CHANGES IN TREE SPECIES IMPORTANCE FOLLOWING HARVESTING DISTURBANCE IN NORTH MISSISSIPPI BETWEEN 1967 AND 1994

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Abstract—We used continuous forest inventory data from the Forest Inventory and Analysis unit of the U.S. Department of Agriculture, Forest Service to study the impacts of timber harvesting on species composition and species importance in a 26-county region in north Mississippi. The region was 59 percent forested and contained 1 965 223 ha of timberland. There were 524 upland sample plots on a 4.8 by 4.8 km square grid. These were measured in 1967 and remeasured in 1977, 1987, and 1994. Across the period, only 110 plots had < 5 percent of basal area removed. In 1967, on these undisturbed plots, *Pinus echinata* Mill., *Carya* spp., *Quercus falcata* Michx., and *Q. alba* L. were the top four overstory ranking species in terms of basal area, accounting for 13.8, 12.7, 10.6, and 9.9 percent of basal area, respectively. Upon final remeasurement of these same undisturbed plots in 1994, *Q. alba* had become dominant and was followed by *P. echinata*, *Q. falcata*, and *Liquidambar styraciflua* L. In contrast, the total 1994 plot population, which included both disturbed and undisturbed plots, was strongly dominated by *P. taeda* L., which accounted for 22.4 percent of basal area. In stands that had > 75 percent of basal area removed, *P. taeda* accounted for > 50 percent of stand basal area. It appears that harvesting disturbance and management preferences has resulted in an alteration of the normal trajectory of species composition dynamics. *P. taeda* is now the dominant species and the dominant overstory softwood across the uplands of north Mississippi. This appears to be markedly different than what would occur naturally as evidenced by the dominance of *Q. alba* on the undisturbed plots. There were also noteworthy differences in understory species composition; most notably *P. taeda* was dominant on disturbed plots and *Cornus florida* L. was dominant on undisturbed plots.

INTRODUCTION

The southern forest has been subjected to a substantial harvesting disturbance since the 1880s (Williams 1989, Davis 1983). After most of the old-growth was cut, a cycle of harvesting second-growth timber began. This has continued up to the present, with harvesting pressure increasing over the last 30 years in both intensity and area covered (Rosson 1994). The result has been shorter and shorter stand rotations and younger stands across the landscape. Depending on ownership objectives, some stands were placed under management, but many were not.

Continued harvesting disturbance impacts stand development over time (Kohm and Franklin 1997). In the South, many second-growth stands have been harvested and replaced with pine plantations while many stands were left to regenerate naturally (Rosson 1994). Such impacts alter species composition and stand development as forests pass through various stages of recovery and succession. The long term consequences are not known but do raise concerns about the maintenance of species diversity and ecosystem health.

Over the last 30 years, intensive forest management has impacted the forest stands of north Mississippi. Much of this disturbance has been directed toward increases in plantation area, established after initial removal of second-growth hardwoods and hardwood-pine stands (Rosson 2001). Locally, continued disturbance and management practices that remove tree species may require decades or longer for enough propagules to reinhabit such areas and successfully reestablish new populations (Duffy and Meier 1992, Peterkin and Game 1984). Shifts in overall species composition across the landscape in north Mississippi have likely occurred, and this gives rise to concern about the maintenance of species diversity and ecosystem health in the area.

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Decreases in species abundance may be detected early on by monitoring shifts in species composition. We tracked changes in species composition between 1967 and 1994 across 26 counties in north Mississippi to determine if stand composition had changed over time across the landscape. We also determined if shifts in species importance had occurred. Such studies can quantify the impacts of forest management on individual species populations over time. Another important facet of these types of studies is to identify instances where overall stand composition may not change but the relative degree of species importance may shift substantially.

METHODS

To determine shifts in species composition and species importance, we compared data from the 1967 and 1994 surveys of upland forests in a 26-county region in north Mississippi (fig.1). The vegetation of this area has been broadly classed as oak-hickory-pine and oak-hickory (Kuchler 1964). An elongated strip called the blackbelt prairie extends through the central portion of this region. This blackbelt is intermixed with forests composed of *Liquidambar*, *Quercus*, and *Juniperus* species (Kuchler 1964). About two-thirds of the study region falls in Braun's Mississippi Embayment Section of the Western Mesophytic Forest Region. The remainder is in the Gulf Slope Section of her Oak-Pine Forest Region (Braun 1950).

