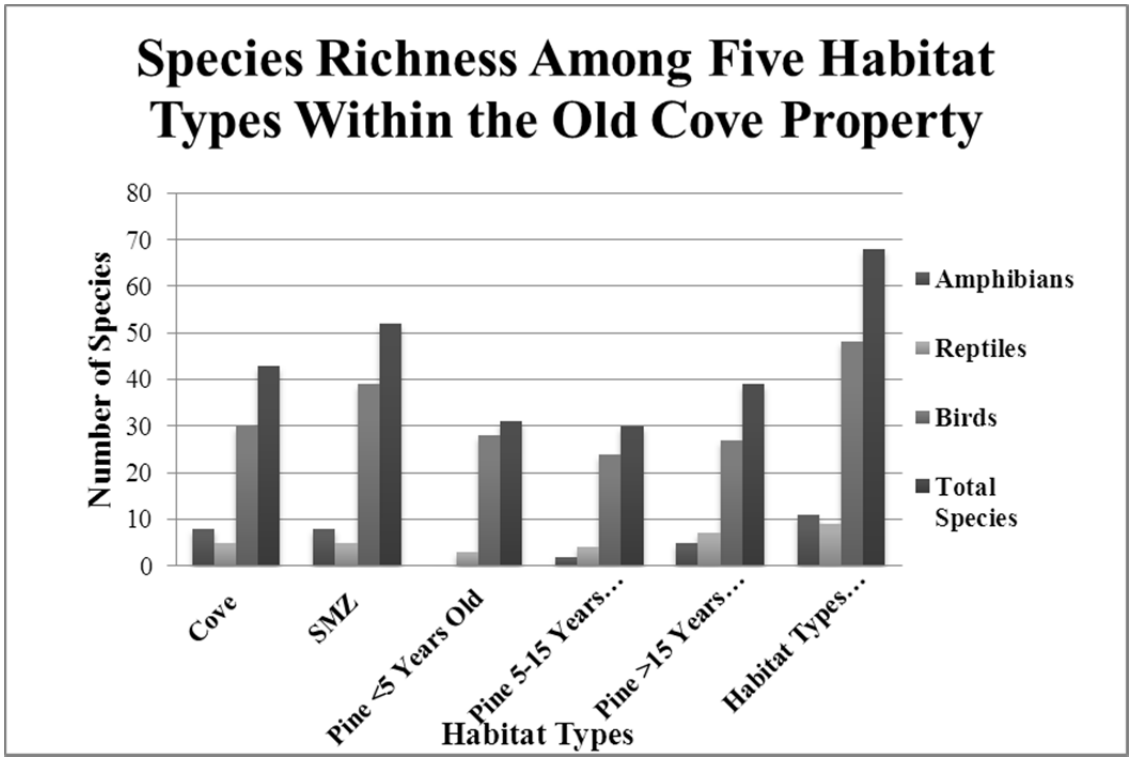

Figure 6.3 Species richness of amphibians, reptiles, and birds detected within streamside management zones, pine plantations, cove sites, and across the landbase of Weyerhaeuser-owned, Old Cove Area, Bellefontaine, MS 2008-2009.

Literature Cited

Allen, A. W., Y. K. Bernal, and R. J. Moulton. 1996. Pine plantations and wildlife in the southeastern United States: An assessment of impacts and opportunities. Information and Technology Report 3, January 1996. U. S. Department of the Interior, National Biological Service, Washington, D. C. 32pp.

Bailey, M. A., J. N. Holmes, K. A. Buhlmann, and J. C. Mitchell. 2006. Habitat management guidelines for amphibians and reptiles of the southeastern United States. Partners in Amphibian and Reptile Conservation Technical Publication HMG-2, Montgomery, AL. 80pp.

Carnus, J., J. Parrotta, E. Brockerhoff, M. Arbez, H. Jactel, A. Kremer, D. Lamb, K. O'Hara, B. Walters. 2006. Planted forests and biodiversity. Journal of Forestry 104: 65-77.

Cody, M. L. 1985. An introduction to habitat selection in birds. Pages 4-46 *in* M. L. Cody, editor. Habitat Selection in Birds, Academic Press, Orlando, FL.

