NCASI Briefing Note
IMPACT. SCIENCE. SOLUTIONS.

Private, Working Forests and Biodiversity in the Southeastern United States

FEBRUARY 2021

Summary

Given that nearly 90% of forests in the southeastern US are privately owned, it is important to understand their conservation value. Biodiversity response to active forest management varies by species and is often influenced by past land use and surrounding landscape features, and must be considered at both stand and landscape scales. Young stands provide important early successional conditions, while older stands support species associated with more mature forest conditions. Even-aged harvest regimes result in stands of a single age. However, retained features within and/or near these stands, such as streamside management zones, conservation biotopes, green (i.e., live) trees, and snags (i.e., dead, standing trees), often provide additional structure supporting biodiversity. Some wildlife species require special management for their needs to be met within private, working forest landscapes. A variety of stand ages and conditions across a landscape provide structural characteristics that provide habitat for a diversity of species. Thus, a landscape of actively managed stands contributes to conservation of biological diversity, as summarized herein.

1.0 Introduction

Private, working forests are a dominant land use across the eastern US, and 86% of forests in the southeastern US are privately owned (Oswalt et al. 2019). The economic incentives of forest management contribute to maintaining forests by reducing risk of conversion of forestland to urban and agricultural uses (NCSSF 2005). Thus, a key benefit of forest management to biodiversity conservation is the opportunity to manage forests to achieve landowner goals (including timber production, recreation, wildlife management, or other objectives, combined or singularly) while retaining forests on the landscape. Private landowners manage for a variety of forest types, stand conditions, and objectives, and, in the southeastern US, 79% of private forests are naturally regenerated (Oswalt et al. 2019). Although only 21% of private southeastern US forests are planted, the 45 million acres of planted forest in the southeastern US make up 71% of all planted forests across the US (Oswalt et al. 2019). More specifically, pine (*Pinus* spp.) management is a predominant regime. Specific details and timing of pine management may differ based on objectives, but overall, similar management phases and practices are used at the stand level throughout the southeastern US. A typical pine rotation is 25 to 35 years and begins with stand establishment (preparing a site and planting seedlings). Active forest management practices commonly used on private pine forestlands in the southeastern US, such as targted herbicide application, fertilization, prescribed fire, thinning, and clearcutting contribute to creating and maintaining structural conditions for a variety of wildlife species, including game species, nongame birds, small mammals, reptiles, and bats.

2.0 Legacy Issues and Land Use Change

Clearing of forests for agriculture production primarily occurred throughout the Coastal Plain and Piedmont regions of the southeastern US from the colonial period until the beginning of the Civil War (Williams 1989). Poor agricultural practices led to decreased soil productivity throughout region. Soil erosion, coupled with low prices for crops and pest damage, resulted in significant acreage of abandoned agricultural land between the end of the Civil War and World War II (Fox et al. 2007). Effects of these legacy soil issues are still evident today, when lands with agricultural histories have different understory species compositions than areas with forested histories (Hedman et al. 2000; Dupouey et al.

2002; Vellend et al. 2007; Brudvig et al. 2013). While agricultural abandonment and intensified management of remaining acres have led to a decline in the proportion of agricultural land use since the 1940s, forest cover in the southeastern US has increased since the early 1900s. Today, urbanization and, more recently, urban sprawl are the greatest threats for forest loss and associated biodiversity reductions (Smith et al. 2004; Brown et al. 2005).

3.0 Active Forest Management

Research has demonstrated that active forest management within managed pine landscapes contributes to conservation of biological diversity (e.g., Loehle et al. 2006; Miller et al. 2009; Verschuyl et al. 2011; Iglay et al. 2012a, 2014, 2018; King and Schlossberg 2014; Bender et al. 2015; Demarais et al. 2017; Parrish et al. 2017b). Active forest management can promote understory vegetation diversity. For example, site preparation and vegetation control can reduce competition from woody species and therefore increase understory vegetation diversity within a rotation (Jones et al. 2009a; Lane et al. 2011b) and across multiple rotations (Jeffries et al. 2010). As noted, forest management is especially important in providing economic incentives to keep forests as forests (NCSSF 2005) and diversify vegetation structures for wildlife across landscapes. Forest management provides a mosaic of early , mid , and late-successional stands. Early-successional stands are particularly important components of forested landscapes because they have declined with changes in natural and anthropogenic disturbances across the eastern US, leading to a decrease in early-successional associated forest species such as songbirds (King and Schlossberg 2014). Although some species depend on a specific forest condition (e.g., early succession) throughout their life cycle, others require different successional conditions depending on their development stages. For example, birds tend to have different requirements for nesting, fledging, and as adults (e.g, Chandler et al. 2012). Therefore, beyond early-successional associated forest species, stands in early succession, particularly those adjacent to mid and late-successional stands, also provide structure for some offspring of species that are considered woodland species in their adult stage.

