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The Distribution of Spruce in West-Central
Virginia Before Lumbering
ROGER A. PIELKE

ABSTRACT

Using estimates of the mean monthly temperature as a function of elevation in west-central Virginia, it is inferred that red spruce (Picea rubens) and other boreal vegetation should be a common natural vegetation type above about 3,000 feet. The current existence of an Appalachian Oak Forest above these heights, however, is due to the lumbering and subsequent repeated burning of the red spruce in this region during the last half of the nineteenth and the beginning of the twentieth centuries. This destruction of the favorable microclimate and soil conditions for spruce germination and initial growth eliminated this species throughout much of its range in this area.

The current documented climatic cooling in the region, however, along with the reestablishment of a moister, cooler climate beneath the oak forest canopy, provides a suitable environment for the reestablishment of spruce. Unfortunately, the distribution of this tree, in regions where it had been eliminated by logging and fire, is limited because of its poor seed mobility. Thus, the dispersal, in a reasonably short time frame, of this tree type over its apparent natural range in the Appalachian Mountains will require reforestation by man.

INTRODUCTION

Recent studies (Little, 1965; Hoffman, 1950) of spruce occurrence in west-central Virginia have found small communities of indigenous red spruce (Picea rubens Sarg.) in only a few locations. In the George Washington National Forest, for example, the only occurrence of red spruce currently catalogued by the Forest Service was a 52-acre stand of mixed red spruce and Northern Hardwoods in northwest Highland County, Virginia (R. G. Brooks, 1979, personal communications). In the Shenandoah National Park, red spruce is quite rare, being reported only on Hawkshill and Stony Man Mountains, and in Limberlost (Mazzeo, 1966); all of these sites are located in the central portion of the park. Langdon and Langdon (1980) have recently catalogued the existing spruce in the park and have shown this species to be endangered in the park and susceptible to complete elimination by even a modest fire.

In West Virginia, on the other hand, close to the border of central Virginia, regions of red spruce are quite extensive, sometimes capping the higher elevations as pure stands. Before the original cutting of the forests in West Virginia, red spruce
was reported as low as 2,500 feet, and to cover an area of over 445,000 acres (Strausbaugh and Core, 1952; Clarkson, 1966; Perkins, 1929; Hopkins, 1899). In the southern Appalachians as a whole, Minckler (1940) estimates that 3,000,000 acres of spruce or mixed spruce-hardwood forests were present before cutting. In Virginia, however, records of forest cover were not kept until after 1924 (Merriman, 1930; Administrative Report of the Virginia State Forester, 1915), which is after much of the original forest was cut. In 1919, before thorough records were kept, Jones (1919) estimated that much less than 5% of Virginia’s forests were virgin. The more thorough documentation of vegetation in West Virginia may have resulted from the political and economic upheaval associated with the Civil War. Until the early 1900’s, Virginia was still recovering from the post-Civil War and Reconstruction period while a much less serious adjustment occurred in West Virginia.

Previous studies (e.g., Strahler, 1972) have maintained that current differences in vegetation between the Allegheny Plateau (predominantly in West Virginia) and the Ridge and Valley (predominantly in Virginia) physiographic regions are due to more mesic conditions in West Virginia. In fact, however, in the higher terrain at equivalent elevations, the Allegheny Plateau is not wetter during the growing season (e.g., April to October, 1974-1978 inclusive: Big Meadows, Shenandoah National Park, Virginia (el. 3,535 feet) had 30.23 inches of rain, while Spruce Knob Lake, West Virginia (el. 3,050 feet) had 26.29 inches). Only in the lower elevations where rain shadows are produced due to the descent of air as it flows downslope are differences in average warm season rainfall found in the central Appalachians.

