GROUNDSTORY VEGETATION RESPONSE TO DIFFERENT THINNING INTENSITIES IN A MINOR STREAM BOTTOM IN MISSISSIPPI: A PRELIMINARY ANALYSIS

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Abstract--Groundstory vegetation typically accounts for the greatest proportion of plant diversity in temperate forests, representing a critical structural component and mediating numerous ecosystem processes, including tree regeneration. The effects of thinning on groundstory vegetation have received limited study in bottomland hardwood stands. This study investigated groundstory vascular plant development following thinning in a minor stream bottom in Mississippi. Thinning treatments representing a range of residual basal areas were used to assess groundstory herbaceous and woody vine and shrub response to canopy opening. Plant community responses were evaluated in terms of cover, relative abundance, and composition. Groundstory species richness and cover were higher in thinned areas 5 years post-thinning. This was primarily attributable to increases in the cover of grasses, sedges, blackberry (*Rubus argutus* Link), and numerous forbs, likely in response to higher light availability that would favor these less shade tolerant species. Overall, cover appears to increase in direct proportion to the intensity of overstory removal. Improved knowledge of groundstory response to thinning in bottomland hardwood stands should assist management efforts aimed at the maintenance of plant diversity (and its many benefits) and at successfully regenerating desirable hardwood species.

INTRODUCTION

The groundstory, the low-statured non-tree vegetation composed of forbs, graminoids, woody vines and shrubs, is an important structural component of forested ecosystems. Indeed, the majority of plant species diversity in eastern temperate deciduous forests occurs in the groundstory, primarily in the herbaceous layer (Whigham 2004). Moreover, the groundstory mediates key processes, including provision of wildlife habitat (browse, cover), soil dynamics (erosion, sedimentation, nutrient availability), and invasive plant establishment, in addition to its well-recognized competitive effects on tree regeneration (Gilliam 2007). In mature bottomland hardwood forest types, like other closed canopy hardwood stands of the eastern temperate region, understory light tends to be low (Aikens and others 2007, Duguid and others 2013, Jenkins and Chambers 1989), and frequent short-term inundation or prolonged flooding likely limit establishment and development of vegetation. Nonetheless, in bottomland hardwoods systems in the southeastern United States, species diversity has been noted to be exceptionally high. Crouch and Golden (1997) identified over 450 vascular plants of 293 genera and 111 different families across a bottomland topographic sequence in western Alabama.

Forest stand management practices, such as thinning, may have significant impacts on groundstory development in bottomland stands. Canopy removal results in increased light availability to the understory and, in bottomland stands, has been shown to be directly related to degree of canopy removal (Jenkins and Chambers 1989). With increased light availability, an increase in groundstory cover typically occurs, even where canopy openings are small (Castleberry and others 2000, Crouch and Golden 1997). An increase in species richness is also frequently evident following canopy disturbance (Jenkins and Parker 2000, Rapp and others 2001). This is in part because high resource conditions allow opportunities for early successional, shade-intolerant species to establish along with resident understory species (Crouch and Golden 1997). At the same time, high resource conditions prevailing after canopy disturbance may drive reductions in species richness, due to the dominance of a few, vigorous early successional species (Jenkins and Parker 2000). Additionally, ground disturbance associated with logging activities may alter plant communities and establishment conditions, in some cases diminishing diversity (Castleberry and others 2000). Canopy and ground disturbance may also favor invasive species, by providing opportunities for expansion or colonization (e.g. Rosen and others 2006, Ruzicka and others 2010).

While groundstory vegetation typically accounts for the greatest proportion of plant diversity in

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Citation for proceedings: Holley, A. Gordon; Connor, Kristina F.; Haywood, James D., eds. 2015. Proceedings of the 17th biennial southern silvicultural research conference. e–Gen. Tech. Rep. SRS–203. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 551 p.

temperate forests, the effects of canopy opening on groundstory vegetation have received only limited study in bottomland hardwood stands (Castleberry and others 2000, Crouch and Golden 1997, Jenkins and Parker 2000, Rapp and others 2001). Moreover, we are unaware of any published literature on the effects of thinning on groundstory response in bottomland systems. The objective of this study was to investigate groundstory vascular plant development 5 years after varying intensities of thinning were applied to a mature hardwood stand within a minor stream bottom in east-central Mississippi.

