THE ISOLATED RED SPRUCE COMMUNITIES OF VIRGINIA AND WEST VIRGINIA

Harold S. Adams, Steven L. Stephenson, Adam W. Rollins, and Mary Beth Adams[1]

Abstract.—Quantitative data on the composition and structure of coniferous forests containing red spruce in the mountains of central and southwestern Virginia and eastern central West Virginia, based on sampling carried out in 67 stands during the 1982 to 1984 field seasons, are provided. The average importance value ([relative basal area + relative density/2]) of red spruce was 46.8, and no other tree species occurred in all 67 stands. Yellow birch, eastern hemlock, Fraser fir, and balsam fir were the only other tree species with an average importance value >5, but the two species of fir were restricted to just a few stands. The general study area encompasses three different physiographic provinces (Appalachian Plateau, Ridge and Valley, and Blue Ridge), and compositional differences were apparent when the groups of stands sampled in the three provinces were compared. For example, fewer tree species (16) were recorded in the tree stratum in the Blue Ridge than in either the Ridge and Valley (21) or the Appalachian Plateau (22). Because the data presented herein were collected more than 25 years ago, they represent a baseline for future studies of montane coniferous forests in the Central Appalachians.

INTRODUCTION

Red spruce (*Picea rubens* Sarg.) is the most characteristic species of the montane coniferous forests that occupy higher peaks and ridges of the Central and Southern Appalachians from Virginia and West Virginia to Tennessee and North Carolina (Oosting and Billings 1951, Whittaker 1956). In many instances, these forests form a distinct dark "cap" on the high-elevation peaks and ridges where they occur. Red spruce has a restricted distribution in the mountains of central and southwestern Virginia and eastern central West Virginia. Presumably, distribution is limited because few areas in this region of the Appalachians reach the elevations necessary to provide the cool, moist conditions that this species requires to grow and reproduce. Paleobotanical studies have indicated that coniferous forests containing red spruce occurred throughout much of Virginia and West Virginia during the height of Wisconsin Glaciation and were still present at relatively low elevations (<500 m) in the southern portion of the Shenandoah Valley in Virginia as recently as 9,500 yrs BP (Harrison et al. 1965, Craig 1969, Whitehead 1972). With climatic warming, however, these coniferous forests were replaced by deciduous forests at all but the highest elevations (Watts 1979). At present, the approximate lower limit for red spruce in central and southwestern Virginia is 975 m, although well developed spruce communities generally do not occur at elevations below 1,200 m. In West Virginia, red spruce generally occurs in areas above 915 m but in a few places can be found at elevations below 800 m. However, forests where the species is dominant are found only at the very highest elevations (>1,200 m). Because the period from 8,000 to 4,000 yrs BP is believed to have been warmer and drier than at present (Delcourt and Delcourt 1984), it seems plausible that red spruce was restricted to even higher elevations during this earlier period.

Today, stands of red spruce are extant at fewer than 20 sites in central and southwestern Virginia (Hoffman 1950, Mazzeo 1966, Adams and Stephenson 1984), and at only two of these (Mount Rogers and Whitetop Mountain in

[1] Emeritus Professor of Biology (HSA), Dabney S. Lancaster Community College, Clifton Forge, VA 24422; Research Professor (SLS), Department of Biological Sciences, University of Arkansas, Fayetteville, AR 72701; (AWR) Assistant Professor of Biology, Lincoln Memorial University, Harrogate, TN 37752; (MBA) Supervisory Soil Scientist, USDA Forest Service, Northern Research Station, Parsons, WV 26287. HSA is corresponding author: to contact, email at steve_linda@ntelos.net.

extreme southwestern Virginia) is the species relatively abundant. Pielke (1981) suggested that red spruce formerly was much more widely distributed in the higher elevations of Virginia than is currently the case, but little evidence supports such a hypothesis. However, red spruce is known to have once been more abundant at some localities but was reduced in extent as a result of logging and (often) subsequent fire (Korstian 1937, Shields 1962).

