Reports

Plant Cover and Biomass Response to Clear-Cutting, Site Preparation, and Planting in *Pinus elliottii* Flatwoods

Abstract. *Pine plantation management did not initially convert natural forests to monocultures; rather it increased plant species richness and diversity. During a 5-year study of two natural watersheds in Florida that were converted to plantations, woody species diminished, but herbaceous species increased. Number of plant species on permanent transects and plots increased. Diversity of cover, frequency, and biomass did not diminish or else increased after harvest.*

In the lower coastal plains of the southeastern United States, large tracts of pinelands are managed for fiber production. Flat, imperfectly to poorly drained, sandy sites (flatwoods) are harvested by clear-cutting, treated with heavy machinery to reduce logging debris and competing vegetation, and planted to pines to ensure adequate survival, optimum spacing, and acceptable future fiber production (*1*). Environmentalists, ecologists, and wildlife biologists express considerable concern for the effects of forest operations on forest flora and fauna (*2*); large-scale operations are vividly destructive of natural stands. The concern is that native flora is jeopardized by plantation management which may so discriminate for a few preferred tree species and against a vast array of others—especially understory species—that many plants are potentially endangered (*3*).

Our aim is not to dismiss these concerns, but to objectively examine new evidence on plant responses to forest management operations in the flatwoods, the most important forest type in the lower coastal plain. These responses are expressed by plant species cover, frequency, and biomass, all of which were measured in the summers before harvest and site preparation and during the first three summers after planting (*4*).

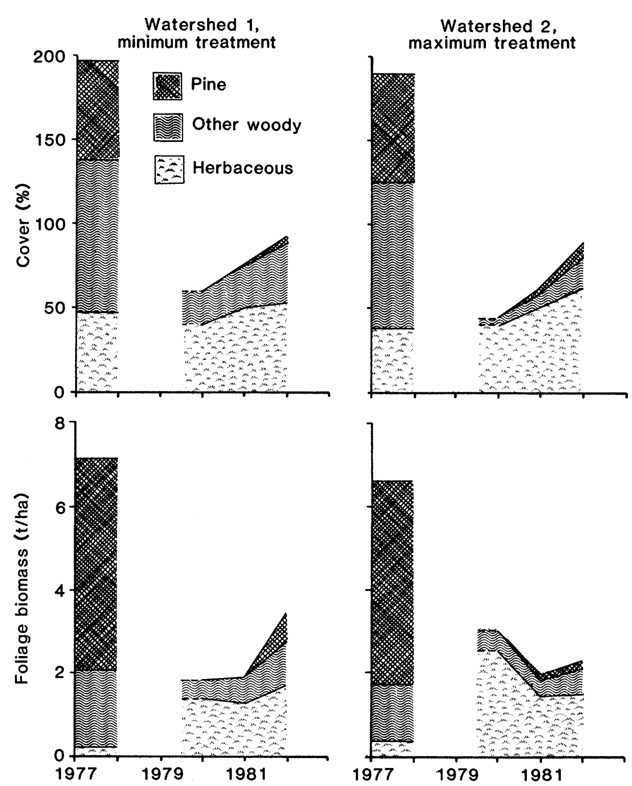
Two of three contiguous experimental watersheds, established in 40-year-old natural flatwood forests 8 km west of Starke, Bradford County, Florida, were chosen for study. The climate is humid and subtropical, with an average rainfall of 145 cm annually. Topography is characteristically flat, with elevations between 43 and 45.5 m above sea level (*5*).

Davis (*6*) described natural flatwoods as

> open woodlands of one to three species of pine: longleaf, slash, and pond pines. Many herbs, saw palmetto, shrubs, and small trees form an understory. Included in general flatwoods areas are small hardwood forests, many kinds of cypress swamps, prairies, marshes, and bay tree swamps.

The study site was typical of the type with slash pine (*Pinus elliottii*) the dominant pine species. There were no prairies or open marshes. There have been no forest fires (*7*) or cattle at the site since 1938.

On the 67-ha site (watershed 1), pinelands, occupying 49 percent of the area, were clear-cut in November and December 1978; light equipment and labor intensive methods were used (*8*). Logging



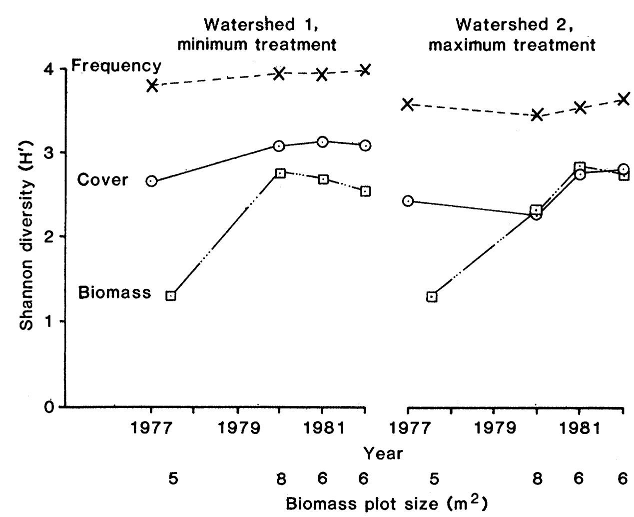


Fig. 1 (left). Plant cover and foliage biomass before clear-cutting of flatwood forests and site preparation by two treatments and for three consecutive years after planting of slash pine; *t*, metric ton. Fig. 2 (right). Shannon diversity index (H') of plant species frequency, cover, and biomass before clear-cutting of flatwood forests and site preparation by two treatments and for three consecutive years after planting of slash pine.

debris and residual understory were chopped twice the following spring and summer with a roller drum chopper (*9*). Bedding and machine planting (*9*) completed operations in November 1979. Hardwood stands, occupying 51 percent of the watershed, were not disturbed (*8*).