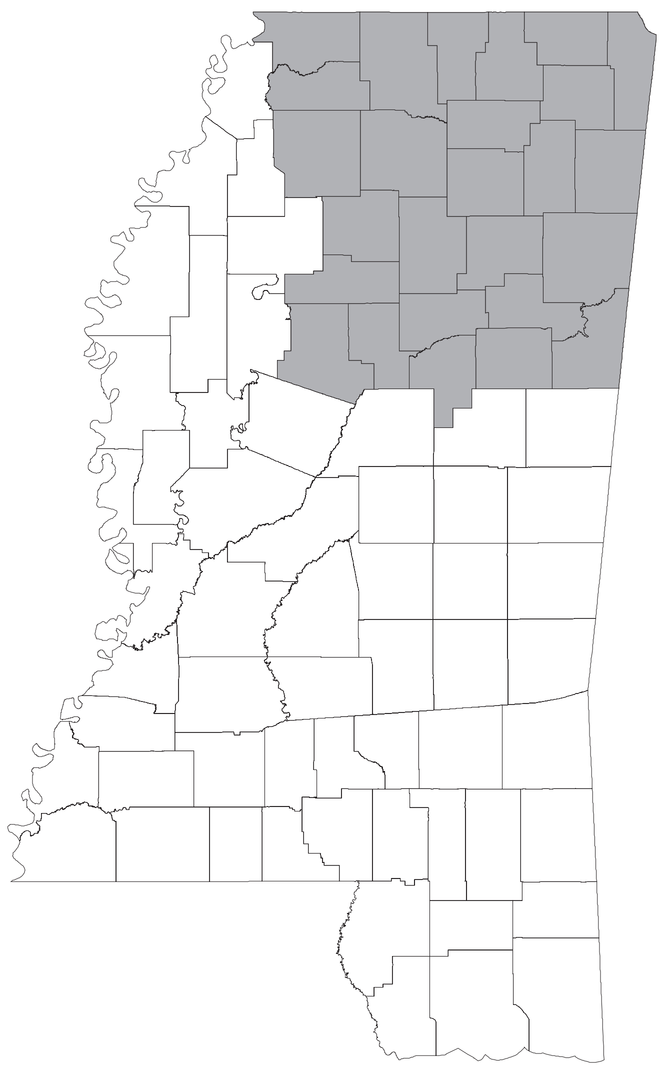

Figure 1—The 26-county study area of north Mississippi.

The data came from forest surveys of Mississippi conducted in 1967, 1977, 1987, and 1994. The sample design consisted of a two-phase method: dot counts on aerial photographs for estimating timberland area and tree measurements on permanently placed sample plots for determining forest stand and tree attributes. The sample design was unchanged throughout all four surveys with sample plots being remeasured each survey. Sample plots were located on a 4.8 km square grid. Each sample plot consisted of a 10-point satellite system covering about 0.4 ha. Trees ≥ 12.7 cm in diameter at breast height (d.b.h.) were tallied on every point, based upon inclusion with an 8.6 m^2 basal area factor prism. Trees < 12.7 cm in d.b.h. were tallied on a 2.2 m radius fixed plot on the first three satellite points. At each satellite point, trees were tallied by species, d.b.h., height, and other tree-character variables for the determination of volume and biomass. Additionally, for each plot, stand level attributes were determined by computer algorithm for stand size and forest type. See Rosson (2001) for more details about the Mississippi surveys.

The 26-county region was 59 percent forested and contained 1 965 223 ha of timberland. In at least one of the surveys during the four survey periods 817 plots were forested. Of these, 606 plots were forested through all four surveys. Eighty-two of these 606 plots were in a bottomland physiographic class and were removed from the plot population. This left 524 upland plots in the study plot population. These study plots were then classed by the amount of cutting disturbance (if any) they received during the four survey periods. The degree of cutting was the amount of stand basal area removed since the previous survey on each sample plot. Across all four measurements, only 110 plots had < 5 percent of stand basal area removed. These plots were labeled the undisturbed plots. Unless otherwise noted, plots that had > 5 percent of their basal area removed by cutting were classified as disturbed. We arbitrarily chose the 5 percent threshold in order to increase the number of undisturbed study plots. Plots that had this low level of cutting (usually consisting of one or two trees per plot) would not impact the overall conclusions inferred from the undisturbed plot population.