In contrast, red spruce occurred over large areas (estimated at >200,000 ha) in the late 19th century in the mountains of eastern central West Virginia (Millspaugh 1891). However, logging between 1880 and 1920 (Clarkson 1964) almost completely eliminated these original forests. The red spruce forests that exist today are much more limited in extent (probably no more than about 24,000 ha) and commonly contain admixtures of various northern hardwoods, including yellow birch (*Betula alleghaniensis*), American beech (*Fagus grandifolia*), and red maple (*Acer rubrum*) (Stephenson and Clovis 1983).

Balsam fir (*Abies balsamea*), often a co-dominant species with red spruce in the Northern Appalachians, reaches its southernmost limit in the Blue Ridge Mountains of northern Virginia (Adams and Stephenson 1985). There it occurs as a minor understory component in a few stands dominated by red oak (*Quercus rubra*) (Stephenson and Adams 1989). In West Virginia, the species is known from just four localities (Stephenson and Adams 1986). Fraser fir (*A. fraseri*), commonly a co-dominant species with red spruce at higher elevations in the Southern Appalachians, reaches its northernmost limit on Mount Rogers in southwestern Virginia, where it occurs as a dominant component of the tree stratum at the highest elevations (Stephenson and Adams 1984).

Interestingly, old-growth stands of red spruce that were never subjected to logging still exist at a limited number of localities in southwestern Virginia and eastern central West Virginia (Adams and Stephenson 1989). The best known of these are the War Spur stand in the Mountain Lake Wilderness Area in Giles County, VA, and the Gaudineer Scenic Area on Shavers Mountain in Randolph County, WV. The latter, which is actually a mixed red spruce/northern hardwood forest, is the most extensive old-growth example of this forest type in the Central Appalachians.

White and Eager (1984) reviewed the extensive body of literature on the status of Southern Appalachian red spruce (including spruce-fir) communities. However, relatively little has been published on the red spruce communities of the Central Appalachians (Stephenson and Clovis 1983). Pauley (1988) described the composition and structure of a second-growth red spruce forest in Pocahontas County, WV, whereas Adams and Stephenson (1989) examined old-growth red spruce communities at three localities in Pocahontas, Tucker, and Randolph Counties. The isolated red spruce communities in central and southwestern Virginia have never been studied intensively, and published reports are limited to those of Shields (1962), Stephenson and Adams (1984), and Rheinhardt (1984), all of which focused on the spruce-fir communities of Mount Rogers and adjacent areas. Other studies include those of Bailey and Ware (1990), who studied the red spruce forests of Highland County, and Adams and Stephenson (1991), who provided a general description of the red spruce forest type in Virginia. For the most part, published information on red spruce communities is found in brief notes (e.g., Chappell 1972).

A general pattern of growth-trend decline that began during the 1960s and early 1970s was documented for red spruce throughout eastern North America, including Virginia and West Virginia, in the latter part of the last century (Adams et al. 1985, McLaughlin et al. 1987, Stephenson 1987, Stephenson and Adams 1993, Hornbeck and Kochenderfer 1998). The exact cause of the observed decline is still not known, but both natural stand dynamics (e.g., competition among individual trees in an over-stocked stand) and various anthropogenic factors (e.g., acid deposition) have been suggested (e.g., Eagar and Adams 1992). Whatever the cause, any significant degradation of red spruce forests probably will have profound consequences for endemic wildlife and local biodiversity. For example, the red spruce forest type is the habitat for several sensitive and endangered species, among them the Virginia northern flying squirrel (*Glaucomys sabrinus fuscus*), restricted to high-elevation forests of the Central Appalachians across Virginia and West

Virginia (Ford et al. 2004, Menzel et al. 2006). Moreover, all known populations of the Cheat Mountain salamander (*Plethodon nettingi*) occur above 900 m in the mountains of four counties in West Virginia and are closely associated with this forest type (Pauley 1993, Dillard et al. 2008).

The overall objective of the studies we report herein was to obtain quantitative data on composition and structure of all strata of vegetation at the Virginia and West Virginia localities where the red spruce forest type occurs. However, the data presented herein are limited largely to the tree stratum.

