RESPONSE OF VASCULAR PLANT COMMUNITIES TO HARVEST IN SOUTHERN APPALACHIAN MIXED-OAK FORESTS: TWO-YEAR RESULTS[1]

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Abstract—A long-term study has been established to monitor the effects of seven silvicultural prescriptions on vascular flora community attributes. Treatments include a control, understory vegetation control, group selection, two levels of shelterwoods, leave-tree, and clearcut. Second growing season, post-treatment results are compared to pre-harvest values for residual basal area, residual mean diameter, and species richness. Species richness is a count of species per defined unit of area. Species richness is reported for tree, shrub, and herb strata, as well as at an overall treatment level. Following treatment, mean residual basal area and diameters are within or near cutting specification ranges for all treatments. Tree stratum species richness declines with increasing canopy disturbance. Shrub stratum species richness appears unaffected by treatment. Similarly, richness of woody species in the herb stratum does not change in response to treatment. An increase in richness of non-woody species in the herb stratum is detectable at a large sampling scale, but not at finer scales.

INTRODUCTION

The management of forested lands for wood products and the maintenance of biological diversity are often not perceived as compatible. The ongoing discussion between forest managers and a public that is increasingly critical of commercial forestry practices-most notably timber harvesting-warrants greater consideration for understanding ecosystem condition in future management regimes. Already land management agencies, the forest industry, and professional forestry organizations have taken steps toward achieving this end. The National Forest Management Act of 1976 mandates the preservation of diversity on all federally managed lands. A task force assembled by the Society of American Foresters (1991) extended its recommendations for maintaining, and where appropriate, enhancing diversity, to all professional foresters working on both public and private lands. The framework, however, for developing a national strategy to achieve these goals did not exist in the early 1990's, and as yet is only in the development stages (Salwasser 1990). Fundamental to that framework, but noticeably lacking, is experimental data demonstrating how natural patterns of diversity and species composition are affected by forest management practices (Roberts and Gilliam 1995).

In May of 1993, the Virginia Polytechnic Institute and State University, College of Forestry and Wildlife Resources, in cooperation with the Jefferson National Forest, the Southern Research Station, and the Westvaco Corporation initiated a long-term study entitled, "The Impacts of Silviculture on Biodiversity in the Southern Appalachians". The objective of this undertaking is to quantify changes in floral and Salamander community attributes over time in response to seven silvicultural treatments. The short-term response of salamanders has been reported elsewhere (Harpole and Haas 1999); this report addresses only changes in the vascular plant community. Specifically, we examined short-term changes in woody and herbaceous plant species richness in response to different levels of canopy removal associated with seven silvicultural treatments.

STUDY AREA

Each of the three 14-ha study sites is located within the Ridge and Valley physiographic province of southwest Virginia. Site selection criteria were stand age, site quality, elevation, aspect, forest type, and recent disturbance history. Sites were to represent south-facing, moderately productive, mixed-oak stands at elevations of 600-1200 m. Sites were to be composed of a contiguous, harvestable stand whose dominant trees were age 60-120. Only sites that appeared to be free of silvicultural disturbance for the previous 15 years were selected. Sites were established on the Jefferson National Forest: the Blacksburg 1 (BB1) and Blacksburg 2 (BB2) sites are located in the Blacksburg Ranger District, while the New Castle (NC) site is located in the New Castle Ranger District.

METHODS

Study Design

A randomized complete block (RCB) experiment with sub-sampling was established with three replicate sites. Each 14-ha study site is divided into seven 2-ha treatment plots to which the seven silvicultural prescriptions were applied. Treatment application was completed in March 1995 for BB1 and June 1996 for both BB2 and NC. Treatments include a control, understory vegetation control, group selection harvest, two levels of shelterwood harvests, a leave-tree harvest, and a clearcut. Understory vegetation control was achieved via streamline basal applications of Garlon 4 and Stalker to undesirable midstory stems. The objective of the chemical control was to favor advance regeneration of preferred species, particularly oaks (*Quercus* spp.). The group selection treatment consisted of up to three harvest groups whose diameters were not to exceed twice the height of the adjacent canopy. The stand was thinned between groups. The two shelterwood harvests differed in the basal area and size distribution of residual stems. The high-leave shelterwood retained 12-14 m^2/ha of dominant canopy basal area. The low-leave shelterwood retained 4-7 m^2/ha of pole timber basal area. The residual stands in each shelterwood treatment may be harvested as deemed necessary following future stand evaluation. The leave-tree harvest was not to exceed 4-6 m^2/ha in sawtimber trees intended to remain throughout the rotation. All stems to 5 cm diameter at breast height (dbh) were removed in the clearcut treatments.