Conant, R. and J. T. Collins. 1998. Reptiles and amphibians of eastern/central North America. Houghton Mifflin Company, New York, NY, USA.

Dickson, J. G. and T. B. Wigley. 2001. Managing forests for wildlife. Pages 83-94 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, Washington, USA.

Fitch, H.S. 1954. Life history and ecology of the five-lined skink *Eumeces fasciatus*. University Kansas Museum of Natural History Publication 8.

Garton, J. S. and R. W. Dimmick. 1969. Food habits of the copperhead in middle Tennessee. Journal of the Tennessee Academy of Science 44(4): 113-117.

Hartley, M. J. 2002. Rationale and methods for conserving biodiversity in plantation forests. Forest Ecology and Management 155: 81-95.

Miller, D. A., T. B. Wigley, K. V. Miller. 2009. Managed forests and conservation of terrestrial biodiversity in the southern United States. Journal of Forestry 107: 197-203.

Mitchell, M. S., S. H. Rutzmoser, T. B. Wigley, C. Loehle, J. A. Gerwin, P. D. Keyser, R. A. Lancia, R. W. Perry, C. J. Reynolds, R. E. Thill, R. Weih, D. White, and P. B. Wood. 2006. Relationships between avian richness and landscape structure at multiple scales using multiple landscapes. Forest Ecology and Management 221: 155-169.

Owens, A. K., K. R. Moseley, T. S. McCay, S. B. Castleberry, J. C. Kilgo, and W. M. Ford. 2008. Amphibian and reptile community response to coarse woody debris manipulation in upland loblolly pine (*Pinus taeda*) forests. Forest Ecology and Management 256: 2078-2083.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington D.C., USA

Ross, B., T. Fredericksen, E. Ross, W. Hoffman, M. L. Morrison, J. Beyea, M. B. Lester, B. N. Johnson, and N. J. Fredericksen. 2000. Relative abundance and species richness of herpetofauna in forest stands in Pennsylvania. Forest Science 46(1): 139-146.

Wigley, T.B., Baughman, W.M., Dorcas, M.E., Gerwin, J.A., Gibbons, J.W., Guynn, D.C., Lancia, R.A., Leiden, Y.A., Mitchell, M.S., Russell, K.R., 2000. Contributions of intensively managed forests to the sustainability of wildlife communities in the south. In: Sustaining southern forests: the science of forest assessment. USDA Forest Service, Southern Forest Research Assessment. Available on line at: http:// www.srs.fs.fed.us/sustain/conf/.

Wilson, M. D. and B. D. Watts. 1999. Response of brown-headed nuthatches to thinning of pine Plantations. Wilson Bulletin 111: 56-60.

Yarrow, G. K. and D. T. Yarrow. 1999. Managing for non-game wildlife. Pages 255-283 *in* G. K. Yarrow and D. T. Yarrow, editors. Managing wildlife: on private lands in Alabama and the Southeast. Sweetwater Press, Birmingham, Alabama, USA.

APPENDIX A

SUMMARY OF BREEDING BIRD SPECIES AND CORRESPONDING PARTNERS IN FLIGHT CONSERVATION SCORES DETECTED ON WEYERHAEUSER OWNED OLD COVE PROPERTY, WEBSTER COUNTY, MS 2008 AND 2009

Table A.1 Species and mean number of birds of each species detected at point stations in 5 stand types on Weyerhaeuser owned Old Cove property, Webster County, MS 2008.

