Miller, J.H. 2001. Pine plantation communities: how do we begin to manage for plant diversity? In: New century: new opportunities: proceedings, 54th annual southern weed science society meeting: 2001 January 22-24. Biloxi, Mississippi. Champaign, IL: Southern Weed Science Society. 215-219.

# PINE PLANTATION COMMUNITIES: HOW DO WE BEGIN TO MANAGE FOR PLANT DIVERSITY?

James H. Miller, USDA Forest Service,
Southern Research Station, Auburn University, AL

## ABSTRACT

Conservation of biological diversity is becoming a flagship issue on public and private forests worldwide while productivity increases are demanded. As concern for diversity maintenance escalates, increasing pressure is being placed on the forestry community to understand the effects of intensifying silvicultural treatments on biodiversity and its sustainable management. Intensity of management must increase to supply commodities demanded by the growing world population. Biodiversity conservation in intensively managed forested regions will depend (at least partially) on species growing in tree plantations, their margins, streamside management zones, and right-of-ways. Within the Southeast, pine plantation acreage is projected to double by 2040, mainly replacing natural pine forests. Replacement and/or establishment of plantations occur through intensive harvesting, using herbicides and mechanical treatments, burning, planting closely-spaced genetically-improved seedlings, and often fertilizing. The singular or additive effects of all these treatments are often assumed to limit plant species richness and diversity, yet little has been documented to support or refute these assumptions. More in-depth research is required by forest vegetation management scientists and other researchers from allied disciplines. To learn more about diversity changes following herbicide treatments for site preparation and release, I have led two teams in conducting both a region-wide research project at 13 locations in 7 states, and a study series in Central Georgia on 7 locations in 3 provinces. The following generalizations come from the findings of these studies as well as from other's related research.

- The Southeast is biologically rich with over 3,000 species of forest-associated plants.
- The richness and diversity of plants associated with pine plantations varies considerably across the region and its numerous physiographic provinces.
- A common flora does exist of species that range across the region, about 500 species.
- Non-native invasive plants are increasingly impacting this floristic diversity, about 120 species.
- Southeastern forests are naturally very resilient because the plant species have evolved through 20 million years of drastic climate-change and more recent episodes of frequent burning, clearing for row crops, old-field succession, and several timber harvests.
- In the Southeast, pine plantations mostly occur within a rich landscape matrix of other land uses.
- Most of the flora is composed of perennials that are capable of residing as underground parts, while both perennials and annuals persist in a rich soil seed bank replenished by continuous seed rain, which fosters resiliency.
- Plant species richness and diversity rebound rapidly after treatments with forestry herbicides, mechanical treatments and burning, with short and long-term compositional shifts according to the selectivity in species control by treatments.
- Total species richness and diversity are only temporarily reduced after most herbicide treatments.
- In the long term (10+ years) only perennial woody and semi-woody plants appear to be influenced by herbicide treatments, not total species richness.
- The density of the pine and/or hardwood canopy eventually dictates the abundance and spatial pattern of understory plants and their development.
- Little is known about how plantation flora compares with that of less managed forests.

## INTRODUCTION

The conservation of biological diversity has gained global recognition as one of the top concerns for sustainable forest management. As concerns for diversity maintenance continue to escalate, more pressure will be placed on forest industry and public forestry to develop a greater understanding of the effects of silvicultural treatments on biodiversity and its sustainable management. In the Southeast, pine plantations are increasingly being reestablished on prior plantations or through replacement of existing natural forest communities. Replacement occurs through: harvesting of most trees; treatments using herbicides and mechanical means to suppress regrowing vegetation and improve rooting environment; planting closely-spaced genetically-improved seedlings; and often using fertilization to stimulate tree growth. The singular or additive effects of all these treatments have been assumed to limit plant species richness and diversity.

---

Invited paper presented at the annual meeting of the Southern Weed Science Society, Jan 24, 2001, Biloxi, MS.

Pine plantation acreage in the southeast is projected to almost double by 2040, mostly through conversion of natural pine stands (1). At present, herbicide and fertilizer treatments are each applied in the region to over one million acres annually, mostly to aid pine plantation establishment. Because of this rapid move toward plantations, it is imperative that we gain a scientific understanding and document the influences of plantation management treatments on diversity and habitat as well as productivity.

The dramatic changes in stand structure that occur by converting a natural forest to a plantation lead many to assume that corresponding changes in composition and abundance of plant species and wildlife uses will also occur. However, in the few research studies in Mississippi that have compared intensive mechanical and herbicide site prep to adjacent pine hardwood forests, very little differences were found in total number of species (although compositional changes were not reported)(9). Thus, many species are conserved, although questions on composition and structural changes still remain.