Information at the stand scale is informative because conditions are important for biodiversity and discrete forest management activities generally occur at the stand scale, particularly in even-aged silviculture. However, stand scale cannot be considered alone (Lee et al. 2002), as landscape scales are often more relevant (Miller et al. 2009). Further, forest managers are required to plan management activities at the landscape or ownership scale. Indeed, sustainable forest management provides a relatively constant supply of stand conditions across a landscape, with those conditions spatially shifting over time (e.g., Greene et al. 2019b). As noted, structurally complex landscapes support various species' habitat requirements, whereas these needs are generally not all met within a single stand. It is also important to note that green trees and snags are likely to be retained even during a final harvest, including in streamside management zones (SMZs; Parrish et al. 2017a, 2018). Furthermore, different species require different forest conditions; therefore, there is no one set of forest management recommendations that will benefit all species in a single stand (e.g, Guldin et al. 2007). Instead, at the landscape scale, forest management can provide a mosaic of the complex structures needed for various species and meet their changing needs throughout the year (e.g., Edwards et al. 2004; Miller and Conner 2005; Brooks 2009; Bender et al. 2015; Homyack et al. 2016; Guzy et al. 2019a, 2019b).

Regenerating pine stands provide early-successional forest structure, characterized by a diverse understory, until pine and possibly hardwood species close the canopy. This closed canopy stage is of least value to biodiversity and is present until a stand is partially harvested by thinning. Managers thin planted stands to reduce competition and release remaining crop trees. Desired tree density after thinning varies by management objectives; a lower density promotes development of an open canopy and a concomittant herbaceous plant community. After thinning, managers may conduct mid-rotation management (fertilization, herbicide, prescribed fire), which could include additional thinning, to promote growth of the remaining trees. Mid-rotation treatments (fire, herbicide) may also be conducted specifically to improve habitat conditions for some species by extending the diversity and duration of herbaceous plant communities in post-thinning stands. Finally, managers perform a final harvest, which is commonly a clearcut, followed by site preparation and replanting to start the next rotation. Each of these forest stages provides different structural characteristics that are required by some wildlife species. However, no one stand can provide structural characteristics required by all wildlife associated with forests, so not all species use all forest stages. This section discusses the primary stages of stand development and some documented responses on biodiversity, with the recognition that many species benefit from stand diversity across the landscape.

4.0 Young Stands

Following a final harvest and during stand establishment, young stands provide relatively complex vegetation structure for a diversity of wildlife species until a stand reaches canopy closure. When establishing planted pine stands, targeted herbicide applications are often used to temporarily suppress competition with young pines and may enhance herbaceous understory communities (Miller and Chamberlain 2008; Jones et al. 2009a, 2012; Jeffries et al. 2010; Lane et al. 2011b). Prescribed fire can also be used when establishing stands, but it is increasingly difficult to use on private lands due to liability risks, air quality and smoke regulations, suburban residential development, cost, and limited burning days (Haines et al. 2001; Melvin 2015). Jones et al. (2009a, 2012) and Campbell et al. (2013) described plant communities in planted pine stands in southern Mississippi that were established with five different treatments that varied in intensity but did not include burning. The five treatments encompassed the range of operational intensities used at the time of the study for establishment of commercially managed pine forests across the southeastern Coastal Plain. Generally, herbaceous vegetation established quickly and was abundant for several years following stand establishment in all but the highest intensity treatment, which was rarely used operationally. Regardless, the effects of herbicides on the plant community were largely temporary. All treatments had similar species compositions by four years of age, and by three years of age if the most intense treatment was excluded (Jones et al. 2012). Similarly, Lane et al. (2011b) found that site preparation treatment (mechanical and chemical with herbaceous weed control) effects on plant species diversity lasted no more than four years and chemical site preparation had the greatest effect, particularly on woody species. Greene et al. (2019a) reviewed literature containing structural characteristics of managed pine forests and found that pine stands during establishment provided structural requirements for Bachman's sparrow (*Aimophila aestivalis*), northern bobwhite (*Colinus virginianus*), prairie warbler (*Dendroica discolor*), and eastern diamondback rattlesnake (*Crotalus adamanteus*). Canopies close as stands age, which tends to cause a decrease in overall diversity (although some species will use these stands, such as Swainson's warblers [*Limnothlypis swainsonii*], a species of conservation concern; Henry et al. 2015) until thinning and associated mid-rotation management occurs.