	Hardwood Coves			Streamside Management Zones			Pine Plantation (≤ 5 years)			Pine Plantation (5-15 years)			Pine Plantation (>15 years)			Total #: All Habitat Types		
Common Name Scientific Name	**Total #**	**Mean #**	**SE**	**Total #**	**Mean #**	**SE**	**Total #**	**Mean #**	**SE**	**Total #**	**Mean #**	**SE**	**Total #**	**Mean #**	**SE**	**Total #:**	**Mean #**	**SE**
Acadian Flycatcher *Empidonax virescens*	5	0.63	0.26	2	0.22	0.22	-	-	-	-	-	-	1	0.08	0.08	8	0.18	0.08
American Crow *Corvus brachyrhynchos*	4	0.5	0.38	8	0.89	0.31	11	1.22	0.4	7	1.17	0.31	2	0.17	0.17	32	0.73	0.15
American Goldfinch *Spinus tristis*	-	-	-	-	-	-	-	-	-	1	0.17	0.17	-	-	-	1	0.02	0.02
Blue Jay *Cyanocitta cristata*	3	0.38	0.26	5	0.56	0.29	3	0.33	0.16	2	0.33	0.21	5	0.42	0.15	18	0.41	0.09
Blue-gray Gnatcatcher *Polioptila caerulea*	-	-	-	5	0.56	0.44	-	-	-	-	-	-	-	-	-	5	0.11	0.09
Brown Thrasher *Toxostoma rufum*	-	-	-	-	-	-	-	-	-	-	-	-	2	0.17	0.17	2	0.05	0.05
Carolina Chickadee *Poecile carolinensis*	-	-	-	-	-	-	-	-	-	-	-	-	3	0.25	0.25	3	0.07	0.07
Carolina Wren *Thryothorus ludovicianus*	4	0.5	0.27	7	0.78	0.22	5	0.56	0.24	2	0.33	0.33	5	0.42	0.19	23	0.52	0.11
Common Yellowthroat *Geothlypis trichas*	-	-	-	2	0.22	0.15	10	1.11	0.31	-	-	-	-	-	-	12	0.27	0.09
Downy Woodpecker *Picoides pubescens*	3	0.38	0.38	-	-	-	-	-	-	-	-	-	-	-	-	3	0.07	0.07
Eastern Towhee *Pipilo erythrophthalmus*	-	-	-	1	0.11	0.11	10	1.11	0.46	8	1.33	0.49	4	0.33	0.19	23	0.52	0.14
Eastern Tufted Titmouse *Baeolophus bicolor*	9	1.13	0.48	4	0.44	0.24	-	-	-	1	0.17	0.17	9	0.75	0.28	23	0.52	0.14

Table A.1 (Continued)

Common Name Scientific Name	Hardwood Coves			Streamside Management Zones			Pine Plantation (≤ 5 years)			Pine Plantation (5-15 years)			Pine Plantation (>15 years)			Total #: All Habitat Types		
	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #:	Mean #	SE
Eastern Wood-pewee *Contopus virens*	3	0.38	0.18	1	0.11	0.11	-	-	-	-	-	-	-	-	-	4	0.09	0.04
Great Crested Flycatcher *Myiarchus crinitus*	3	0.38	0.18	-	-	-	1	0.11	0.11	-	-	-	2	0.17	0.11	6	0.14	0.05
Hairy Woodpecker *Picoides villosus*	1	0.13	0.13	1	0.11	0.11	1	0.11	0.11	-	-	-	-	-	-	3	0.07	0.04
Hooded Warbler *Setophaga citrina*	3	0.38	0.18	6	0.67	0.33	2	0.22	0.22	8	1.33	0.33	13	1.08	0.29	32	0.73	0.14
Indigo Bunting *Passerina cyanea*	-	-	-	16	1.78	0.36	17	1.89	0.31	2	0.33	0.21	10	0.83	0.27	45	1.02	0.16
Kentucky Warbler *Geothlypis formosa*	-	-	-	2	0.22	0.15	2	0.22	0.15	-	-	-	9	0.75	0.31	13	0.3	0.1
Louisiana Waterthrush *Parkesia motacilla*	3	0.38	0.26	1	0.11	0.11	-	-	-	-	-	-	-	-	-	4	0.09	0.06
Mourning Dove *Zenaida macroura*	-	-	-	4	0.44	0.24	6	0.67	0.24	2	0.33	0.21	1	0.08	0.08	13	0.3	0.08
Northern Bobwhite *Colinus virginianus*	-	-	-	10	1.11	0.35	4	0.44	0.18	1	0.17	0.17	-	-	-	15	0.34	0.1
Northern Cardinal *Cardinalis cardinalis*	4	0.5	0.38	8	0.89	0.26	8	0.89	0.31	9	1.5	0.62	19	1.58	0.29	48	1.09	0.16
Northern Parula *Setophaga americana*	-	-	-	2	0.22	0.15	-	-	-	-	-	-	1	0.08	0.08	3	0.07	0.04
Pileated Woodpecker *Dryocopus pileatus*	3	0.38	0.26	4	0.44	0.18	2	0.22	0.15	-	-	-	-	-	-	9	0.21	0.07