THE GENERAL STUDY AREA

Forest communities with red spruce in Virginia and West Virginia occur within three general physiographic provinces from east to west: Blue Ridge, Ridge and Valley, and Appalachian Plateau. The high-elevation areas in the mountains of central and southwestern Virginia where red spruce occurs include portions of both the Blue Ridge and Ridge and Valley physiographic provinces of the Southern Appalachian Mountains (Fenneman 1938), whereas in eastern central West Virginia red spruce is limited to some of the higher areas of the Appalachian Plateau. However, the Appalachian Plateau occupies a considerably greater area than either the Blue Ridge or Ridge and Valley physiographic provinces. As such, the Appalachian Plateau has a larger variety of habitats where red spruce is found. These range from bogs and valleys to side slopes and ridgetops. Ridge and Valley localities are generally restricted to high-elevation ridges and upper slopes, are typically limited in extent (usually only a few hectares), and are isolated from one another. There are only a few localities (mostly high-elevation ridges but with red spruce also extending to upper side slopes and drainages) where red spruce is found in the Blue Ridge as well, although these localities support the largest and most extensive stands in Virginia.

Blue Ridge

The mountains of the Blue Ridge are located to the east of the Ridge and Valley province and consist of two rather distinct sections separated by the Roanoke River, the southernmost stream cutting through this ridge system. The northern section, separated from the ridges of the Ridge and Valley by the broad, flat Shenandoah Valley, is an irregular range of relatively rugged, broad-topped mountains that only occasionally exceed 1,200 m. The southern section consists of an elevated plateau deeply cut by stream valleys. The highest mountains in Virginia occur in this section of the Blue Ridge; two peaks (Mount Rogers and Whitetop) exceed 1,680 m. The Blue Ridge is composed primarily of metamorphosed igneous rocks.

Ridge and Valley

The mountain ridges of the Ridge and Valley province generally run in a southwest-northeast direction and form a relatively narrow belt along the western boundary of Virginia. These ridges are rather level-crested, often with steep slopes, and are usually capped with Clinch (Tuscarora) sandstone of Silurian age. The less resistant (mostly Ordovician) shales and limestones have eroded away, producing the intervening valleys. Elevations in the region generally range from 300 to 1,050 m, but many ridgetops exceed 1,200 m and a few reach heights in excess of 1,375 m.

Appalachian Plateau

In West Virginia, red spruce forests are found within the Allegheny Mountain Section of the Appalachian Plateau (Fenneman 1938). The mountains of this region tend to have broad, flat summits underlain by resistant sandstones and conglomerates, with shales and limestones exposed on side slopes (Core 1966). Much of this part of West Virginia is above 915 m in elevation, with the highest point (Spruce Knob in Pendleton County) reaching 1,480 m above sea level.

Climate

Climatological data for high-elevation areas in the mountains of central and southwestern Virginia and eastern central West Virginia are limited, but data from a U.S. Weather Bureau station established in November 1971 at the University of Virginia Mountain Lake Biological Station (elevation 1,168 m) in Giles County, give some indication of the climate of the general study area during the approximately 10 years immediately prior to the time that our sampling was carried out. The average annual precipitation, based on the period of 1972-1983, is 136.3 cm. The average monthly precipitation

ranges from a low of 8.9 cm in August to a high of 14.8 cm in June. The mean annual temperature is 8.1 °C. Average monthly temperatures range from a low of -3.7 °C in January to a high of 18.5 °C in July. The lowest temperature of record is -31.7 °C, and the record maximum temperature is 31.1 °C. The average frost-free season is about 142 days (U.S. Department of Commerce 1972-1984). Data from the Cranberry Glades region (elevation 1,030 m) of Pocahontas County, WV, indicate similar climatic conditions, with a mean annual precipitation of approximately 130 cm, a mean annual temperature of 5.6 °C, and an average frost-free season of about 140 days (Darlington 1943). Canaan Valley (elevation 975 m) in Tucker County, WV, based on the information available for 1945-1964, is characterized by an average annual precipitation of 136 cm. Mean annual temperature is 8.1 °C and average monthly temperatures range from a low of -2.2 °C in January to a high of 18.4 °C in July. The frost-free period is relatively short, presumably because of cold-air drainage into the valley, and averages only about 92 days (Weedfall and Dickerson 1965).