5.0 Thinning and Mid-Rotation Management

In mid-rotation and older planted pine stands, thinning is widely applied to regulate tree density and overstory structure to promote growth of high quality sawtimber and poles. In addition, prescribed fire and targeted herbicide applications may be used to reduce cover of hardwood stems, thus promoting development of a pine-grassland structure (e.g., Jones and Chamberlain 2004; Welch et al. 2004; Jones et al. 2009b; Iglay et al. 2010, 2012a, 2012b, 2018). Lang et al. (2016) reported that average basal area (i.e., tree density) after thinning (first or second thinning) on private timberlands in the Gulf region was 72 to 76 ft2/acre, which is within the range described by Nordman et al. (2016) as "excellent" for southern open pine wildlife species in dry hilly pine woodlands. Furthermore, planting pine stands at lower densities (≤1310 stems/ha [≤530 stems/ac]) and using mid-rotation management (e.g., prescribed fire, herbicide) to reduce mid-story canopy can extend "excellent" open pine conditions up to eight years after thinning (Greene et al. 2019b). Prescribed fire is sometimes used following a thinning to control midstory vegetation and is an optimal management practice for biodiversity. However, Iglay et al. (2010) found that effective hardwood midstory removal was not possible with dormant season prescribed fire alone in stands with advanced hardwood growth (stands were thinned five years prior to study implementation), but was achievable with a single herbicide application with and without subsequent prescribed fire. It is important to note that Iglay et al. (2010) also stated that there was no "best" treatment for control of well-established hardwood midstory species. Within these same stands, Iglay et al. (2014) detected 338 plant species in mid-rotation pines stands managed without additional treatment (controls), with repeated prescribed fire, with a single herbicide application, and with a combination of herbicide and fire. As noted, prescribed fire is not always a feasible option in private, working forests. Although herbicides cannot provide all ecological functions of fire (e.g., immediately remove leaf litter layer, trigger release and germination of seeds in certain plant species), herbicides can provide structural characteristics similar to fire-maintained stands (Wigley et al. 2002) with concomitant responses by some wildlife species (Iglay et al. 2018).

Overall, thinning effects have been found to be positive or neutral on vertebrate diversity (Verschuyl et al. 2011; Demarais et al. 2017). Specifically, birds, small mammals, reptiles, and bats have all been found to respond positively to thinning (Verschuyl et al. 2011; Greene et al. 2016). Responses are often species specific and, not surprisingly, most

negative impacts are linked to disturbance-sensitive species (Verschuyl et al. 2011). While bird community metrics (e.g., diversity and richness) have been found to be similar in young and thinned stands, community assemblages differed as more forest generalist species were detected in thinned stands than in young stands, which had more early-successional associated species (Wilson and Watts 2000).

6.0 Final Harvest

Pine stands in the southeastern US are typically harvested between 25 and 35 years of age. Clearcutting is the most common type of harvest and allows for new trees to regenerate in completely open conditions (Deal 2018). Species responses to a final harvest vary, mainly due to each species' life history, harvest size, and landscape context (Demarais et al. 2017). Clearcuts tend to have temporary negative effects on terrestrial salamander species, particularly in the southeastern US, because the removal of trees increases soil temperature and reduces soil moisture (Tilghman et al. 2012). However, it is important to note that these effects are not long lasting, and terrestrial salamanders are probably not extirpated from an area following a clearcut (Tilghman et al. 2012). Birds associated with mature forests decrease in abundance following a clearcut because the structural characteristics they require are no longer available within that stand, except in SMZs or other set aside areas and adjacent mature stands. However, a variety of species require young, regenerating forests and are prevalent in young stands after a clearcut (Zwolak 2009; Lane et al. 2011a, 2013; Hanberry et al. 2012, 2013; King and Schlossberg 2014). For example, species associated with open forests, such as whip-poor-wills (*Caprimulgus vociferous*) increase in abundance following a clearcut (Wilson and Watts 2008). Whip-poor-wills were detected using regenerating forest edges along adjacent mature stands, probably so they could use resources from both stands (Wilson and Watts 2008). Similarly, clearcuts create edges that bats use for foraging (Morris et al. 2010). Habitat heterogeneity promoted through forest harvest is also important for maintaining populations of economically important species, such as white-tailed deer (*Odocoileus virginianus*; e.g., Edwards et al. 2004) and wild turkey (*Meleagris gallopavo*; e.g., Miller and Conner 2005).

7.0 Fine Filter and Mesofilter Management

As discussed, active forest management can be viewed as a coarse filter. That is, most species can find appropriate habitat conditions within a sustainably managed landscape. However, some species, usually those that need very specific forest conditions, require management targeted to meet their needs, which is termed fine filter management. For example, red-cockaded woodpeckers (*Dryobates borealis*) require large trees with heart rot for natural cavities or insertion of artificial cavities (Jackson and Jackson 1986); therefore, special management is needed to support nesting and roosting habitat within standard pine management. There are also unique ecological sites that some species require, such as cliff faces, rocky outcrops, and glades. For example, the Red Hills salamander (*Phaeognathus hubrichti*) requires high canopy cover, preferably from hardwoods, on steep slopes and ravines (Steen et al. 2014). Although managers cannot create these unique ecological features, they can reduce or avoid harvesting on steep slopes where Red Hills salamanders are known to occur.

