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Introduction

Ground flora is an important component of bottomland hardwood ecosystems (Harris and Gosselink, 1990). Herbaceous plants and small woody stems constitute important habitat components for various wildlife species such as white-tailed deer (*Odocoileus virginianus)*, wild turkey (*Meleagris gallopavo*), and small mammals (Brabander et al., 1985). This strata also provides browse, cover, and nesting sites for numerous species of insects, birds, fish, amphibians and reptiles. Alterations of the ground flora strata could have a significant impact on populations of these and other wildlife species (Bonham, 1989).

Reproduction cutting methods (i.e., clearcutting, seed-tree, shelterwood, or selection) are designed to regenerate a stand by natural or artificial means (Smith, 1986). Alterations of ground flora using silvicultural treatments and the degree of impact on floral and faunal communities in bottomland hardwood ecosystems are not well known (Lockaby and Stanturf, 1996). Therefore, the objective of this study was to evaluate ground flora composition following complete and partial harvesting in a bottomland hardwood ecosystem.

Materials and Methods

The study site was located on Pittman Island, Issaquena County, Mississippi on land owned by Anderson-Tully Company. This area was located inside the levee system of the Mississippi River (batture lands). The woody plant community consisted of riverfront hardwoods including sugarberry (*Celtis laevigata* Willd.), green ash (*Fraxinus pennsylvanica* Marsh.), and American elm (*Ulmus americana* L.). Other tree species included sycamore (*Platanus occidentalis* L.), sweet pecan (*Carya illinoensis* (Wang.) K. Koch), bitter pecan (*Carya aquatica* (Michx. f.) Nutt.), Nuttall oak (*Quercus nuttallii* Palmer), water oak (*Quercus nigra* L.), overcup oak (*Quercus lyrata* Walt.), boxelder (*Acer negundo* L.), red maple (*Acer rubrum* L.), common persimmon (*Diospyros virginiana* L.) and honey locust (*Gleditsia triacanthos* L.). Distribution of these species was based on physiographic conditions such as ridge/swale topography (Hodges and Switzer, 1979).

Permanent plots were installed during the summer of 1995 using a systematic plot design. Treatment plots were 20 ha in size and each treatment (clearcut, selection, and control) was replicated three times. Within each treatment sixteen 0.10-ha circular plots were installed. Eight of these plots were used to evaluate ground flora composition using a l-m square plot located 5 m from plot center.

The study site was harvested during the winter of 1995-96. After harvesting, clearcuts were recentered and all remaining stems > 5 cm diameter at breast height (1.4 m above ground) were felled to establish a complete or biological clearcut. Selection cuts were harvested according to Anderson-Tully Company guidelines with approximately 50% of the basal area removed. Species favored to keep during marking included green ash, sweet pecan, Nuttall oak, and well-formed sugarberry.

Two herbaceous inventories were conducted during May and July 1996. These periods were separated by a flood that inundated the study site for approximately three weeks, followed by six weeks of dry weather. All plants within each of the 1-meter square plots were identified to species and classified as a forb, composite, legume, fungi, vine, or woody stem.

Calculations included Shannon-Weaver diversity indices (Shannon and Weaver, 1949) and importance values by species (sum of relative frequency and relative density). Sorenson's Community Similarity equation was also used to compare species composition between treatments (Mueller-Dombois and Ellenburg, 1974). Analysis-of-variance was used to determine if significant differences occurred between treatments ($P \leq .05$ level). Duncan's Multiple Range Test was used for mean separation (Little and Hills, 1974).

Nomenclature of tree species followed Duncan and Duncan (1988). Nomenclature of herbaceous plants followed Smith (1988, 1994), Godfrey and Wooten (1981), and Radford et al. (1968).

Results

A total of 43 families and 67 species of herbaceous and woody plants was recorded during May and July 1996 (see Appendix). Of the 67 species recorded, 49% were forbs, 35% were woody and herbaceous vines, and 16% were woody stems. Many of these species were opportunistic annuals and perennials that quickly invade a site after a disturbance.

Species diversity of ground flora for May 1996 was greatest for the harvested treatments ($F = 10.05$, $P = 0.01$, $df = 8$; Table 1). No difference was found for species evenness ($F = 3.02$, $P = 0.12$, $df = 8$) or richness (number of species) between all treatments ($F = 2.84$, $P = 0.14$, $df = 8$) although controls were consistently lower in evenness (Table 1). Wild parsley (*Trepocarpus aethusae* Nutt.) had the highest mean importance value in selection and control treatments while stinging nettle (*Urtica chamaedryoides* Pursh) had the highest mean importance value in the clearcut treatment during May, 1996 (Table 2). Other species displaying high importance values were false nettle (*Boehmeria cylindrica* (L.) Sw.), sugarberry, and butterweed (*Senecio glabellus* Poir.) (Table 2). Similarity of community composition was greatest between the two harvesting treatments and lowest for the clearcut versus control treatments (Table 3).