MATERIALS AND METHODS

For most of the 67 stands considered herein, quantitative data on topographic variables and composition and structure of the tree stratum were obtained from sampling during the 1982 to 1984 field seasons. Some additional data were collected between 1992 and 2001. Thirty of the 67 stands are located in central and southwestern Virginia; 14 in the Blue Ridge physiographic province; and 16 in the Ridge and Valley or, in one instance, in a region of transition between the latter province and the Appalachian Plateau (Fig. 1). All 37 stands in West Virginia are located within the Allegheny Mountain Section of the Appalachian Plateau. Criteria for selection of the unit of vegetation (stand) actually sampled were that (1) vegetation be relatively homogeneous (with respect to floristics and plant structure) and at least 1 hectare in size; (2) topography of the area be uniform; (3) there be no obvious evidence that a major disturbance (e.g., logging, fire) had occurred during the lifetime of the trees sampled; and (4) red spruce be present in the tree stratum. We recorded slope inclination and aspect at several locations within each stand, and elevation was estimated using U.S. Geologic Survey 7.5-minute quadrangle maps, benchmarks, and obvious topographic features. In each stand, we recorded diameters at breast height (d.b.h., 1.37 m above ground level) of all live stems of trees (≥2.5 cm d.b.h.) in a single 20-m by 50-m (0.1 ha) quadrat. In two stands, both located on Spruce Knob of the Appalachian Plateau region, we used two 10-m by 10-m plots due to the high tree density and low biodiversity of the stands. We tallied stems of seedlings (individuals of tree species <1.0 m high) and shrubs (including vines) by species in either ten 1-m by 20-m, two 10-m by 10-m, or four 5-m by 5-m quadrats placed at regular intervals along a 50-m tape used to establish the center line of the larger quadrat. In most stands, we estimated percent cover of herbaceous plants, exposed rock, wood debris, and bryophytes from ten 1-m by 1-m quadrats spaced at 5-m intervals along the baseline tape. Cover values were determined with the use of a cover-class rating scale described by Daubenmire (1968). We also recorded any additional species not encountered within the quadrats but observed within the stand.

In most localities, we extracted cores at breast height from at least five representative larger red spruce trees to determine their approximate ages (*sensu* Adams et al. 1985). After cores were air dried, glued in grooved boards, and sanded, we counted growth rings using a binocular microscope.

We pooled quadrat data for each locality and calculated relative basal area and relative density values separately for size classes designated as trees (stems ≥10 cm d.b.h.) and small trees (stems <10 cm d.b.h. but ≥2.5 cm d.b.h.). For each locality, we calculated species importance value indices for trees and small trees as one-half the sum of relative basal area and relative density. Vascular plant nomenclature used herein follows Radford and others (1968), except that *Betula alleghaniensis* is used instead of *B. lutea*.

RESULTS AND DISCUSSION

Mean values for vegetation and site characteristics of red spruce stands sampled in each physiographic province are