The original occurrence of red spruce in the higher elevations of central Virginia is of interest because if it can be demonstrated; then there should be justification for extensive replantings of the tree today. Such areas are valuable as a visual resource to the recreationist and as a boreal habitat to be used in studies by botanists and zoologists. In the southern Appalachians, for example, birds such as the golden-crown kinglet (Regulus satrapa satrapa), the hermit thrush (Hylocichla guttata faxonii), and the magnolia warbler (Dendroica magnolia) inhabit spruce forests almost exclusively (C. E. Stevens, personal com-
munication, 1979). In addition, where logging is permitted, the spruce could provide a source of pulpwood and saw-timber for the lumber industry. As reported by Gibson (1913), the spruce of the southern Appalachians was stronger and had more clear lumber than that found in New England and the Canadian maritime provinces. In 1909, Virginia produced 79,672,000 board-feet of spruce saw-timber (4.9% of the U.S. spruce production) and 46,089 cords of spruce pulpwood (2.8% of the U.S. total spruce pulpwood). As a comparison, the leader in spruce lumbering in 1909, Maine, cut 421,297,000 board-feet (24.1% of U.S. spruce) and 552,032 cords (33.4% of U.S. spruce pulpwood) (Murphy, 1917). In the Laurel Forks Planning Document (1974) of the George Washington National Forest, it is mentioned that 40% of the forests in the Laurel Forks Unit in Highland County, Virginia, were spruce; the original source of this information could not be found. Recently, V. H. Gaines, District Ranger for this area, reported that before the first logging around 1920, most of the area west of the Laurel Forks (a small tributary stream in the Ranger District) was red spruce. He reports that toward the end of the logging operation, forest fires burned over most of this area with one fire alone destroying 30,000,000 board-feet of predominantly decked spruce logs. Currently the George Washington National Forest (GWNF) cuts so little spruce that it is reported under miscellaneous (R. G. Brooks, Timber Staffs Officer, GWNF, personal communication, 1979). As will be suggested later in this paper, some of the spruce cut in 1909 apparently came from a number of areas in central Virginia.

INVESTIGATION

The original motivation for the current study originated from a study of the distribution of monthly mean temperatures as a function of elevation in west-central Virginia and east-central West Virginia (Pielke and Mehring, 1977). In that study, mean temperatures were found to be primarily dependent on elevation, and not on whether the climatological recording sites were in the West Virginia Highlands or in the Virginia Mountains. Figure 1 (reproduced from Pielke and Mehring, 1977) shows the analyzed temperature distribution for a portion of the Blue Ridge Mountains of Virginia for July, while Table 1 gives
the estimate of monthly mean temperatures at a series of elevations in the region, using 1958-1973 climatological data. The highest elevation in Figure 1 is approximately 4,000 feet in the Blue Ridge, and 4,400 feet in the Alleghenies to the northwest. In West Virginia the highest elevations are about 4,800 feet.

![Map of temperature regions](image)

**Figure 1.** Estimates of mean monthly temperature in °F in July over a portion of central Virginia (adapted from Pielke and Mehring, 1977). The plotted temperatures correspond to elevations (e.g. 76°F ~ 300 feet; 73°F ~ 1,300 feet; 70°F ~ 2,000 feet; 68°F ~ 2,600 feet; 67°F ~ 3,000 feet). Areas with mean summer temperatures less than or equal to 68°F, and therefore expected to have a climate favorable for red spruce, are indicated by crosshatching.
Table 1. Estimates of mean monthly temperature as a function of elevation in west-central Virginia and east-central West Virginia (adapted from Pielke and Mahrer, 1977). The 68°F contour is included in the Table to indicate the expected times of the year when spruce seed are likely to be permanently damaged by heat.

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Annual Range of Mean Temperatures (°F)</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
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<td>59</td>
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<td>34</td>
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<td>45</td>
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<td>72</td>
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<tr>
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<td>40</td>
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<td>38</td>
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<td>68</td>
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<td>61</td>
<td>56</td>
<td>46</td>
<td>35</td>
<td>26</td>
</tr>
<tr>
<td>5000</td>
<td>39</td>
<td>20</td>
<td>21</td>
<td>29</td>
<td>40</td>
<td>49</td>
<td>56</td>
<td>59</td>
<td>59</td>
<td>54</td>
<td>44</td>
<td>34</td>
<td>24</td>
</tr>
</tbody>
</table>

| Standard Error of Estimate (°F) | 1.6 | 1.4 | 1.4 | 1.3 | 1.1 | 1.1 | 1.1 | 1.1 | 1.3 | 1.4 | 1.4 | 1.4 |
The conditions in which red spruce grow and propagate are discussed in Little (1965), Murphy (1917), Korstian (1937), and Oosting and Billings (1951). These trees are found in regions where the average temperatures are between 40°F and 55°F, with January averages between 10°F and 35°F, while July has mean values between 65°F to 70°F. Seeds are permanently injured by long exposure above 92°F, with temperatures between 68°F and 86°F favorable for germination when adequate moisture is present. Germination and initial establishment are best in shade, while better growth is attained in the sun after establishment. Average precipitation ranges from about 35 inches in the northern part of its range to 80 inches in the Smokies. The frost-free period is from 100 to 180 days. Generally red spruce grows in podzolic soils with a pH of 4.0 to 5.5. In spruce stands in the Smokies, the underlying rocks are metamorphosed, principally gneiss, with occasional outcroppings of quartzite and schists. In the spruce stands in New England the trees are found on light-colored granites, while in West Virginia spruce has been found where the parent rock material is sandstone or sandstone conglomerate. Comparable climatic and soil conditions are found in most of the higher elevations of central Virginia.