Mesofilter management is the intermediate scale that focuses on retaining features that benefit biodiversity (Hunter 2005). Retained features include green trees, snags, coarse woody debris (CWD), and SMZs. Although snags, SMZs, and other set aside areas play a role throughout the rotation, they become particularly important to increase wildlife value in recently harvested stands (Parrish et al. 2017b). For example, cavity nesting birds [red-bellied woodpecker (*Melanerpes carolinus*), red-headed woodpecker (*M. erythrocephalus*), downy woodpecker (*Picoides pubescens*), hairy woodpecker (*P. villosus*)] were only detected in clearcuts with snags in eastern Texas and were not detected in clearcuts with all snags removed (Dickson et al. 1983). These features also provide structural characteristics that are typically required of species associated with older forests. For example, bats commonly use snags for roosting (Miles et al. 2006). CWD has been found to have mixed effects on various species, and particularly on small mammals. One study found white-footed mice (*Peromyscus leucopus*) abundance increased with increasing CWD (Boggs et al. 2020); yet in other studies, inconsistent or no relationships were detected among various rodent species and CWD in the southeastern US (Marshall et al. 2012; Homyack et al. 2014; Fritts et al. 2017). SMZs are a component of state-approved best management practices (BMPs) designed to protect water quality, but also provide structural characteristics of older forests (Warrington et al. 2017) and potential connectivity across a landscape. It is important to note that minimum SMZ widths, as recommended

by BMPs, are commonly exceeded in practice. For example, in the West Gulf Coastal Plain, retention was 3.6 to 13.6% higher within operational landscapes than was recommended by state BMP manuals, and most green tree retention was within SMZs (Parrish et al. 2018). A study in Arkansas found that SMZs maintained according to state BMP guidance provided protection for semi-aquatic and terrestrial salamanders, therefore maintaining community diversity in managed forests, with wider SMZs providing greater value for uncommon salamander species (Guzy et al. 2019b).

Other components of working forest landscapes can provide benefits to biodiversity. Open areas are often limiting on managed pine landscapes. Gated roads and roadsides can help provide some open areas. Additionally, food plots are commonly created and maintained in the southeastern US to benefit game species, particularly white-tailed deer and wild turkey. These areas create forest openings and edges that can also benefit nongame species (e.g., ground nesting birds, pollinators), particularly when food plots are large and rectangular shaped, which may reduce nest predation (Conner and Perkins 2003). Furthermore, ditches along forest roads have been shown to provide conditions for 25 species of amphibians and reptiles, including the spotted turtle (*Clemmys guttata*), a species of conservation concern (Homyack et al. 2016; O'Bryan et al. 2016). Aquatic features imbedded within managed stands can also be important for biodiversity (Johnson et al. 2016).

8.0 Role of Forest Certification

Certification programs, through adherence to standards verified by third party audits, help to ensure that biodiversity measures are maintained through sustainable forest management and wood procurement practices. Englund and Berndes (2015) presented seven principles with underlying specific criteria to assess sustainability standards, particularly in relation to biodiversity. These principles include: (1) endangered species; (2) habitat destruction and fragmentation; (3) habitat degradation and modification; (4) overexploitation; (5) invasive species and GMOs; (6) energy use and GHG emissions; and (7) research, awareness, and education. Using these principles, Sustainable Forestry Initiative (SFI®) and Forest Stewardship Council (FSC®) standards were found to be "stringent" from a biodiversity perspective (Englund and Berndes 2015). Other authors have concluded that, overall, contemporary forest management coupled with forest certification has resulted in landscapes that support and contribute to conservation of biological diversity (e.g., Miller et al. 2009; Demarais et al. 2017). Furthermore, forest certification programs provide long-term assurances that forests will be managed sustainably for the foreseeable future.

9.0 Conclusion

Biodiversity is important to private, working forest landowners and managers across the southeastern US. At a landscape scale, common forest management practices described herein provide structural characteristics that meet most forest species' needs. Retained features provide additional structure that is particularly important to some species immediately after a final harvest. There is a smaller group of species that requires targeted management, which are addressed by managers on a site-specific basis to meet sustainability objectives. Demonstration of sustainable management is accomplished, in part, through forest certification programs. Keeping forests as forests allows landowners and managers to continue creating and maintaining habitat for a high diversity of forest-dependent species.

For an overview of this information, please see NCASI Fact Sheet: Forest Management Contributions to Biodiversity in the Southeastern United States.

10.0 References

Bender, M.J., Castleberry, S.B., Miller, D.A., and Wigley, T.B. 2015. Site occupancy of foraging bats on landscapes of managed pine forest. *Forest Ecology and Management* 336:1-10. https://doi.org/10.1016/j.foreco.2014.10.004.

Boggs, A.D., Moorman, C.E., Hazel, D.W., Greenberg, C.H., and Pacifici, K. 2020. Relationships between white-footed mice and logging residue: informing the sustainability of potential wood bioenergy harvests. *Forest Ecology and Management* 457:117706. https://doi.org/10.1016/j.foreco.2019.117706.

Brooks, R.T. 2009. Habitat-associated and temporal patterns of bat activity in a diverse forest landscape of southern New England, USA. *Biodiversity Conservation* 18:529-545. https://doi.org/10.1007/s10531-008-9518-x.

Brown, D.G., Johnson, K.M., Loveland, T.R., and Theobald, D.M. 2005. Rural land-use trends in the conterminous United States, 1950–2000. *Ecological Applications* 15:1851-1863. https://doi.org/10.1890/03-5220.

Brudvig, L.A., Grman, E., Habeck, C.W., Orrock, J.L., and Ledvina, J.A. 2013. Strong legacy of agricultural land use on soils and understory plant communities in longleaf pine woodlands. *Forest Ecology and Management* 310:944-955. https://doi.org/10.1016/j.foreco.2013.09.053.