Table A.1 (Continued)

Common Name	Scientific Name	Hardwood Coves			Streamside Management Zones			Pine Plantation (< 5 years)			Pine Plantation (5-15 years)			Pine Plantation (>15 years)			Total #: All Habitat Types		
		Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #:	Mean #	SE
Pine Warbler	*Setophaga pinus*	1	0.13	0.13	-	-	-	3	0.33	0.17	-	-	-	19	1.58	0.29	23	0.52	0.13
Prairie Warbler	*Setophaga discolor*	-	-	-	-	-	-	9	1	0.17	-	-	-	2	0.17	0.11	11	0.25	0.07
Red-bellied Woodpecker	*Melanerpes carolinus*	1	0.13	0.13	2	0.22	0.15	1	0.11	0.11	-	-	-	-	-	-	4	0.09	0.04
Red-eyed Vireo	*Vireo olivaceus*	12	1.5	0.42	6	0.67	0.29	4	0.44	0.18	3	0.5	0.22	7	0.58	0.26	32	0.73	0.14
Red-headed Woodpecker	*Melanerpes erythrocephalus*	1	0.13	0.13	-	-	-	-	-	-	-	-	-	-	-	-	1	0.02	0.02
Ruby-throated Hummingbird	*Archilochus colubris*	-	-	-	-	-	-	4	0.44	0.18	1	0.17	0.17	1	0.08	0.08	6	0.14	0.05
Scarlet Tanager	*Piranga olivacea*	-	-	-	-	-	-	2	0.22	0.15	-	-	-	-	-	-	2	0.05	0.03
Summer Tanager	*Piranga rubra*	4	0.5	0.19	5	0.56	0.18	2	0.22	0.15	-	-	-	3	0.25	0.18	14	0.32	0.08
White-breasted Nuthatch	*Sitta carolinensis*	3	0.38	0.18	-	-	-	-	-	-	-	-	-	-	-	-	3	0.07	0.04
White-eyed Vireo	*Vireo griseus*	1	0.13	0.13	4	0.44	0.24	14	1.56	0.34	13	2.17	0.31	13	1.08	0.29	45	1.02	0.16
Wood Thrush	*Hylocichla mustelina*	5	0.63	0.26	-	-	-	4	0.44	0.29	-	-	-	2	0.17	0.11	11	0.25	0.09
Worm-eating Warbler	*Helmitheros vermivorum*	5	0.63	0.32	2	0.22	0.15	-	-	-	5	0.83	0.17	-	-	-	12	0.27	0.08

Table A.1 (Continued)

Common Name Scientific Name	Hardwood Coves			Streamside Management Zones			Pine Plantation (< 5 years)			Pine Plantation (5-15 years)			Pine Plantation (>15 years)			Total #: All Habitat Types		
	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #:	Mean #	SE
Yellow-billed Cuckoo *Coccyzus americanus*	3	0.38	0.26	5	0.56	0.18	-	-	-	3	0.5	0.34	5	0.42	0.26	16	0.36	0.1
Yellow-breasted Chat *Icteria virens*	4	0.5	0.27	13	1.44	0.41	25	2.78	0.28	6	1	0	14	1.17	0.41	73	1.66	0.19
Yellow-throated Vireo *Vireo flavifrons*	1	0.13	0.13	1	0.11	0.11	1	0.11	0.11	-	-	-	-	-	-	3	0.07	0.04
Total Breeding Birds Detected	89			127			151			74			152			604		

Table A.2 Species and mean number of birds of each species detected at point stations in 5 stand types on Weyerhaeuser owned Old Cove property, Webster County, MS 2009.

