

Chapter 4

Plant Communities



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4.1 Introduction

Plant communities are assemblages of plant species that share specific habitat conditions along similar environmental gradients, with species interacting where they occur together. Plant communities have a characteristic range of stand physiognomy and suite of ecological processes, including natural disturbance regimes (Grossman et al. 1998; Jennings et al. 2002, 2003). They also are believed to support distinctive assemblages of microbial and animal species, especially among smaller and less mobile organisms. Terrestrial ecological communities are classified based on vegetation because plants are the most persistent and observable life form in these systems.

Plant communities are an important component of biodiversity, crucial for the maintenance of ecological processes and food pathways necessary for survival of many interdependent species. Because communities provide habitat for a multitude of common and poorly known organisms, conservation of their diversity offers a means to protect the many species that are not the focus of individual species conservation efforts. Even where we expect climate change to lead to different species assemblages, conserving the present diversity of communities protects the diversity of site conditions or habitat niches that will make up future communities as well as the pool of species that will compose future communities.

The plant communities in red spruce ecosystems across the central and southern Appalachians share many common features. Nevertheless, each community has its

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own distinct diagnostic species, substrate, topographic position, moisture regime, and disturbance regime. For some aspects of management and study, they may be addressed collectively. For others, the distinctions among different communities are crucial, and recognition of them may be essential for conservation success.

Communities in which red spruce is dominant or co-dominant often share a number of associated plant species. Co-dominant tree canopy species include Fraser fir (*Abies fraseri*), balsam fir (*Abies balsamea*), yellow birch (*Betula alleghaniensis*), eastern hemlock (*Tsuga canadensis*), yellow buckeye (*Aesculus flava*), red maple (*Acer rubrum*), American beech (*Fagus grandifolia*), black cherry (*Prunus serotina*), Fraser magnolia (*Magnolia fraseri*), and pitch pine (*Pinus rigida*). These communities range from closed canopy forests to woodlands (i.e., <60% canopy cover).

Shrubs may vary from a sparse to dense layer of lower-stature woody vegetation. Great laurel (*Rhododendron maximum*) is the most commonly associated shrub. Other frequently associated shrub species are common winterberry (*Ilex verticillata*), mountain laurel (*Kalmia latifolia*), Catawba rhododendron (*Rhododendron catawbiense*), southern mountain cranberry (*Vaccinium erythrocarpum*), minniebush (*Menziesia pilosa*), skunk currant (*Ribes glandulosum*), alderleaf viburnum (*Viburnum lantanoides*), and northern wild raisin (*Viburnum nudum* var. *cassinoides*).

Herbaceous layers are sparse to dense in spruce forests. Ferns are often an important ground cover in upland sites. Common fern associates are mountain woodfern (*Dryopteris campyloptera*), evergreen woodfern (*Dryopteris intermedia*), and fernally clubmosses (*Lycopodium* spp.). A small set of broadleaf herbs and graminoids is common in upland sites, including white woodsorrel (*Oxalis montana*), Canada mayflower (*Maianthemum canadense*), clustered goldenrod (*Solidago glomerata*), Fernald's bladder sedge (*Carex intumescens* var. *fernaldii*), and flattened oatgrass (*Danthonia compressa*). In wetlands, graminoids such as tawny cotton-grass (*Eriophorum virginicum*) and three-seeded sedge (*Carex trisperma* var. *trisperma*) may be characteristic.

Mosses, liverworts, and lichens often grow densely on live tree trunks, fallen logs, and the forest floor, giving these forests a distinctive carpeted appearance. Significant diversity in the red spruce ecosystem is contained within the bryophyte layer. More than 20 species of peatmoss (*Sphagnum* spp.) are associated with red spruce wetland types. Common bazzania liverwort (*Bazzania trilobata*) is typical in both upland and wetland communities of the central Appalachians, while several species of haircap mosses (*Polytrichum* spp.) and stairstep moss (*Hylocomium splendens*) are abundant in both regions.

4.1.1 *Vegetation Patterns*

Among spruce-dominated communities, the distinction between uplands and wetlands is a fundamental division leading to very different floristic and soil characteristics. Upland communities occur in a broad range of exposed and sheltered topographic settings at high elevations. Wetland communities tend to occur in frost pockets and along small headwater streams. They are especially abundant in the central Appalachians where the broad ridgetops of the Allegheny Highlands are dissected into gently sloping headwater basins. Much of the diversity of the red spruce ecosystem in the central Appalachians is found in its wetland plant communities. Spruce wetlands are rare and very limited in extent in the more heavily dissected southern Appalachians, but are an important component of community diversity.

Substrate structure, rock type, and soil type can be important factors differentiating communities. Shallow soils over bedrock and relict talus and periglacial boulder fields each support very different communities from deep soils. Soil chemistry matters as well. Additionally, wetlands with peat soils support unique communities. In the central Appalachians, most upland red spruce communities occur on acidic, nutrient-poor soils that develop on ridgetop-forming sandstone. Limestone or calcareous shale support more nutrient-demanding plant communities, with spruce-fir communities in wetland areas and richer northern hardwood components in upland areas. In the southern Appalachians, spruce and spruce-fir communities occur on a wide variety of soils formed from igneous and metamorphic rocks (see Chap. 3). Most are on highly acidic rocks such as quartzite, granitic gneiss, and felsic schist; no limestone occurs at high elevation in the southern Appalachians. Where examples also occur on amphibolite or calc-silicate, rocks which are associated with distinctive vegetation at lower elevations, the vegetation does not appear to be notably different. In the central Appalachians, most upland red spruce communities occur on Spodosols or soils that show evidence of spodic horizon development. Soils in the southern Appalachians appear to be a heterogeneous mix of primarily Entisols and Inceptisols, along with organic soils on bedrock. Extensive Spodosols have not been reported (see Chap. 3).

While descriptions of plant communities such as the International Vegetation Classification (IVC) generally focus on the best examples of natural vegetation presently available, disturbance history plays a large role in determining the vegetation growing on the landscape today. Anthropogenic disturbances, particularly logging and burning, have resulted in many successional communities such as mixed red spruce – northern hardwood forests and mixed red spruce – pitch pine forests (see Sect. 1.2.3 in Chap. 1). The local invasion of young red spruce into northern hardwood understories on middle-slope positions in the central Appalachians suggests that red spruce associations once occupied, and will in the future occupy, a wider variety of environments in the region (Fleming and Moorhead 1996). In the southern Appalachians, large expanses of spruce-fir forests that were logged and burned still do not support any forest after more than 100 years (see Sect. 1.2.3 in Chap. 1). Logging of swamps and subsequent burning of the peat substrate have left the central Appalachians with large expanses of successional shrubland areas where

red spruce – hemlock – yellow birch swamps once existed. Natural disturbances also play a significant role in determining plant community composition, especially in central Appalachian wetland areas where periodic flooding and beaver activity support cyclic patterns of plant communities.

An interesting aspect of vegetation patterns in the southern Appalachians is the existence of several mountain ranges that extend to elevations that support red spruce in nearby ranges, around 1,680 m (5,510 ft), but which lack any red spruce. Fraser fir is also absent from these ranges, but some other tree, shrub, and herb species primarily found in red spruce forests are sometimes present. The regional climate of these ranges is not apparently different, but all have their highest peaks somewhat lower than the highest peaks in ranges that contain red spruce, generally below 1,800 m (6,000 ft). It is believed that these ranges contained red spruce and possibly Fraser fir forests at the end of the Pleistocene, but that during the warmer, drier Hypsithermal period between the Pleistocene and the present, they were not cool enough to support the species (see Sect. 1.2.2 in Chap. 1). As community zones shifted uphill, red spruce as a species and as a community was “pushed off the top of the mountain” (Schafale 2024). This hypothesis assumes that the dispersal ability of red spruce is limited enough that it has not been able to disperse to these ranges in the thousands of years since that time.

4.1.2 Plant Communities and the International Vegetation Classification

The plant community descriptions in this chapter are based on the IVC, supplemented by studies focused on red spruce communities in West Virginia (Byers et al. 2007, 2010), and the state classification of North Carolina (Schafale 2024), the two states with most of the red spruce ecosystems in the region. The IVC (Jennings et al. 2004; Federal Geographic Data Committee 2008; Faber-Langendoen et al. 2018; NatureServe 2022) is a hierarchical standardized classification of plant communities which is intended to document biodiversity, rank conservation priorities, and provide a structure to detect ecosystem responses to threats such as invasive species, land use changes, and climate change. Individual state Natural Heritage Programs have often produced classifications to address natural community diversity within their jurisdiction, which match the IVC to varying degrees. West Virginia uses the same associations and names as the IVC. North Carolina uses different names but all communities in the red spruce ecosystem have a one-to-one correspondence with associations in the IVC. Both names are used in the description of these communities.

Thirty-two red spruce associations are documented in the IVC, including 20 upland red spruce associations and 12 wetland red spruce associations ranging from southeastern Canada southward to North Carolina and Tennessee. The central and southern Appalachians are home to 11 upland associations and 8 wetland associations. All central and southern Appalachian red spruce associations are at risk

of extinction or elimination due to their restricted range, relatively few occurrences, recent and widespread declines, and threats such as introduced insects, acid deposition, and climate change.

Conservation status ranks for IVC associations have been developed and applied by NatureServe in cooperation with its network members including states, provinces, and tribes. “G” ranks indicate global (range-wide) conservation status and “S” ranks indicate subnational, e.g. state-level, conservation status. Conservation status ranks are defined in Table 4.1.

Table 4.1 NatureServe conservation status ranks for plant communities (NatureServe 2022)

Rank	Definition
GX, SX	Presumed Collapsed—Collapsed throughout its range (GX), or extirpated in the jurisdiction (SX), due to loss of key dominant and characteristic taxa and/or elimination of the sites and ecological processes on which the type depends. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered
GH, SH	Possibly Collapsed—Known from only historical occurrences but still some hope of rediscovery range-wide (GH) or from the jurisdiction (SH). The association has been searched for unsuccessfully, but not enough to state with certainty that it is not present
G1, S1	Critically Imperiled—At very high risk of collapse (G1) or extirpation in the jurisdiction (S1) due to very restricted range, very few occurrences, very steep declines, very severe threats, or other factors
G2, S2	Imperiled—At high risk of collapse (G2) or extirpation in the jurisdiction (S2) due to restricted range, few occurrences, steep declines, severe threats, or other factors
G3, S3	Vulnerable—At moderate risk of collapse (G3) or extirpation in the jurisdiction (S3) due to a fairly restricted range, relatively few occurrences, recent and widespread declines, threats, or other factors
G4, S4	Apparently Secure—At fairly low risk of collapse (G4) or extirpation in the jurisdiction (S4) due to an extensive range and/or many occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors
G5, S5	Secure—At very low or no risk of collapse (G5) or extirpation in the jurisdiction (S5) due to a very extensive range, abundant occurrences, and little to no concern from declines or threats
GNR, SNR	Unranked—Global or subnational rank not yet assessed
G#G#, S#S#	Range Rank—A numeric range rank (e.g., G1G2, S2S3). A question mark (?) is used to indicate uncertainty about the exact status of an association

4.2 Central Appalachians

Four upland red spruce forest associations and one upland woodland association occur in the central Appalachians. All five of the associations have high global and state conservation priority.

4.2.1 Upland Red Spruce Communities

Upland red spruce forests and woodlands occupy the highest, coolest, and wettest environments in the central Appalachians, topping the ridges and knobs of the Allegheny Mountains at elevations above 1,000 m (3,300 ft) and two knobs on North Fork Mountain in the Ridge and Valley above 1,190 m (3,900 ft). The Red Spruce/Southern Mountain Cranberry Forest association is found in the highest and wettest topographic positions, while the Red Spruce/Heath Rocky Woodland association may be just as high in elevation but is restricted to drier summits along the Allegheny Front. Throughout the middle and upper elevations, Red Spruce–Yellow Birch Forest is the most common association. The Red Spruce/Rhododendron Forest association is generally found in sheltered locations at middle and lower elevations within the red spruce zone. At lower elevations and grading into northern hardwood forests, the Red Spruce – Hemlock – Beech Forest association may extend to elevations as low as 875 m (2,870 ft). In the central Appalachians, red spruce forest and woodland associations are characterized by relatively gentle slopes and less disturbed landscapes, as compared to other forest associations.