## MANAGING PLANT DIVERSITY

### Resiliency of Southeastern Forests

Southeastern forest communities are naturally very resilient and represent fairly new assemblages, because most have underwent frequent burning for 10,000+ years, natural reforestation after clearing and replacement with row crops and pastures over a 200 year period, several timber harvests of increasing intensity, and most recently the cessation of regular burning. The more recent harvests were often followed by intensive mechanical land clearing and tree planting. Because of this history, these communities are considered fire sub-climax and are composed of very robust species. Most of the flora is comprised of perennial plants (9, 12), which can subsist as underground plant parts, or in the soil seed bank following burning or blow-down disturbance. Although poorly studied and understood, the continuous replenishment of soil seed banks is critical for sustained resiliency (11). This natural resiliency also limits the efficacy of competition suppression treatments. The spatial and temporal patterns of operational forestry herbicide treatments also encourage plant reinvasions from surrounding untreated or non-forested lands, margins, and right-of-ways. If future management concentrates tree plantations in confined areas then the lack of landscape diversity may lead to other outcomes.

### Southeastern Forests are Rich and Diverse

The richness and diversity of plants associated with pine plantations varies considerably across the southeastern forest region and its numerous physiographic provinces. Distinct forest communities inhabit each physiographic province and vary within each province according to topographic and landform variation. However, a common flora does exist of species that range throughout the region, especially in the provinces where pine plantations are predominantly grown (14). Special plant species, often rare or endangered, do occur in each sub-region and state, especially in unique habitats (e.g., bogs, marshes, bays, estuarine margins, glades, etc.). There is a pressing need to understand the micro- and macro-effects of plantation establishment on biodiversity in all the situations where they occur.

### Plantation Management Impacts on Richness and Diversity

The influence of plantation establishment on floristic diversity has only been studied in a few situations and in general not well reported. To learn more about diversity changes following herbicide treatments for site preparation and release, I have led two teams in conducting both a region-wide research project at 13 locations in 7 states and a study series in Central Georgia on 7 locations (3, 12, 13). The following generalizations come from these studies as well as from the research of others. Because herbicides treatments are often used in conjunction with other silvicultural treatments they are also briefly discussed.

Forest communities regrow after all intensities of herbicide treatments, either operational or lengthy-intensive experimental treatments (2, 4, 5, 9, 12, 17, 19, 20, 21,22). Perennials plants temporarily reside underground as rootstocks, thickened lateral roots (runners), rhizomes, bulbs, and corms, while both perennial and annual plants can persist in a rich soil seed bank. The vigor of sprouting and root sprouting of woody plants is influenced by the season of herbicide application as well as the season of cutting and burning (7). Spring burns and cuttings result in the least vigor, and each herbicide has an optimum timing window for maximum efficacy. Wind, surface waters, and activities of birds and mammals are continuously moving and depositing seeds into the soil seed bank (11). Seed germination can occur immediately after release, over the first growing season, or over a 10-to-50-year period (10). The soil seed bank extends to a depth of 6 or more inches with the majority of seeds at about 1 to 3 inches. Many notable seed bank species in the Southeast are ragweed (*Ambrosia artemisiifolia*), blackberries (Rubus sp.), pokeweed (*Phytolacca Americana*), fireweed (*Erechtites hieracifolia*), horseweed (*Conyza canadensis*), beautyberry (*Callicarpa americana*), and many asters (Aster sp.)(12). The rate of regrowth of vegetative cover is influenced by application rate, site productivity, herbicide resistant species and their regeneration strategies (19).

Mechanical treatments have the most direct influence on the underground plant parts. These treatments can displace many plants when windrowing or destroy them through exposure by disking. However, even the most intensive, rootrake-pile treatments leave many underground parts in place, and often only mix the surface soil seed bank (5).

Most forest herbicides by design are either short-lived at toxic levels in the soil (from one to six months), or have no residual soil activity (15). Once inside plants, herbicides can continue to assert control activities over an extended period, often over several years at sub-lethal levels, causing growth suppression or partial damage. These damaged plants can recover and regrow, and often become a sizable component of associated woody plants in pine plantations (3, 13). Plants not harmed by treatment may also regrow faster if available resources (moisture, nutrients, and light) increase after the treatment. Plants that are damaged will recover or decline depending upon competitive position and advantage, and stressors such as drought.

Herbicide selectivity alters the long-term composition of perennial plants (3, 8, 13). The composition of the plant community associated with pine plantations will be altered by the specific selectivity of the herbicide(s) used and the efficacy of treatment. For example, Arsenal™ generally enhances the occurrence of legumes and blackberries (Rubus sp.), while Tordon™ and Garlon™ reduce legumes and blackberry. Accord™ controls huckleberries (Vaccinium spp.), while Velpar™ releases these commonly occurring shrubs. These changes in composition can greatly influence wildlife habitat value.