	Hardwood Coves			Streamside Management Zones			Pine Plantation (< 5 years)			Pine Plantation (5-15 years)			Pine Plantation (>15 years)			Total #: All Habitat Types		
Common Name Scientific Name	**Total #**	**Mean #**	**SE**	**Total #**	**Mean #**	**SE**	**Total #**	**Mean #**	**SE**	**Total #**	**Mean #**	**SE**	**Total #**	**Mean #**	**SE**	**Total #:**	**Mean #**	**SE**
Acadian Flycatcher *Empidonax virescens*	14	1.75	0.49	1	0.11	0.11	-	-	-	-	-	-	-	-	-	15	0.37	0.14
American Crow *Corvus brachyrhynchos*	-	-	-	7	0.78	0.28	9	1	0.29	8	1.33	0.49	11	1.22	0.36	35	0.85	0.15
American Robin *Turdus migratorius*	1	0.13	0.13	-	-	-	-	-	-	-	-	-	-	-	-	1	0.02	0.02
Blue Grosbeak *Passerina caerulea*	-	-	-	1	0.11	0.11	-	-	-	1	0.17	0.17	-	-	-	2	0.05	0.03
Blue Jay *Cyanocitta cristata*	2	0.25	0.25	5	0.56	0.29	3	0.33	0.33	-	-	-	9	1	0.53	19	0.46	0.16
Blue-gray Gnatcatcher *Polioptila caerulea*	1	0.13	0.13	2	0.22	0.15	-	-	-	-	-	-	-	-	-	3	0.07	0.04
Brown-headed Nuthatch *Sitta pusilla*	-	-	-	2	0.22	0.15	-	-	-	-	-	-	-	-	-	2	0.05	0.03
Carolina Chickadee *Poecile carolinensis*	-	-	-	2	0.22	0.22	1	0.11	0.11	1	0.17	0.17	-	-	-	4	0.1	0.06
Carolina Wren *Thryothorus ludovicianus*	11	1.38	0.46	14	1.56	0.6	6	0.67	0.37	4	0.67	0.33	8	0.89	0.31	43	1.05	0.2
Chipping Sparrow *Spizella passerina*	-	-	-	1	0.11	0.11	-	-	-	1	0.17	0.17	1	0.11	0.11	3	0.07	0.04
Common Yellowthroat *Geothlypis trichas*	-	-	-	6	0.67	0.24	-	-	-	-	-	-	-	-	-	6	0.15	0.07
Downy Woodpecker *Picoides pubescens*	2	0.25	0.16	1	0.11	0.11	-	-	-	-	-	-	-	-	-	3	0.07	0.04

Table A.2 (Continued)

Common Name	Scientific Name	Hardwood Coves			Streamside Management Zones			Pine Plantation (< 5 years)			Pine Plantation (5-15 years)			Pine Plantation (>15 years)			Total #: All Habitat Types		
		Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #:	Mean #	SE
Eastern Bluebird	*Sialia sialis*	-	-	-	2	0.22	0.15	-	-	-	-	-	-	-	-	-	2	0.05	0.03
Eastern Towhee	*Pipilo erythrophthalmus*	-	-	-	3	0.33	0.17	4	0.44	0.24	-	-	-	3	0.33	0.17	10	0.24	0.07
Eastern Tufted Titmouse	*Baeolophus bicolor*	11	1.38	0.53	4	0.44	0.29	-	-	-	1	0.17	0.17	2	0.22	0.15	18	0.44	0.14
Eastern Wild Turkey	*Meleagris gallopavo*	-	-	-	-	-	-	-	-	-	1	0.17	0.17	-	-	-	1	0.02	0.02
Eastern Wood-pewee	*Contopus virens*	7	0.88	0.61	2	0.22	0.22	11	1.22	0.28	3	0.5	0.34	3	0.33	0.17	26	0.63	0.16
Great Crested Flycatcher	*Myiarchus crinitus*	5	0.63	0.26	4	0.44	0.29	-	-	-	-	-	-	-	-	-	5	0.12	0.06
Gray Catbird	*Dumetella carolinensis*	-	-	-	-	-	-	2	0.22	0.22	1	0.17	0.17	-	-	-	3	0.07	0.04
Hairy Woodpecker	*Picoides villosus*	3	0.38	0.18	1	0.11	0.11	-	-	-	-	-	-	-	-	-	4	0.1	0.06
Hooded Warbler	*Setophaga citrina*	6	0.75	0.53	5	0.56	0.29	9	1	0.33	12	2	0.63	14	1.56	0.34	46	1.12	0.19
Indigo Bunting	*Passerina cyanea*	-	-	-	10	1.11	0.35	7	0.78	0.22	3	0.5	0.34	2	0.22	0.15	22	0.54	0.12
Kentucky Warbler	*Geothlypis formosus*	-	-	-	1	0.11	0.11	-	-	-	-	-	-	-	-	-	1	0.02	0.02
Mourning Dove	*Zenaida macroura*	-	-	-	2	0.22	0.15	-	-	-	-	-	-	1	0.11	0.11	3	0.07	0.04