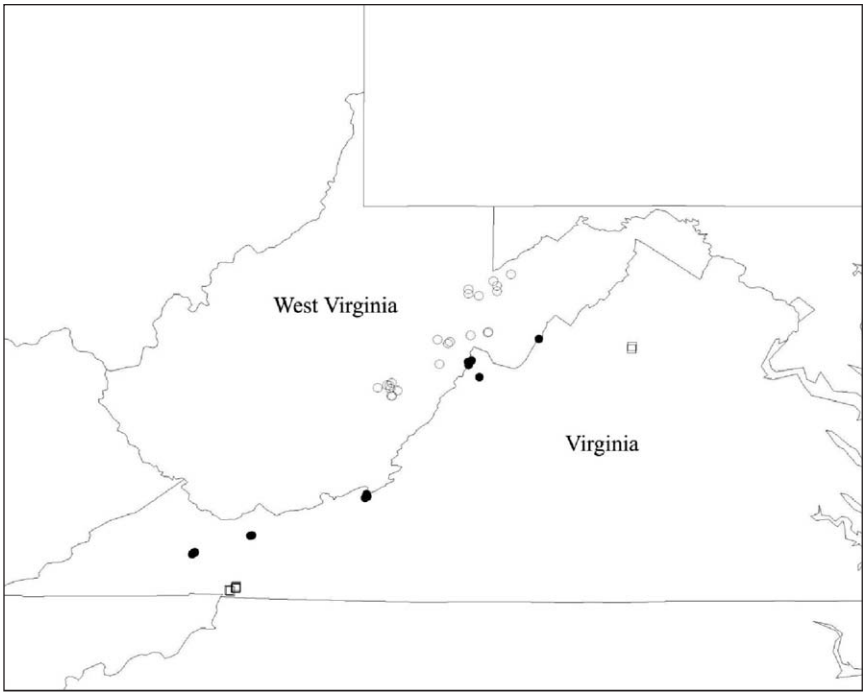

Figure 1.—General locations of stands sampled in southwestern Virginia and eastern central West Virginia. Note: squares = Blue Ridge, closed circles = Ridge and Valley, and open circles = Appalachian Plateau.

provided in Table 1. The highest average elevation (1,568 m) and slope inclination (20 percent) occurred in the Blue Ridge, whereas lowest values for these parameters (1,158 m and 11 percent, respectively) were recorded in the Appalachian Plateau. Based on values of aspect transformation, the Appalachian Plateau stands would seem to occur on drier (0.96) slope exposures on average than either the Blue Ridge (1.12) or Ridge and Valley (1.21), although values of other parameters measured or determined in each of the stands (e.g., bryophyte cover [41 percent]) suggest otherwise. Highest values for rock cover (22 percent), herbaceous cover (115 percent), tree density (899/ha), and small-tree density (842/ha) were recorded in the Blue Ridge Province. Conversely, richness of vascular plants (20 species) was lowest in this province. Lowest values for rock cover (2 percent), bryophyte cover (18 percent), small-tree basal area (1.19 m^2/ha), and sapling density (702/ha) were noted in the Ridge and Valley, although the highest value for tree basal area (44.7 m^2/ha) was calculated here. In fact, except for number of tree seedlings, the overall understory component in this province was less well developed than in the two other provinces. This result might suggest that stands in this province are, on average, more mature than those sampled in the Blue Ridge or Appalachian Plateau. The lowest values for basal area of trees and density of seedlings were recorded in Appalachian Plateau Province (35.2 m^2/ha and 32,698/ha, respectively). Generally speaking, values for tree density are comparable to those of hardwood stands we have sampled in the mid-Appalachian region, although basal areas are somewhat higher (Adams et al., personal observations; Rheinhardt and Ware 1984; Stephenson and Adams 1989). It is also interesting to note that the values recorded for small-tree density in all provinces were less than those recorded for trees, which is opposite the condition usually noted in mid-Appalachian hardwood forests (Adams et al., personal observation). It may be that the denser canopy coverage typical of red spruce stands hinders development of this stratum. Most certainly the dense cover suppresses red spruce saplings. The first two authors have determined age of small saplings (1 to 1.5 m tall) to be up to 75 years.

Thirty-two species of trees were tallied in the 67 stands sampled (Table 2). Red spruce, with an average importance value of 46.81, was dominant and the only species occurring in all stands. Its importance value ranged from 1.2 in a stand in the Fernow Experimental Forest to 100.0 in a second-growth stand on Cheat Mountain, both stands located in the Appalachian Plateau. Only four other species (yellow birch, eastern hemlock [*Tsuga canadensis*], Fraser fir, and balsam fir, in decreasing rank) had average importance

values exceeding 5. Among species other than red spruce, yellow birch was the most consistently present species (occurring in 53 stands), red maple was present in 37 stands, hemlock was present in 32, and American beech and serviceberry (*Amelanchier arborea*) each occurred in 20 stands. Black birch (*Betula lenta*) and black cherry (*Prunus serotina*) were recorded in 19 and 17 stands, respectively. All other species (24) were present in ten or fewer stands; seven species were found as trees in only one stand each.