Campbell, T.N., Jones, P.D., Ezell, A.W., and Demarais, S. 2013. Growth and competition response in intensively established loblolly pine plantations at crown closure. *Journal of Forestry* 111:313-318. https://doi.org/10.5849/jof.12-045.

Chandler, C.C., King, D.I., and Chandler, R.B. 2012. Do mature forest birds prefer early-successional habitat during the post-fledging period? *Forest Ecology and Management* 264:1-9. https://doi.org/10.1016/j.foreco.2011.09.018.

Conner, M.L., and Perkins, M.W. 2003. Nest predator use of food plots within a forest matrix: An experiment using artificial nests. *Forest Ecology and Management* 179:223-229. https://doi.org/10.1016/S0378-1127(02)00516-9.

Deal, R. 2018. *The Dictionary of Forestry*, 2nd ed. Washington, DC: Society of American Foresters.

Demarais, S., Verschuyl, J.P., Roloff, G.J., Miller, D.A., and Wigley, T.B. 2017. Tamm Review: Terrestrial vertebrate biodiversity and intensive forest management in the U.S. *Forest Ecology and Management* 385:308-330. https://doi.org/10.1016/j.foreco.2016.10.006.

Dickson, J.G., Conner, R.N., and Williamson, J.H. 1983. Snag retention increases bird use of a clear-cut. *Journal of Wildlife Management* 47:799-804. https://doi.org/10.2307/3808615.

Dupouey, J.L., Dambrine, E., Laffite, J.D., and Moares, C. 2002. Irreversible impact of past land use on forest soils and biodiversity. *Ecology* 83:2978-2984. https://doi.org/10.1890/0012-9658(2002)083[2978:IIOPLU]2.0.CO;2.

Edwards, S.L., Demarais, S., Watkins, B., and Strickland, B.K. 2004. White-tailed deer forage production in managed and unmanaged pine stands and summer food plots in Mississippi. Wildlife Society Bulletin 32:739-745. https://doi.org/10.2193/0091-7648(2004)032[0739:WDFPIM]2.0.CO;2.

Englund, O., and Berndes, G. 2015. How do sustainability standards consider biodiversity? *Wiley Interdisciplinary Reviews: Energy and Environment* 4:26-50. https://doi.org/10.1002/wene.118.

Fox, T.R., Jokela, E.J., and Allen, H.L. 2007. The development of pine plantation silviculture in the southern United States. *Journal of Forestry* 105:337-347. https://doi.org/10.1093/jof/105.7.337.

Fritts, S.R., Moorman, C.E., Grodsky, S.M., Hazel, D.W., Homyack, J.A., Farrell, C.B., Castleberry, S.B., Evans, E.H., and Greene, D.U. 2017. Rodent response to harvesting woody biomass for bioenergy production. *Journal of Wildlife Management* 81:1170-1178. https://doi.org/10.1002/jwmg.21301.

Greene, R.E., Iglay, R.B., and Evans, K.O. 2019a. Providing open forest structural characteristics for high conservation priority wildlife species in southeastern U.S. pine plantations. *Forest Ecology and Management* 453:117594. https://doi.org/10.1016/j.foreco.2019.117594.

Greene, R.E., Iglay, R.B., Evans, K.O., Miller, D.A., Wigley, T.B., and Riffell, S.K. 2016. A meta-analysis of biodiversity responses to management of southeastern pine forests—opportunities for open pine conservation. *Forest Ecology and Management*, Special Section: Forest Management for Climate Change 360:30-39. https://doi.org/10.1016/j.foreco.2015.10.007.

Greene, R.E., Iglay, R.B., Evans, K.O., Wigley, T.B., and Miller, D.A. 2019b. Estimating capacity of managed pine forests in the southeastern U.S. to provide open pine woodland condition and gopher tortoise habitat. *Forest Ecology and Management* 432:200-208. https://doi.org/10.1016/j.foreco.2018.09.005.

Guldin, J.M., Emmingham, W., Carter, S.A., and Saugey, D. 2007. Silvicultural practices and management of habitat for bats. 177-205 in Lacki, M.J., Hayes, J.P., and Kurta, A. (eds.). *Bats in Forests: Conservation and Management*. Baltimore, MD: John Hopkins University Press.

Guzy, J., Halloran, K., Homyack, J., Thornton-Frost, J., and Willson, J. 2019a. Differential responses of amphibian and reptile assemblages to size of riparian buffers within managed forests. *Ecological Applications* 29:e01995. https://doi.org/10.1002/eap.1995.

Guzy, J., Halloran, K., Homyack, J., and Willson, J.D. 2019b. Influence of riparian buffers and habitat characteristics on salamander assemblages in headwater streams within managed forests. *Forest Ecology and Management* 432:868-883. https://doi.org/10.1016/j.foreco.2018.10.006.

Haines, T.K., Busby, R.L., and Cleaves, D.A. 2001. Prescribed burning in the South: trends, purpose, and barriers. *Southern Journal of Applied Forestry* 25:149-153. https://doi.org/10.1093/sjaf/25.4.149.