METHODS

Site Description

The study site is located on the Noxubee River floodplain within the Samuel D. Hamilton Noxubee National Wildlife Refuge in Noxubee County, in east-central Mississippi. The study site has been previously described by Meadows and Skojac (2012). Briefly, the site is a flat, minor stream bottom adjacent to the Noxubee River, which is subject to short-duration flooding events, primarily in winter and spring. The soils are predominantly of the Urbo silty clay loam series (fine, mixed, active, acid, thermic Vertic Epiaquept). Average site indices (base age 50) are 100 feet for cherrybark oak (*Quercus pagoda* Raf.), 96 feet for water oak (*Q. nigra* L.), and 90 feet for sweetgum (*Liquidamber styraciflua* L.). The site supports an approximately 70-year-old mixed species hardwood stand, dominated by red oaks (*Quercus* spp.) and sweetgum. The red oak species [*Q. pagoda*, *Q. nigra*, and to lesser extent *Q. phellos* L. (willow oak)] represented 51 percent of stand basal area prior to treatment. Sweetgum comprised 23 percent of stand basal area prior to treatment, with hickory (*Carya* spp.), green ash (*Fraxinus pennsylvanica* Marsh.), swamp chestnut oak (*Q. michauxii* Nutt.), overcup oak (*Q. lyrata* Walt.), and American elm (*Ulmus americana* L.) comprising the remaining basal area (Meadows and Skojac 2012).

Experimental Design

The study area covers 30 acres, divided into 2-acre rectangular treatment units, each 264 feet by 330 feet. Four thinning treatments and a control were applied in a randomized complete block design, with each treatment replicated three times. Thinning treatments were applied in October 2007. Thinning treatments were based on a stand quality management approach (Meadows and Skojac 2012), which selects trees for retention based on species and stem quality, with little regard for uniformity of spacing that typically dictates thinning treatments in plantations or simple species mixtures. The four thinning approaches differed in their retention levels based on the quality of sawlogs retained (preferred only, or preferred, desirable, and acceptable) and whether they retained pole sized trees that were potential sawlogs in the future (preferred poles or no poles). As a consequence, the different thinning treatments produced varying levels of residual basal area, ranging from 48 to 69 square feet per acre in thinned areas to 108 square feet per acre in the control (table 1).

Table 1--Pre- and post-treatment basal area (BA) by thinning intensity 5 years after implementing thinning treatments in a minor stream bottom hardwood forest in east-central Mississippi. Table modified from Meadows and Skojac (2012)

Treatment	Pre-treatment BA	Residual BA
	------------*feet²/acre*---------	
Control	113	108
Acceptable/superior	122	69
Acceptable/no pole	108	61
Desirable/superior	126	57
Desirable/no pole	112	48

Measurements and Data Analysis

We used a series of approximately 1/4000th acre (1m², 10.76 square feet) plots to measure groundstory vegetation in the summer of 2012 (fifth year post-harvest). There were on average eight vegetation plots per treatment unit. Plots were grouped in sets of four, positioned in four cardinal directions 19.7 feet from a central point located halfway between the bole and dripline of a residual overstory red oak tree. Plots were located in this manner to capture the range of variation in the residual stand. All non-tree herbaceous and woody plants (forbs, graminoids, woody vines, and shrubs) that occurred in the plot were identified by species (or species groups for grasses, sedges, and several genera) and percent cover. For analyses, we assessed rank abundance, estimated species richness using EstimateS Software Version 8.2 (Colwell 2012), and evaluated cover between thinning treatments. Analysis of variance (ANOVA) was performed using the PROC GLM procedure in SAS 9.2 (SAS Institute Inc., Cary, NC) to assess treatment effects on cover and species richness. Tukey's HSD test was used for multiple comparisons. Due to the limited replication, we used $\alpha = 0.10$ for evaluation of significance.

RESULTS AND DISCUSSION

Across the study site, plant abundance reflected the common pattern seen in most plant communities, with relatively few dominant species comprising the majority of groundstory cover and most other species exhibiting low abundance. Across the site, grasses were the most dominant, followed by sedges, blackberry (*Rubus argutus* Link), greenbriar (*Smilax* spp.), crossvine (*Bignonia capreolata* L.), grape (*Vitus* spp.), switchcane [*Arundinaria gigantea* (Walter) Muhl.], and poison ivy [*Toxicodendron radicans* (L.) Kuntze] (fig. 1).