Upland red spruce habitats are characterized by a short growing season, low temperatures, high precipitation, high relative humidity, and low evapotranspiration rates. Solar radiation is high. The coldest temperatures and highest precipitation are found in the high elevation Red Spruce/Southern Mountain Cranberry Forest association. The warmest temperatures are experienced by the lower elevation Red Spruce – Hemlock – Beech Forest association. Temperature extremes, including frost and summer heat, are greatest in the Red Spruce/Heath Rocky Woodland association that occurs on the exposed summits of the Allegheny Front.

Dominant species in upland red spruce communities are red spruce, yellow birch, and common bazzania liverwort. Other important species are red maple, eastern hemlock, mountain holly (*Ilex montana*), great laurel, southern mountain cranberry, evergreen woodfern, pellucid plait moss (*Hypnum imponens*), and common broom moss (*Dicranum scoparium*).

The flora of central Appalachian upland red spruce communities is characterized by a generally northern affiliation. A few of the species whose largest distributions occur to the north include the foundation species red spruce as well as white woodsorrel, painted trillium (*Trillidium undulatum*), and late lowbush blueberry (*Vaccinium angustifolium*). Mixed with the northern-affiliated species, and giving a unique character to the ecosystem, are several characteristic central and southern

Appalachian species such as Blue Ridge St. Johns-wort (*Hypericum mitchellianum*), minniebush, and southern mountain cranberry. One hundred sixty-six vascular plant species, 45 bryophyte species, and 105 fungi have been documented within upland red spruce vegetation plots in West Virginia (Byers et al. 2010).

Myxomycetes, or slime molds, have been documented in the red spruce ecosystem in West Virginia by Steven L. Stephenson (Appendix D in Byers et al. 2010). He noted that five species are possibly restricted to spruce and spruce-fir forests. One of these, *Diderma simplex*, is also a rare species. *Colloderma oculatum* and *Diderma roanense* are occasional, and *Barbeyella minutissima* and *Lepidoderma tigrinum* are abundant.

4.2.1.1 Red Spruce – Yellow Birch Forest

Association CEGLO08501. *Picea rubens*/*Betula alleghaniensis*/*Bazzania trilobata* forest (Fig. 4.1). NatureServe Conservation Status: G2; VA: S1, WV: S2.

This is the typical forest encountered in the heart of red spruce habitat in the central Appalachians, with widespread distribution in the middle and upper elevations (1,070–1,400 m [3,500–4,600 ft]) of the red spruce zone in West Virginia. The community occurs on both gentle slopes bordering high-elevation valley floors and on more exposed ridge crests and rocky summits. The canopy typically has strong



Fig. 4.1 Example of the Red Spruce – Yellow Birch association. Photo by Elizabeth Byers

dominance by red spruce, with yellow birch next in importance. Shrub cover is sparse to moderate, herbs are sparse, and the forest floor often has high cover by bryophytes. In West Virginia, two common floristic variants of this community occur. In one variant, shrubs and herbs are almost entirely absent, and the dense canopy shades a luxuriant green carpet of the common bazzania liverwort. Another variant is characterized by post-fire increases in the shrub mountain laurel, which locally dominates the shrub layer. The local invasion of young red spruce into northern hardwood understories on middle-slope positions suggests that this association once occupied, or will in the future occupy, a wider variety of environments in the region (Fleming and Moorhead 1996).

This community is geographically and environmentally restricted, occurring primarily in the Allegheny Mountains of West Virginia (Greenbrier, Pendleton, Pocahontas, Randolph, and Tucker counties) and at two sites in the Ridge and Valley region of Pendleton County. It also occurs in scattered stands in Virginia (Highland and Rockingham counties; Stevens 1969) in the Alleghenies and adjacent Ridge and Valley region. Its former extent has been reduced by logging and subsequent fires (Allard and Leonard 1952; Clarkson 1964; Pielke 1981; Stephenson and Clovis 1983). This type has good short-term viability, healthy regeneration, and protected status of many stands, but is restricted to the highest elevations of the central Appalachians and only occupies a small portion of its former range.

Within the narrowly defined ecology of the red spruce zone in the central Appalachians, this community has a relatively broad ecological amplitude and a central position, and as a result it has no indicator species that differentiate it from other upland red spruce communities. Instead, the other four upland red spruce communities differentiate themselves from this community through their diagnostic species, which reflect their own particular niches along environmental gradients within the red spruce zone.

The canopy is strongly dominated by red spruce, with lower cover of yellow birch and red maple. Other trees that occasionally occur with low cover in the canopy include eastern hemlock, sweet birch (*Betula lenta*), striped maple (*Acer pensylvanicum*), eastern white pine (*Pinus strobus*), American mountain-ash (*Sorbus americana*), Allegheny serviceberry (*Amelanchier laevis*), and northern red oak (*Quercus rubra*). The subcanopy is very similar in dominance and composition to the canopy, with the occasional addition of Fraser magnolia, mountain maple (*Acer spicatum*), downy serviceberry (*Amelanchier arborea* var. *arborea*), and American beech.

The tall shrub stratum is strongly dominated by saplings of the regenerating canopy species, especially red spruce and yellow birch. Mountain holly, mountain laurel, and great laurel occur frequently in the tall shrub layer. Rarely, a small amount of American witch-hazel (*Hamamelis virginiana*), minniebush, or catberry (*Nemopanthus mucronatus*) may be present. The short shrub stratum is also dominated by regenerating canopy species, with mountain holly, southern mountain cranberry, mountain laurel, and great laurel present. Occasionally very low cover of minniebush, northern lowbush blueberry, velvetleaf blueberry (*Vaccinium myrtilloides*), black huckleberry (*Gaylussacia baccata*), common greenbrier (*Smilax rotundifolia*), and alderleaf viburnum may be present.

The herbaceous stratum often includes evergreen woodfern, white woodsorrel, and eastern hay-scented fern (*Dennstaedtia punctilobula*). Less common are painted trillium, Canada mayflower, mountain woodfern, tree clubmoss (*Lycopodium obscurum*), ghost pipe (*Monotropa uniflora*), white-edge sedge (*Carex debilis* var. *rudgei*), partridge-berry (*Mitchella repens*), and whorled aster (*Oclemena acuminata*). The non-vascular stratum is strongly dominated by common bazzania liverwort, with lesser amounts of pellucid plait moss, common broom moss, eastern haircap moss (*Polytrichum pallidisetum*), recurved brotherella moss (*Brotherella recurvans*), and white pincushion moss (*Leucobryum glaucum*).

Sites range from mesic to submesic and are characterized by the climatic conditions common to all red spruce types in the central Appalachians, including cold winter microclimates, low mean annual temperature, short growing seasons, frequent fog, and high annual precipitation, high relative humidity, and low evapotranspiration rates. Soils are typical of the red spruce zone, characterized as acidic, infertile, frigid silt or sandy loams, with thick surficial duff accumulations. Soils typically have high organic matter, high cation-exchange capacity, high exchangeable nitrogen, and generally lacking in micronutrients. Pennsylvanian sandstones of the Pottsville Group underlie this community at almost all sites, although outliers occur on older sandstone ridges to the east. See Chap. 3 for more details on soils supporting red spruce.

4.2.1.2 Red Spruce/Southern Mountain Cranberry Forest

Association CEG007131. *Picea rubens* – (*Abies fraseri*)/*Vaccinium erythrocarpum*/Dryopteris campyloptera/Hylocomium splendens forest (Fig. 4.2). Nature-Serve Conservation Status: G2; NC: S2, TN: SNR, VA: S1, WV: S1.

This community occurs primarily in the southern Appalachians, but disjunct occurrences are present in the central Appalachians. There it is restricted to the very highest elevations and coolest climate niche within the red spruce zone in West Virginia, occurring primarily on ridgetops at elevations above 1,350 m (4,400 ft) with one at lower elevation occurrence (1,140 m [3,740 ft]) in a cold stream bottom. Extensive logging and fires significantly reduced the extent of this community type during the early part of the twentieth century. Well-developed, undisturbed examples of this community are extremely rare in the central Appalachians.

This community is characterized by a dense canopy of red spruce and much lower cover of yellow birch and red maple. Although Fraser fir is included parenthetically in the global name, and is abundant in Southern Appalachian examples, this species is not native to the central Appalachians and does not occur in stands of this association in West Virginia. Black cherry and American mountain-ash are occasionally present in the canopy. The subcanopy is much less dense, with yellow birch, red spruce, and red maple as co-dominants, and occasional low cover by American mountain-ash or American beech. The understory consists of sparse to dense southern mountain cranberry, on a luxuriant carpet of liverworts and mosses. Dominant species, with high constancy and cover, include red spruce, yellow birch, southern mountain



Fig. 4.2 Example of the Red Spruce/Southern Mountain Cranberry Forest association. Photo by Elizabeth Byers

cranberry, common bazzania liverwort, and pellucid plait moss. Diagnostic species include southern mountain cranberry, mountain holly, mountain woodfern, Clinton lily (*Clintonia borealis*), and painted trillium.

The shrub strata are dominated by southern mountain cranberry, which generally grows as a short shrub but can reach heights of more than 2 m (6.6 ft) where growing conditions are favorable. The tall shrub layer may also include mountain holly, striped maple, and regenerating canopy saplings. Occasionally, minniebush, great laurel, early azalea (*Rhododendron prinophyllum*), and alderleaf viburnum may be present in the tall shrub stratum. The short shrub stratum has a species distribution very similar to the tall shrub layer, including occasional trace amounts of late lowbush blueberry.

The herbaceous layer is sparse and includes evergreen woodfern, mountain woodfern, Canada mayflower, white woodsorrel, Clinton lily, and painted trillium. Less common herbaceous species include eastern hay-scented fern, treelike clubmoss (*Lycopodium dendroideum*), Appalachian rockcap fern (*Polypodium appalachianum*), running clubmoss (*Lycopodium clavatum*), tree clubmoss, whorled aster, and cinnamon fern (*Osmunda cinnamomea* var. *cinnamomea*).

Bryophytes and lichens make up a considerable percent of the vegetative coverage in this community, occurring on the surface of the soil, trees, and fallen logs.

Bryophyte cover is high in this forest type, with common bazzania liverwort dominant, followed by pellucid plait moss, common broom moss, and recurved broth-erella moss. Other common bryophytes include white pincushion moss, eastern haircap moss, and beaked bow moss (*Dicranodontium denudatum*). The many-forked cladonia lichen (*Cladonia furcata*) is common on the ground, and fruticose or foliose lichens are common on tree trunks.

Soils are typical of the red spruce zone, with high organic matter and nitrogen, low pH, and generally low in micronutrients. Pennsylvanian sandstones of the Pottsville Group, often forming a resistant caprock on the ridges, underlie this community at most sites. The expression of this community farther south is described in Sect. 4.3.1.3.

4.2.1.3 Red Spruce – (Eastern Hemlock)/Great Laurel Forest

Association Cegl006152. *Picea rubens* – (*Tsuga canadensis*)/*Rhododendron maximum* forest (Fig. 4.3). NatureServe Conservation Status: G2G3; NC: S1, TN: SNR, WV: S2.

