COMMUNITY COMPOSITION IN CANOPY GAPS AS INFLUENCED BY
PRESENCE OR ABSENCE OF RHODODENDRON MAXIMUM

Christopher T. Rivers, David H. Van Lear, Barton D. Clinton, and Thomas A. Waldrop

Abstract—The process of gap formation and recolonization plays an important role in the structure and composition in southern deciduous 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 fire. 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, Poulsen 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 Elliott Rock Wilderness Area; Tailulah Ranger District of the


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Chattahoochee National Forest in Rabun County, Georgia along Thomas Creek, Pigeon Ranger District of the Oconee National Forest in Transylvania County, North Carolina along Pisgah Creek and Loon Creek in the Great Smoky Mountains; Wayah Ranger District of National Forest in Clay County, North Carolina along the Tallulah River and Bleck Creek; and in Towns County Georgia, along Mill Creek in the Southern Nantahala Wilderness. Elevation of study sites ranged from 518 to 758 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 disturbance events to determine the composition and distribution of plant species.

Pest Delineation and Physical Characteristics
Reclassification of the southern Appalachian area was based on the type of disturbance that created canopy gaps. To determine the effect of different disturbance types on plant communities, maximum height density classes were classified into separate density categories (table 1), as described by Baker (1994).

Table 1—Density and basal area of high by thicket density category (Baker and Van Lear in press)

<table>
<thead>
<tr>
<th>Thicket Density</th>
<th>Basal Area</th>
<th>Number of Stems</th>
</tr>
</thead>
<tbody>
<tr>
<td>High 1-22</td>
<td>4-10 100m</td>
<td>2-7</td>
</tr>
<tr>
<td>Medium 5-11</td>
<td>5-10 100m</td>
<td>2-6</td>
</tr>
<tr>
<td>Low 2-5</td>
<td>2-4 100m</td>
<td>2-3</td>
</tr>
</tbody>
</table>

In this study no gaps were sampled with a "high" density rating. Gaps not meeting the following criteria: 1) gap-making tree(s) must have been canopy trees at the time of gap and 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 10 m from a stream. Gap size was estimated by assuming the internodal growth of previously successional growth-determinant individuals within the gap.

Twentv-two gaps of varying size were selected, with eleven containing R. maximum with a minimum density of 200 stems/ha and eleven where this species was mostly absent. The smallest gap was 2.27 m2 and the largest gap was 260.3 m2 as suggested by Runnels (1982). Distance across the widest part of the gap, and a shelter belt of more than 50% canopy cover, were the two factors used to determine the size of the first, coinciding with the center of the disturbance were measured. Using the formula for the area of an ellipse, area was determined. Gap size (40 m2-260.3 m2) ranged from one-tree openings to larger gaps made up of death from six trees.

Vegetation Sampling
Vegetation was sampled during the summer and fall of 1989. Basal area of gap-surrounding trees were at least 10 cm ground line diameter (GLD), denoting that they were no larger than 10 cm, longest distance across the gap, and 2) a shorter distance perpendicular to the first with the intersection of the two gradient areas coinciding with the center of the disturbance. Advanced regeneration and new seedlings were inventoried in 1-m-wide transects along each of the two principal gradient areas. These transects were further divided into 10 m-lengths where frequency was recorded to distribute vegetation plots uniformly across the understory forest. Percent cover of R. maximum was visually estimated and placed into Braun-Blanquet category classes for the individual 1-m sections and averaged to determine total percent cover for each gap class. All vegetation classes were determined using Barbour and others (1987). The area of the gap was divided into 10 m-lengths, and the frequency of occurrence in plots, contributing to its overall importance value.

Average woody species richness and density in gaps with R. maximum were significantly lower than in gaps containing a mixture dominated by R. maximum. Species richness averaged 18.7 species/gap and 3.8 (P < 0.001) while density averaged 677 stems/m2 and 51.9 (P < 0.001) for the two gap types, respectively. Twenty-three species of woody species richness decreased significantly from 7.7 speeies/gap in R. maximum gaps (fig. 1) demonstrating that advanced regeneration was not present at the time of gap formation and subsequent seedling growth was initiated. Average density was also significantly lower, 1.0 and 5.5 for gaps with and without R. maximum present, respectively, (fig. 2). Shade-tolerant woody species were almost completely eliminated and shade-tolerant species were severely reduced to levels where little or no recruitment into the overstory could occur. Total tree regeneration was higher in gaps containing R. maximum, which may be due to the seedlings of Philipps and Murphy (1985) and Clinton and others (1994).

RESULTS AND DISCUSSION

Vegetation
In the Southeastern Appalhian Mountains R. maximum is the dominant substory species, occupying approximately 30% of the forest and others (1996). R. maximum is one of the forest's most successful pioneers and hardwood forest disturbances because non-recovery of canopy tree seedlings is the most important factor. Seedling establishment in R. maximum is limited by factors such as reduced seed outfall by R. maximum (Hill and others 1990) (fig. 3). Gaps were affected low intensity, indirect effects of induced.
maximum density increased (fig. 1). Average species density decreased from 47.0 to 6.7 individuals/m² (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, midstory 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 midstory will eventually contribute to the decrease of species richness in the overstory and alter forest structure and composition.

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REFERENCES
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