The data from the 1967 survey were not directly available but were reconstructed from the 1977 data set. This was possible because measurements from the 1967 survey were maintained in the records of the 1977 data set. For example, information about tree attributes such as previous d.b.h., was available for survivor trees (trees measured in 1967 and measured again in 1977). Some stand information, such as the previous forest type and stand size, was available as well.

To determine shifts in species composition and species importance, we compared data from the 1967 and 1994 surveys. It was only necessary to monitor plot data from the 1977 and 1987 surveys to determine whether plots were disturbed or eliminated from the plot population by conversion from a forest to nonforest state.

The data are presented in two types of format: (1) a set of tables (for 1967 and 1994) for all upland forest plots that remained in forest across four survey periods (tables 1 and 2) and (2) a set of tables (for 1967 and 1994) for the upland forest plots that were undisturbed across the four survey periods (tables 3 and 4). Comparisons can be made between and within 1967 and 1994 for each set of tables. It was determined that the best temporal comparison would be between the total plot population (disturbed and undisturbed combined together) and the undisturbed plot population. This seemed the best logical comparison since the present forest condition in north Mississippi is a complex consisting of both disturbed and undisturbed stands. The comparisons thus reflect the number of disturbed plots and degree of disturbance in the total plot population. Each table lists the 15 most dominant species in the overstory and understory. In all cases, these 15 species capture at least 85 percent of all tree species importance in north Mississippi.

Table 1—Importance, by basal area, of the 15 most dominant trees, by canopy position, for all remeasured plots in north Mississippi, 1967[a]

Common name	Scientific name	Basal area	Basal area[b]
		thousand m²	*percent*
Overstory trees[c]			
Shortleaf pine	*Pinus echinata* Mill.	3 349.00	23.82
Post oak	*Quercus stellata* Wangenh.	1 419.08	10.09
Loblolly pine	*P. taeda* L.	1 408.72	10.02
Southern red oak	*Q. falcata* Michx.	1 324.80	9.42
White oak	*Q. alba* L.	1 157.52	8.23
Sweetgum	*Liquidambar styraciflua* L.	1 066.92	7.59
Hickory	*Carya* sp. Nutt.	1 046.16	7.44
Black oak	*Q. velutina* Lam.	444.17	3.16
Blackjack oak	*Q. marilandica* Muenchh.	356.32	2.53
Blackgum	*Nyssa sylvatica* Marsh.	355.03	2.53
Winged elm	*Ulmus alata* Michx.	240.63	1.71
Yellow-poplar	*Liriodendron tulipifera* L.	215.79	1.53
Cherrybark oak	*Q. falcata var. pagodifolia* Ell.	210.55	1.50
Shumard oak	*Q. shumardii* Buckl.	180.34	1.28
Scarlet oak	*Q. coccinea* Muenchh.	166.96	1.19
Total		14 059.22	92.05
Understory trees[d]			
Shortleaf pine	*P. echinata* Mill.	1 697.20	19.44
Loblolly pine	*P. taeda* L.	1 048.39	12.01
Sweetgum	*Liquidambar styraciflua* L.	906.91	10.39
Flowering dogwood	*Cornus florida* L.	643.16	7.37
Southern red oak	*Q. falcata* Michx.	483.48	5.54
Post oak	*Q. stellata* Wangenh.	449.95	5.16
White oak	*Q. alba* L.	428.00	4.90
Hickory	*Carya* sp. Nutt.	421.85	4.83
Red maple	*Acer rubrum* L.	270.14	3.10
Blackjack oak	*Q. marilandica* Muenchh.	229.76	2.63
Black oak	*Q. velutina* Lam.	228.00	2.61
Water oak	*Q. nigra* L.	205.12	2.35
Winged elm	*Ulmus alata* Michx.	198.10	2.27
Common persimmon	*Diospyros virgininana* L.	184.80	2.12
Blackgum	*N. sylvatica* Marsh.	168.64	1.93
Total		8 728.22	86.66

[a] All FIA plots in the study area that remained forested for the entire study period (1967–94), n = 606.
[b] Based on all live trees in sample.
[c] Trees ≥ 12.7 cm d.b.h.
[d] Trees ≥ 2.5 but <12.7 cm d.b.h.