Thinning treatments generally supported greater species richness than the control (figs. 2 and 3). Gap creation generally favors increased species richness, by providing higher resources (light, belowground resources) and a greater range of habitat conditions for shade-intolerant vegetation to establish along with resident vegetation (Crouch and Golden 1997, Rapp and others 2001). The highest intensity thinning (which removed a greater amount of basal area) did not favor higher species richness. This may support the findings of other studies that more intense canopy disturbance may facilitate dominance by a small number of vigorous colonizers, which may limit or exclude other species and reduce species richness (Jenkins and Parker 2000). Alternatively, it may suggest that greater logging disturbance associated with increased canopy removal may have limited species richness (Castleberry and others 2000) relative to the control. Overall, species numbers were lower than observed in several other studies (e.g. Crouch and Golden 1997, Rapp and others 2001); however, our study represents a much narrower range of site conditions. Additionally, we did not identify a number of groups to the species level (grasses, sedges, and several genera) so species richness is undoubtedly higher than estimated.

Treatment effects on cover showed a similar trend to species richness, with higher overall cover in all thinning treatments (fig. 4). Canopy openings tend to favor significant increases in groundstory cover due to enhanced light availability, which typically limits plant development under a closed canopy (Castleberry and others 2000, Jenkins and Parker 2000). This increase appeared to be attributable not only to increases in the cover of woody vines, shrubs, and graminoids following thinning, but also a substantial increase in the cover of forbs (table 2). More specifically, it was evident that grasses, sedges, and blackberry were large contributors to increased cover post-thinning. These species are particularly favored by increased light availability. Ruderal species such as smallspike false nettle [*Boehmeria cylindrica* (L.) Sw.] and other forbs also contributed to increased cover with canopy opening, as evidenced from studies in other bottomland systems (e.g., Rapp and others 2001). The availability of a number of key food plants for wildlife species (e.g., smooth ticktrefoil [*Desmodium laevigatum* (Nutt.) DC.], blackberry) was higher in the thinning treatments (table 2), while several other wildlife species were not (e.g., grape, greenbriar). Also of note, the invasive Japanese honeysuckle (*Lonicera japonica* Thunb.) did not develop higher cover in thinning treatments, despite its recognition as a colonizer of disturbed bottomland sites (Ruzicka and others 2010). Overall, cover increased in linear fashion in relation to residual basal area across the thinning treatments (fig. 5).

SUMMARY

Groundstory species richness and cover were higher in thinned areas 5 years post-thinning. This was primarily attributable to increases in the cover of grasses, sedges, blackberry, and numerous forbs, likely in response to higher light availability that would favor these less shade tolerant species. Wildlife would likely benefit

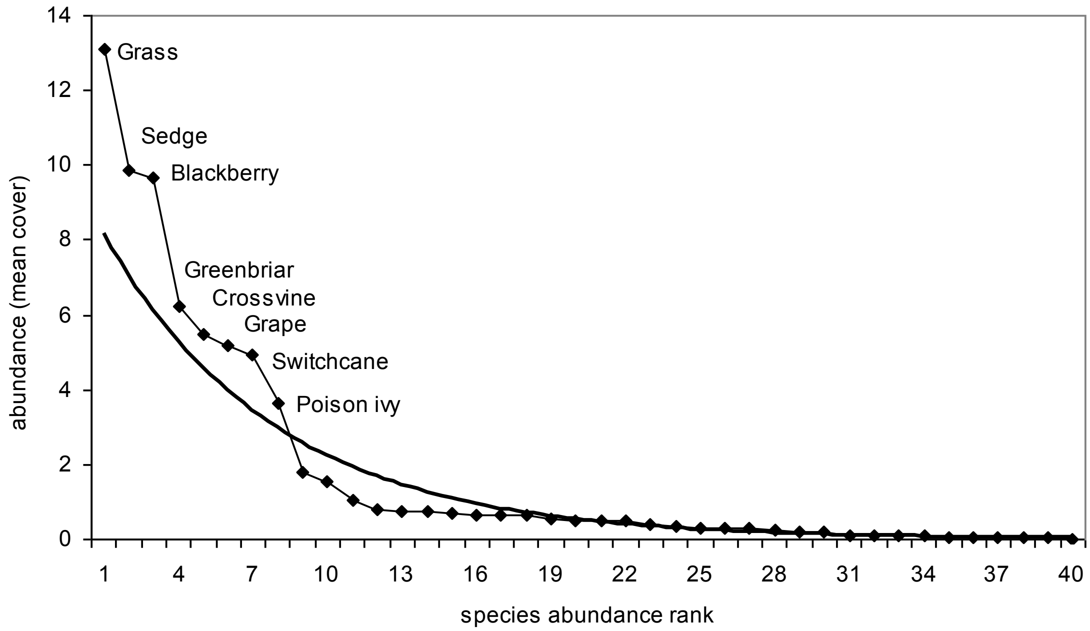

Figure 1--Species abundance rank based upon percent cover 5 years after implementing thinning treatments in a minor stream bottom hardwood forest in east-central Mississippi. Dominant species are indicated.