Vegetation was sampled using a nested plot design. Species composition lists of all vascular flora were compiled by conducting a 100 percent walk through inventory of each 2-ha treatment plot. Nested within each treatment plot are three randomly located 24x24 m tree plots. The species, dbh, canopy position, and spatial location were recorded for each tree within a tree plot. The tree stratum was defined as all stems >5 m. Tree plots were further divided into sixteen 6x6 m shrub plots. Three randomly selected shrub plots were used to record crown diameter and number of rootstocks by species within the shrub stratum. Shrubs were defined as those stems 1-5 m in height. The herbaceous stratum was sampled in 1x1 m herb plots systematically nested along the perimeter of tree plots. Of the eight herb plots per tree plot, six were randomly selected and sampled. Attributes measured in herb plots were number of individuals and percent cover by species. The herb stratum includes all woody and non-woody stems <1 m in height. Herb plot sampling and treatment plot walk through inventories were performed in mid-May to early June and again in early August in order to account for differences in early and late season species assemblages. Shrub and tree plots were sampled only once in June. Pre-treatment sampling was conducted on all sites the growing season immediately prior to treatment application. BB1, therefore, was first sampled in 1993 while BB2 and NC were sampled in 1995. Post-treatment sampling was conducted the second full growing season following treatment application: BB1 in 1996, BB2 and NC in 1998. Pre- vs. post-harvest comparisons allowed for an initial assessment of treatment effects on plant community attributes.

Data Analysis

Species richness is calculated as the number of species per unit of area. Richness values are not comparable across different units of area. Changes in woody, herbaceous, and total species richness were evaluated by stratum and at the

Table 1-Pre-treatment vs. post-treatment mean ba[sal area] ... breast height (cm) for each of seven silvicultural t[reatments] ... Blacksburg 2, and New Castle study sites on Jeff[erson] ...

	Pre-treatment	
Treatment	Basal area	D.
Control	23.6	1
Understory herbicide	27.3	1
Group selection	27.8	1
High-leave shelterwood	28 0	1
Low-leave shelterwood	28.9	1
Leave-tree	28.0	[illegible]
Clearcut	29.6	[illegible]

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Table Z-Changes in tree stratum species richness, 2 years post treatment for each of seven silvicultural treatments. Mean of Blacksburg 1, Blacksburg 2, and New Castle study sites on Jefferson National Forest, southwest VA

Treatment	Species richness (per 576 m²)[a]		
	Pre-treatment	Post-treatment	Net change
Control	9.3	9.9	0.6
Understory herbicide	10.6	9.8	-0.8
Group selection	10.6	7.6	-3.0
High-leave shelterwood	9.2	6.6[b]	-2.6
Low-leave shelterwood	10.8	3.9[b]	-5.7
Clearcut	9.9	1.8"	-8.1

[a] Number of species per 576-m^2 tree plot.
[b] Post-treatment species richness significantly lower than pre-treatment values (α = 0.1).

canopy disturbance. The clearcut, leave-tree, and low-leave shelterwood treatments respectively retained only 1.6. 3.2, and 3.9 species/576 m^2. Absence of species from the tree plot does not reflect an absence of a species from the treatment Plot, and may be a function of changes in species evenness. rather than a treatment level change in richness. Additionally, the absence of a species in the tree stratum does not preclude its existence in the shrub or herb strata.

Shrub species richness in pre-treatment plots ranged from 6.2 to 9.2 species/108 m^2 (table 3). No change in shrub species richness in response to treatment was observed. While harvesting reduced richness of the main canopy in the tree plots, there is no reason to suspect that the shrub stratum would be similarly affected.

Neither the richness of woody species or non-woody species in the herb stratum was affected by treatment. Number of woody species ranged from 11.6 to 14.0 species/6 m^2 before treatment (table 4). The "umber of non-woody species ranged from 4.1 to 11.4 species/6 m^2 (table 5). Species richness was anticipated to increase within the herb stratum in response to canopy manipulation. The apparent lack of such a tendency does not mean that richness did not increase, but only that it was not detectable at such a small scale of sampling.