Using the criteria listed above, it appears that the mean monthly temperature during the warmest summer month (July in eastern North America) exerts a strong control on the southern and lower elevation geographical limits of spruce. This limiting value is about 68°F and correlates well with the southern limit of red spruce in New England. In Figure 1, the 68°F contour of July mean temperatures corresponds roughly to the 2,500 ft. contour. Although temperature conditions alone, of course, do not guarantee the natural existence of red spruce in the higher elevations of central Virginia, the documented original occurrence of red spruce in West Virginia at about the same elevations makes its likelihood greater.

Given that extensive stands of red spruce should occur in the central Virginia mountains, there are two possible explanations as to why there are only a few remnants.

a) For a period after the last major continental glacial retreat, weather conditions were warmer than they are
now (reaching a maximum about 7,000 BP (before the present)). Conditions could have been unfavorable for spruce at any elevation in central Virginia; whereas, in West Virginia and in the mountains further south, the elevations were sufficiently higher so as to provide a refuge for spruce. When conditions once again cooled, spruce could migrate to lower elevations there but could not be regenerated farther east. Whittaker (1956), for example, uses this argument to explain the lack of spruce in the higher elevations in the south-western part of the Great Smoky Mountain National Park, maintaining that a 1,200-foot upward displacement of spruce and fir would have removed these boreal trees from that portion of the Park. Craig (1969) documents this change-over from a boreal forest (with spruce) to an oak-hickory forest about 9,520 BP at an elevation of about 1,600 feet, just to the west of the Blue Ridge Mountains in central Virginia. Equally important, however, he finds the reemergence of small quantities of spruce pollen in the most recently deposited layers in one of his ponds, perhaps an indication of spruce at higher elevations.

or b) Extensive areas of spruce covered the higher elevations of the Blue Ridge and the Alleghenies before the original cuttings. This lumbering not only removed the favorable microclimate for the continued germination and growth of spruce (direct sunlight can prevent germination and kill young seedlings, although larger trees grow well under such conditions), but the debris left after logging created extensive fuel for fires which killed any spruce which managed to germinate as well as destroyed the thick underlying layers of organic soil (this could explain why the initial attempts of the Forest Service to reforest with red spruce were generally unsuccessful—because the new hardwood overstory was too young to provide sufficient shade for the spruce). In 1925, for example, immediately after the intensive period of logging in the mountains of western Virginia, 102,000 acres burnt over during
the spring fire season (VA Forestry Dept. Newsletter, 1925). Some areas in the mountains burnt over almost yearly until forest cover was reestablished (Virginia Forestry Dept. Newsletter, 1924).

The first hypothesis is plausible except that it fails to explain why there are any remnants of red spruce in the Blue Ridge and the Alleghenies. Since spruce and fir currently occur only a short distance below the tops of mountains in this region, it is clear that a 1,200-foot vertical displacement of this vegetation type, as proposed by Whittaker (1956) for the Smokies, would have removed these species completely. If the post-glacial retreat period was, therefore, sufficiently warm to exterminate the spruce in that range, how were they reestablished? Spruce should be spatially more extensive if they had managed to survive in the mountains during the warm period since they would have migrated to lower elevations. If they were logged out and burnt over, however, trees that managed to survive would be only able to spread their seeds out to a radius of 200 feet (Murphy, 1917) or 1,200 feet (Korstian, 1937). Since red spruce must attain an age of about 45 years before it produces significant seed (Murphy, 1917), it is no wonder the remaining red spruce enclaves are small.

Historical evidence also supports the second hypothesis. Maps of spruce distributions prepared during the early part of this century (e.g., Hough, 1918; Shantz and Zon, 1924; and Volume IV of the 10th United States Census, 1880) indicate that this tree was much more extensive in the late 1800's and early 1900's than it is now. Numerous other writers of that period (Berry, 1924; Gibson, 1913; Mathews, 1915; Rogers, 1905, 1916; Coker and Totten, 1937; Newhall, 1890; Hough, 1918; Meehan, 1853; Record, 1934; and Cooper, 1859) report the more extensive occurrences of spruce, often indicating their growing southward along the Alleghenies to South Carolina and Georgia. More recently, Shields (1962) reports that before logging, spruce tended to form a continuous belt from northern West Virginia to the Great Smokies.