Table 2—Importance, by basal area, of the 15 most dominant trees, by canopy position, for all remeasured plots in north Mississippi, 1994[a]

Common name	Scientific name	Basal area	Basal area[b]
		thousand m²	*percent*
Overstory trees[c]			
Loblolly pine	*Pinus taeda* L.	3792.69	22.44
Shortleaf pine	*P. echinata* Mill.	1900.78	11.25
Sweetgum	*Liquidambar styraciflua* L.	1723.77	10.20
Southern red oak	*Quercus falcata* Michx.	1521.05	9.00
White oak	*Q. alba* L.	1402.67	8.30
Post oak	*Q. stellata* Wangenh.	1101.31	6.52
Hickory	*Carya* sp. Nutt.	1031.32	6.10
Cherrybark oak	*Q. falcata var. pagodifolia* Ell.	491.58	2.91
Black oak	*Q. velutina* Lam.	437.37	2.59
Water oak	*Q. nigra* L.	433.22	2.56
Yellow-poplar	*Liriodendron tulipifera* L.	358.99	2.12
Red maple	*Acer rubrum* L.	317.06	1.88
Blackgum	*Nyssa sylvatica* Marsh.	274.29	1.62
Winged elm	*Ulmus alata* Michx.	228.25	1.35
Eastern redcedar	*Juniperus virginiana* L.	197.65	1.17
Total		16900.03	90.01
Understory trees[d]			
Loblolly pine	*P. taeda* L.	895.45	17.97
Sweetgum	*Liquidambar styraciflua* L.	763.65	15.33
Flowering dogwood	*Cornus florida* L.	520.96	10.45
White oak	*Q. alba* L.	275.53	5.53
Red maple	*A. rubrum* L.	266.48	5.35
Hickory	*Carya* sp. Nutt.	248.15	4.98
Winged elm	*U. alata* Michx.	245.41	4.93
Shortleaf pine	*P. echinata* Mill.	209.21	4.20
Eastern redcedar	*J. virginiana* L.	172.54	3.46
Blackgum	*N. sylvatica* Marsh.	147.19	2.95
Southern red oak	*Q. falcata* Michx.	121.71	2.44
Black cherry	*Prunus serotina* Ehrh.	110.43	2.22
Yellow-poplar	*Liriodendron tulipifera* L.	95.22	1.91
Post oak	*Q. stellata* Wangenh.	88.20	1.77
Ironwood	*Ostrya virginiana* (Mill.) K. Koch	87.34	1.75
Total		4982.97	85.24

[a] All FIA plots in the study area that remained forested for the entire study period (1967–94), n = 606.
[b] Based on all live trees in sample.
[c] Trees ≥ 12.7 cm d.b.h.
[d] Trees ≥ 2.5 but < 12.7 cm d.b.h.

Table 3—Importance, by basal area, of the 15 most dominant trees, by canopy position, for all remeasured plots on undisturbed stands in north Mississippi, 1967[a]

Common name	Scientific name	Basal area	Basal area[b]
		thousand m²	*percent*
Overstory trees[c]			
Shortleaf pine	*Pinus echinata* Mill.	256.97	13.79
Hickory	*Carya* sp. Nutt.	237.33	12.74
Southern red oak	*Quercus falcata* Michx.	197.28	10.59
White oak	*Q. alba* L.	184.83	9.92
Post oak	*Q. stellata* Wangenh.	182.95	9.82
Sweetgum	*Liquidambar styraciflua* L.	179.01	9.61
Black oak	*Q. velutina* Lam.	98.19	5.27
Blackgum	*Nyssa sylvatica* Marsh.	70.12	3.76
Loblolly pine	*P. taeda* L.	66.07	3.55
Blackjack oak	*Q. marilandica* Muenchh.	55.62	2.99
Cherrybark oak	*Q. falcata var. pagodifolia* Ell.	36.77	1.97
Yellow-poplar	*Liriodendron tulipifera* L.	30.08	1.61
Red maple	*Acer rubrum* L.	25.02	1.34
Scarlet oak	*Q. coccinea* Muenchh.	24.64	1.32
Shumard oak	*Q. shumardii* Buckl.	23.88	1.28
Total		1862.93	89.58
Understory trees[d]			
Shortleaf pine	*P. echinata* Mill.	217.44	17.51
Sweetgum	*Liquidambar styraciflua* L.	150.78	12.14
White oak	*Q. alba* L.	100.46	8.09
Flowering dogwood	*Cornus florida* L.	98.93	7.97
Hickory	*Carya* sp. Nutt.	88.48	7.12
Southern red oak	*Q. falcata* Michx.	70.20	5.65
Eastern redcedar	*Juniperus virginiana* L.	60.34	4.86
Post oak	*Q. stellata* Wangenh.	58.74	4.73
Loblolly pine	*P. taeda* L.	50.23	4.04
Winged elm	*Ulmus alata* Michx.	44.26	3.56
Water oak	*Q. nigra* L.	43.62	3.51
Sourwood	*Oxydendrum arboreum* (L.) DC.	39.70	3.20
Black oak	*Q. velutina* Lam.	37.58	3.03
Common persimmon	*Diospyros virgininana* L.	30.31	2.44
White ash	*Fraxinus americana* L.	22.85	1.84
Total		1241.90	89.69