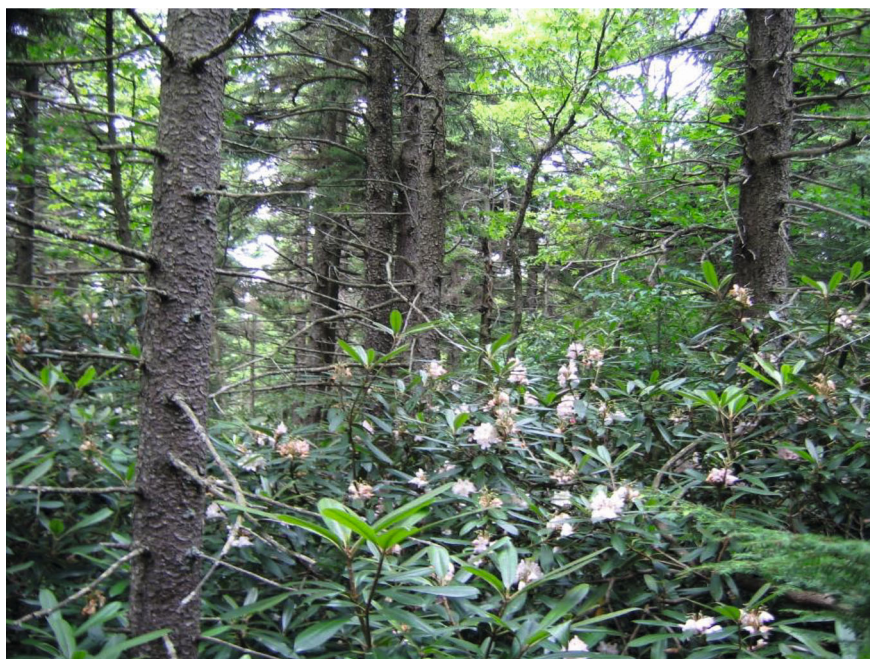


Fig. 4.3 Example of the Red Spruce – (Eastern Hemlock)/Great Laurel Forest association. Photo by James Vanderhorst

This association occurs in both the central and southern Appalachians. In the central Appalachians of West Virginia, it is environmentally restricted within a somewhat limited geographic range. Its former extent was probably limited to moist, sheltered areas in the lower elevation range of red spruce, and has been reduced by logging and subsequent fires (Allard and Leonard 1952; Clarkson 1964; Pielke 1981; Stephenson and Clovis 1983).

This species-poor forest type occurs primarily at low and middle elevations within the central Appalachian red spruce zone. It generally grows on moist, protected land-forms and can include slope forests, boulder fields, ravines, and occasional ridges. This community has the lowest species richness of the central Appalachian red spruce forest types. It has the highest cover of tall shrubs, almost exclusively great laurel, and the lowest cover of herbaceous species.

The canopy layer is dominated by red spruce with lower cover by eastern hemlock, red maple, and yellow birch. Occasionally, sweet birch and downy serviceberry are also present in the canopy. The subcanopy is dominated by yellow birch and red spruce, with lower cover of eastern hemlock and red maple. Other subcanopy trees may include American mountain-ash, downy serviceberry, sweet birch, and Fraser magnolia.

The tall shrub layer is dense and strongly dominated by great laurel. Low cover of mountain holly and various tree seedlings may intermix, and occasionally a few shrubs of mountain laurel occur. The short shrub layer is much less dense but has the same dominance and species distribution as the tall shrubs. Occasional low cover of southern mountain cranberry, minniebush, and late lowbush blueberry may occur in the short shrub stratum.

The herbaceous layer is extremely sparse, with evergreen woodfern, mountain woodfern, whorled aster, white woodsorrel, and Appalachian rockcap fern. The bryophyte layer is strongly dominated by common bazzania liverwort, with much lower cover of pellucid plait moss, white pincushion moss, recurved brotherella moss, and common broom moss.

Soils are typical of the red spruce zone, with high organic matter and nitrogen, low pH, and generally low micronutrients. Pennsylvanian sandstones of the Pottsville Group underlie this community at most sites, with rare extensions onto the adjacent Mississippian Mauch Chunk shale. The expression of this community farther south is described in Sect. 4.3.1.8.

4.2.1.4 Red Spruce – Hemlock – Beech Forest

Association CEG006029. *Picea rubens* – *Tsuga canadensis* – *Fagus grandifolia* / *Dryopteris intermedia* forest (Fig. 4.4). NatureServe Conservation Status: G3; WV: S3. This association is also described in the Spodic Shale Upland Conifer Forest Ecological Site Description discussed in Chap. 3.

This community occurs in the Allegheny Mountain region of West Virginia, at elevations above 850 m (2,800 ft). Small additional stands may occur in the Allegheny



Fig. 4.4 Example of the Red Spruce – Hemlock – Beech Forest association. Photo by James Vanderhorst

Mountain region of Maryland and possibly in Pennsylvania. This forest type occupies relatively warmer, lower elevations within the red spruce zone in the central Appalachians. At the lower elevation margin of this community type, the forest grades into adjacent northern hardwoods forest, with a steadily decreasing spruce component. The Red Spruce – Hemlock – Beech forest association is characterized by a mixed canopy of red spruce, eastern hemlock, and deciduous trees, with a dense subcanopy, generally sparse shrub layer, and relatively diverse, fern-dominated herb layer. A less common variant of this association extends into the middle and upper elevations of the spruce zone along slightly richer substrates underlain by shale and limestone. Floristically, the richer variant has less hemlock but is otherwise quite similar to the lower elevation community. The similarities are probably due to a slight amelioration of environmental stresses at lower elevations and/or on richer substrates, which allows other species to compete successfully with red spruce.

Diagnostic species include American beech, eastern hemlock, black cherry, sugar maple (*Acer saccharum* var. *saccharum*), sweet birch, Fraser magnolia, striped maple, common greenbrier, evergreen woodfern, Canada mayflower, white wood-sorrel, and partridge-berry. Species richness is relatively high for the red spruce system, with the highest values on shale and limestone substrates.

The canopy is dominated by red spruce with eastern hemlock, yellow birch, and red maple. Less common are American beech, black cherry, and sweet birch, and

occasional canopy species include sugar maple, Fraser magnolia, tuliptree (*Liriodendron tulipifera*), and cucumber magnolia (*Magnolia acuminata*). The subcanopy is relatively lush and exhibits co-dominance by several species, including red spruce, yellow birch, eastern hemlock, striped maple, red maple, American beech, and sugar maple. Less common subcanopy species include cucumber magnolia, sweet birch, Fraser magnolia, black cherry, hawthorn (*Crataegus* spp.), Allegheny serviceberry, white ash (*Fraxinus americana*), and American basswood (*Tilia americana*).

The shrub layers are relatively sparse in this community compared to other upland spruce communities. The tall shrub layer is dominated by regenerating tree saplings, especially red spruce, American beech, eastern hemlock, and striped maple. Shrubs that are occasionally present include mountain holly, great laurel, mountain laurel, and alderleaf viburnum. The short shrub layer is sparse and consists largely of regenerating tree species, with occasional presence of southern mountain cranberry, mountain holly, common greenbrier, mountain laurel, and minniebush.

This community has the richest herbaceous layer of any of the upland spruce communities in West Virginia and is strongly dominated by evergreen woodfern. Other common species include Canada mayflower, white woodsorrel, partridgeberry, eastern hay-scented fern, painted trillium, Indian cucumber-root (*Medeola virginiana*), whorled aster, mountain woodfern, nightcaps (*Anemone quinquefolia*), treelike clubmoss, jack-in-the-pulpit (*Arisaema triphyllum*), white-edge sedge, flattened oatgrass, sweet-scented bedstraw (*Galium triflorum*), shining clubmoss (*Huperzia lucidula*), running clubmoss, tree clubmoss, roundleaf orchid (*Platanthera orbiculata*), Appalachian rockcap fern, and heartleaf foamflower (*Tiarella cordifolia*). The non-vascular stratum has the lowest bryophyte cover among upland red spruce communities in West Virginia. Common bazzania liverwort and pellucid plait moss are the dominant species, followed by common broom moss, delicate fern moss (*Thuidium delicatulum*), recurved brotherella moss, and beaked bow moss.

Soils are typical of the red spruce zone, with high organic matter and nitrogen, low pH, and generally low micronutrients. This community has high concentrations of the macronutrient sulfur and the micronutrient iron. A variety of geologic formations underlie this community type, including Pennsylvanian Pottsville sandstone, Mississippian Mauch Chunk shale and Greenbrier limestone, Devonian Hampshire shale, and Silurian Tuscarora sandstone.

4.2.1.5 Red Spruce/Heath Rocky Woodland

Association CEGLO06254. *Picea rubens*/*Kalmia latifolia* – *Menziesia pilosa* woodland (Fig. 4.5). NatureServe Conservation Status: G2; WV: S1.

This community is a West Virginia endemic occupying about 5 km² (1.9 mi²) and restricted to a 50 km (31 mi) linear band along the Allegheny Front with a small outlier on Panther Knob in the Ridge and Valley region. This association has a limited habitat on exposed acidic bedrock and talus, within the restricted cool, moist climate of the red spruce zone. It is more threatened than other spruce communities not only because of its limited acreage but because of unique threats such as vacation home



Fig. 4.5 Example of the Red Spruce/Heath Rocky Woodland association. Photo by Elizabeth Byers

development on these highly scenic rocky ridgetops, industrial wind development along the Allegheny Front, and strip mining.

This red spruce rocky woodland occupies high elevations in the drier northeastern part of the red spruce range in West Virginia and is characterized by a stunted, open canopy of red spruce, with abundant heath shrubs and lichens. Large seasonal temperature variations characterize this habitat. In some areas, this community has been impacted by fire (for blueberry production) in the period following European settlement, and Native Americans may also have practiced burning in this community. Fire is likely to convert this community to the more common Blueberry Heath Barren (CEGL003958). Following the extensive logging and slash fires of 1885–1920, this community expanded to cover previously forested areas along the Allegheny Front. Soils are slowly accumulating again in the absence of widespread fires, with both in-situ organic matter deposition and windblown soil deposits as likely mechanisms. In more sheltered areas this community is following a slow successional pathway back to red spruce forest. However, the core of this red spruce community is maintained naturally by acidic bedrock outcrops and their shallow, infertile, and sometimes waterlogged soils.

Dominant species, with high constancy and cover, include red spruce and mountain laurel. Diagnostic species include mountain laurel, pitch pine, Allegheny serviceberry, catberry, late lowbush blueberry, minniebush, black huckleberry, black chokeberry (*Aronia melanocarpa*), Appalachian gooseberry (*Ribes rotundifolium*),

fire cherry (*Prunus pensylvanica* var. *pensylvanica*), eastern teaberry (*Gaultheria procumbens*), bracken fern (*Pteridium aquilinum*), Appalachian rockcap fern, grey reindeer lichen (*Cladonia rangiferina*), and lesser rocktripe lichen (*Umbilicaria muehlenbergii*). Species richness in this type is the highest within the upland red spruce forest and woodland types with most of the diversity in the shrub strata.

This upland spruce type has a low, stunted, open woodland canopy strongly dominated by red spruce, with much lower cover of pitch pine, red maple, yellow birch, Allegheny serviceberry, American mountain-ash, and eastern hemlock. The tall shrub layer is dominated by mountain laurel with catberry, great laurel, and regenerating tree saplings. The short shrub layer is diverse and often includes late lowbush blueberry, minniebush, black huckleberry, catberry, black chokeberry, great laurel, and southern mountain cranberry. Occasional shrubs include Appalachian gooseberry, fire cherry, eastern teaberry, skunk currant, velvetleaf blueberry, mountain holly, striped maple, mountain maple, American witch-hazel, early azalea, and northern wild raisin.