Table A.2 (Continued)

Common Name	Scientific Name	Hardwood Coves			Streamside Management Zones			Pine Plantation (< 5 years)			Pine Plantation (5-15 years)			Pine Plantation (>15 years)			Total #: All Habitat Types		
		Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #	Mean #	SE	Total #:	Mean #	SE
Northern Bobwhite	*Colinus virginianus*	-	-	-	7	0.78	0.32	-	-	-	4	0.67	0.33	-	-	-	11	0.27	0.1
Northern Cardinal	*Cardinalis cardinalis*	2	0.25	0.16	8	0.89	0.11	8	0.89	0.42	13	2.17	0.75	11	1.22	0.4	42	1.02	0.19
Northern Parula	*Setophaga americana*	-	-	-	1	0.11	0.11	-	-	-	-	-	-	-	-	-	1	0.02	0.02
Ovenbird	*Seiurus aurocapilla*	1	0.13	0.13	-	-	-	-	-	-	-	-	-	-	-	-	1	0.02	0.02
Pileated Woodpecker	*Dryocopus pileatus*	2	0.25	0.16	2	0.22	0.15	-	-	-	-	-	-	-	-	-	4	0.1	0.06
Pine Warbler	*Setophaga pinus*	1	0.13	0.13	8	0.89	0.31	-	-	-	-	-	-	7	0.78	0.28	16	0.39	0.11
Prairie Warbler	*Setophaga discolor*	-	-	-	10	1.11	0.39	14	1.56	0.24	2	0.33	0.21	-	-	-	26	0.63	0.14
Red-bellied Woodpecker	*Melanerpes carolinus*	2	0.25	0.16	3	0.33	0.17	-	-	-	-	-	-	-	-	-	5	0.12	0.05
Red-eyed Vireo	*Vireo olivaceus*	17	2.13	0.23	9	1	0.29	4	0.44	0.24	5	0.83	0.17	9	1	0.29	44	1.07	0.14
Red-shoulder Hawk	*Buteo lineatus*	-	-	-	2	0.22	0.15	-	-	-	-	-	-	-	-	-	2	0.05	0.03
Ruby-throated Hummingbird	*Archilochus colubris*	2	0.25	0.25	1	0.11	0.11	4	0.44	0.18	-	-	-	3	0.33	0.17	10	0.24	0.08
Scarlet Tanager	*Piranga olivacea*	2	0.25	0.25	-	-	-	-	-	-	-	-	-	-	-	-	2	0.05	0.03

Table A.2 (Continued)