[a] All FIA plots in the study area that remained forested for the entire study period (1967–94), n = 606.
[b] Based on all live trees in sample.
[c] Trees ≥ 12.7 cm d.b.h.
[d] Trees ≥ 2.5 but < 12.7 cm d.b.h.

Table 4—Importance, by basal area, of the 15 most dominant trees, by canopy position, for all remeasured plots on undisturbed stands in north Mississippi, 1994[a]

Common name	Scientific name	Basal area	Basal area[b]
		thousand m²	*percent*
Overstory trees[c]			
White oak	*Quercus alba* L.	523.12	13.57
Shortleaf pine	*Pinus echinata* Mill.	448.31	11.63
Southern red oak	*Q. falcata* Michx.	403.93	10.48
Sweetgum	*Liquidambar styraciflua* L.	379.32	9.84
Hickory	*Carya sp.* Nutt.	299.03	7.76
Post oak	*Q. stellata* Wangenh.	287.76	7.47
Loblolly pine	*P. taeda* L.	266.03	6.90
Cherrybark oak	*Q. falcata var. pagodifolia* Ell.	167.96	4.36
Water oak	*Q. nigra* L.	137.06	3.56
Black oak	*Q. velutina* Lam.	124.26	3.22
Yellow-poplar	*Liriodendron tulipifera* L.	111.37	2.89
Willow oak	*Q. phellos* L.	72.38	1.88
Scarlet oak	*Q. coccinea* Muenchh.	70.49	1.83
Blackgum	*Nyssa sylvatica* Marsh.	62.72	1.63
Red maple	*Acer rubrum* L.	59.49	1.54
Total		3 853.58	88.57
Understory trees[d]			
Flowering dogwood	*Cornus florida* L.	156.92	19.99
Sweetgum	*Liquidambar styraciflua* L.	127.18	16.20
Red maple	*A. rubrum* L.	56.58	7.21
Eastern redcedar	*Juniperus virginiana* L.	55.83	7.11
Winged elm	*Ulmus alata* Michx.	48.63	6.20
White oak	*Q. alba* L.	44.59	5.68
Blackgum	*N. sylvatica* Marsh.	35.40	4.51
Sourwood	*Oxydendrum arboreum* (L.) DC.	32.96	4.20
Loblolly pine	*P. taeda* L.	24.51	3.12
Hickory	*Carya sp.* Nutt.	22.85	2.91
Chestnut oak	*Q. prinus* L.	16.31	2.08
Southern red oak	*Q. falcata* Michx.	16.18	2.06
Post oak	*Q. stellata* Wangenh.	15.92	2.03
Sassafras	*Sassafras albidum* (Nutt.) Nees	14.96	1.91
Common persimmon	*Diospyros virgininana* L.	11.19	1.43
Total		784.86	86.64

[a] All FIA plots in the study area that remained forested for the entire study period (1967–94), n = 606.
[b] Based on all live trees in sample.
[c] Trees ≥ 12.7 cm d.b.h.
[d] Trees ≥ 2.5 but < 12.7 cm d.b.h.