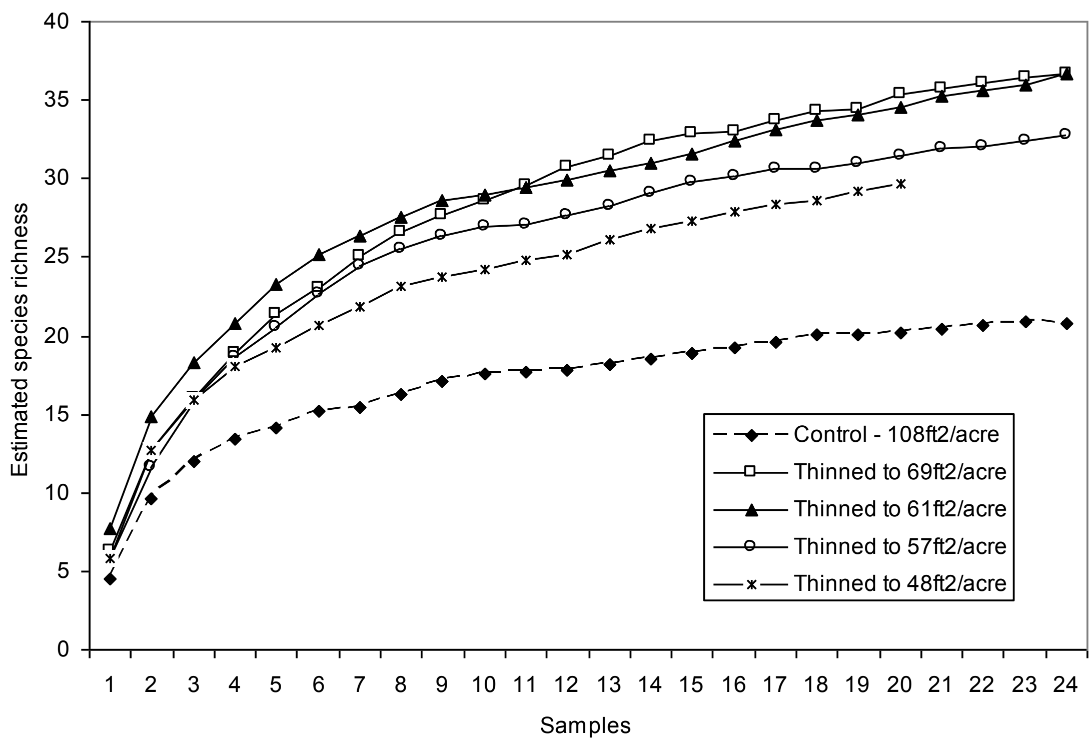

Figure 2--Species richness among thinning treatments 5 years after implementing thinning treatments in a minor stream bottom hardwood forest in east-central Mississippi. Richness estimates based on Estimates species richness software (Colwell 2012).