Of the 32 species recorded as trees, 10 occurred in all three regions, seven in two of the three, and 15 in only one region. Yellow birch was more consistently present in the Blue Ridge and Appalachian Plateau provinces, whereas red maple, eastern hemlock, and serviceberry were more consistently present in the Ridge and Valley and Appalachian Plateau provinces. The frequency of occurrence of American beech was proportionally comparable for all provinces, but that of black birch was greater in the Ridge and Valley and black cherry was more frequent in the Appalachian Plateau.

Eleven species were present in both the Blue Ridge and Ridge and Valley provinces. Of those, only white oak (*Q. alba*) did not also occur in the Appalachian Plateau. The Blue Ridge and Appalachian Plateau provinces had 12 species in common; of these, fire cherry (*Prunus pensylvanica*) and mountain ash (*Sorbus americana*) were not recorded in the Ridge and Valley province. Of the 14 species tallied in both the Ridge and Valley and Appalachian Plateau, four (sugar maple [*Acer saccharum*], cucumber magnolia [*Magnolia acuminata*], mountain holly [*Ilex ambigua*], and yellow-poplar [*Liriodendron tulipifera*]) were absent from the Blue Ridge province. The three species

Table 1.—Mean values for vegetation and site characteristics of red spruce stands sampled in the mid-Appalachians of Virginia and West Virginia. Note: n = 9-14 for the Blue Ridge, 14-16 for the Ridge and Valley, and 11-37 for the Appalachian Plateau. Species richness values are based on presence of all vascular plants recorded in plots.

Parameter	Blue Ridge Province	Ridge and Valley Province	Appalachian Plateau Province
Elevation (m)	1,568	1,244	1,158
Slope (%)	20	17	11
Aspect (°)	0-295	5-350	0-350
Transformed aspect[a]	1.12	1.21	0.96
Exposed rock (%)	22	2	6
Wood (%)	15	13	13
Stand age (yr)[b]	92	92	87
Tree basal area (m^2/ha)[c]	40.9	44.7	35.2
Tree density (N/ha)[c]	899	727	814
Small-tree BA (m^2/ha)[d]	1.77	1.19	1.76
Small-tree density (N/ha)[d]	842	443	588
Tree saplings (N/ha)[e]	3,131	702	1290
Tree seedlings (N/ha)[f]	138,300	158,990	32,698
Shrubs (N/ha)	7,261	4,368	6,741
Herb cover (%)	115	21	24
Bryophyte cover (%)	41	18	41
Species richness	20	25	25

[a] Beers and others (1966)

[b] Based on data at least 5 cored trees per stand where done, then averaged for all stands per province

[c] Stems ≥10 cm d.b.h.

[d] Stems 2.5-9.9 cm d.b.h.

[e] Stems <2.5 cm d.b.h. but ≥ 1 m tall

[f] Stems <1 m tall

Table 2.—Mean importance values for trees (stems ≥10 cm d.b.h.) within each of the three physiographic provinces and the overall mean importance value for all 67 stands.