The herbaceous layer is sparse and usually dominated by Canada mayflower, bracken fern, and Appalachian rockcap fern. Additional herbaceous species may include crinkled hairgrass (*Deschampsia flexuosa* var. *flexuosa*), wild sarsaparilla (*Aralia nudicaulis*), trailing arbutus (*Epigaea repens*), and brownish sedge (*Carex brunnescens*). The non-vascular stratum has significant diversity, much of which occurs as abundant crustose lichens on the rocky substrate. Nonvascular cover often includes grey reindeer lichen, lesser rocktripe lichen, pellucid plait moss, white pincushion moss, red-stemmed feather moss (*Pleurozium schreberi*) and common toadskin lichen (*Lasallia papulosa*), in addition to crustose lichens.

Soil is sparse in this rocky woodland, generally occurring in cracks and pore spaces between rocks. Some of the soil may be residual, sheltered from major fires in the last century. Soil chemistry characteristics include the highest values for organic matter within the red spruce zone. The macronutrients potassium and magnesium and the micronutrient manganese are high compared to other upland spruce communities, although they are low compared to other forest soils in West Virginia. Sulphur and iron are very low. Pennsylvanian sandstones of the Pottsville Group underlie this community.

4.2.2 Wetland Red Spruce Communities

Wetland red spruce communities in the central Appalachians are embedded in matrix upland forest systems, except where the land is kept open by human actions. Often, they occur adjacent to or in mosaics with other high elevation wetland types (Byers et al. 2007). Red spruce wetlands occur primarily in flat-lying headwater basins, ranging in size from <1 ha (2.5 ac) to about 3,000 ha (7,400 ac) of contiguous wetland in Canaan Valley. The flat-lying basins where many wetlands occur function as frost pockets, catching and pooling cold air that drains from the surrounding uplands. The wetlands are drained by low-gradient, meandering, small headwater

streams. Drainage is impounded in these high, flat-lying basins by natural dams of resistant sandstone. Rainfall is plentiful, averaging about 1,300 mm/year (51 in/year). Communities in this system may have substrates of shallow to deep peat or, less commonly, mineral soil. Soils are acidic to circumneutral (i.e., nearly neutral, pH of 6.5 to 7.5).

Forested swamps occupy the less disturbed margins or slightly higher areas in open wetlands. Ombrotrophic bogs are rare but occur in undisturbed portions of a few of the larger wetlands. The more central, flood- or beaver-influenced portions contain shrub swamps, sedge fens, wet meadows, and open marshes. Undisturbed examples exist (e.g., Cranberry Glades), where old-growth swamp buffers the central peatlands, which have been dated to 10,000 years old (Darlington 1943). In pre-settlement time, some wetland mosaics in this system had significant forested components (e.g., Canaan Valley and Cranesville Swamp in West Virginia, Finzel Swamp and Hammel Glades in Maryland), while others (e.g., Cranberry Glades, Big Run Bog) were largely open peatlands with forested swamp only on the margins.

4.2.2.1 Red Spruce – Yellow Birch/Mannagrass Swamp

Association CEG006556. *Picea rubens* – *Acer rubrum*/*Ilex verticillata* swamp forest (Fig. 4.6). NatureServe Conservation Status: G3; PA: S3, VA: S1, WV: S1.

This mixed woodland or forested swamp occurs on saturated and temporarily to semi-permanently flooded soils of the Allegheny Mountains region of West Virginia, at elevations between 770 and 1,220 m (2,500 and 4,000 ft). It also occurs in extreme west-central Virginia (Highland County), and outliers are reported from the Pocono Plateau and Ridge and Valley provinces of Pennsylvania (Fike 1999). In West Virginia, it is a small-patch type that occupies flat to very gently sloping land (0–2° slopes) in floodplains of streams and on the margins between upland forest and open wetland. When this community occurs in a floodplain setting, it often is characterized by fluvial morphological features such as backwater sloughs, levees, and meander scrolls. Microtopography is characterized by irregular moss-covered hummocks formed over buttressed tree roots, woody stem clusters, tip-up mounds, nurse logs, and decaying wood. Soils are poorly drained muck, peat, or silt/clay loam, with an average pH of 4.2.

The community is characterized by an open to closed canopy of red spruce, eastern hemlock, and yellow birch, with occasional additions of red maple, black ash (*Fraxinus nigra*), balsam fir, eastern white pine, or blackgum (*Nyssa sylvatica*). The subcanopy is similar in composition to the canopy. The tall-shrub layer is characterized by speckled alder, great laurel, the regenerating canopy species, and occasionally common winterberry. The short-shrub layer is sparse with species composition similar to the tall-shrub layer. The herbaceous layer is diverse and variable, including slender mannagrass (*Glyceria melicaria*), orange jewelweed (*Impatiens capensis*), cinnamon fern, American golden-saxifrage (*Chrysosplenium americanum*), arrowleaf tearthumb, rice cutgrass, white turtlehead (*Chelone glabra*),



Fig. 4.6 Example of the Red Spruce – Yellow Birch/Mannagrass Swamp community. Photo by Elizabeth Byers

skunk-cabbage, Canada mayflower, marsh-marigold (*Caltha palustris* var. *palustris*), sensitive fern (*Onoclea sensibilis*), and bristly-stalked sedge (*Carex leptalea* ssp. *leptalea*). Bryophytes are abundant and diverse, dominated by peatmosses (*Sphagnum palustre*, *Sphagnum fallax*, *Sphagnum squarrosum*, *Sphagnum divinum*, and *Sphagnum girgensohnii*) filling the mucky hollows, Appalachian leafy moss (*Rhizomnium appalachianum*) in the seepy areas, and pellucid plait moss and common broom moss blanketing the woody hummocks.

4.2.2.2 Red Spruce – Hemlock/Great Laurel Swamp Forest

Association Cegl006277. *Picea rubens* – (*Tsuga canadensis*)/*Rhododendron maximum* swamp forest (Fig. 4.7). NatureServe Conservation Status: G2?; MD: SNR, NC: S1, NY: S1, PA: S1, TN: SH, VA: S1, WV: S2.

This red spruce wetland forest occurs in small patches in the central and southern Appalachian Mountains north to the high Allegheny Plateau of New York and Pennsylvania. In the central Appalachians, this acidic conifer swamp occurs on saturated, temporarily flooded, and semi-permanently flooded soils in headwater basins of the Allegheny Mountains region of West Virginia and Maryland, at elevations from 770 to 1,150 m (2,500–3,800 ft). It occupies flat to very gently sloping land (0–1° slopes)



Fig. 4.7 Example of the Red Spruce – Hemlock/Great Laurel Swamp Forest community. Photo by Brian Streets

along small streams, often in mixed wetland mosaics. It is a small-patch type which forms islands in open shrublands or peatlands, and occurs in backswamp locations, separated from the adjacent stream by a levee. It is also found along the margins of beaver-influenced wetlands. Microtopography is characterized by interfingering of wetter and drier areas, with irregular mossy hummocks formed over tree roots, tip-up mounds, nurse logs, and decaying wood. Tree roots are often buttressed and may form thick “root rafts” on top of mucky soils. Hollows are typically filled with standing water or muck. Anthropogenic disturbance includes historical logging and fires around 1900 and occasionally more recent logging. Soils are poorly drained muck, peat, or organic-rich silt loam, with an average pH of 3.8.

This evergreen swamp is characterized by an open to closed canopy of inundation-stressed trees and a dense great laurel shrub layer over a sparse herbaceous layer and abundant bryophytes. The canopy is dominated by red spruce and eastern hemlock with lower cover of red maple and yellow birch, and occasional presence of blackgum, American larch (*Larix laricina*), or eastern white pine. The subcanopy is dominated by eastern hemlock with yellow birch, red maple, and red spruce. Species that may be present with low cover in the subcanopy include white ash, sweet birch, blackgum, cucumber magnolia, Allegheny serviceberry, northern spicebush (*Lindera benzoin*), tuliptree, and American mountain-ash. The tall shrub layer is dominated by great laurel. Other commonly occurring species in the tall-shrub layer include

common winterberry, eastern hemlock, red spruce, and American mountain-ash. Low cover of catberry and mountain laurel may be present. The short shrub layer species composition is similar to that of the tall-shrub stratum, with the occasional addition of northern wild raisin. The herbaceous ground layer is sparse and variable and often includes three-seeded sedge, cinnamon fern, red maple, skunk-cabbage, eastern hayscented fern, slender mannagrass, and partridge-berry. Nonvascular plants are dominated by peatmosses (*Sphagnum palustre*, *Sphagnum fallax*, *Sphagnum girgensohnii*, *Sphagnum recurvum*, *Sphagnum divinum* and *Sphagnum papillosum*), common bazzania liverwort, and pellucid plait moss.

4.2.2.3 Balsam Fir/Oatgrass Swamp

Association Cegl006592. *Abies balsamea* – *Picea rubens*/*Danthonia compressa* – *Lycopodium* spp./*Sphagnum* spp. swamp forest (Fig. 4.8). NatureServe Conservation Status: G2; WV: S2.

This acidic conifer woodland or forested swamp occurs on moist to saturated soils in headwater basins in the Allegheny Mountains region of West Virginia, at elevations from 960–1,130 m (3,150–3,700 ft). It is a small-patch community fed by slow seepage and rainfall. It occupies gently sloping land (1–10° slopes) along small headwater streams and in mixed wetland mosaics, often at the base of upland



Fig. 4.8 Example of the Balsam Fir/Oatgrass Swamp community. Photo by James Vanderhorst

slopes. Microtopography is characterized by irregular hummocks formed over tree roots, tip-up mounds, nurse logs, and decaying wood. Soils are moderately to poorly drained loamy soils with mottling in the upper 20 cm (8 in) and occasional gleyed horizons.

The canopy is open to closed and dominated by balsam fir and red spruce, with occasional presence of black cherry. Older balsam fir trees are stressed by the balsam woolly adelgid (*Adelges piceae*). The subcanopy is dominated by balsam fir with smaller amounts of red spruce, red maple, and yellow birch. The tall-shrub layer is also dominated by balsam fir and red spruce. The short-shrub layer contains regenerating canopy species and locally abundant velvetleaf blueberry and bushy St. John's-wort. The herbaceous ground layer is fairly diverse, typically including 25–50 species. The most abundant species are flattened oatgrass, tree clubmoss, and bristly dewberry. Other herbaceous species with high constancy include the regenerating canopy species, running clubmoss, long sedge (*Carex folliculata*), eastern hay-scented fern, bracken fern, and whorled aster. Nonvascular plants are dominated by peatmoss species and haircap moss species; white pincushion moss is also common. The community is characterized by a number of diagnostic species that highlight the slightly drier habitat of this swamp type, including white-edge sedge, hawthorn, running clubmoss, fan clubmoss (*Lycopodium digitatum*), partridge-berry, haircap mosses, black cherry, and bracken fern.

4.2.2.4 Balsam Fir/Winterberry Swamp

Association CEGLO06591. *Abies balsamea* – *Picea rubens*/*Ilex verticillata*/*Sphagnum* spp. swamp forest (Fig. 4.9). NatureServe Conservation Status: G2; WV: S1.

This acidic conifer woodland swamp occurs on temporarily to semi-permanently flooded soils in frost-pocket headwater basins in the Allegheny Mountains region of West Virginia, at elevations from 980–1,120 m (3,200–3,600 ft). It is a small-patch community fed by seepage, occasional overflow from low-gradient headwater streams, and rainfall. It occupies flat to very gently sloping land (0–3° slopes) along small headwater streams, often in mixed wetland mosaics. The microtopography is characterized by interfingering of wetter and drier areas, with irregular hummocks formed over tree roots, tip-up mounds, nurse logs, and decaying wood. Beaver activity periodically causes inundation stress that kills trees in this community, and there is evidence of migration of balsam fir populations, possibly in response to fluctuating hydrology. Older balsam fir trees are also stressed by the balsam woolly adelgid. Soils are poorly to very poorly drained clayey or mucky soils with mottling in the upper 20 cm (8 in) and occasional gleyed horizons.