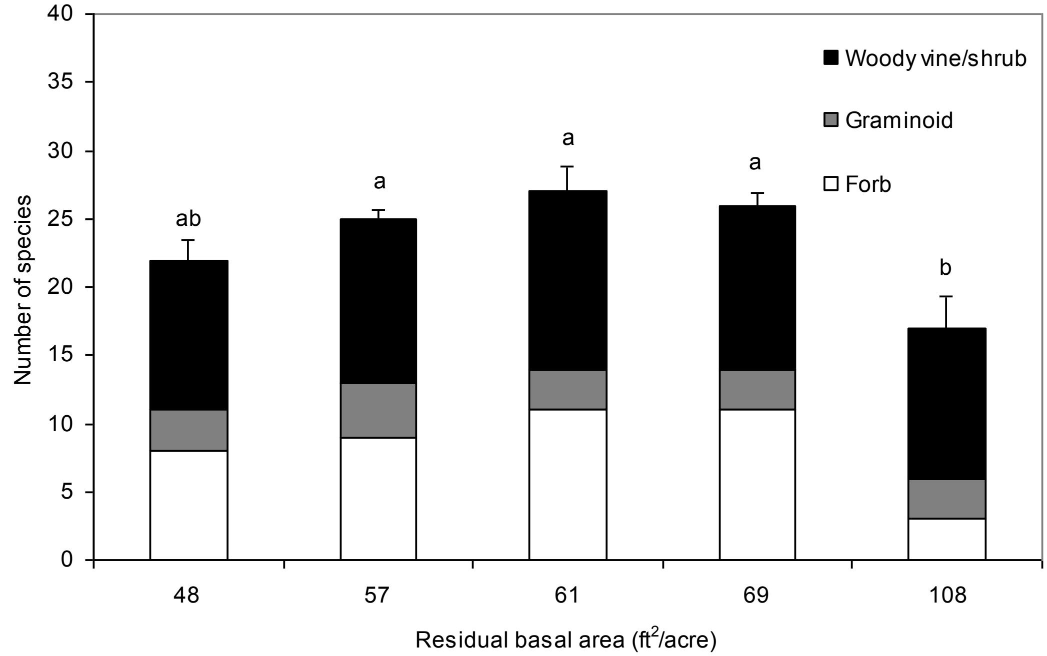

Figure 3--Species richness by treatment for the main groups of groundstory plants (forb, graminoid, woody vine/shrub) 5 years after implementing thinning treatments in a minor stream bottom hardwood forest in east-central Mississippi. Significance was analyzed using Tukey's HSD test on the total number of species; columns sharing different letters are significantly different ($P < 0.10$).

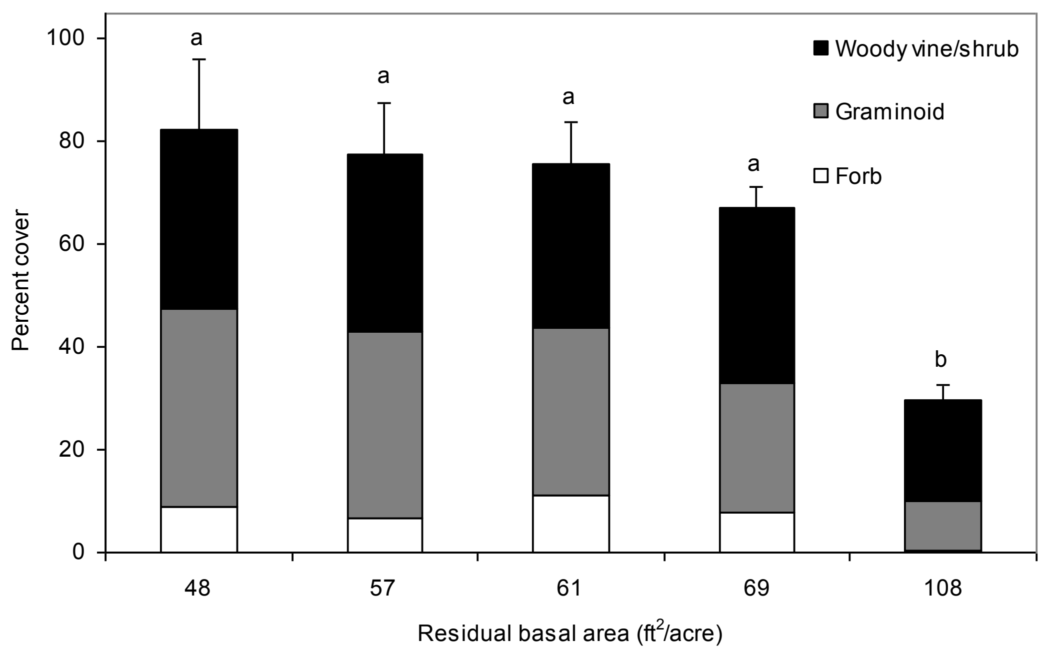

Figure 4--Percent cover by treatment for the main groups of groundstory plants (forb, graminoid, woody vine/shrub) 5 years after implementing thinning treatments in a minor stream bottom hardwood forest in east-central Mississippi. Significance was analyzed using Tukey's HSD test on the total number of species; columns sharing different letters are significantly different ($P < 0.10$).

