4104

COMMUNITY COMPOSITION IN CANOPY GAPS AS INFLUENCED BY PRESENCE OR ABSENCE OF *RHODODENDRON MAXIMUM*[1]

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Abstract-The process of gap formation and recolonization plays an important role in the structure and composition in southern Appalachian forests. The understory composition existing before a disturbance will shape successional patterns of the future stand. *Rhododendron maximum* is native to the southern Appalachians and exists as a major understory component in cove forests. Its frequency of occurrence has been increasing over the past century due to the demise of the American Chestnut, heavy logging at the turn of the century. and suppression of tire. Increasing densities of *R. maximum* reduced species richness and coverage in the regeneration layer and reduced recruitment into understory and midstory strata. Woody and herbaceous species regenerated poorly, if at all. under *R. maximum's* dense canopy. Only shade-tolerant woody species like *Tsuga canadensis.* and *Acer rubrum* regenerate in *R. maximum* thickets, and their densities are markedly decreased.

INTRODUCTION

In the southern Appalachians forest canopy disturbance occurs frequently (Runkle 1982). Magnitude of disturbance varies greatly from hurricanes removing complete stands to a single limb dying. Removal of part of the canopy layer creates a void in the integrity of the canopy, which Barden (1989) defines as a canopy gap. The process of canopy gap formation and recolonization plays a substantial role in determining structure and composition of southern Appalachian forests. Understory composition existing before the disturbance will shape successional patterns of the future stand (Clebsch and Busing 1989).

R. maximum is native to the southern Appalachians (Bowers 1960) and exists as a major understory component. Its frequency of occurrence has been increasing over the past century due to changes in natural and anthropogenic disturbance factors (McGinty 1972; Phillips and Murdy 1985). Its increase in abundance and range is reducing species richness and altering patterns of succession (Baker and Van Lear In Press).

Effects of various sized forest gaps on understory vegetation have been studied extensively (Runkle 1982. Canham 1989, Clebsch and Busing 1989. Poulson and others 1989, Phillips and Shure 1990, Runkle and others 1992). However, little is known regarding the effects of *R. maximum* on gap succession in the southern Appalachians (Hedman and Van Lear 1994).

The most comprehensive and detailed investigations of *R. maximum* have occurred at the Coweeta Hydrologic Laboratory near Franklin North Carolina (McGinty 1972; Monk and others 1985; Phillips and Murdy 1985). McGinty (1972) suggests *R. maximum* did not occur as frequently in the early 1900's as it does now. Native Americans initially used fire as a management tool (Cronon 1983), which may have controlled the occurrence of *R. maximum.* European settlers continued this practice for clearing land and driving game. Exclusion of fire in this century is considered a disturbance and a change in historical management, since fire was historically present throughout the landscape (Monk and others 1985, Phillips and Murdy 1985, MacCleery 1992, Baker and Van Lear In Press) and may have contributed to the up slope migration of *R. maximum.*

Historically, *R. maximum* occurred primarily in riparian zones out of competitive necessity, but fire suppression and other factors allowed it to spread up slope, often to ridge tops. Fire probably top killed *R. maximum* and allowed other species a chance to grow ahead of its resprouting. Frequent fire, especially in the growing season, could have completely killed individual stems (Baker and Van Lear 1998).

As a result of the increasing abundance of *R. maximum,* southern Appalachian cove forests will probably experience a significant structural and compositional change over the next century (Hedman and Van Lear 1994, Clinton 1995, Baker and Van Lear In Press). *R. maximum* often has by far the highest importance value of all understory species in the southern Appalachians (Hedman and Van Lear 1994, Baker and Van Lear In Press). Although scattered overstory and midstory trees are found in the regeneration layer under *R. maximum* canopies. Vigorous thickets of *R. maximum* are capable of suppressing this regeneration. However, *Acer rubrum* and *Tsuga canadensis* are sometimes capable of establishing and competing under a *R. maximum* canopy (Clinton and others 1994).