The canopy is open and dominated by stunted, inundation-stressed balsam fir and red spruce, with occasional presence of yellow birch and red maple. The subcanopy is dominated by balsam fir and eastern hemlock, with smaller amounts of red spruce and red maple. Serviceberry species may be present with very low cover in the subcanopy. The shrub layer is dominated by common winterberry, the regenerating



Fig. 4.9 Example of the Balsam Fir/Winterberry Swamp community. Photo by Leah Ceperley

canopy species, and speckled alder. Low cover of great laurel, bushy St. John's-wort, and velveteal blueberry may be present. The herbaceous ground layer is dense and diverse, typically including 30–40 species. The most abundant species are nodding sedge, long sedge, and bristly dewberry. Other herbaceous species with high constancy include regenerating woody species and arrowleaf tearthumb, cinnamon fern, stiff marsh bedstraw, crested shieldfern (*Dryopteris cristata*), three-seeded sedge, orange jewelweed, marsh blue violet (*Viola cucullata*), Fraser's marsh-St. John's-wort (*Triadenum fraseri*), soft rush, awl-fruit sedge, fowl mannagrass (*Glyceria striata*), dotted smartweed (*Polygonum punctatum*), American manna-grass (*Glyceria grandis* var. *grandis*), white woodsorrel, evergreen woodfern, and Canada mayflower. Nonvascular plants are dominated by peatmosses. Indicator species include hoary sedge (*Carex canescens*), long sedge, nodding sedge, American mannagrass, and Fraser's marsh-St. John's-wort.

4.2.2.5 Balsam Fir – Black Ash Swamp

Association CEG006003. *Fraxinus nigra* – *Abies balsamea*/*Rhamnus alnifolia* swamp forest (Fig. 4.10). NatureServe Conservation Status: G1; PA: S1, WV: S1.

This community is a lush, circumneutral, seepage-fed, mixed woodland or forested swamp of the Allegheny Mountains in West Virginia. It is a late-successional, small-patch community limited to frost-pocket wetlands on the Mississippian Greenbrier



Fig. 4.10 Example of the Balsam Fir – Black Ash Swamp community. Photo by Elizabeth Byers

limestone, at elevations from 960 to 1,000 m (3,150–3,200 ft). The community occurs in flat headwater basins and backswamps along small streams. Microtopography is characterized by irregular hummocks formed over buttressed tree roots, tip-up mounds, nurse logs, and decaying wood. Soils are poorly drained muck or organic-rich silt loam over mottled or gleyed silty clay.

This rich swamp provides habitat for several rare shade-tolerant calciphile wetland species. The canopy is open to closed and dominated by stunted, inundation-stressed balsam fir, black ash, and eastern hemlock. Black ash is rapidly being lost from this community due to the emerald ash borer (*Agrilus planipennis*). Eastern hemlock and balsam fir are stressed by the hemlock woolly adelgid (*Adelges tsugae*) and balsam woolly adelgid, respectively. The subcanopy is dominated by balsam fir with varying amounts of yellow birch, eastern hemlock, red spruce, and black ash. The tall-shrub layer is dominated by speckled alder with locally abundant common winterberry and sometimes vigorous red spruce regeneration in this stratum. The short-shrub layer is dominated by alderleaf buckthorn (*Rhamnus alnifolia*) or rarely by silky dogwood (*Cornus amomum*). The herbaceous ground layer is extensive and diverse, typically including >50 species. The most abundant species are brome-like sedge (*Carex bromoides* ssp. *bromoides*) and fowl mannagrass. Other common species include Jack-in-the-pulpit, marsh-marigold, nodding sedge, crested shield-fern, orange jewelweed, soft rush, northern bugleweed, Canada mayflower, cinnamon fern, golden groundsel (*Packera aurea*), arrowleaf tearthumb, bristly dewberry,

and roughleaf goldenrod. Grove meadow grass (*Poa alsodes*) is locally abundant. Dominant bryophytes are peatmosses, pellucid plait moss, delicate fern moss, and common bazzania liverwort. Diagnostic species are brome-like sedge, glade spurge (*Euphorbia purpurea*), black ash, purple avens (*Geum rivale*), bog Jacob's-ladder (*Polemonium vanbruntiae*), and alderleaf buckthorn.

4.2.2.6 Red Spruce/Heath Peat Woodland

Association CEG006588. *Picea rubens*/*Rhododendron maximum* – *Kalmia latifolia*/*Eriophorum virginicum*/*Sphagnum* spp. swamp forest (Fig. 4.11). NatureServe Conservation Status: G2G3; PA: S2S3, WV: S2.

This acidic conifer woodland occurs on saturated soils in headwater basins of the Allegheny Mountains region of West Virginia, at elevations from 860 to 1,300 m (2,800–4,200 ft), and extends into eastern Pennsylvania. In West Virginia, it is a small-patch type that occupies flat to very gently sloping land (0–1° slopes) along the margins of open peatlands and in seepage-fed portions of wetland mosaics. Seepage from adjacent upland forest and the high water table in adjacent open wetlands keep the community wet enough to kill trees during wet years, leaving numerous snags. Microtopography is characterized by a mix of rounded peat hummocks and irregular moss-covered hummocks formed over tree roots, woody stem clusters, and decaying



Fig. 4.11 Example of the Red Spruce/Heath Peat Woodland community. Photo by Elizabeth Byers

wood. Bedrock is typically sandstone or shale. Soils are moderately to very poorly drained peat, underlain by clay-rich deposits, with an average pH of 3.6.

This community is characterized by an open canopy of stunted, inundation-stressed trees with a diverse shrub and herb layer growing on hummock-forming bryophytes. The canopy is dominated by eastern hemlock and red spruce, occasionally including low cover of red maple or yellow birch. Canopy height is <15 m (50 ft) and sometimes as low as 5 m (16 ft), approaching the threshold between woodland and shrubland physiognomy. The tall-shrub layer includes the canopy species along with great laurel, mountain laurel, catberry, and common winterberry. Other species that occasionally occur with low cover in the tall-shrub layer include northern wild raisin, mountain holly, red chokeberry (*Aronia arbutifolia*), red maple, American mountain ash, Allegheny serviceberry, and American witch-hazel. The short-shrub layer is similar in composition to the tall-shrub layer. The herbaceous layer typically includes bristly dewberry, cinnamon fern, bog goldenrod, and the regenerating canopy species. Species with lower cover often include three-seeded sedge, roundleaf sundew (*Drosera rotundifolia* var. *rotundifolia*), eastern hay-scented fern, nodding sedge, slender mannagrass, tawny cotton-grass, whorled aster, and soft rush. A lush bryophyte layer is dominated by peatmosses (*Sphagnum fallax*, *Sphagnum recurvum*, *Sphagnum divinum*, *Sphagnum affine*, and *Sphagnum capillifolium*) and common haircap moss (*Polytrichum commune*). Most of the diversity in this community type is in the shrub and herb layers.

4.2.2.7 Red Spruce/Three-Seeded Sedge Peat Woodland

Association CEG006590. *Picea rubens*/*Carex trisperma*/*Sphagnum* spp. – *Polytrichum* spp. swamp forest (Fig. 4.12). NatureServe Conservation Status: G2; WV: S2.

This acidic conifer woodland swamp occurs on saturated and temporarily flooded organic soils in headwater basins of the Allegheny Mountains region of West Virginia, at elevations from 1,000 to 1,430 m (3,200–4,600 ft). It is a small-patch community that occupies flat to very gently sloping land (0–2° slopes) along the margins of open peatlands, forming narrow spits, fingers, or islands. It also occurs in peaty depressions within high plateau spruce forests. Microtopography is characterized by a mix of rounded peat hummocks and irregular moss-covered hummocks formed over tree roots, woody stem clusters, tip-up mounds, nurse logs, and decaying wood. Bedrock is typically sandstone or occasionally shale and may be encountered at <20 cm (8 in) depth. Soils are poorly drained muck, peat, or organic-rich silt/clay loam. Depth of organic soil varies greatly from 5 to 120 cm (2–47 in), with an average pH of 3.5.

The community is characterized by an open canopy of red spruce and a sparse shrub layer growing on irregular hummocks, with swales and hollows occupied by three-seeded sedge and peat-forming bryophytes. Additional canopy species that occur occasionally include eastern white pine, red maple, Allegheny serviceberry, pitch pine, American mountain ash, and yellow birch. The tall-shrub layer is also



Fig. 4.12 Example of a Red Spruce/Three-seeded Sedge Peat Woodland community. Photo by Elizabeth Byers

dominated by red spruce with occasional low cover by northern wild raisin, catberry, and black chokeberry. The short-shrub layer includes red spruce, velvetleaf blueberry, and late lowbush blueberry. The herbaceous layer is dominated by three-seeded sedge and may include low cover by bristly dewberry, cinnamon fern, creeping snowberry (*Gaultheria hispidula*), small cranberry (*Vaccinium oxycoccos*), and white-edge sedge. Bryophytes have high ground cover dominated by peatmosses with lesser amounts of haircap mosses, pellucid plait moss, and white pincushion moss.

4.2.2.8 Red Spruce/Southern Mountain Cranberry Swamp

Association CEGJ006593. *Picea rubens*/*Vaccinium erythrocarpum*/*Sphagnum* spp. – *Bazzania trilobata* swamp forest (Fig. 4.13). NatureServe Conservation Status: G2; WV: S2.

This acidic conifer woodland or forested swamp occurs on saturated and temporarily flooded soils in headwater basins of the Allegheny Mountains region of West Virginia, at elevations from 1,140 to 1,400 m (3,700–4,600 ft) above sea level. It is a small-patch community maintained by slow seepage, low-energy overflow inundation, and rainfall. It occupies gently sloping land (0–6° slopes) on the margins between upland spruce forest and open beaver-influenced headwater



Fig. 4.13 Example of a Red Spruce/Southern Mountain Cranberry Swamp community. Photo by Brian Streets

wetlands, and alluvial bottoms along high-elevation meandering streams. Standing snags are common, the result of inundation stress during wet years and beaver-influenced water table fluctuations. Microtopography is characterized by irregular hummocks formed over tree roots, tip-up mounds, decaying wood, and around woody stem clusters. Soils are somewhat poorly drained peat, muck, or organic-rich mottled silt loam, generally underlain by clay.

The canopy is open to closed and strongly dominated by red spruce. The subcanopy is also dominated by red spruce, with lower cover by red maple and yellow birch. The tall-shrub layer is similar in composition to the subcanopy, with the occasional low cover by mountain holly, great laurel, or American mountain ash. The short-shrub layer is dominated by the diagnostic species southern mountain cranberry, with locally abundant mountain laurel. The herbaceous ground layer is variable and sparse; evergreen woodfern or New York fern (*Thelypteris noveboracensis*) may be locally abundant, with low cover of cinnamon fern, Canada mayflower, Clinton lily, and three-seeded sedge. Bryophytes have high ground cover with common bazzania liverwort blanketing the abundant downfall and peatmosses (*Sphagnum girgensohnii*, *Sphagnum fallax*, *Sphagnum palustre*, and *Sphagnum rubellum*) filling the mucky hollows; haircap mosses and pellucid plait moss are also common.

4.2.2.9 Pitch Pine – Red Spruce/Heath Peat Woodland

Association CEGLO06587. *Pinus rigida* – *Picea rubens*/*Viburnum nudum* var. *cassinoides*/*Sphagnum* spp. swamp woodland (Fig. 4.14). NatureServe Conservation Status: G1G2; NY: SNR, WV: S1.

This acidic dwarf woodland swamp occurs on saturated and temporarily flooded soils in the Allegheny Mountains region of West Virginia, at elevations from 981 to 1,220 m (3,200–4,000 ft). This community occurs in narrow bands (10–200 m [33–650 ft] wide) immediately west of the Allegheny Front, between the upland forest of the summit ridge and open peatlands, with one stand to the west in the headwaters of Lindy Run. It is a small-patch type that occupies flat-lying land ($<1^\circ$ slope). Microtopography is characterized by irregular moss-covered hummocks formed over tree roots, woody stem clusters, tip-up mounds, and decaying wood. Soils are poorly drained peat. The underlying acidic sandstone bedrock (Pennsylvanian Allegheny and Pottsville Formations) is generally encountered at <70 cm (27 in) depth. Depth of organic soil is 20–70 cm (8–27 in), and soil pH averages 3.5.