Table 2--Groundstory percent cover for dominant forb, graminoid, and woody vine/shrub species across the different thinning treatments 5 years after implementing thinning treatments in a minor stream bottom hardwood forest in east-central Mississippi

	Residual overstory basal area (*feet²/acre*)				
Taxa	48	57	61	69	108
Forb					
Boehmeria cylindrica	0.6	1.4	0.4	0.6	
Elephantopsus carolinianus	0.3	0.1	4.8	1.4	0.1
Lycopus angustifolius	6.0	0.6	0.0	3.4	
Other	2.2	4.4	6.0	2.3	0.1
Subtotal	9.1	6.5	11.3	7.8	0.3
Graminoid					
Grass*	18.1	17.5	14.7	19.2	4.5
Sedge**	12.9	12.0	10.2	5.3	4.1
Arundinaria gigantea	7.5	3.3	7.8	0.8	1.1
Other	0.0	3.8	0.0	0.0	0.0
Subtotal	38.4	36.6	32.7	25.3	9.8
Woody vine/shrub					
Bignonia capreolata	5.4	5.6	6.4	3.7	4.3
Lonicera japonica	0.7	1.1	1.3	0.6	1.4
Rubus argutus	14.5	4.8	10.1	11.0	0.4
Smilax rotundifolia	3.3	8.4	3.3	8.6	6.2
Toxicodendron radicans	2.8	3.5	2.8	2.9	0.7
Vitis rotundifolia	3.8	6.8	4.7	4.5	4.6
Other	4.7	4.4	3.1	2.7	2.1
Subtotal	35.0	34.5	31.6	34.0	19.6
Grand total	82.5	77.6	75.6	67.0	29.6

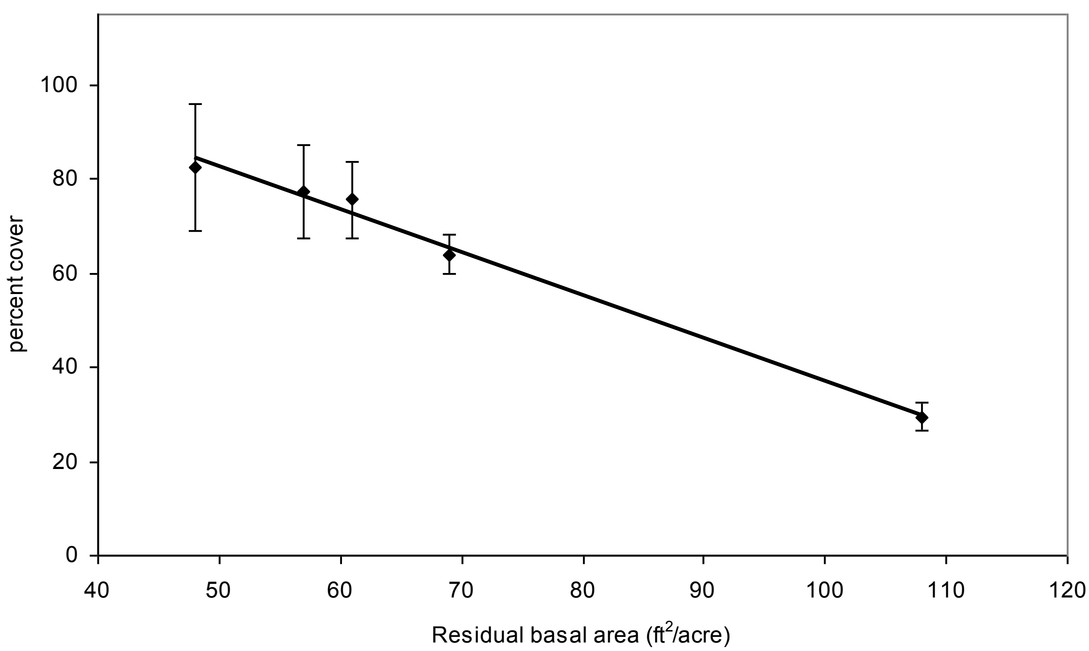

Figure 5--Regression of percent cover by residual basal area (square feet per acre) 5 years after implementing thinning treatments in a minor stream bottom hardwood forest in east-central Mississippi. Standard error bars shown.

from the increased abundance. Overall, cover appears to increase in direct proportion to the intensity of overstory removal. Future work should improve knowledge of groundstory response to thinning in bottomland hardwood stands, and thus assist management efforts aimed at the maintenance of plant diversity (and its many benefits), and at successfully regenerating desirable hardwood species.

ACKNOWLEDGEMENTS

We acknowledge the Samuel D. Hamilton Noxubee National Wildlife Refuge for access to research sites, Steve Meadows and Tracy Hawkins (USDA Forest Service) for project installation, and Rory Thornton (USDA Forest Service) and Chris Doffitt (Mississippi State University) for botanical assistance.

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