Many present-day investigators, however, discount these earlier records of wide-spread spruce distributions. As shown in Table 2, however (reproduced from Murphy, 1917), spruce were
Table 2. Red spruce lumber produced in the eastern United States as reported by Murphy (1917), based on the 1909 United States Census on forest products

<table>
<thead>
<tr>
<th>State</th>
<th>Amount in 1,000 bd. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maine</td>
<td>421,297</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>253,107</td>
</tr>
<tr>
<td>West Virginia</td>
<td>242,897</td>
</tr>
<tr>
<td>New York</td>
<td>127,864</td>
</tr>
<tr>
<td>Vermont</td>
<td>123,164</td>
</tr>
<tr>
<td>Virginia</td>
<td>79,672</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>36,911</td>
</tr>
<tr>
<td>North Carolina</td>
<td>24,277</td>
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<tr>
<td>South Carolina</td>
<td>13,803</td>
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<tr>
<td>Pennsylvania</td>
<td>7,307</td>
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<tr>
<td>Maryland</td>
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<tr>
<td>Georgia</td>
<td>2,789</td>
</tr>
<tr>
<td>Kentucky</td>
<td>2,226</td>
</tr>
<tr>
<td>Delaware</td>
<td>1,610</td>
</tr>
<tr>
<td>Tennessee</td>
<td>720</td>
</tr>
<tr>
<td>Rhode Island</td>
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<td>Connecticut</td>
<td>262</td>
</tr>
<tr>
<td>New Jersey</td>
<td>125</td>
</tr>
<tr>
<td>Ohio</td>
<td>78</td>
</tr>
</tbody>
</table>

logged in 1909 from states such as Delaware, Georgia, Kentucky and South Carolina (which are considered today to have had no native spruce during modern times) thereby adding credibility to the early maps and discussions of tree distributions. Murphy (1917) states that all of the spruce cut in these states was red spruce. By 1915 Murphy reports that significant stands of red spruce were left only in Maine, New Hampshire, Vermont, Massachusetts, New York, Maryland and West Virginia (today on the order of 60,000 acres of native red spruce occur in West Virginia, as contrasted with over 445,000 acres in the late 1800’s). The present-day disagreement with these earlier maps and discussions, however, has been based on botanical collections obtained after most of the original forest was cut. Current distribution maps, therefore, document a forest region pro-
foundly influenced by logging and fire and not the original vegetative cover.

Another possible indication of the original presence of spruce is the occurrence of understory vegetation which thrives in a similar environment. Westveld (1953), Little (1965), Shields (1962), and Oosting and Billings (1951) discuss such red spruce associates. Examples include *Oxalis montana*, *Maianthemum canadense*, and witch hobble (*Viburnum alnifolium*). Table 3 lists the current distributions of these and other similar species for several counties with land in west-central Virginia, along with the locations in this area where red spruce is reported today. Although such vegetation indicators do not guarantee that spruce was present in the original forest, they indicate that climate and soil conditions are favorable for its presence today.

The evidence concerning original spruce distributions in western Virginia may never be conclusive without more detailed contemporaneous descriptive comments on the original forest cover at the higher elevations; individuals who were fortunate enough to view these extensive virgin tracts, even as recently as the early 1900’s, are now gone. State by state tabulation of spruce, however, as well as the maps of spruce distribution, suggests spruce was much more extensive than they are today. The following scenario is offered to explain their radical reduction in range.

1. Originally spruce occurred mixed with northern hardwoods in the higher elevations of western Virginia, and scattered in stream beds and swamps in the northern Piedmont. At elevations of 4,000 feet and higher spruce may have formed a solid forest.

2. Around 1900, lumbering in western Virginia accelerated, with the cutting of spruce reaching a peak just before 1910 (Murphy, 1917). In the cutting of spruce, considerable debris was left which eventually was ignited and burnt over at least once, removing much of the organic soils, as well as destroying the remaining trees. As reported by Little (1965), because of its shallow root system, thin bark, and characteristic resinous exudation, red spruce of all ages is easily killed by fire. As reported by Gibson (1913):
Table 3. Some vegetation normally associated with red spruce and the distribution by county in a portion of central Virginia (this table was prepared from information provided by Charles E. Stevens)

<table>
<thead>
<tr>
<th></th>
<th>Mountain Ash (Sorbus americana)</th>
<th>Hobblebush (Viburnum alnifolium)</th>
<th>Vaccinium angustifolium</th>
<th>Clintonia borealis</th>
<th>Maianthemum canadense</th>
<th>Oxalis montana</th>
<th>Red Spruce (Picea rubens)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albemarle</td>
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</table>
“Seedlings do not thrive on mineral soil, and for that reason make a poor showing where fires have burned. It does not spread vigorously in old fields as white pine does. It must have forest conditions or it will do little good. For that reason it does not promise great things for the future.”