The objective of this study was to determine effects of *R. maximum* on community composition and species richness in various-sized canopy gaps in cove forests of the southern Appalachians.

METHODS

Study Site Locations

This study was conducted in the Blue Ridge Mountain Physiographic province of the southern Appalachian Mountains. Sites were located in Andrew Pickens Ranger District of Sumter National Forest in Oconee County, South Carolina along Slatten Branch in the Ellicott Rock Wilderness Area: Tallulah Ranger District of the

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Chattahoochee National Forest in Rabun County. Georgia along Thomas Creek: Pisgah Ranger District of the Pisgah National Forest in Tansylvania County, North Carolina along Pigeon River and Looking Glass Creek in the Shining Rock Wilderness: Wayah Ranger District of Nantahala National Forest in Clay county, North Carolina along the Tallulah River and Beech Creek: and in Towns County Georgia. along Mill Creek in the Southern Nantahala Wilderness. Elevation of study sites ranged from 518 to 756 m.

Historical Land Use

In this study most gaps were located in United States Forest Service Wilderness areas. There is no vegetation management, with the exception of fire suppression. allowing natural processes to determine the composition and distribution of plant species.

Plot Delineation and Physical Characteristics

Reconnaissance of the southern Appalachian area was Conducted in the spring of 1996 to locate gaps in which to determine *effects* of *R. maximum.* Sites selected contained wind-thrown trees in the riparian area that created canopy gaps. To determine the effect of different densities of *R. maximum on* species richness in the regeneration layer. *R.* maximum thicket densities were classified into separate density categories (table I). as described by Baker (1994).

Table I-Density and basal area of *R. maximum* by thicket density category (Baker and Van Lear in press)

Thicket density	Basal area	Number of stems
	m^2/ha	*x 1000/ha*
High	11-22	8-17
Medium	*5-11*	*510*
LOW	2-5	3-6
Scarce	*o-2*	*o-3*

In this study no gaps were sampled with a "High" density rating. Gaps met the following criteria: 1) gap-making tree(s) must have been upper canopy trees at the time of gap formation, 2) gaps must be naturally occurring, 3) gaps must be less than 7 years old. 4) gaps must occur on only one site type. i.e., mesic. and 5) gaps were restricted to a linear zone no greater than 35 m from a stream. Gap age was estimated by examining the internodal growth of previously suppressed growth-determinant individuals within the gap.

Twenty-two gaps of Varying size were selected. with eleven containing *R.* maximum with a minimum density of 2000 stems/ha and eleven where this species was mostly absent. Gap size was measured using the extended gap m&hod suggested by Runkle (1962). Distance across the widest part of the gap, and a shorter distance perpendicular to the first, coinciding with the center of the disturbance were measured. Using the formula for the area of an ellipse gap area was determined. Gap size (40 m^2-286 m^2) ranged from one-tree openings to larger gaps made from the death of six trees.

Vegetation Sampling

Vegetation was sampled during the summer and fall of 1996. Bases of gap-surrounding trees were at least 10-cm ground line diameter (gld), denoting that they were no longer saplings. Vegetation was sampled along two gradients: 1) longest distance across the gap, and 2) a shorter distance perpendicular to the first with the intersection of the two gradient lines coinciding with the center of the disturbance. Advanced regeneration and new seedlings were inventoried in l-m wide transects located along each of the two principle gradient lines. These transects were further divided into l-m lengths where frequency was recorded to distinguish vegetative preference from the center of the gap towards the undisturbed forest. Percent cover of *R. maximum was* visually estimated and placed into Braun-Blaunquet category classes for *the* individual l-m' sections and averaged to determine total percent cover for that gap. Percent cover classes were determined using Barbour and others (1967). The area of the gap was determined using the formula for an ellipse. Species nomenclature followed Radford and others (1968).