Results from the Z-ha walk through inventories support the claim that herb stratum species richness Increased following canopy removal. Significant increases in non-woody species richness were observed in the group selection, high-leave

Table 3—Changes in shrub stratum species richness, 2 years post treatment for each of seven silvicultural treatments. Mean of Blacksborg 1, Blacksburg 2. and New Castle study sites on Jefferson National Forest, southwest VA

Treatment	Species richness[a] (per 106 m²)[b]		
	Pre-treatment	Post-treatment	Net change
Control	9.2	7.4	-1.8
Understory herbicide	9.1	6.9	-2.2
Group selection	7.7	7.9	0.2
High-leave shelterwood	7.0	6.3	-0.7
Low-leave shelterwood	7.0	5.7	-1.3
Leave-tree	9.0	6.2	-2.8
Clearcut	6.2	4.6	-1.4

[a] No significant difference between pre- and post-treatment species richness for any treatment (o-0.1).
[b] Number of species per three 36-m^2 shrub plot.%

Table 4—Changes in woody species richn
treatment for each of seven silvicultural tr
Blacksburg 2, and New Castle study sites

Treatment	Pre-treatment
Control	13.6
Understory herbicide	12.9
Group selection	13.7
High-leave shelterwood	12.3
Low-leave shelterwood	11.3
Leave-tree	13.3
Clearcut	14.0

[a] No significant difference between pre- and post-
[b] Number of species per six 1-m^2 herb plots.

Table 5—Changes in non-woody species
treatment for each of seven silvicultural
Blacksburg 2, and New Castle study site

Treatment	Pre-treatment
Control	10.4
Understory herbicide	8.8
Group selection	11.3
High-leave shelterwood	5.1
Low-leave shelterwood	6.6
Leave-tree	11.4
Clearcut	4.1

[a] No significant difference between pre- and pos
[b] Number of species per six 1-m^2 herb plots.

shelterwood. leave-tree. and clearcut treatments (table 6). Extreme variability in the response of the three replicates tc the low-leave shelterwood precluded that treatment from exhibiting significant result;. Results suggest that small ar sampling plots may be inappropriate for detecting changes in species richness for herbaceous species.

Walk through inventories revealed no significant changes the number of woody species at the treatment plot level. Number of pre-treatment species ranged from 32 to 39 species/2 ha (table 7). Tree species not detected at the tre plot level on highly disturbed treatments Were observed at the treatment plot level.

CONCLUSION

Initial analyses of changes in species richness demonstra a reduction of species in the tree stratum for high-disturbance treatments. Shrub stratum species richness appears unaffected, regardless of level Of overstory

Table S-Changes in non-woody species richness per treatment plot, 2 years post treatment for each of seven siivicuiturai treatments. Mean of Blacksburg 1, Blacksburg 2, and New Castle study sites on Jefferson National Forest, southwest VA

	Species richness (per 2 ha)[a]		
Treatment	Pre-treatment	Post-treatment	Net change
Control	51	78	27
Understory herbicide	44	71	27
Group selection	50	115[b]	65
High-leave shelterwood	35	92[b]	57
Low-leave shelterwood	52	150	98
Leave-tree	36	138[b]	102
Clearcut	43	124[b]	98

[a] Number of species per 2-ha treatment plot.
[b] Post-treatment species richness significantly higher than pre-treatment value ($\alpha = 0.1$).

Table 7-Changes in woody species richness per treatment plot, 2 years post treatment for each of seven silvicultural treatments. Mean of Blacksburg 1, Biacksburg 2, and New Castle study sites on Jefferson National Forest, southwest VA

	Species richness[a] (per 2 ha)[b]		
Treatment	Pre-treatment	Post-treatment	Net change
Control	37	38	1
Understory herbicide	36	39	3
Group selection	39	44	5
High-leave shelterwood	32	39	7
Low-leave shelterwood	35	44	9
Leave-tree	38	43	5
Clearcut	35	41	6

[a] No significant difference between pre- and post-treatment species richness for any treatment ($\alpha = 0.1$).
[b] Number of species per 2-ha treatment plot.

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