Species diversity, evenness and richness all declined after inundation of the site during the 1996 growing season (July sampling; Table 3). No difference in diversity ($F = 2.61$, $P = 0.15$, $df = 8$) or evenness ($F = 3.67$, $P = 0.09$, $df = 8$) was found between treatments although selection cuts still had the highest mean diversity. Selection cuts also had greater richness than the other treatments ($F = 9.05$, $P = 0.02$, $df = 8$). The controls were consistently lower in diversity and evenness among all treatments (Table 1). With the exception of sugarberry seedlings and butterweed, species displaying high importance values in May were zero in July (Table 2). Two species of low importance in May had high mean importance values in July, buckwheat vine (*Brunnichia ovata* (Walt.) Shinners) and blackberry (*Rubus trivialis* Michx). These species, both herbaceous vines, were released after flood waters receded. Unlike the May sampling period, similarity of community composition was greatest for the selection and control treatments. The clearcut and control treatments remained the least similar (Table 3).

Discussion

Previous floristic studies in bottomland hardwoods have involved primarily tree species composition and successional relationships of woody plants (Carter et al., 1990; Wiseman, 1982). Baker and Hodges (in press) examined diversity of three canopy levels in clearcuts of different ages. They found that diversity stabilized at all canopy levels by year 35. Francis (1984) also found that herbaceous species abundance and above-ground biomass were higher in one-year-old clearcut areas, but declined after four years. Once openings are created, woody vines, shrubs, briers and herbaceous species quickly invade a site (Sharitz and Mitsch, 1993). In our study species composition one year

Table 1. Diversity, evenness, and richness by reproduction cutting method during the first growing season after harvest (1996) on Pittman Island, Issaquena County, MS.

	Reproduction Cutting Method		
	Clearcut	Selection	Control
May 1996			
Diversity	2.70a[1]	2.74a	2.34b
Evenness	0.81a	0.81a	0.74a
Richness	28a	30a	24a
July 1996			
Diversity	2.02a	2.31a	1.95a
Evenness	0.80a	0.76a	0.69a
Richness	13b	21a	Slab

[1]Numbers followed by the same letter within a row are not different ($P \leq 0.05$).

after harvest consisted of opportunistic annuals and perennials along with the release of perennial species that were on the site prior to harvest. Over time these species will probably decline in abundance and eventually be replaced by shrub and tree species (Baker and Hodges, in press).

Maintaining diversity in vegetation communities is an important aspect of bottomland hardwood ecosystems (Harris and Gosselink, 1990). Between 75 and 100 species of fish complete one or more of their life stages (egg, larvae, juvenile, and adult) in bottomland hardwood ecosystems by utilizing the ground flora. Species such as catfish (*Ictalurus* spp.), gar (*Atractosteus spatula* and *Lepisosteus* spp.), crappie (*Pomoxis* spp.), minnows and shiners (Cyprinidae) utilize ground vegetation for deposition of eggs and rearing of young (Killgore et al., 1994).

Having a variety of vegetation communities (trees, shrubs, and herbaceous plants) on a site is important for sustainability of resources such as wildlife habitat and water quality (Harris and Skoog, 1980). Assessment of ground flora composition after harvesting will aid in determining if suitable forage and nesting habitat is present for preferred wildlife species such as white-tailed deer, wild turkey and waterfowl. Assessment also has implications for determining the effects of harvesting on the regeneration and natural succession of bottomland hardwood ecosystems.

Conclusions

Growing season flooding along with harvesting practices are major factors affecting ground flora composition and diversity in the batture lands of the Mississippi River. Flood depth, duration and frequency are key factors that determine the kind of plant and animal species found in bottomland sites (Harris and Gosselink, 1990). Major disturbances, such as clearcutting, may revert a stand back to an earlier successional stage, therefore changing species composition of the site (Hanna, 1981). Natural succession is greatly influenced by differences in elevation and rate of deposition on bottomland hardwood ecosystems (Hodges, 1997). Increases in resources, such as light and nutrient availability, following a major disturbance result in a temporary increase in species diversity. Through succession these increases in ground flora composition will probably decline and advance into other seral stages.

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Table 2. Importance values (sum of relative frequency and relative density) for dominant ground flora by reproduction cutting method during the first growing season after harvest (1996) on Pittman Island, Issaquena County, MS.

	Reproduction Cutting Method		
Species	Clearcut	Selection	Control
May 1996			
Boehmeria cylindrica	75	57	13
Celtis laevigata	58	88	99
Senecio glabellus	81	63	22
Trepocarpus aethusae	73	111	149
Urtica chamaedryoides	106	109	76
July 1996			
Boehmeria cylindrica	0	0	0
Brunnichia ovata	67	84	111
Celtis laevigata	54	120	135
Rubus trivialis	80	99	96
Senecio glabellus	0	36	0
Trepocarpus aethusae	0	0	0
Urtica chamaedryoides	0	0	0

Table 3. Community Similarity Index for combinations of reproduction cutting methods during the first growing season after harvest (1996) on Pittman Island, Issaquena County, MS.

	Reproduction Cutting Method Combination		
Sampling Period	Clearcut/Selection	Clearcut/Control	Selection/Control
May 1996	0.71	0.42	0.59
July 1996	0.46	0.38	0.66

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202

Appendix. Species list for ground flora during the first growing season after harvest (1996) on Pittman Island, Issaquena County, MS.