Vegetation is characterized by an open canopy with an understory of ericaceous shrubs over a mat of peatmosses. The dwarfed canopy is dominated by red spruce and pitch pine, with low cover of red maple and eastern hemlock. The tall-shrub layer contains abundant catberry and mountain laurel and lower cover of great laurel and



Fig. 4.14 Example of the Pitch Pine – Red Spruce/Heath Peat Woodland community. Photo by Elizabeth Byers

the regenerating canopy species. The short-shrub layer is similar in composition to the tall-shrub layer, with the addition of abundant velvetleaf blueberry and low but consistent cover of black huckleberry, black chokeberry, late lowbush blueberry, northern wild raisin, and the dwarf-shrub small cranberry. The herbaceous layer is sparse, with bristly dewberry, eastern teaberry, goldthread, robin-run-away, tawny cotton-grass, trailing arbutus, tree clubmoss, cinnamon fern, white beakrush (*Rhynchospora alba*), three-seeded sedge, and roundleaf sundew. Bryophytes have high cover and are dominated by peatmosses (*Sphagnum rubellum*, *Sphagnum divinum*, *Sphagnum fallax*, and *Sphagnum papillosum*), common haircap moss, and eastern haircap moss. Indicators include goldthread, robin-run-away, roundleaf sundew, tawny cotton-grass, and catberry.

4.3 Southern Appalachians

4.3.1 Upland Red Spruce and Spruce-Fir Communities

In the southern Appalachians, communities with red spruce range from Mt. Rogers in southernmost Virginia, southwestward through North Carolina and Tennessee as far as the Great Balsam Mountains and Great Smoky Mountains. Upland communities reach their range limit a bit south of Richland Balsam and a few miles west of Kuwohi Mountain (a.k.a. Clingmans Dome), though comparable elevations continue along the Great Smoky Mountains crest. In between, they are present on Plott Balsam Mountain, Black Mountains, Unaka Mountain, Roan Mountain, and Grandfather Mountain, as a few small patches. The southern Appalachians contain higher elevations than the central Appalachians (highest peak—Spruce Knob at 1,482 m), extending upward to the highest peaks east of the Rocky Mountains and Black Hills. Even accounting for the lower latitude, the climate of the highest peaks is more extreme. A diverse array of topographic settings and substrates, as well as a broad range of altitude, leads to high community diversity. Eight distinct forest communities are recognized, all of them globally imperiled. One of the most important differences in vegetation between the central and southern Appalachians is the presence, often as a dominant or co-dominant tree, of Fraser fir and the absence of balsam fir. Fir in general is more extensive across the Southern Appalachians or was before the introduced balsam woolly adelgid devastated its populations. Fraser fir dominated the forest cover in the extreme climate of the highest peaks, where red spruce is much less abundant. Throughout the broad middle elevations of the spruce zone, Fraser fir was co-dominant or at least abundant, and yellow birch, the only common hardwood, is of limited importance. The communities are thus classified into elevational groups, with some dominated by Fraser fir at the highest elevations, those with mixed spruce and fir at middle elevations, and those with mixed red spruce and hardwoods or hemlock at the lower elevations.

The flora of the southern Appalachian spruce-fir forests is similar to that of the central Appalachians in having substantial northern affinities, as well as containing southern species. Many species are shared, but there is a larger number of southern species and a somewhat smaller number of northern species. Thus, alderleaf viburnum, white woodsorrel, Clinton lily, and painted trillium are common, but goldthread and lowbush blueberry are not components. Meanwhile, southern mountain cranberry, minniebush, Blue Ridge St. John's-wort, and other species shared with the central Appalachians are joined by more strictly southern endemics such as Roan rattlesnakeroot (*Ageratina roanensis*), Blue Ridge white heart-leaved aster (*Eurybia chlorolepis*), and, in some mountain ranges, by even narrower endemic species such as Rugel's ragwort (*Rugelia nudicaulis*).

A variety of successional states exist in the southern Appalachian spruce-fir forests. Several substantial areas were protected from logging by rugged terrain or came into conservation ownership before they were logged. The largest area is in the Great Smoky Mountains National Park, but old growth forests also remain in the Black Mountains, on Grandfather Mountain, Richland Balsam, Mt. Rogers, and in small pockets elsewhere (see Chap. 1). Most of the smaller protected areas are either on the highest peaks, where the dominant Fraser fir was less valued than red spruce as timber, or at the lower elevations where patchy distributions of red spruce made building logging railroads unprofitable. Nevertheless, a much larger acreage was devastated by early twentieth century logging and slash fires. Much of this acreage still does not support forest 100 or more years after the disturbance. There were some areas where logging occurred, but subsequent fires did not occur. In those areas, Fraser fir tended to dominate the regeneration and spruce has been slow to reclaim co-dominance. Because of the importance of Fraser fir in most communities, the impact of the balsam woolly adelgid was devastating for even the unlogged remnants. More details can be found in Chap. 5.

4.3.1.1 Fraser Fir Forest (Herb Subtype)

Association CEG006049. *Abies fraseri*/*Viburnum lantanoides*/*Dryopteris campyloptera* – *Oxalis montana*/*Hylocomium splendens* forest (Fig. 4.15). NatureServe Conservation Status: G1; NC: S1, TN: S1, VA: S1.

This community is restricted to the highest peaks of North Carolina, Tennessee, and southernmost Virginia. It is generally above about 1,880 m (6,200 ft) in elevation, though it is a bit lower on the more northerly Mt. Rogers and on Grandfather Mountain, known for its extreme weather. Only a half dozen peaks support this community, although Fraser fir forests are abundant on these peaks. All occurrences of this community have been devastated by the balsam woolly adelgid, which killed all mature Fraser firs from the 1960 to 1980s. Prior to that, this community existed as dense forests periodically broken by wind throw gaps. Red spruce and yellow birch were minor but highly constant canopy components, while American mountain-ash dominated limited patches. Striped maple and mountain maple were the primary understory trees other than red spruce and Fraser fir. Alderleaf viburnum, southern



Fig. 4.15 Example of the Fraser Fir Forest (Herb Subtype) community. Photo by Gary Fleming

mountain cranberry, mountain highbush blueberry (*Vaccinium simulatum*), smooth highbush blueberry (*Vaccinium corymbosum*), and red elderberry (*Sambucus racemosa* var. *racemosa*) often formed an open shrub layer. Lush cover of mosses, ferns, herbs, and fir seedlings carpeted the ground. Because the smooth bark of mature Fraser fir provides especially good habitat for epiphytic mosses and liverworts, the tree trunks too were often lush and green. Mountain woodfern, evergreen woodfern, southern lady fern (*Athyrium asplenoides*), hay-scented fern, whorled aster, white wood sorrel, and Appalachian white snakeroot are often abundant. Stairstep moss, haircap mosses, and smoothcap mosses (*Atrichum* spp.) are often the dominant bryophytes.

Because the balsam woolly adelgid kills older trees but not seedlings and small saplings, advance regeneration in some of the devastated forests has developed into dense stands of young fir. Other areas became dominated by blackberries (*Rubus canadensis*, *Rubus alleghaniensis*). Some young fir stands are now maturing, but balsam woolly adelgids occasionally return and kill the maturing trees in some stands.

4.3.1.2 Fraser Fir Forest (Rhododendron Subtype)

Association Cegl006308. *Abies fraseri*/(*Rhododendron catawbiense*, *Rhododendron carolinianum*) forest. NatureServe Conservation Status: G1; NC: S1, TN: S1.

This community is not only restricted to the highest peaks of North Carolina and Tennessee, it is restricted to only a small portion of the area on those peaks, occurring on sharply convex slopes and near the edges of rock outcrops. As in the Herb Subtype, Fraser fir dominates the canopy, and red spruce, yellow birch, and American mountain ash occur as minor or patchy components. The canopy is often small and stunted. A dense shrub layer occurs in the forest, generally dominated by *Rhododendron* spp. Other shrubs may include minniebush or southern bush honeysuckle (*Diervilla sessilifolia*). Herbs are sparse and sometimes completely absent, except on small rock outcrops within the community. However, bryophytes may be abundant in some places, on the ground and on tree trunks. As with other Fraser fir forests, the balsam woolly adelgid has devastated all examples of this community. With less understory presence of Fraser fir, fewer examples have regenerated, and some examples have come to resemble heath bald vegetation.

4.3.1.3 Red Spruce – Fraser Fir Forest (Herb Subtype) or Red Spruce – Southern Mountain Cranberry Forest (Deciduous Shrub Understory Type)

Association: CEGLO07131. *Picea rubens* – (*Abies fraseri*)/*Vaccinium erythrocarpum*/*Oxalis montana* – *Dryopteris campyloptera*/*Hylocomium splendens* forest (Fig. 4.16). Nature Serve Conservation Status: G2; NC: S2, TN: S1, VA: S1, WV: S1.

This community is the most extensive community in the middle elevations of the spruce-fir zone in the southern Appalachians, roughly from 1,680 to 1,880 m (5,500–6,200 ft). It is most extensive in North Carolina but extends into Tennessee and southernmost Virginia. The highest elevation spruce forests in West Virginia are in the same IVC community, hence it is described above for the central Appalachians.

In the southern Appalachians, prior to balsam woolly adelgid disturbance, it had a dense canopy consisting of both red spruce and Fraser fir. At present, most stands are somewhat open, but regeneration of fir and red spruce from existing seedlings has closed the canopy in some areas. Yellow birch is a highly constant component but limited in cover. Striped maple and mountain maple are the primary understory trees other than red spruce and Fraser fir. Alderleaf viburnum, southern mountain cranberry, mountain highbush blueberry, smooth highbush blueberry, and red elderberry are frequent shrubs, but are not usually dense. Where the canopy is broken, blackberries sometimes become dense. Beneath intact canopies, lush ground cover of mosses, ferns, herbs, and red spruce and Fraser fir seedlings is common. Mountain woodfern, evergreen woodfern, southern lady fern, hay scented fern, whorled aster, white wood sorrel, Appalachian white snakeroot and, in the Smokies, Rugel's ragwort, are frequent and abundant vascular plants. Stairstep moss, haircap mosses, and smoothcap mosses are often the dominant bryophytes. *Bazzania* liverworts, which are often dominant in the central Appalachians, are not a major component.



Fig. 4.16 Example of the Red Spruce – Fraser Fir Forest (Herb Subtype) or Red Spruce – Southern Mountain Cranberry Forest (Deciduous Shrub Understory Type) community. Photo by Gary Fleming

4.3.1.4 Red Spruce – Fraser Fir Forest (Rhododendron Subtype) or Red Spruce – Fraser Fir Forest (Evergreen Shrub Understory Type)

Association CEGLO07130. *Picea rubens* – (*Abies fraseri*)/(*Rhododendron catawbiense*, *Rhododendron maximum*) forest (Fig. 4.17). NatureServe Conservation Status: G1; NC: S1, TN: S1, VA: S1.



Fig. 4.17 Example of the Red Spruce – Fraser Fir Forest (Rhododendron Subtype) or Red Spruce – Fraser Fir Forest (Evergreen Shrub Understory Type) community. Photo by Gary Fleming

Like the Herb Subtype, this community occurs in the middle elevations of the spruce zone, roughly from 1,680 to 1,880 m (5,500–6,200 ft). It is restricted to a few areas on sharply convex slopes and near edges of rock outcrops. The canopy may be a mix of red spruce and Fraser fir or may be more strongly dominated by red spruce. The canopy may be dense or somewhat open, and the trees may be somewhat stunted. Allegheny serviceberry may occur in the understory, along with red spruce, Fraser fir, or yellow birch. The shrub layer is dense and usually dominated by Catawba rhododendron or great laurel. Shrubs common in the other spruce communities may also be present, as well as evergreen fetterbush (*Pieris floribunda*), deerberry (*Vaccinium stamineum*), and other species. Herbs are generally sparse. Mountain woodfern, brownish sedge, or various species shared with the Herb Subtype may be present in small numbers.