All stems <10 cm (to the nearest cm) gld were considered understory and all stems >10 cm gld were consldered either midstory or overstory. Stems <1 cm were consldered part of the regeneration layer. Species densities (stems/ha) and basal areas (m^2/ha) were recorded to calculate Importance Values of each understory species using relative density and relative frequency. Midstory importance Values were determined from relative density and relative basal area. Importance value combines density and size to a weighted contribution per species to community composition.

In this study most individuals in sample plots were identified to the species level. When species level could not be determined. identification was made to the genus level. which was consistent across all plots.

Data Analysis

The relationship of site characteristics and R. maxrmum density (stems/ha, BA/ha) was determined using linear regression analysis. Linear regression was also used to determine relationships and compare seedling height in gaps with *R. maximum* present and absent. The relationship of species richness and density to percent cover of R. maxrmum was determined using non-linear regression analysis. Differences among absent. scarce. low. and medium thicket density plots were tested for significance using analysis of variance (ANOVA; SAS 1967) followed by t-tests. All statistical comparisons were conducted at the $\alpha = 0.05$ significance level.

RESULTS AND DISCUSSION

Gap Vegetation

In the Southern Appalachian Mountains *R. maximum* is the dominant subcanopy species, occupying approximately 30 million ha (Nilsen and others 1996). Expansion of this species is a concern for ecologist; and hardwood forest managers because recruitment Of canopy tree seedlings is inhibited under cover of *R. maximum.* Potential causes include reduced *seed* rain by *R. maximum* foliage. Nilsen and others (1996) found that seedling presence and fitness were affected by low light, indirect effects of inhibited mycorrhizal synthesis, lower bacterial or invertebrate activity and competition for resources. A limited number of competing species can exist under a canopy of *R. maximum,* but usually only at low population levels. It is debatable whether or not in the absence of disturbance they can grow through the dense R. maximum canopy.

Midstory vegetation

Stems >1 cm gld—Gaps containing *R.* maximum had little midstory vegetation other than this thicket-forming ericaceous shrub. Tsuga canadensis. *Halesia carolina, Tilia americana,* and *Hamamelis virginiana,* in descending order. were next most important in gaps containing *R. maximum.* Adjacent overstory species composition differs from these species and demonstrates non-random replacement under a canopy of *R. maximum.* Barden (1960) found a similar trend in his study of replacement in cove forests in the southern Appalachians.

Gaps *where R. maximum* was absent contained *Hamamelis virginiana, Tsuga canadensis Acer saccharum* and *Fagus grandifolia* in descending importance. *Hamamelis virginiana* was usually found as stump sprouts with very rapid growth. It had a high frequency of occurrence in plots, contributing to its overall high importance value.

Species richness and density were significantly lower in gaps containing a midstory dominated by *R. maxrmum.* Species richness averaged 16.7 species in gaps with R. maximum and 51.9 without (fig. 1), while density averaged 9.1 individuals/m^2 in gaps with *R. maximum,* significantly lower than 50.9 individuals/m^2 in gaps without (fig. 2). Average midstory species richness decreases significantly from 7.7 species in open gaps to 1 .ı species in *R. maximum* gaps (fig. 1) demonstrating that advanced regeneration was not present at the time of gap formation and subsequent seedling growth was inhibited. Average midstory density was also significantly lower. 1.0 and 0.1 for gaps without and with *R. maximum,* respectively (fig. 2). Shade-intolerant midstory species were almost completely eliminated and shade-tolerant species were severely reduced to levels where little to no recruitment into the overstory could occur. Total tree regeneration was higher in gaps containing little to no R. *maximum* than in gaps containing *R maxrmum.* which agrees with the findings of Phillips and Murdy (1985) and Clinton and others (1994).

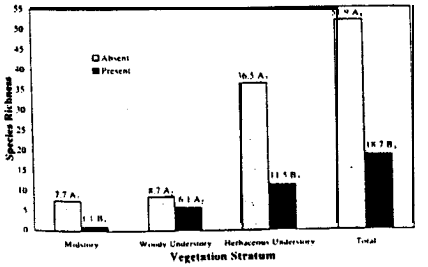

Figure 1—Relation between species richness and vegetation stratum with *R. maximum* present and absent in southern Appalachian cove forest gaps. (Means with the same letter and subscript were not significantly different at 0.05 level).