Plant succession continues within pine plantations. In general, after any type of disturbance, forbs dominate first-year revegetation and usually start to decline after the first or second year, with perennial grasses becoming their replacements in the ground-layer (9, 12, 19). Vines and blackberry species continue to increase in abundance, with blackberry peaking from ages 10 to 15 years. The growth of hardwoods and pines eventually suppress shrub abundance during the same timeframe (22).

There were no differences in overstory or understory plant species richness and diversity, 10 to 11 years after treatments with the commonly used site preparation and release herbicides in Central Georgia (3, 13). The proportion of pines to hardwoods was increased and selected woody species were less abundant or absent where herbicides were initially effective in control.

Pine canopy development eventually regulates successional trends in plantations (13, 22). The development in density of pine and/or hardwood canopy eventually dictates the density and spatial pattern of understory plants and their development. Very dense pine canopies can in certain micro-sites essentially eliminate understory plants. The spatial patterns of understory richness, layer development, and overall abundance are dictated by topographic, micro-site, and stand variability. Our research with different forestry herbicides has found that at the time of plantation canopy closure, wide variations in pine-hardwood proportions did not influence the understory composition as would be assumed (3, 13). However, woody plant diversity has been shown by others to be different after a wider range of site preparation treatments, from chainsaw felling to rootraking-herbicides-fertilization (8).

Fertilization influences on understory vegetation have been little studied. Fertilization increases the amount and speed of vegetation regrowth not reduced or eliminated by concomitant herbicide treatments (17). Rapid canopy closure after fertilization, even with thinning, results in reduced understory vegetation (18). Toxic effects of some fertilizers have been reported to retard understory vegetative regrowth (18). Fertilization can result in increased ground-layer abundance, but there is little documented information on species changes (17).

Burning shifts the composition of the plant community due to the top killing of woody plants and the stimulation of other herbaceous plants to germinate and to grow faster, due to available post-burn mineralized nutrients. Top killed woody plants also can create structure to accommodate woody vine development. The absence of follow-up prescribed burning in developing stands permits maximum development of residual and invading vines and woody plants. Season of burning influences the size of woody plants killed and their resprouting vigor (7) as well as plant seed germination (6).

Diversity Decreased by Invasions of Non-native Plants

Non-native and native invasive plants are decreasing floristic diversity increasingly in the region and especially in pine plantations (16). Initially, invasive non-native plants add to richness by their entry, but then restrict richness and diversity due to their exclusive invasive habits. Herbicide applications with establishment of pine plantations are in many instances our most effective means of combating exotic invasive plants. Exotic plant spread is probably the greatest foreseeable threat to native plant diversity in the Southeast besides human development.

## RECOGNIZED WAYS TO MAINTAIN DIVERSITY

There is emerging some recognized principles for maintaining or enhancing diversity that can be applied to plantation management, which are:

- Survey for diversity and include diversity management in plans
- Treat stands differently using a range of treatments.
- Treat adjoining stands differently through time.
- Identify and specifically manage special areas of high diversity or those that are habitat for threatened, rare, or endangered species.

- Leave and protect ample streamside management zones, buffers, and stand margins.
- Manage within-forest right-of-ways (ROW's) for diversity and habitat features.
- Do not plant exotics and contain or eliminate exotics within the forest.
- Regularly patrol ROW's, landings, and streamsides for exotic plants and control when present.
- In vegetation management treatments, target only competitors and leave noncompetitive plants.
- Plant trees using wide spacing.
- Leave standing and down wood to encourage the biotic webs of organisms that inhabit coarse woody debris.

## SUMMARY

Pine plantations will play an increasing role in biodiversity conservation within the landscape matrix of natural and conservation forests, right-of-ways, and urban-suburban community forests. Yet little is known about the conserving capabilities of pine plantations as they interplay with other land uses, as well as the benefits of coexisting plants to the long-term health and sustainability of forestlands. It is known that plants associated with pine plantations influence nutrient increment and conservation, wildlife diversity and productivity, wildfire intensity, and the pine productivity of a stand. More short- and long-term, detailed research is needed on species changes following herbicide, mechanical, burning, and fertilization treatments for pine plantation management. Developments in plant diversity management are essential in order to protect species richness for future generations with their unknown needs, to sustain and improve soil health and productivity, and to contribute to the maintenance of life-critical processes.

## LITERATURE CITED

1. Alig, R.J.; Hobenstein, W.G.; Murray, B.C, and Haight, R.G. 1990. Changes in area of timberland in the United States, 1952-2040, by ownership, forest type, region, and state. USDA For. Serv. Gen. Tech. Rep. No. SE-64.