4.3.1.5 Red Spruce – Fraser Fir Forest (Boulderfield Subtype)

Association CEG007128. *Picea rubens*/*Ribes glandulosum* forest. NatureServe Conservation Status: G1; NC: S1.

This community occurs on talus or relict periglacial boulderfields and is an extension of the yellow birch-dominated boulderfield forests that occurs in similar settings at slightly lower elevations. It is one of the rarest of spruce communities, with only a

few examples definitively known, exclusively in North Carolina. The only extensive stand is on Grandfather Mountain.

The boulderfields consist of large loose rock fragments that entirely cover the ground surface. Boulders generally rest on other boulders, with extensive void space between them. Soil consists of organic matter in pockets between rocks and on their surfaces. Despite the limited rooting environment, this community generally has a well-developed closed or somewhat open canopy. The canopy consists almost exclusively of red spruce and yellow birch. Both species are capable of establishing in shallow organic deposits on raised surfaces, then wrapping their roots around the object to seek deeper levels. The understory is dominated by mountain maple, with American mountain ash the only other frequent species. Alderleaf viburnum is the most constant and abundant species in the sparse shrub layer, but skunk currant, characteristic of boulderfield environments, may also be present. The herb layer consists primarily of species that are able to live on bare rock. There is often extensive moss cover. Appalachian rockcap fern is extensive in most places. Other herbs typical of spruce-fir forests are present in limited favorable soil pockets, including mountain woodfern, evergreen woodfern, white woodsorrel, and shining clubmoss.

4.3.1.6 Red Spruce – Fraser Fir Forest (Birch Transition Herb Subtype)

Association Cegl006256. *Picea rubens* – (*Betula alleghaniensis*, *Aesculus flava*)/*Viburnum lantanoides*/*Solidago glomerata* forest. NatureServe Conservation Status: G1; NC: S1, TN: SNR.

This community occurs in the lower elevations of the red spruce zone, where red spruce tends to be co-dominant with yellow birch and other northern hardwood species. It typically occurs around 1,370–1,680 m (4,500–5,500 ft) elevation and is recognized only in North Carolina and Tennessee. Though fundamentally an elevation-driven transitional community between spruce-fir and northern hardwood forests, this community generally occurs with a patchy distribution, interfingering with both higher and lower communities where it occurs.

The forest is usually dense where not recently disturbed, consisting predominantly of red spruce and yellow birch; Fraser fir may be present in small numbers. Yellow buckeye (*Aesculus flava*), red maple, sugar maple, beech, red oak, or sweet birch may be present, and any of these species may occasionally be abundant. The understory often includes striped maple and mountain maple as well as the various canopy species. Shrubs may be sparse to moderate in density. Southern mountain cranberry, alderleaf viburnum, and mountain holly are the most frequent. The herb layer may be dense or sparse. Most of the frequent species are shared with higher elevation spruce-fir forests, such as white wood sorrel, evergreen woodfern, shining clubmoss, whorled aster, and Clinton lily, but species more typical of northern hardwoods communities, such as Canada mayflower, cucumber root, Blue Ridge white heart-leaved aster, and New York fern are also often present.

This community is one of the more abundant red spruce communities of the southern Appalachians, though its overall coverage is not well known. In the dendritically dissected topography of the Blue Ridge, lower elevation is associated with increased acreage, but this is offset by the discontinuous occurrence of the community. In some places, the increased proximity to land clearing and settlement at the lower elevations have led to greater loss of this community. But in more remote mountain ranges, logging railroads often were built at higher elevation and patches were left uncut on rugged or steep lands below the logged areas. Though the patchy and discontinuous distribution is sometimes interpreted as a result of logging history, this does not generally appear to be the case. It is also present in the unlogged parts of the Great Smoky Mountains and other mountain ranges. This complex natural distribution complicates decisions about appropriate sites for red spruce restoration activities.

4.3.1.7 Red Spruce – Fraser Fir Forest (Birch Transition Shrub Subtype)

Association Cegl004983. *Picea rubens* – (*Betula alleghaniensis*, *Aesculus flava*)/*Rhododendron (maximum, catawbiense)* forest (Fig. 4.18). NatureServe Conservation Status: G1?; NC: S1, TN: SNR, VA: S1.

This community occurs in the lower elevations of the red spruce zone, where red spruce tends to co-dominate with yellow birch and other northern hardwood species. It typically occurs around 1,370–1,680 m (4,500–5,500 ft) elevation on more convex ridges and around rock outcrops, and is known in North Carolina, Tennessee, and southernmost Virginia. It is a lower elevation analogue to the Red Spruce – Fraser Fir Forest (Shrub Subtype) association. It is much less extensive on the landscape than the Red Spruce – Fraser Fir Forest Birch Transition Herb Subtype association, but its overall abundance is not well known.

This community is a dense to open forest, with red spruce and yellow birch generally dominant. Red oak, red maple, beech, and eastern hemlock may also be present. The understory may include serviceberry, striped maple, and mountain maple. The shrub layer is dense and usually dominated by great laurel but may have abundant Catawba rhododendron or mountain laurel. Deciduous shrubs such as alderleaf viburnum, southern mountain cranberry, or mountain holly may be present in smaller amounts. The herb layer is sparse, containing mainly species typical of other spruce-fir forests, such as mountain woodfern, evergreen woodfern, and whorled aster. Appalachian rockcap fern may be abundant where rock cover is high.



Fig. 4.18 Example of the Red Spruce – Fraser Fir Forest (Birch Transition Shrub Subtype) community. Photo by Gary Fleming

4.3.1.8 Red Spruce – Fraser Fir Forest (Low Rhododendron Subtype) or Red Spruce Forest (Protected Slope Type)

Association Cegl006152. *Picea rubens* – (*Tsuga canadensis*)/*Rhododendron maximum* forest. NatureServe Conservation Status: G2?; NC: S1, TN: SNR, WV: S1.

This community occurs at lower elevations in moist, but not wet, sites with sheltered topography, such as heads of ravines. It is recognized in both the central and southern Appalachians and was described above as Red Spruce – (Eastern Hemlock)/Great Laurel Forest. In the southern Appalachians, it generally occurs at elevations that do not support continuous spruce-fir forests (as low as 1,200 m [3,900 ft]) in sites that have cold air drainage or a cooler microclimate. It is generally surrounded by northern hardwoods, sometimes by oak forests, but may extend uphill to mix with other spruce-fir forests. Most known examples are in small patches and, while some may have been reduced or destroyed by past logging, it was always naturally limited in extent.

The southern Appalachian examples have dense to open canopies that are dominated by red spruce in combination with eastern hemlock or yellow birch. Most are marked by a dense shrub layer dominated by great laurel. Mountain laurel may co-dominate, and lower elevation mesophytic shrubs such as dog hobble (*Leucothoe*

fontanesiana) may possibly occur. Herbs are sparse to nearly absent. Bryophytes are not as prominent as they are in higher elevation forests, nor as prominent as they are in the central Appalachians. Given the sheltered topography, wind throw, lightning, and other natural disturbances are more limited than in many communities, and trees can grow quite large.

4.3.2 Wetland Red Spruce Communities

Though the southern Appalachians have a great diversity of wetland communities, only one has enough red spruce to be considered a spruce community. Examples of several additional open bog/poor fen communities may contain scattered stunted stems of red spruce, but the species is too limited in cover and frequency to include here. These wetlands are notable, however, because they support red spruce at elevations below the lowest upland populations, and often at some distance from them. They presumably represent Pleistocene relict populations, often containing other disjunct species of northern affinities, now rare in the southern Appalachians. Though these wetlands are likely sites of cold air drainage and accumulation, the survival of red spruce in them, including through the warmer, drier period between the Pleistocene and the present, suggests a broader physiological tolerance in red spruce than is generally recognized.

4.3.2.1 Swamp Forest – Bog Complex (Spruce Subtype) or Red Spruce – (Eastern Hemlock)/Great Laurel Swamp Forest

Association CEG006277. *Picea rubens* – (*Tsuga canadensis*)/*Rhododendron maximum* saturated forest (Fig. 4.19). NatureServe Conservation Status: G2?; MD: SNR, NC: S1, NY: S1, PA: S1, TN: SH, VA: S1, WV: S2.

This community, as defined in the IVC, is the widest-ranging spruce community, occurring in the central and southern Appalachians, and further north in Pennsylvania and New York. While it may be more broadly defined than other communities, its limited species richness makes it appear similar in widely separated locations. Its expression in the central Appalachians is described above.

In the southern Appalachians, this community occurs in small to medium-sized flat valley bottoms at moderate elevations from 1,640 m (5,300 ft) down to as low as 1,100 m (3,600 ft). Such settings are rare in a region where most streams at these elevations have high gradients and narrow valleys. These settings appear perched, generally dropping into a more typical steep gorge or ravine downstream. Amid the complex geology of the region, it is generally unclear if they are caused by more resistant rock in the valley, by resistant rock at the outlet preventing downcutting, or if they represent relicts of valleys formed at a higher base level.

In contrast to the central Appalachians, the southern Appalachian examples tend to be heterogeneous. Microtopography caused by stream deposition or hummock



Fig. 4.19 Example of the Swamp Forest – Bog Complex (Spruce Subtype) or Red Spruce – (Eastern Hemlock)/Great Laurel Swamp Forest community. Photo by Gary Fleming

and hollow topography often amounts to 1 m (3.3 ft) or more of fine-scale relief, and wetness varies from permanently saturated and periodically shallowly flooded in low areas to moist but somewhat drained in the higher areas. Areas of groundwater seepage are often also visible. Soils are predominantly mineral, but they have numerous local pockets of shallow to deep muck in the wetter areas.

The name Swamp Forest – Bog Complex reflects the heterogeneity in vegetation. The community is predominantly forested, with a canopy dominated by red spruce or, rarely, a mix of red spruce with eastern hemlock. In one unique example Carolina hemlock (*Tsuga caroliniana*) is co-dominant in the canopy. Red maple, yellow birch, sweet birch, and other species may occur in the canopy, in addition to serviceberry frequently present in the midstory. The forest matrix generally has a dense shrub layer dominated by great laurel. Mountain laurel, wetland shrubs such as northern wild raisin, black elderberry (*Sambucus nigra* ssp. *canadensis*), and black chokeberry, and high elevation shrubs such as alderleaf viburnum and red elderberry are generally present. Disjunct shrubs of northern affinities, Canada yew (*Taxus canadensis*), and long-stalked holly (*Ilex collina*), are present in some examples. Interspersed with this forested matrix are small openings, too small to recognize as separate communities, in wetter microsites. Most are only a few meters across, but they form a small break in the canopy. Peat moss often covers these openings. Widespread wetland species such as cinnamon fern, royal fern, slender mannagrass, and northern roughleaf goldenrod (*Solidago patula*) are frequent in them. Less frequent species include several wetland orchids and several species associated with larger bog communities.

4.4 Discussion

4.4.1 Rare Plants of the Red Spruce Ecosystem

Five globally rare plants have important populations within central Appalachian red spruce communities. White monkshood is found in small forest seeps and Blue Ridge St. John's-wort is found in sunnier seep areas. Glade spurge and bog Jacob's-ladder grow together in shaded limestone-influenced spruce-fir swamps. Long-stalk holly prefers high-gradient cool stream edges. Two additional globally rare plants, bog bluegrass (*Poa paludigena*) and Tennessee pondweed (*Potamogeton tennesseensis*) have been recorded, but their known populations are small and red spruce communities are not their essential habitat. The globally rare rock skullcap (*Scutellaria saxatilis*) is found in rocky forests in a variety of forest types, including red spruce.