He further adds; . . . “no second forest of evergreens (referring to spruce-fir) is likely on tracts which have been severely burned.”

Barden (1978), in discussing balds in North Carolina, supports this argument. He mentions that spruce were quite common in his study area until it was cleared and the remaining debris burnt. Then, after a few years, a second burning occurred which killed the young spruce which had still managed to germinate after the first fire. In this case the spruce that remain are only slowly spreading into the bald.

If the spruce had been killed on many of the ridges in the Virginia mountains, there is currently no seed source to reestablish the range. Since fires will generally burn upslope, this destruction of spruce up to the ridgelines undoubtedly happened frequently.

3. In concert with this burning and resultant removal of an overstory and of favorable soils, the climate in the Northern Hemisphere warmed markedly from the early 1900’s until about 1940 (Diaz and Quayle, 1978). Apparently related to this warming, the length of growing season in central and northern Virginia increased by about two weeks between 1900 and 1950 (Pielke, et al., 1979), further decreasing the survival chances of any remaining spruce seedlings. Much of the spruce which was planted in the 1930’s by the Civilian Conservation Corps was placed in this highly unfavorable environment, without much probability of success.

4. Since 1940 the climate of the Northern Hemisphere has cooled markedly and returned to conditions which correspond more to the late 1880’s than to the early part of this century (Diaz and Quayle, 1978). In relation to weather
conditions in the mountains, the observed drop in mean monthly summer temperatures in Virginia between 1942 and 1972, \(-2.2^\circ\text{F}\), (van Loon and Williams, 1976) corresponds to about a 600-foot increase in the effective climatic elevation in the mountains (see Table 1). Apparently associated with this change, the growing season in central and western Virginia has decreased over two weeks since the early 1950’s and is currently at the lowest point this century (Pielke, et al., 1979). Also, the hardwoods in the forest have matured creating a more favorable microclimate under their canopies for successful spruce germination and growth, and the soils have improved as the leaves and other debris from the hardwoods decay. During the period after the last major glacial retreat, warmer conditions prevailed than in the early 1900’s, but since cutting and subsequent burning did not occur, the microclimate existing under softwood forests would have minimized fluctuations in altitudinal levels of forest type. Undoubtedly, the stresses put on the forests of Virginia during the last 100 years were the greatest since the last major continental glaciation.

Thus, conditions today appear adequate to support red spruce in central Virginia at elevations above 3,000 feet or so. Above 4,000 feet climatic conditions are probably optimal for solid stands of red spruce. Indeed a visit to Hawkstown (elevation 4,049 feet) in Shenandoah National Park shows that where older individuals of the other central Virginia boreal conifer, balsam fir (Abies balsamea), are present to provide seed, the young firs form a dense understory. Even more significantly, fir is germinating and growing on the southwest side of the trail to Hawkstown. Since in the northern, mid-latitudes this aspect is known to be warmer and drier than other orientations at the same elevation (e.g., Whittaker and Niering, 1965, p. 436), it provides evidence that the other boreal conifer, spruce, should thrive at considerably lower elevations on the cooler, moister north-facing slopes; particularly since it is known that red spruce grows more readily at lower elevations than fir in other mountains in the southeastern United States (Whittaker, 1956). In addition, native red spruce has been reported at elevations as low as 2,700 feet in
Highland County (C. E. Stevens, personal communication, 1979), undoubtedly remnants from the more extensive stands of spruce that occurred in the original forest.

Because red spruce apparently was more extensive at higher elevations in Virginia in the original forest, it should be justifiable to reforest those areas with this tree. Minckler (1940) advocates such reforestation practice in the higher mountains of North Carolina. To wait for it to occur naturally will take hundreds of years because of the slowness with which spruce reaches good seed-bearing size (45 years) and the limited dispersal of its seed (out to 200 to 1,200 feet). A renewed mixed spruce/hardwood and solid spruce cover of the higher elevations of Virginia would not only add a harvestable timber in those areas where cutting is permitted, but would diversify the recreational and wildlife opportunities of the region. Indeed, it would be interesting to see what would be found in these restored mature spruce forests. Egleston (1884), for example, reported that in West Virginia, under dense spruce canopies, snow and ice were frequently found even in mid-summer among the moss-covered rocks!

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