Common Name	Scientific Name	Hardwood Coves Total #	Hardwood Coves Mean #	Hardwood Coves SE	Streamside Management Zones Total #	Streamside Management Zones Mean #	Streamside Management Zones SE	Pine Plantation (< 5 years) Total #	Pine Plantation (< 5 years) Mean #	Pine Plantation (< 5 years) SE	Pine Plantation (5-15 years) Total #	Pine Plantation (5-15 years) Mean #	Pine Plantation (5-15 years) SE	Pine Plantation (>15 years) Total #	Pine Plantation (>15 years) Mean #	Pine Plantation (>15 years) SE	Total #: All Habitat Types	Total #: All Habitat Types Mean #	Total #: All Habitat Types SE
Summer Tanager	*Piranga rubra*	2	0.25	0.16	2	0.22	0.15	-	-	-	-	-	-	-	-	-	4	0.1	0.06
White-eyed Vireo	*Vireo griseus*	-	-	-	5	0.56	0.44	12	1.33	0.24	7	1.17	0.48	15	1.67	0.24	39	0.95	0.16
Wood Thrush	*Hylocichla mustelina*	7	0.88	0.44	4	0.44	0.25	-	-	-	-	-	-	2	0.22	0.22	13	0.32	0.12
Worm-eating Warbler	*Helmitheros vermivorum*	3	0.38	0.18	1	0.11	0.11	-	-	-	5	0.83	0.4	-	-	-	9	0.22	0.08
Yellow-billed Cuckoo	*Coccyzus americanus*	2	0.25	0.16	7	0.78	0.32	-	-	-	2	0.33	0.21	1	0.11	0.11	12	0.29	0.09
Yellow-breasted Chat	*Icteria virens*	-	-	-	13	1.44	0.24	33	3.67	0.5	6	1	0.68	22	2.44	0.34	74	1.81	0.26
Yellow-throated Vireo	*Vireo flavifrons*	1	0.13	0.13	1	0.11	0.11	-	-	-	-	-	-	-	-	-	2	0.05	0.03
Total Breeding Birds Detected		107			156			127			80			124			594		

Table A.3 Partners in Flight Conservation Scores for each breeding bird detected during the duration of the study on Weyerhaeuser owned Old Cove property, Webster County, MS 2008 and 2009.

Common Name Scientific Name	Partners in Flight Scores[a]	Common Name Scientific Name	Partners in Flight Scores[a]
Acadian Flycatcher *Empidonax virescens*	15	Kentucky Warbler *Geothlypis formosus*	16
American Crow *Corvus brachyrhynchos*	11	Louisiana Waterthrush *Parkesia motacilla*	13
American Goldfinch *Spinus tristis*	8	Mourning Dove *Zenaida macroura*	11
American Robin *Turdus migratorius*	6	Northern Bobwhite *Colinus virginianus*	16
Blue Grosbeak *Passerina caerulea*	12	Northern Cardinal *Cardinalis cardinalis*	12
Blue Jay *Cyanocitta cristata*	14	Northern Parula *Setophaga americana*	15
Blue-grey Gnatcatcher *Polioptila caerulea*	11	Ovenbird *Seiurus aurocapilla*	10
Brown Thrasher *Toxostoma rufum*	15	Pileated Woodpecker *Dryocopus pileatus*	14
Brown-headed Nuthatch *Sitta pusilla*	20	Pine Warbler *Setophaga pinus*	14
Carolina Chickadee *Poecile carolinensis*	16	Prairie Warbler *Setophaga discolor*	18
Carolina Wren *Thryothorus ludovicianus*	13	Red-bellied Woodpecker *Melanerpes carolinus*	13
Chipping Sparrow *Spizella passerina*	9	Red-eyed Vireo *Vireo olivaceus*	11
Common Yellowthroat *Geothlypis trichas*	13	Red-headed Woodpecker *Melanerpes erythrocephalus*	15
Downy Woodpecker *Picoides pubescens*	14	Red-shoulder Hawk *Buteo lineatus*	12
Eastern Bluebird *Sialia sialis*	11	Ruby-throated Hummingbird *Archilochus colubris*	12
Eastern Towhee *Pipilo erythrophthalmus*	16	Scarlet Tanager *Piranga olivacea*	12
Eastern Tufted Titmouse *Baeolophus bicolor*	13	Summer Tanager *Piranga rubra*	16

Table A.3 (Continued)

Common Name Scientific Name	Partners in Flight Scores[a]	Common Name Scientific Name	Partners in Flight Scores[a]
Eastern Wild Turkey *Meleagris gallopavo*	11	White-breasted Nuthatch *Sitta carolinensis*	9
Eastern Wood-Peewee *Contopus virens*	14	White-eyed Vireo *Vireo griseus*	14
Great Crested Flycatcher *Myiarchus crinitus*	12	Wood Thrush *Hylocichla mustelina*	15
Gray Catbird *Dumetella carolinensis*	11	Worm-eating Warbler *Helmitheros vermivorum*	14
Hairy Woodpecker *Picoides villosus*	13	Yellow-billed Cuckoo *Coccyzus americanus*	15
Hooded Warbler *Setophaga citrina*	14	Yellow-breasted Chat *Icteria virens*	13
Indigo Bunting *Passerina cyanea*	14	Yellow-throated Vireo *Vireo flavifrons*	15