Hanberry, B.B., Demarais, S., and Jones, J.C. 2012. Breeding bird relationships to landscape metrics in coastal plain Georgia. *International Scholarly Research Notices* 2012:359572. https://doi.org/10.5402/2012/359572.

Hanberry, B.B., Edwards, S.L., Demarais, S., and Jones, J. 2013. Small mammal responses to intensively established pine plantations in coastal plain Mississippi. *Southern Journal of Applied Forestry* 37:53-58. https://doi.org/10.5849/sjaf.11-027.

Hedman, C.W., Grace, S.L., and King, S.E. 2000. Vegetation composition and structure of southern coastal plain pine forests: an ecological comparison. *Forest Ecology and Management* 134:233-247. https://doi.org/10.1016/S0378-1127(99)00259-5.

Henry, D.R., Miller, D.A., and Sherry, T.W. 2015. Integrating wildlife conservation with commercial silviculture —demography of the Swainson's warbler (Limnothlypis swainsonii), a migrant bird of conservation concern in southern pine forests, USA. Chapter 10 in Zlatic, M. (ed.). *Precious Forests–Precious Earth*. Rijeka, Croatia: InTech. http://dx.doi.org/10.5772/61168.

Homyack, J.A., Lucia-Simmons, K.E., Miller, D.A., and Kalcounis-Rueppell, M. 2014. Rodent population and community responses to forest-based biofuel production. *Journal of Wildlife Management* 78:1425-1435. https://doi.org/10.1002/jwmg.786.

Homyack, J.A., O'Bryan, C.J., Thornton, J.E., and Baldwin, R.F. 2016. Community occupancy of herpetofauna in roadside ditches in a managed pine landscape. *Forest Ecology and Management* 361:346-357. https://doi.org/10.1016/j.foreco.2015.11.037.

Hunter, M.L. Jr. 2005. A mesofilter conservation strategy to complement fine and coarse filters. *Conservation Biology* 19:1025-1029. https://doi.org/10.1111/j.1523-1739.2005.00172.x.

Iglay, R.B., Demarais, S., Wigley, T.B., and Miller, D.A. 2012a. Bird community dynamics and vegetation relationships among stand establishment practices in intensively managed pine stands. *Forest Ecology and Management* 283:1-9. https://doi.org/10.1016/j.foreco.2012.07.008.

Iglay, R.B., Greene, R.E., Leopold, B.D., and Miller, D.A. 2018. Bird conservation potential of fire and herbicide treatments in thinned pine stands. *Forest Ecology and Management* 409:267-275. https://doi.org/10.1016/j.foreco.2017.11.021.

Iglay, R.B., Leopold, B.D., and Miller, D.A. 2014. Vegetation responses to fire and herbicide in intensively managed, mid-rotation pine. *Forest Ecology and Management* 328:69-78. https://doi.org/10.1016/j.foreco.2014.05.029.

Iglay, R.B., Leopold, B.D., Miller, D.A., and Burger, L.W. Jr. 2010. Effect of plant community composition on plant response to fire and herbicide treatments. *Forest Ecology and Management* 260:543-548. https://doi.org/10.1016/j.foreco.2010.05.010.

Iglay, R.I., Riffell, S.K., Miller, D.A., and Leopold, B.D. 2012b. Effects of switchgrass intercropping and biomass harvesting on plant communities in intensively managed pine stands. Paper 3.6 in *Proceedings from the Sun Grant National Conference: science for biomass feedstock production and utilization*, vol. 1. New York: Springer.

Jackson, J.A., and Jackson, B.J.S. 1986. Why do red-cockaded woodpeckers need old trees? *Wildlife Society Bulletin* 14:318-322. https://www.jstor.org/stable/3782255.

Jeffries, S.B., Wentworth, T.R., and Allen, H.L. 2010. Long-term effects of establishment practices on plant communities across successive rotations in a loblolly pine (Pinus taeda) plantation. *Forest Ecology and Management* 260:1548-1556. https://doi.org/10.1016/j.foreco.2010.08.003.

Johnson, B.A., Homyack, J.A., Barrett, K., and Baldwin, R.F. 2016. Factors influencing herpetofaunal assemblages of aquatic systems in a managed pine forest. *Forest Ecology and Management* 379:124-132. https://doi.org/10.1016/j.foreco.2016.08.012.

Jones, J.D.J., and Chamberlain, M.J. 2004. Efficacy of herbicides and fire to improve vegetative conditions for northern bobwhite in mature pine forests. *Wildlife Society Bulletin* 32:1077-1084. https://doi.org/10.2193/0091-7648(2004)032[1077:EOHAFT]2.0.CO;2.

Jones, P.D., Demarais, S., and Ezell, A.W. 2012. Successional trajectory of loblolly pine (Pinus taeda) plantations established using intensive management in Southern Mississippi, USA. *Forest Ecology and Management* 265:116-123. https://doi.org/10.1016/j.foreco.2011.10.037.

Jones, P.D., Edwards, S.L., Demarais, S., and Ezell, A.W. 2009a. Vegetation community responses to different establishment regimes in loblolly pine (Pinus taeda) plantations in southern MS, USA. *Forest Ecology and Management* 257:553-560. https://doi.org/10.1016/j.foreco.2008.09.033.