RESULTS

For all remeasured plots in 1967, the dominant overstory species was *P. echinata* (table 1). It accounted for 23.8 percent of the basal area across the 26 north Mississippi counties. Ranked next in importance were *Q. stellata* and *P. taeda*, each accounting for 10 percent of the basal area in the study area. These three species, together, made up 44 percent of total overstory basal area.

Pinus echinata was also dominant in the understory (table 1). There, it accounted for 19.4 percent of basal area. Ranked next were *P. taeda* and *L. styraciflua*, accounting for 12 and 10 percent of the understory basal area, respectively.

By 1994, *P. taeda* had become dominant in the overstory (table 2). The relative rankings remained very close, but many of the top 15 species changed in their rank position. *Pinus echinata* moved from number 1 to number 2 position, replaced by *P. taeda,* which moved from number 3 to number 1. *Quercus marilandica*, *Q. shumardii*, and *Q. coccinea* dropped below number 15 while *Q. nigra*, *Acer rubrum* L., and *Juniperus virginiana* L. were new additions to the top 15 species. Change in importance rank did not always indicate a substantial shift in basal area between 1967 and 1994. For example, *P. echinata* moved from number 1 to number 2 in rank, and the basal area change was very large, dropping from 3 349.0 thousand m^2 in 1967 to 1 900.8 thousand m^2 in 1994. In contrast, *Q. falcata* var. *pagodifolia* moved from number 13 to number 8 in rank but the basal area change was from 210.6 thousand m^2 to 491.6 thousand m^2.

The understory of the total plot population also had substantial shifts in species ranks. *Pinus echinata* was number 1 in 1967 but was replaced by *P. taeda* by 1994. Basal area for *P. echinata* decreased from 1 697.2 thousand m^2 to 209.2 thousand m^2 in 1994, dropping it to number 8 in rank. *Quercus marilandica*, *Q. velutina*, *Q. nigra*, and *Nyssa sylvatica* Marsh. dropped below the top 15 while *J. virginiana*, *Prunus serotina* Ehrh., *Liriodendron tulipifera* L., and *Ostrya virginiana* (Mill.) K. Koch moved into the top 15.

In the subset of undisturbed plots, *P. echinata* was dominant in the overstory in 1967. It accounted for 13.8 percent of total basal area (table 3). Ranked next were *Carya* spp. and *Q. falcata*, representing 12.7 and 10.6 percent of basal area, respectively. By the time of the 1994 survey *Q. alba* had surpassed *P. echinata* in dominance (table 4). *Acer rubrum* and *Q. shumardii* dropped out of the top 15 species while *Q. nigra* and *Q. phellos* moved into the top 15.

Pinus echinata was dominant in the understory of the undisturbed plots in 1967. Ranked next was *L. styraciflua*. Together, these two species accounted for almost 30 percent of total basal area in the understory. By 1994, *Cornus florida* L. was ranked number 1 while *L. styracilflua* remained in the number 2 position. *Cornus florida*, alone, accounted for 20 percent of understory basal area. One of the biggest shifts between 1967 and 1994 was *P. echinata* dropping out of the top 15 understory species. Also dropping off the list were *Q. nigra*, *Q. velutina*, and *Fraxinus americana* L. In 1994, new additions were *A. rubrum*, *N. sylvatica*, *Q. prinus*, and *Sassafras albidum*.

DISCUSSION

Between 1967 and 1994, only 110 (21 percent) out of 524 sample plots went through the four survey periods with harvesting < 5 percent of basal area. These 110 plots were used as the baseline (control) group in our study to mimic how north Mississippi stands may develop over time when undisturbed.

When levels of harvesting disturbance are this high, two modes of regeneration influence and impact stand development. The first is implementation of plantations after harvest. The establishment of plantations usually indicates intense cutting activity and site disturbance (clearcutting) since large open areas are necessary to operate planting equipment efficiently. The second is natural regeneration after some form of harvesting activity. This may range from removing only 10 percent of a stand to clearcutting. The implementation of plantations is usually the more intrusive action and has the potential to allow a single species to dominate an entire landscape. In addition to intensive overstory removal, plantation establishment may involve substantial site preparation and competition control; both may strongly influence post-harvest species abundance. However, a clearcut operation, without subsequent plantation establishment, allows the invasion of opportunistic species to become established. Additionally, stump sprouting may result in a forest stand very similar to the one that was cut.