2. Blake, P.M.; Hurst, G.A.; Terry, T.A. 1987. Responses of vegetation and deer forage following application of hexazinone. South. J. Appl. For. 11:176-180.

3. Boyd, R.S.; Freeman, J.D.; Miller, J.H.; Edwards, M.B. 1995. Forest herbicide influences on floristic diversity seven years after broadcast pine release treatments in central Georgia, USA. New Forests 10:17-37

4. Cain, M.D.; Yaussy, D.A. 1984. Can hardwoods be eradicated from pine sites? South. J. Appl. For. 8:7-13.

5. Conde, L.F.; Swindel, B.F.; Smith, J.E. 1983. Plant species cover, frequency, and biomass: early responses to clearcutting, burning, windrowing, discing, and bedding in *Pinus elliottii* flatwoods. For. Ecol. Mang. 6:319-331.

6. Cushwa, C.T.; Martin, R.E.; Miller, R.L. 1968. The effects of fire on seed germination. J. Range Mang. 21:250-254.

7. Kush, J.S.; Meldahl, R.S.; Boyer, W.D. 1999. Understory plant community response after 23 years of hardwood control treatments in natural longleaf pine (*Pinus palustris*) forests. Can. J. For. Res. 29: 1047-1054.

8. Harrington, T.A.; Edwards, M.B. 1996. Structure of mixed pine and hardwood stands 12 years after various methods and intensities of site preparation in the Georgia Piedmont. Can. J. For. Res. 26:1490-1500.

9. Hurst, G.A.; Wilson, L.M.; Leopold, B.D.; Watkins, R.M.; Weinstein, M.D. 1994. Plant species richness following chemical and mechanical site preparation in Mississippi. *In*: Proc. Environmental Issues Affecting the Forestry and Forest Products Industries in the Eastern United States. USDA For. Serv., Northeastern For. Exp. Sta., GTR NE-219.

10. Hyatt, L.A. 1999. Differences between seed bank composition and field recruitment in a temperate zone deciduous forest. Am. Midl. Nat 142:31-38.

11. Leck, M.A.; Parker, V. T.; Simpson, R.L. (eds.) 1989. Ecology of Soil Seed Banks. Academic Press; San Diego, CA. 462 p.

12. Miller, J.H.; Zutter, B.R.; Zedaker, S.M.; Edwards, M. B.; Newbold, R.A. 1995. Early plant succession in loblolly pine plantations as affected by vegetation management. South. J. Appl. For. 19:109-126

13. Miller, J.H.; Boyd, R.S.; Edwards, M.B. 1999. Floristic diversity, stand structure, and composition 11 years after herbicide site preparation. Can. J. For. Res. 29:1073-1083.

14. Miller, J.H.; Miller, K.V. 1999. Forest Plants of the Southeast and Their Wildlife Uses. Southern Weed Science Society; Champaign, IL. 454 p.

15. Neary, D.G.; Bush, P.B.; Michael, J.L. 1993. Fate, dissipation and environmental effects of pesticides in southern forests: a review of a decade of research progress. Env. Tox. Chem. 12:411-428.

16. Stapanian, M.A; Sundberg, S.D.; Baumgardner, G.A.; Liston, A. 1998. Alien plant species composition and associations with anthropogenic disturbance in North American forests. Plant Ecol. 139:49-62.

17. Sword, M.A.; Tiarks, A.E.; Haywood, J.D. 1998. Establishment treatments affect the relationships among nutrition, productivity and competing vegetation of loblolly pine saplings on a Gulf Coastal Plain site. For. Ecol. Mang. 105:175-188.

18. Thomas, S.C.; Halpern, C.B.; Falk, D.A.; Liguori, D.A.; Austin, K.A. 1999. Plant diversity in managed forests: understory responses to thinning and fertilization. Ecol. Appl. 9:864-879.

19. Wilkins, R.N.; Marion, W.R.; Neary, D.G.; Tanner, G.W. 1993. Vascular plant community dynamics following hexazinone site preparation in the lower Coastal Plain. Can. J. For. Res. 23:2216-2229.

20. Zutter, B.R.; Glover, G.R.; Gjerstad, D.H. 1987. Vegetation response to intensity of herbaceous weed control in a newly planted pine plantation. New Forests 4:257-271.

21. Zutter, B.R.; Zedaker, S.M. 1988. Short-term effects of hexazinone applications on woody species diversity in young loblolly pine (*Pinus taeda*) plantations. For. Ecol. Mang. 24:183-189.

22. Zutter, B.R.; Miller, J.H. 1998. Eleventh-year response of loblolly pine and competing vegetation to woody and herbaceous plant control on a Georgia flatwood site. South. J. Appl. For. 22:88-95.