Jones, P.D., Mixon, M.R., and Demarais, S. 2009b. Habitat quality following mid-rotation treatment in conservation reserve program pines. *Journal of Wildlife Management* 73:1166-1173. https://doi.org/10.2193/2008-462.

King, D.I., and Schlossberg, S. 2014. Synthesis of the conservation value of the early-successional stage in forests of eastern North America. *Forest Ecology and Management* 324:186-195. https://doi.org/10.1016/j.foreco.2013.12.001.

Lane, V.R., Miller, K.V., Castleberry, S.B., Cooper, R.J., Miller, D.A., Wigley, T.B., Marsh, G.M., and Mihalco, R.L. 2011a. Bird community response to a gradient of site preparation intensities in pine plantations in the coastal plain of North Carolina. *Forest Ecology and Management* 262:1668-1678. https://doi.org/10.1016/j.foreco.2011.07.029.

Lane, V.R., Miller, K.V., Castleberry, S.B., Miller, D.A., Wigley, T.B., Marsh, G.M., and Mihalco, R.L., 2011b. Plant community responses to a gradient of site preparation intensities in pine plantations in the Coastal Plain of North Carolina. *Forest Ecology and Management* 262:370-378. https://doi.org/10.1016/j.foreco.2011.03.043.

Lane, V.R., Miller, K.V., Castleberry, S.B., Miller, D.A., Wigley, T.B. Jr., and Mihalco, R.L. 2013. Small mammal responses to site preparation techniques in North Carolina Coastal Plain pine plantations. *Southern Journal of Applied Forestry* 37:226-232. https://doi.org/10.5849/sjaf.13-028.

Lang, A., Baker, S., and Mendell, B. 2016. Forest management practices of private timberland owners and managers in the U.S. South (2016 update). *Forest Resources Association Technical Release* 2016:16-17.

Lee, M., Fahrig, L., Freemark, K., and Currie, D.J. 2002. Importance of patch scale vs landscape scale on selected forest birds. *Oikos* 96:110-118. https://doi.org/10.1034/j.1600-0706.2002.960112.x.

Loehle, C., Van Deusen, P., Wigley, T.B., Mitchell, M.S., Rutzmoser, S.H., Aggett, J., Beebe, J.A., and Smith, M.L. 2006. A method for landscape analysis of forestry guidelines using bird habitat models and the Habplan harvest scheduler. *Forest Ecology and Management* 232:56-67. https://doi.org/10.1016/j.foreco.2006.05.040.

Marshall, M.M., Lucia, K.E., Homyack, J.A., Miller, D.A., and Kalcounis-Rueppell, M.C. 2012. Effect of removal of woody biomass after clearcutting and intercropping switchgrass (*Panicum virgatum*) with loblolly pine (*Pinus taeda*) on rodent diversity and populations. *International Journal of Forestry Research* 2012:703970. https://doi.org/10.1155/2012/703970.

Melvin, M.A. 2015. *National Prescribed Fire Use Survey Report*. Technical Report 02-15. Washington, DC: National Association of State Foresters; and Newton, GA: Coalition of Prescribed Fire Councils, Inc. http://www.prescribedfire.net/.

Miles, A.C., Castleberry, S.B., Miller, D.A., and Conner, L.M. 2006. Multi-scale roost-site selection by evening bats on pine-dominated landscapes in southwest Georgia. *Journal of Wildlife Management* 70:1191-1199. https://doi.org/10.2193/0022-541X(2006)70[1191:MRSBEB]2.0.CO;2.

Miller, D.A., and Chamberlain, M.J. 2008. Plant community response to burning and herbicide site preparation in eastern Louisiana, USA. *Forest Ecology and Management* 255:774-780. https://doi.org/10.1016/j.foreco.2007.09.064.

Miller, D.A., and Conner, L.M. 2005. Seasonal and annual home ranges of female eastern wild turkeys in a managed pine landscape in Mississippi. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 59:89-99.

Miller, D.A., Wigley, T.B., and Miller, K.V. 2009. Managed forests and conservation of terrestrial biodiversity in the southern United States. *Journal of Forestry* 107:197-203. https://doi.org/10.1093/jof/107.4.197.

Morris, A.D., Miller, D.A., and Kalcounis-Rueppell, M.C. 2010. Use of forest edges by bats in a managed pine forest landscape. *Journal of Wildlife Management* 74:26-34. https://doi.org/10.2193/2008-471.

NCSSF. 2005. *Global Markets Forum. Summary Report of the National Commission on Science for Sustainable Forestry.* Washington, DC: National Commission on Science for Sustainable Forestry.

Nordman, C., White, R., Wilson, R., Ware, C., Rideout, C., Pyne, M., and Hunter, C. 2016. *Rapid assessment metrics to enhance wildlife habitat and biodiversity within southern open pine ecosystems*, ver. 1.0. Washington, DC: United States Fish and Wildlife Service; and Arlington County, VA: NatureServe. For the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative.