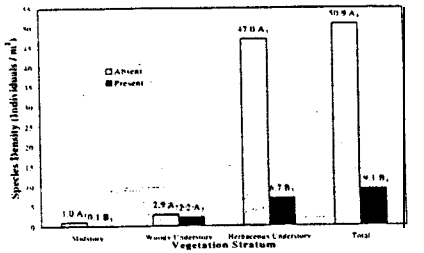

Figure 2—Relation between species density and vegetation stratum with *R. maximum* present and absent in southern Appalachian cove forest gaps. (Means with the same letter and subscript were not significantly different at 0.05 level).

Understory Vegetation

Woody species-Acer *rubrum, Liriodendron tulipifera, Betula lenta. and Tsuga canadensis were the most* important woody species in gaps containing *R. maximum. Acer rubrum, Betula lenta. Liriodendron tulipifera,* and *Quercus rubra* in gaps without *R. maximum were most* important. Brokaw (1965) found that shade tolerant species were dense in all gap sizes, which agrees with our findings.

Average woody-species richness and density in gaps with *R. maximum* were not significantly lower than open areas. Richness decreased from 6.7 species to 6.1 and density decreased from 2.9 individuals/m^2 to 2.2 from open to *R. maximum* gaps. respectfully (fig. 1 and 2). *Acer rubrum, Liriodendron tulipifera,* and *Betula lenta* are the three most important species in gaps whether or not *R. maximum* was present.

Lack of significance in species woody richness is probably due to high germination percentages of understory woody species which are capable of sprouting in small transient patches of light. However. species density data show that few of these sprouting individuals are capable of survival in gaps dominated by *R. maximum.*

Acer rubrum seedlings may be able to grow into the midstory with less difficulty than the other species due to their greater shade tolerance. The species is currently present in the midstory. Most other seedlings present. including *Betula* and *Liriodendron* seedlings. will likely succumb to detrimental effects of *R. maximum* and never reach mid- to upperstory positions.

Herbaceous species—Most important herbaceous species in gaps containing *R. maximum were Tiarella cordifolia, Smilax rotundifolia. Polystichum acrosticoides, Mitchella repens* and *Viola blanda.* Gaps with *R. maximum* absent contained *Tiarella cordifolia, Thelypteris noveboracensis, Polystichum acrosticoides. Thalictrum clavatum,* and *Solidago curtisii,* in decreasing order of importance. All these species are typical mesic constituents. and are moderately shade tolerant.

Herbaceous species were most adversely affected by increases in *R maximum* density with average richness decreasing significantly from 36.5 to 11.5 species as *R.*

maximum density increased (fig. 1). Average species density decreased from 47.0 to 6.7 individuals/m^2 (fig. 2).

Vegetational Relationships

As *R. maximum* density increased the number of potential overstory species decreased. Similarly, richness and density of potential midstory and understory species decreased. Herbaceous species experienced the most dramatic decrease (fig. 1 and 2). These findings indicate that future diversity of Appalachian cove forests will be reduced as *R. maximum* coverage increases. The high density of herbaceous species in the lower density thickets diminishes the relative importance of midstory and overstory species. Herbaceous vegetation may also be a detriment to regenerating overstory species.

CONCLUSIONS

In gaps where *R. maximum* dominated the shrub layer, mid/understory development and diversity were restricted. Species richness and density were significantly lower in gaps containing *R. maximum and* richness and density of the herbaceous layer was also dramatically reduced. *Tsuga canadensis* and *Acer rubrum* were the most dominant species inventoried in gaps with *R. maximum.*

Species of varying-degrees of tolerance to understory conditions are capable of establishment in small to medium size canopy openings in the absence of an evergreen understory. Continued and increasing presence of *R. maximum* in the mid-story will eventually contribute to the decrease of species richness in the overstory and alter forest structure and composition.

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