A number of state-rare species within the central Appalachian red spruce wetland communities have northern affiliations, including some that are disjunct, such as balsam fir, American larch, and bog rosemary. Additional state-rare species with primarily northern distributions include black ash, Bartram shadbush (*Amelanchier bartramiana*), creeping snowberry, small cranberry, goldthread, robin-run-away, bog buckbean (*Menyanthes trifoliata*), black-girdle bulrush (*Scirpus atrocinctus*), lake-bank sedge (*Carex lacustris*), slender sedge (*Carex lasiocarpa*), and few-flower sedge (*Carex pauciflora*).

In West Virginia, 145 state-rare plant species have been documented in red spruce wetlands, including 60 critically imperiled species, 56 imperiled species, and 29 vulnerable species. This represents a remarkable 31% of West Virginia's rare flora; nearly one-third of the rare plants in the state may be found on 0.1% of its land surface (Byers et al. 2007).

The southern Appalachians have several globally rare species. Most of these are southern Appalachian endemics, such as bent avens (*Geum geniculatum*), Smoky Mountain mannagrass (*Glyceria nubigena*), small mountain bittercress (*Cardamine clematidis*), Clingman's hedge-nettle (*Stachys clingmanii*), Grandfather Mountain leptodontium moss (*Leptodontium vituscululoides* var. *sulfureum*), the liverwort *Plagiochila exigua*, and other bryophytes. A few plants, such as white monkshood and Blue Ridge Saint John's-wort are examples of species shared with the central Appalachians.

A large number of additional state-rare species also occur. These include species that are common far to the north, but which occur rarely as disjunct populations or which extend southward as small populations along the Appalachians. Examples include blunt-lobe grapefern (*Botrychium oneidense*), bluejoint reedgrass (*Calamagrostis canadensis*), northern beech fern (*Phegopteris connectilis*), necklace sedge (*Carex projecta*), slender wood reedgrass (*Cinna latifolia*), clasping twisted-stalk (*Streptopus amplexifolius*), rosy twisted-stalk (*Streptopus lanceolatus*), and bryophytes such as peak moss (*Brachydontium trichoides*) and the liverwort *Bazzania nudicaulis*.

The relationship of rare plant species to spruce communities varies. Some of the species noted here occur only in spruce communities while others also occur in open bogs and seeps, in rock outcrop communities, or in northern hardwoods forests, and some may be more concentrated in those other communities. Of particular note is that some of the rare species associated with red spruce wetlands in West Virginia occur in open wetlands in North Carolina but are not found in red spruce forests there. Some species that are relatively common in red spruce wetlands in West Virginia, such as three-seeded sedge, are state-rare in North Carolina.

4.4.2 Associated Plant Communities

While red spruce forests are often the predominant plant communities in the elevational zones and on the landforms where they occur, there are sometimes associated communities occurring in small patches among them. These communities often harbor a disproportionate number of rare species. Some of these species are shared with adjacent spruce communities while others are not. Because these communities are often small, the surrounding forest can have important effects on their composition.

In the central Appalachians, some rocky or barren areas within the red spruce ecosystem have resulted from anthropogenic fires, but the disjunct occurrence of circumboreal lichens (*Arctoparmelia centrifuga*, *Clauzadeana maculata*, *Fuscidea praeurptorum*) and timber rattlesnakes (*Crotalus horridus*) attest to the natural status of the rock fields at some scale. These associated communities include High Elevation Sandstone Boulderfield, Mountain Laurel – Black Huckleberry Heath Barren, and Blueberry Heath Barren.

On the broad ridgetops and plateau areas of the central Appalachians, characteristic wetland communities are embedded within the red spruce forest. Many of these wetlands do not occur outside of the red spruce forest in this region. They are often characterized by soils that are too saturated to support tree species, and typically are bordered by red spruce swamp communities. They include the globally critically imperiled Bog-rosemary Peatland and Barbara's-buttons Ice-scour Prairie; globally imperiled communities including Cranberry – Beakrush Peatland, Nodding Sedge – Prickly Bog Sedge Seep, and Star Sedge Fen; and globally vulnerable communities of Cottongrass Fen, Golden Saxifrage Seep, American Bur-reed Marsh, Hairy-fruit Sedge Floodplain Prairie, Rough Sedge Seep, and Twisted Sedge Rivershore.

Other special wetland types that are embedded in red spruce forests include the state-rare Montane Tall Sedge Fen, Tamarack Swamp, Bluejoint Wet Meadow, Silvery Sedge Fen, Blueberry – Bracken Fern Shrub Swamp, Chokeberry – Wild Raisin Peatland, Red Maple – Blackgum/Peatmoss Swamp, and Quaking Aspen Swamp. Wetland communities that occur within the red spruce ecosystem but are also distributed more widely in the central Appalachians include Softstem Bulrush Marsh, Bushy St. Johnswort Shrub Swamp, Goldenrod Wet Meadow, Meadowsweet Shrub Swamp, Rice Cutgrass Marsh, Silky Willow Shrub Swamp, Speckled Alder

Alluvial Thicket, Threeway Sedge Fen, Tussock Sedge Wet Meadow, and Woolgrass Wet Meadow.

In the higher-relief southern Appalachians, rock outcrop communities are often associated with spruce-fir forests. High Elevation Rocky Summit (Typic Subtype) (Michaux's Saxifrage – Wretched Sedge – Poverty Oatgrass – Mountain Dwarf-dandelion Grassland), High Elevation Rocky Summit (High Peak Subtype) (Michaux's Saxifrage – Wretched Sedge – Whorled Wood Aster – Clustered Goldenrod Grassland), and High Elevation Rocky Summit (High Peak Lichen Subtype) (Common Toadskin Lichen – Carolina Rocktripe Lichen Nonvascular Vegetation) are sparsely vegetated or mixed-structure open communities on rock outcrops. These communities, especially the first, are notable for the number of rare plant species associated with them. Of particular importance is a suite of globally rare, narrow endemic, often federally listed species, including Roan Mountain bluet (*Houstonia montana*), Blue Ridge goldenrod (*Solidago spithamea*), spreading avens (*Geum radiatum*), and Heller's blazing star (*Liatris helleri*). These combine with northern species at their southern range limit, such as highland rush (*Oreojuncus trifidus*) and deerhair bulrush (*Trichophorum cespitosum*). Less rare northern species, such as three-tooth cinquefoil (*Sibbaldiopsis tridentata*), also occur in these communities. Some of these species occur in Arctic tundra or in the alpine tundra of New England, and some of the southern endemic species are close relatives of species in these habitats. For example, spreading avens is closely related to the globally imperiled mountain avens (*Geum peckii*) of New Hampshire and Nova Scotia. It is widely believed that, during the Pleistocene, the climate was cold enough that the southern Appalachians had a timberline and that there was alpine tundra vegetation on the high peaks. That tundra vegetation disappeared from the southern Appalachians as spruce-fir forests migrated uphill, but some of its flora survives on the open rock outcrops.

In addition to rock outcrop communities, non-forest communities in the spruce-fir zone also include shrub-dominated Heath Bald communities of several types and the enigmatic Grassy Bald communities. The three Grassy Bald communities: Grassy Bald (Grass Subtype) (Flattened Oatgrass – Threetooth Cinquefoil Grassland, Grassy Bald (Sedge Subtype) (Pennsylvania Sedge Grassland), and Grassy Bald (Alder Subtype) (*Alnus viridis crispal*/*Carex pensylvanica* Shrubland), cover significant acreage in association with spruce-fir forests in just a couple of places. They harbor rare species, most of which are not in adjacent forests, including globally rare endemics such as Gray's lily (*Lilium grayi*) and long distance disjuncts such as green alder (*Alnus viridis crispal*). They likely represent remnants of Pleistocene alpine tundra. Several Heath Bald communities may also be associated with red spruce. These dense shrublands generally are not known for supporting rare species. An additional notable community associated with red spruce forests is known in the literature as Beech Gap – Northern Hardwood Forest (Beech Gap Subtype) (American Beech/Pennsylvania Sedge – Appalachian White Snakeroot Forest). They occur in ridgetop saddles (gaps) or exposed ridges in the elevational range of spruce-fir forests.

At their lower elevation boundary, spruce forests interfinger with various typical Northern Hardwood and Hemlock – Northern Hardwood Forest communities dominated by yellow birch, eastern hemlock, yellow buckeye, sugar maple, and beech, or on warmer slope aspects, forests dominated by red oak. These communities are much more extensive in the central and southern Appalachians than are spruce-fir forests, both downhill in the same mountain ranges and in ranges that do not have spruce-fir forests. It is notable that, where spruce-fir forests are present uphill, scattered individuals of red spruce often are found in these lower elevation communities. Most occur only as saplings, but occasional trees reach the canopy.

4.4.3 Management Implications

Plant communities are important to consider during three management stages. First, land acquisition decisions should be based in part on an inventory of existing plant communities, including their rarity and condition, as these are important conservation targets. Second, restoration activities should be guided by the plant communities that a particular habitat niche is likely to support. Third, recreation or other development activities should avoid disturbance to rare and threatened plant communities, especially to those that occur only in small patches.

As detailed in this chapter, red spruce communities range from those dominated by red spruce or Fraser fir in contiguous forest to small-patch wetlands. When considering restoration or other management actions at the project scale, it is important to recognize the particular environmental setting of the project and the specific plant communities that occur in that environment. Knowing the potential plant communities provides essential information on rare species, rare habitats, disturbance regimes, soil types, and reference conditions. A crucial implication of spruce community diversity is that reference condition and appropriate restoration goals are not the same for every site. The appropriate amount of spruce in the canopy varies, with the lowest elevation communities having substantial hardwood components and the highest southern Appalachian communities dominated by Fraser fir. Shrub cover and composition also varies, and high shrub cover does not necessarily indicate a need for management. In addition to avoiding harm to the many rare species that inhabit spruce forests, managers need to avoid harm to rare communities.

When considering restoration of small-patch wetland communities within the red spruce ecosystem, it is important to survey the site for legacy erosion and entrenchment of streams from extensive logging and fires a century ago. Today, many embedded wetlands are drained by entrenched or incised streams that are disconnected from their floodplains. Today's wetland plant communities may be drier and more vulnerable than the original well-connected wetlands. In these cases, restoration of hydrology is key. The target plant community of the successfully restored area may be significantly wetter than that of pre-restoration wetlands.

Current threats and stresses include climate change, air pollution, ongoing effects and new infestations of balsam woolly adelgid, and, especially on private lands,

conversion of land use to residential or second homes, coal mining, and wind energy development. Non-native invasive plants are less problematic than in forest ecosystems with richer soils or milder climates, but they can still be a serious problem, especially along road corridors and in wetlands or forest openings. An increase in management activity would exacerbate this threat, as heavily used trails and especially roads often act as corridors for invasion, heavy equipment is a major vector of spread, and canopy opening can trigger invasion. Excessive deer herbivory, while not a direct threat to red spruce seedlings, negatively impacts the ecosystem by reducing or removing palatable shrubs and herbs, including rare species. Deer trails are active vectors for non-native invasive species. There are a number of tree pathogens and invasive insects in addition to balsam woolly adelgid that impact components of spruce forests, including hemlock woolly adelgid, emerald ash borer, beech bark disease, and beech leaf disease.

Plant communities directly reflect specific environmental gradients and ecological processes and are a key measure of beta diversity. While rare species may be considered the fine filter of biodiversity, plant communities are the equally important coarse filter ensuring conservation of habitat niches and the many species they support. Knowledge of the plant communities associated with a piece of land is fundamental to management for biodiversity conservation.

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