O'Bryan, C.J., Homyack, J.A., Baldwin, R.F., Kanno, Y., and Harrison, A.L. 2016. Novel habitat use supports population maintenance in a reconfigured landscape. *Ecosphere* 7:e01228. https://doi.org/10.1002/ecs2.1228.

Oswalt, S.N., Smith, W.B., Miles, P.D., and Pugh, S.A. 2019. F*orest Resources of the United States, 2017: a technical document supporting the Forest Service 2020 update of the RPA Assessment*. General Technical Report WO-97. Washington, DC: United States Department of Agriculture, Forest Service. https://doi.org/10.2737/WO-GTR-97.

Parrish, M.C., Demarais, S., Ezell, A.W., Wigley, T.B., Jones, P.D., and Riffell, S.K. 2017a. Retained vegetation density of streamside management zones and stringers in southern intensively managed pine forests. *Forest Ecology and Management* 397:89-96. https://doi.org/10.1016/j.foreco.2017.04.024.

Parrish, M.C., Demarais, S., Wigley, T.B., Jones, P.D., Ezell, A.W., and Riffell, S.K. 2017b. Breeding bird communities associated with land cover in intensively managed pine forests of the southeastern *U.S. Forest Ecology and Management* 406:112-124. https://doi.org/10.1016/j.foreco.2017.09.063.

Parrish, M.C., Demarais, S., Wigley, T.B., Riffell, S.K., Ezell, A.W., and Jones, P.D. 2018. Operational green tree retention and land cover patterns in intensively managed pine forest landscapes of the southeastern United States. *Forest Science* 64:564-576. https://doi.org/10.1093/forsci/fxy009.

Smith, W.B., Miles, P.D., Vissage, J.S., and Pugh, S.A. 2004. *Forest Resources of the United States*, 2002. General Technical Report NC-241. St. Paul, MN: United States Department of Agriculture, Forest Service, North Central Research Station. https://doi.org/10.2737/NC-GTR-241.

Steen, D.A., Godwin, J.C., McClure, C.J.W., and Barbour, M. 2014. Informing management of endemic habitat specialists: multiscale habitat selection by the Red Hills salamander. *Journal of Wildlife Management* 78:463-470. https://doi.org/10.1002/jwmg.678.

Tilghman, J.M., Ramee, S.W., and Marsh, D.M. 2012. Meta-analysis of the effects of canopy removal on terrestrial salamander populations in North America. *Biological Conservation* 152:1-9. https://doi.org/10.1016/j.biocon.2012.03.030.

Vellend, M., Verheyen, K., Flinn, K.M., Jacquemyn, H., Kolb, A., Calster, H.V., Peterken, G., Graae, B.J., Bellemare, J., Honnay, O., Brunet, J., Wulf, M., Gerhardt, F., and Hermy, M. 2007. Homogenization of forest plant communities and weakening of species–environment relationships via agricultural land use. *Journal of Ecology* 95:565-573. https://doi.org/10.1111/j.1365-2745.2007.01233.x.

Verschuyl, J.P., Riffell, S., Miller, D.A., and Wigley, T.B. 2011. Biodiversity response to intensive biomass production from forest thinning in North American forests - a meta-analysis. *Forest Ecology and Management* 261:221-232. https://doi.org/10.1016/j.foreco.2010.10.010.

Warrington, B.M., Aust, W.M., Barrett, S.M., Ford, W.M., Dolloff, C.A., Schilling, E.B., Wigley, T.B., and Bolding, M.C. 2017. Forestry best management practices relationships with aquatic and riparian fauna: a review. *Forests* 8:331. https://doi.org/10.3390/f8090331.

Welch, J.R., Miller, K.V., Palmer, W.E., and Harrington, T.B. 2004. Response of understory vegetation important to the northern bobwhite following imazapyr and mechanical treatments. *Wildlife Society Bulletin* 32:1071-1076. https://doi.org/10.2193/0091-7648(2004)032[1071:ROUVIT]2.0.CO;2.

Wigley, T.B., Miller, K.V., DeCalesta, D.S., and Thomas, M.W. 2002. Herbicides as an alternative to prescribed burning for achieving wildlife management objectives. 124-138 in Ford, W.M., Russell, K.R., and Moorman, C.E. (eds.). *Proceedings: The role of fire for nongame wildlife management and community restoration: traditional uses and new directions*. General Technical Report NE-288. Newtown Square, PA: United States Department of Agriculture, Forest Service, Northeastern Research Station.

Williams, M. 1989. *Americans and their forests. A historical geography*. Cambridge, UK: Cambridge University Press.

Wilson, M., and Watts, B. 2000. Breeding bird communities in pine plantations on the coastal plain of North Carolina. *The Chat* 64:1-14.

Wilson, M.D., and Watts, B.D. 2008. Landscape configuration effects on distribution and abundance of Whip-poor-wills. *Wilson Journal of Ornithology* 120:778-783. https://doi.org/10.1676/06-108.1.

Zwolak, R. 2009. A meta-analysis of the effects of wildfire, clearcutting, and partial harvest on the abundance of North American small mammals. *Forest Ecology and Management* 258:539-545. https://doi.org/10.1016/j.foreco.2009.05.033.