On the disturbed plots, the most substantial change in species composition between 1967 and 1994 was *P. echinata* dropping from the number 1 ranking to number 2. Although the shift was only one position in the overstory ranking, the larger change was in basal area. *Pinus echinata* dropped from 3 349.0 to 1 900.8 thousand m^2 in total landscape basal area, a 43-percent decrease. In contrast, *P. taeda* went from third in importance in 1967 to first in 1994. Basal area of *P. taeda* went from 1 408.7 to 3 792.7 thousand m^2, a 169-percent increase. This left little available niche space for hardwood development.

On the undisturbed plots, *P. echinata* was number 1 in 1967 and moved to number 2 in 1994. Even though it moved downward in rank its basal area increased, going from 257.0 thousand m^2 to 448.3 thousand m^2, a 74-percent increase. *Quercus alba* became the most dominant species with basal area increasing from 184.3 thousand m^2 to 523.1 thousand m^2, a 184-percent increase. If stand succession is progressing normally on these undisturbed plots, oaks should move into dominance over time, in place of pine, in north Mississippi. This would be especially so if the successional phases are given the opportunity to proceed, without interruption, for 75 years or more.

One of the important things these data show is that replacement stands on these disturbed areas concentrate larger relative amounts of basal area in fewer species. In the disturbed stands, almost 25 percent of total basal area was in the number 1 ranked species, *P. echinata* in 1967 and *P. taeda* in 1994. The cause of most of this was old field invasion or management preference (disturbance) for *P. taeda* through the 1970s, 1980s and 1990s.

In forests of north Mississippi, between 1967 and 1994, *P. echinata* has been displaced by *P. taeda* as the landscape dominant mostly because of preference for *P. taeda* in plantation management (Rosson 2001, Rosson 1995). However, many other species have changed position in relative ranking across the landscape because of this disturbance. Some changes have been minor but many have been substantial.

Stand dynamics analysis is difficult because of the complexity involved in separating natural stand succession dynamics from anthropogenic disturbance dynamics. Our study used a control group of undisturbed plots to compare with disturbed plots but the control group may have been of limited value. First, the ownership properties of these plots may have biased their status. Personal ownership values (such as preservation or economics) may have influenced stand development. Second, we did not know the status of the undisturbed plots prior to 1967. Some may have been disturbed recently while there may have been many years since disturbance in other stands. Therefore, some of the undisturbed plots may have been further into successional stages than others.

None of the species in the overstory of the undisturbed plots are considered very tolerant (on the hierarchical scale of very tolerant, tolerant, intermediate, intolerant, and very intolerant) as described by Baker (1950). *Quercus alba*, the dominant hardwood, is considered intermediate in tolerance. The other major components, *P. echinata*, *L. stryaciflua*, *Carya* spp., and *P. taeda* are all considered intolerant. This indicates that succession is still progressing and that overstory stand development is still in early recovery from past disturbances.

In the understory, *C. florida* is the only tree that is considered very tolerant. Other indicators of advancing succession are *A. rubrum*, *N. sylvatica*, and *Diospyros virginiana* L., all considered tolerant.

Our preliminary study has demonstrated the replacement of *P. echinata* by *P. taeda* across north Mississippi along with the suppression of the hardwood component. Future studies will include refinements in defining the control group of plots and testing the sensitivity of species associations. Also, work needs to be done on assessing the overall impact of changes in species dominance and relative species ranking across the landscape. We do not know the degree of disturbance that is harmful to forest ecosystems, especially disturbance that impacts species populations. For example, there are no indicator values in place that define limits to which specific population numbers may fall before irreparable harm is done to a forest ecosystem or to where species populations cannot recover.

Presently, the data demonstrate the resilience of hardwoods to displacement disturbance. As site disturbances decrease, hardwoods maintain or return to dominant positions, as *Q. alba* has done. Additionally, available habitat is shared on a more even basis by several species rather than one or two dominants. The natural type of oak-pine in north Mississippi appears persistent as foresters try to silviculturally maintain the dominance of pine because of current economic benefits. Unknown is how long the hardwood component can be suppressed and still maintain enough resilience to regenerate and occupy their normal positions in stand composition. Future studies will compare disturbed and undisturbed areas directly. This will give a more rigorous indication of the impact of harvesting disturbance on stand development.

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