APPENDIX B

SUMMARY OF ANOVA RESULTS OF HERPETOFAUNA CAPTURED ON WEYERHAEUSER OWNED OLD COVE PROPERTY, WEBSTER COUNTY, MS 2008 AND 2009

Table B.1 PROC GLM ANOVA results for differences in amphibian species richness and catch-per-unit (CPUE[a]) effort between 2 stand types: coves and streamside management zones within the Weyerhaeuser owned Old Cove property, Bellefontaine, MS from 2008-2009.

	Site Type		
Taxa	*F*	Df	*P*
Total Amphibian Species Richness	0.21	1	0.6504
Total Amphibian CPUE[a]	8.15	1	0.0089
Salamander Species Richness	4.52	1	0.0445
Salamander CPUE	13.59	1	0.0012
Anuran Species Richness	2.59	1	0.1213
Anuran CPUE	2.38	1	0.1366
Eurycea bislineata CPUE	17.81	1	0.0003
Eurycea longicauda guttolineata CPUE	3.62	1	0.0696
Plethodon mississippi CPUE	0.89	1	0.3563

[a]CPUE = Total number of captured individuals per habitat type ÷ Number of sites representing the habitat type

Table B.2 PROC GLM ANOVA results for differences in reptile species richness and catch-per-unit (CPUE[a]) effort between 2 stand types: cove and streamside management zones within the Weyerhaeuser owned Old Cove property, Bellefontaine, MS from 2008-2009.

	Site Type		
Taxa	*F*	Df	*P*
Total Reptile Species Richness	0.06	1	0.8134
Total Reptile CPUE[a]	0.58	1	0.4558
Snake Species Richness	0.93	1	0.3454
Snake CPUE	0.00	1	0.959
Lizard Species Richness	0.01	1	0.9091
Lizard CPUE	0.50	1	0.4857
Turtle Species Richness	0.66	1	0.4259
Turtle CPUE	0.66	1	0.4259
Scincella lateralis CPUE	0.91	1	0.3508

[a]CPUE = Total number of captured individuals per habitat type ÷ Number of sites representing the habitat type

Table B.3 PROC GLM ANOVA results for differences in amphibian species richness and catch-per-unit effort (CPUE [a]) among 3 categories of pine stands: <5 year, 5-15 year, and >15 year within the Weyerhaeuser owned Old Cove property, Bellefontaine, MS from 2008-2009.

	Site Type		
Taxa	*F*	Df	*P*
Total Amphibian Species Richness	3.54	2	0.0393
Total Amphibian CPUE	3.38	2	0.045
Salamander Species Richness	1.00	2	0.3793
Salamander CPUE	1.05	2	0.3611
Anuran Species Richness	2.77	2	0.0754
Anuran CPUE	2.77	2	0.0754
Plethodon mississippi CPUE	1.05	2	0.3611

[a]CPUE = Total number of captured individuals per habitat type ÷ Number of sites representing the habitat type

Table B.4 PROC GLM ANOVA results for differences in amphibian species richness and catch-per-unit effort (CPUE[a]) among 3 categories of pine stands: <5 year, 5-15 year, and >15 year within the Weyerhaeuser owned Old Cove property, Bellefontaine, MS from 2008-2009.

	Site Type		
Taxa	*F*	Df	*P*
Total Reptile Species Richness	6.24	2	0.0046
Total Reptile CPUE	10.57	2	0.0002
Snake Species Richness	1.00	2	0.3793
Snake CPUE	1.00	2	0.3793
Lizard Species Richness	4.64	2	0.0159
Lizard CPUE	9.56	2	0.0005
Turtle Species Richness	0.83	2	0.4458
Turtle CPUE	0.83	2	0.4458
Scincella lateralis CPUE	9.37	2	0.0005

[a]CPUE = Total number of captured individuals per habitat type ÷ Number of sites representing the habitat type