Species	Blue Ridge Province (n = 14)	Ridge and Valley Province (n = 16)	Appalachian Plateau Province (n = 37)	All Stands (n = 67)
Picea rubens	42.5	63.4	41.3	46.8
Betula alleghaniensis	11.2	6.3	14.8	12.0
Tsuga canadensis	3.4	9.1	11.7	9.4
Abies fraseri	30.7	–	–	6.4
A. balsamea	–	–	10.1	5.6
Acer rubrum	0.1	5.3	6.5	4.9
Fagus grandifolia	1.0	2.4	5.0	3.5
Quercus rubra	6.3	4.3	<0.1	2.4
Prunus serotina	0.3	0.2	3.4	2.0
Betula lenta	0.3	3.0	2.0	1.9
Acer saccharum	–	<0.1	1.8	1.0
Amelanchier arborea	0.1	1.8	0.8	0.9
Sorbus americana	2.4	–	0.2	0.6
Acer pensylvanicum	0.4	0.6	0.4	0.5
Magnolia acuminata	–	0.5	0.6	0.5
Tilia heterophylla	–	–	0.7	0.4
Quercus alba	0.8	0.9	–	0.4
Ilex ambigua	–	0.7	<0.1	0.2
Prunus pensylvanica	0.1	–	0.2	0.1
Nyssa sylvatica	–	0.5	–	0.1
Magnolia fraseri	–	–	0.2	0.1
Sassafras albidum	–	0.3	–	<0.1
Acer spicatum	0.3	–	–	<0.1
Pinus strobus	–	0.2	–	<0.1
Hamamelis virginiana	–	0.2	–	<0.1
Alnus rugosa	–	–	0.1	<0.1
Crataegus sp.	–	–	<0.1	<0.1
Liriodendron tulipifera	–	<0.1	<0.1	<0.1
Fraxinus nigra	–	–	<0.1	<0.1
Carya tomentosa	–	0.1	–	<0.1
Castanea dentata	–	<0.1	–	<0.1
Fraxinus americana	<0.1	–	–	<0.1
Total Number of Species	16	21	22	32

(Fraser fir, mountain maple [*Acer spicatum*], and white ash [*Fraxinus americana*]) found only in the Blue Ridge tend to prefer more mesic conditions, whereas five of the six species (the exception being white pine [*Pinus strobus*]) found only in Ridge and Valley tend to favor less mesic situations. Of the six species of trees tallied only in the Appalachian Plateau, all but hawthorn (*Crataegus* spp.) typically have a preference for more mesic environments.

Overall, based on average importance values (IVs) for species represented in the tree stratum, the Blue Ridge and Ridge and Valley tree composition had a similarity value of 59.3 percent (based on 100 – [sum of differences in IV of all species]); the Ridge and Valley and Appalachian Plateau, 68.6 percent; and the Blue Ridge and Appalachian Plateau, 58.4 percent. The greater similarity of the Ridge and Valley and Appalachian Plateau provinces most likely can be attributed to their proximity to one another. It also is interesting to note that fewer species (16) were recorded in the tree stratum of the Blue Ridge than in either the Ridge and Valley (21) or Appalachian Plateau (22) provinces. In the Blue Ridge, only two species (red spruce and yellow birch) were tallied in 75 percent or more of all sampled stands, in the Ridge and Valley only one (red spruce) was this frequent, and in the Appalachian Plateau four species (red spruce, yellow birch, eastern hemlock, and American beech) were tallied in >75 percent of all stands. In every instance, the majority of species recorded were found in fewer than 25 percent of the number of sampled stands (12 in the Blue Ridge, 14 in the Ridge and Valley, and 10 in the Appalachian Plateau). Red spruce was the leading dominant in all three provinces. Fraser fir was the second-leading dominant in the Blue Ridge, owing to its abundance in six of seven stands on Mount Rogers. Yellow birch and hemlock shared roles as second- and third-leading dominants in the Ridge and Valley and Appalachian Plateau. Two other species (red maple and northern red oak) occupied important ecological positions in two provinces (the Blue Ridge and Ridge and Valley).

Eleven species shared the role of leading dominant in the 67 sampled stands, but only five species shared this role in the Blue Ridge, four in the Ridge and Valley, and nine in the Appalachian Plateau. Of the species tallied as leading dominants, only Fraser fir and northern red oak did not share that role in the Appalachian Plateau. Red spruce was the leading dominant in 32 stands, hemlock in nine, balsam fir in seven, Fraser fir in six, and yellow birch in five. Two species (northern red oak and black cherry) were the leading dominant in each of two stands, and four additional species were the leading dominant in one stand each.