Family	Scientific Name	Common Name
ACANTHACEAE	*Justicia ovata* (Walt.) Lindau var. *lanceolata* (Chapm.) R.W. Long	water willow
ACERACEAE	*Acer rubrum* L. var. *rubrum*	red maple
AMARANTHACEAE	*Amaranthus albus* L.	pigweed
ANACARDIACEAE	*Toxicodendron radicans* (L.) Kuntze	poison-ivy
APOCYNACEAE	*Trachelospermum difforme* (Walt.) Gray	climbing dogbane
AQUIFOLIACEAE	*Ilex decidua* Walt. var. *decidua*	possumhaw
ARISTOLOCHIACEAE	*Aristolochia serpentaria* L.	Virginia snakeroot
ASCLEPIADACEAE	*Gonolobus gonocarpus* (Walt.) Perry	angle-pod
BIGNONIACEAE	*Bignonia capreolata* L.	crossvine
	Campsis radicans (L.) Seem.	trumpet creeper
BORAGINACEAE	*Heliotropium indicum* L.	Indian helitrope
CHENOPODIACEAE	*Chenopodium album* L. var. *album*	pigweed
COMMELINACEAE	*Commelina virginica* L.	day-flower
COMPOSITAE	*Senecio glabellus* Poir.	butterweed
	Solidago canadensis L.	goldenrod
CORNACEAE	*Cornus drummondii*Meyer	swamp dogwood
CRUCIFERAE	*Capsella bursa-pastoris* (L.) Medic.	Shepard's purse
	Cardamine hirsuta L.	cress
CUCURBITACEAE	*Melothria pendula* L.	creeping cucumber
CYPERACEAE	*Carex cherokeensis* Schwein.	Cherokee sedge
	C. crus-corvi Shuttlw. ex Kuntze	sedge
EBENACEAE	*Diospyros virginiana* L.	common persimmon
E UPH ORBIACEAE	*Acalypha rhomboidea* Raf.	three-seeded mercury
FAGACEAE	*Quercus nigra* L.	water oak
FUMARIACEAE	*Corydalis flavula* (Raf.) DC.	pale corydalis
GRAMINEAE	*Leptochloa filiformis* (Lam.) Beauv.	sprangletop
	Panicum capillare L. var. *capillare*	panic grass
	P. laxiflorum Lam.	panic grass
JUGLANDACEAE	*Carya illinoensis* (Wang.) K. Koch	sweet pecan
LABIATAE	*Teucrium canadense* L. var. *canadense*	wood sage
LEGUMINOSAE	*Gleditsia triacanthos* L.	honey locust
	Vicia sativa L.	common vetch
	V. tetrasperma (L.) Moench	common vetch
LILIACEAE	*Smilax bona-nox* L.	greenbriar
	S. rotundifolia L.	greenbriar
	S. tamnoides L. var. hispida (Muhl.) Fern.	greenbriar
LOGANIACEAE	*Gelsemium sempervirens* (L.) Jaume St. -Hill	yellow jessimine
MENISPERMACEAE	*Cocculus carolinus* (L.) DC.	Carolina moonseed
OLEACEAE	*Forestiera acuminata* (Michx.) Poir.	swamp privet
	Fraxinus pennsylvanica Marsh.	green ash
OXALIDACEAE	*Oxalis dillenii* Jacq.	wood sorrell
PASSIFLORACEAE	*Passiflora lutea* L.	yellow passion flower
PHYTOLACCACEAE	*Phytolacca americana* L.	pokeweed
POLYGONACEAE	*Brunnichia ovata* (Walt.) Shinners	buckwheatvine
	Polygonum Dunctatum Ell.	smartweed
	P. tenue Michx.	smartweed
	P. virginianum L.	jumpseed
RHAMNACEAE	*Berchemia scandens* (Hill) K. Koch	rattan vine
ROSACEAE	*Rubus flagellaris* Willd.	dewberry
	R. trivialis Michx.	blackberry
RUBIACEAE	*Spermacoce glabra* Michx.	smooth buttonweed
	Galium aparine L.	bedstraw
SOLANACEAE	*Physalis angulata* L.	ground cherry
	P. Dubescens L.	ground cherry
ULMACEAE	*Ulmus americana* L.	American elm
	Celtis laevigata Willd.	sugarberry
UMBELLIFERAE	*Trepocarpus aethusae* Nutt.	parsely
	Sanicula canadensis L.	black snakeroot
URTICACEAE	*Urtica chamaedryoides* L.	stinging nettle
	Boehmeria cylindrica (L.) Sw.	false nettle
VALERIANACEAE	*Valerianella radiata* (L.) Dufr.	corn salad
VIOLACEAE	*Viola sororia* Willd. var. *sororia*	violet
VITACEAE	*Ampelopsis arborea* (L.) Koehne	pepper vine
	Parthenocissus auinauefolia (L.) Planchon	Virginia creeper
	Vitis aestivalis Michx.	summer grape
	V. mustanzensis Buckl.	grape
	V. rotundifolia Michx.	muscadine