On the 49-ha site (watershed 2), pinelands, occupying 74 percent of the area, were concurrently clear-cut with heavy equipment (*8*). Resin-soaked stumps from a previous harvest were extracted from the soil and removed. Logging debris and residual understory were first burned and then pushed into windrows (*10*). Spaces between windrows were harrowed and then bedded and machine planted as in watershed 1. Hardwood stands, occupying 26 percent of the watershed, were not disturbed (*8*).

A 140-ha control site (watershed 3) was not disturbed (*8*).

Management regimes for southern pine plantations vary by site and ownership. Regeneration regimes, which are commonly practiced on a large scale, are all intermediate in destructiveness between the regimes imposed on watersheds 1 and 2; hence, our regimes may be called minimum and maximum treatments, respectively.

Of 300 10-m transects permanently established on the three watersheds (100 clusters of three transects each), 26 transects were within the area subsequently clear-cut on watershed 1, and 24 were within the clear-cut area on watershed 2. Cover and frequency for each plant species along these transects were recorded in identical, nondestructive surveys in the midsummers of 1977, 1980, 1981, and 1982.

Of 27 plots (10 by 10 m) permanently established on the three watersheds, six were within each of the two clear-cut areas. Overstory foliage biomass was determined by destructive sampling of trees on these plots in the summers of 1977 and 1978 (*11*); midstory foliage biomass was determined from a subplot (5 by 5 m) in each plot; and understory foliage biomass was determined from five subplots (1 by 1 m) in each plot. Postharvest foliage biomass was determined in the summers of 1980, 1981, and 1982 by destructive sampling of distinct subplots of 8, 6, and 6 m^2 in each plot, respectively.

The total amount of vegetation in a forest is vividly reduced by clear-cutting and site preparation. For our experiment, that reduction was measured by the sum of crown covers recorded for each species and by total foliage biomass (Fig. 1). Thus, under any common plantation regeneration regime, foliage cover and biomass may be reduced by two-thirds or more after harvest (Fig. 1). The reduction is, however, borne by woody species. The previously dominant genus (*Pinus*) was practically eliminated by harvest, and planted pine seedlings were typically a minor component of the vegetation for several years following planting (Fig. 1). In general, the woody component was dramatically reduced, especially by more intensive site preparation (Fig. 1).

Table 1. Total number of plant species identified in flatwood forests in Bradford County, Florida, before harvests (1977–1978) and after site preparation and planting (1980, 1981, and 1982).

Year	Plant species: Transects	Plant species: Biomass plots*
	Watershed 1	
1977–1978	69	41 (5)
1980	85	74 (8)
1981	81	63 (6)
1982	88	75 (6)
	Watershed 2	
1977–1978	52	47 (5)
1980	53	62 (8)
1981	56	55 (6)
1982	63	72 (6)

*Numbers in parentheses are biomass plot sizes (square meters).

Collectively, herbaceous species in our experiment increased after forest operations: crown covers increased slightly (Fig. 1, top) and biomass dramatically (Fig. 1, bottom). *Andropogon* and *Panicum* were especially abundant postharvest. Thus, clear-cutting, site preparation, and planting in a predominantly woody forest increased the herbaceous component, at least initially. This response has been described in several other lower coastal plains ecosystems (*12*).

What of changes in species composition in response to forest operations? The transect data are directly comparable year-to-year and show an increase in species richness following either sequence of forest operations (Table 1). The increase after maximum treatment appears more modest (*13*) and is perhaps delayed. Counts from the biomass plots are not so directly comparable because of variable plot size. Discounting for this source of variation (*14*), the indicated trends in species richness on the biomass plots reinforce the transect results (Table 1). [In both instances the 1981 species counts appear depressed, perhaps because of drought (*8*).]

From data on cover, frequency, and biomass by species (*4*) for each year of our survey, we computed the Shannon index of diversity (*15*) $H' = -\Sigma p_i \log p_i$, where p_i is the proportion of total cover (frequency or biomass) accounted for by the *i*th species (Fig. 2). Species diversity (*16*) was increased by both series of forest operations. As with species richness, the increase in diversity appeared more modest and perhaps delayed after maximum treatment. Increased diversity (and richness), in comparison with that of the natural stand, clearly persisted for 3 years after regeneration by either series of forest operations (Fig. 2).

The increase in species diversity occurred because forest operations (i) reduced, but did not eliminate, late successional tree and shrub species that dominated the undisturbed forest; and (ii) allowed the reappearance, after disturbance, of native, early successional forb and grasslike species (*4*). Subsequent trends in diversity, as the planted pines assert dominance on the site, are expected to be less ecologically favorable, but the trends cannot be accurately projected at this time.

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References and Notes

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4. Methods and results through two postharvest years are described in detail by L. F. Conde, B. F. Swindel, and J. E. Smith (*For. Ecol. Manage.*, in press).
5. Soils of the Stilson-Pelham-Mascotte association dominate the pinelands. The moderately well-drained Stilson series (Arenic Plinthic Paleudult) occurs in higher sites. Soils on imperfectly and poorly drained areas typically have spodic horizons at about 50 cm, the Mascotte series (Ultic Haplaquod) being most common. Soils of the Surrency series (Arenic Umbric Paleaquult) are dominant in hardwood swamps.
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13. Windrows are likely habitats for additional plant species, but windrows created in site preparation on watershed 2 were not surveyed.
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17. Container Corporation of America offered the land and fire protection for this study and imposed the prescribed treatments.

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