Either yellow birch or red spruce was the second-leading dominant in just more than half of all stands studied. In addition, red maple occupied this position in the Ridge and Valley and Appalachian Plateau provinces, whereas American beech and eastern hemlock were also second-leading dominants in the Appalachian Plateau. One stand in the Appalachian Plateau had no second-leading dominant since all of the trees were red spruce. Although 12 species were recorded as second-leading dominants, only four of these were recorded in the Blue Ridge. The Ridge and Valley and Appalachian Plateau had nine and ten species, respectively. The leading dominants when yellow birch was the second-leading dominant were red spruce (five stands) and eastern hemlock (one stand) in the Blue Ridge; red spruce and eastern hemlock (one stand each) in the Ridge and Valley; and red spruce (six stands), eastern hemlock (two stands), and beech and sugar maple (one stand each) in the Appalachian Plateau. When red spruce was the second-leading dominant, leading dominants were Fraser fir (five stands) and yellow birch (one stand) in the Blue Ridge; hemlock (two stands) and yellow birch (one stand) in the Ridge and Valley; and balsam fir (five stands) and hemlock (two stands) in the Appalachian Plateau. These data suggest that it is not uncommon for a reciprocal relationship, with respect to leading dominant and second-leading dominant, to exist between red spruce and yellow birch and between red spruce and eastern hemlock.

The 67 stands sampled in the present study were similar in that all contained red spruce. As already noted, however, compositional differences were apparent when the groups of stands sampled in the three provinces were compared. Moreover, four basic subtypes of the red spruce forest type can be distinguished. These are (1) the red spruce-dominated (red spruce IV>60); (2) the bog type with two different expressions (eastern hemlock-dominated and balsam fir-

dominated); (3) the Fraser fir type; and (4) the red spruce/hardwood admixture with two different expressions (northern hardwood and "oak"). The red spruce-dominated subtype occurs in all three physiographic provinces and typically is found on higher-elevation ridgetops and upper slopes. Red spruce had an average importance value of 85.6 in stands representing this subtype, although 16 other species were present at low importance values. The bog type red spruce community typically occurs at lower elevations in low-lying areas. The eastern hemlock-dominated bog type is found in all three provinces, although only one such stand was sampled in the Blue Ridge (Limberlost in the northern Blue Ridge in Shenandoah National Park). Eastern hemlock, red spruce, and yellow birch had a combined importance value of 88.0 in the eastern hemlock-dominated bog type. The balsam fir-dominated bog type, found only in the Appalachian Plateau province, is dominated by balsam fir, red spruce, eastern hemlock, and yellow birch (with a collective importance value of 89.5). Yellow birch is not as important as in the eastern hemlock bog type.

The Fraser fir/red spruce subtype is found only in the southern Blue Ridge province at Mount Rogers. The elevation of Mount Rogers exceeds that of any other mountain in Virginia and West Virginia. Mount Rogers is unique in that it is the only known location of naturally occurring Fraser fir outside of the Southern Appalachians of Tennessee and North Carolina. Fraser fir, red spruce, and yellow birch had a combined importance value of 94.2 in the Fraser fir/red spruce subtype, and only four other tree species were present. The northern hardwood/red spruce admixture subtype was not found in the Blue Ridge province and only one stand occurred in the Ridge and Valley province. Three species (yellow birch, American beech, and red spruce) had a combined importance value of 64.0 in this subtype. Collectively, five species (northern red oak, red maple, white oak, black birch, and red spruce) had an importance value of 85.3 in the "oak"/red spruce subtype community. These communities are not common and only one example of each was found in each of the three physiographic provinces.

In summary, montane coniferous forests containing red spruce are much less extensive today than they were in the late 19th century, and this forest type is now considered to be endangered (Noss et al. 1995). Management options are not as yet clearly defined but have been addressed in several recent studies (e.g., Hornbeck and Kochenderfer 1998, Schuler et al. 2002, Rentch et al. 2007). Subsequent research on natural stand dynamics in montane coniferous forests in the Central Appalachians could use the data presented herein as a baseline representing conditions more than 25 years ago.

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