CASRI

The Central Appalachian Spruce Restoration Initiative

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RESTORATION APPROACH OF THE CENTRAL APPALACHIAN SPRUCE RESTORATION INITIATIVE

INTRODUCTION

This document describes CASRI's approach to red spruce-northern hardwood ecosystem restoration in the Central Appalachians. CASRI embarked on restoration work to further the realization of its vision: *a functioning red spruce (Picea rubens)-northern hardwood forest ecosystem, restored across portions of its former range on both public and private lands, with the scale, connectivity, maturity and other features that provide functional habitat to sustain and enhance the viability of the many species and natural communities dependent on this ecosystem*. This vision developed from the desire and intent of many to sustain an important part of the natural heritage and biodiversity of the Central Appalachians. Action towards the vision was stimulated by the formal recovery efforts instigated by the US Fish and Wildlife Service for the West Virginia Northern Flying Squirrel (*Glaucomys sabrinus fuscus*, WVNFS), which depends on these habitats. As suggested by Schuler et al. (2002), WVNFS recovery would best be aided by expanding the coverage of red spruce forest and accelerating red spruce stand development for mature to old-growth structural characteristics (Schuler et al. 2002).

The red spruce-northern hardwood ecosystem in the Central Appalachians contains matrix red spruce forest communities and embedded small-patch high elevation wetland communities. In speaking of "spruce" restoration CASRI refers to this entire ecosystem. CASRI's restoration targets are defined by reference species assemblages as described by the National Vegetation Classification (NVC) combined with additional references on forest structure and ecological processes. This document reflects the current restoration approach of CASRI and its partners and is intended to help guide restoration action as we work together to accomplish our goals.

DEFINING RESTORATION

The work of ecological restoration may be viewed as "*the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed*" (SER 2004). Falk (1990) had the philosophy that: "*Restoration uses the past not as a goal but as a reference point for the future. If we seek to recreate…communities of centuries past, it is not to turn back the evolutionary clock but to set it ticking again*."

The Society for Ecological Restoration (SER 2004) identifies nine key attributes of restored ecosystems (briefly explained in Appendix A), which include:

- characteristic species assemblages,
- indigenous species,
- functional taxonomic groups,
- appropriate physical environment,
- ecological function,

- integration into the larger landscape,
- threat reduction,
- resilience to normal periodic stresses, and
- self-sustainability.

Some of these attributes (such as indigenous species and appropriate physical environment) may be addressed in individual restoration project plans, but others (i.e. integration into the larger landscape and threat reduction) rely on the strategic landscape- scale conservation actions of the partners and others.

The Society for Ecological Restoration (SER 2004) remarked that restoration "attempts to return an ecosystem to its historic trajectory." The term 'historic' can lead to multiple interpretations as to the desired end-point for forest restoration. A useful definition of historic may be taken from the USFWS Biological Integrity, Diversity and Environmental Health Policy (601 FW 3.6(d)) which states historic conditions to be the "*composition, structure, and functioning of ecosystems resulting from natural processes that we believe, based on sound professional judgment, were present prior to substantial human related changes to the landscape."* In the case of spruce forest restoration this means targeting the forest conditions present prior to significant logging, logging-associated fires, and grazing which dramatically altered the ecosystem. These actions occurred largely after 1880 in the Central Appalachians.

Another important component to the SER discussion of restoration is that the restored ecosystem is reset onto a desired *trajectory* towards the "reference condition." This implies that the end result is not achieved directly, but that the "stage is set" to allow for the necessary changes to occur naturally. "Restored" does not mean that future management may not be necessary; rather, management will be limited to the maintenance and stewardship actions necessary to support movement of the system towards the desired reference condition. Accordingly, adoption of a reference ecosystem as a benchmark is consistent with returning an ecosystem to its historic trajectory (SER 2004) or dynamics (Christenson et al. 1995), after which natural self-renewing processes operate within the historic range of variability and a forest management context.

CASRI's Working Definition of Restoration

CASRI uses the following definition of restoration to guide its work: *Establishing desired ecological conditions that initiate or accelerate recovery of red spruce-northern hardwood ecosystem communities along historic trajectories with functioning natural processes and minimal management intervention.*

CASRI restoration aims to move a site's vegetation and other natural processes back onto a course of development and function, respectively, within its historic range of variation that existed prior to the severe disturbances that moved it off-course. Though often focused on the short-term return of conifers to a site to move it toward an intact and functional reference community, we work with the knowledge that it will take decades, if not centuries, to reach a restored condition. Finally, we expect that climate change may affect the target plant communities and prevent some from fully developing along their historic trajectories.

Restoration Planning

CASRI develops restoration plans to further its restoration goals and objectives. In order to adequately plan and manage for a community-level restoration effort, CASRI uses reference communities to provide a benchmark for determining target composition, structure, and function (Rentch et al. 2007). Central Appalachian spruce forest reference conditions are described by the NVC communities in Appendix B.

Current CASRI restoration planning for any site addresses the following key reference community and ecosystem elements:

- Vegetation *composition* (plant species occurrence and distribution);
- Vegetation *structure* (vertical, horizontal, tree size, snags, woody debris);
- Ecosystem *natural processes* and *functions* (soils, hydrology, wildlife populations, intact wildlife habitat),
- Spatial *arrangement* and *connectivity* of restored habitats from a landscape perspective.

We strive to address all attributes of a restored ecosystem (see Defining Restoration section) in planning. We expect our results to improve as these plans become more sophisticated given availability of new scientific information on this high elevation ecosystem's communities, functions and processes.

RESTORATION GOALS

In recognition of the long temporal scale for achieving CASRI's vision, we have developed long-term restoration goals to facilitate planning.

The long-term goals of restoration are tied directly to the stated vision of CASRI:

- Increase the ecological integrity of the high elevation red spruce-northern hardwood ecosystem communities through active and passive management that sets them on a trajectory towards reference conditions with mature/old growth structure; and
- Protect lands to conserve this ecosystem and the native wildlife and plant communities that rely on it.

Restoration of spruce communities will enhance the long-term resiliency of the ecosystem to outside pressures such as climate change, invasive species, and development. It will enhance existing habitat for priority wildlife and plant species and create opportunities for their populations to expand. Ultimately the restoration will help perpetuate the biological diversity and integrity of this forest ecosystem. Through these goals, the vision of a functioning high elevation spruce ecosystem can be realized on a landscape scale.

CASRI acknowledges the uncertainty around future climate scenarios and how these may affect the future of spruce forest in West Virginia and the Central Appalachians. Our goal to accelerate spruce forest development aims to make stands more intact structurally and the forest more connected from a landscape perspective. An intact network of forested landscapes will be healthier and more resilient to changes in temperature or precipitation from future climate change effects. Through accelerated and well planned restoration actions, we hope to increase the likelihood that the spruce forest ecosystem will persist, ecologically intact and functional, into the future and be able to adapt to changes in response to climate stressors.

Restoration Objectives

CASRI uses a set of seven biological restoration objectives to guide site-specific project planning. These objectives were developed to move a project site onto a trajectory towards full ecological restoration:

1. Consider threats from the surrounding landscape in project selection and design. Reduce, mitigate, or eliminate threats where possible.
2. Restore the hydrology and soils by treating erosion problems and hydrologic disruptions to reduce soil loss and improve site characteristics to support natural vegetative growth and system functioning.
3. Establish foundation species to comprise the eventual overstory canopy through planting, spruce release or other means.
4. Build structural characteristics (e.g., coarse woody debris, standing snags, tree density by height or diameter class, shrub and herb density) and spatial arrangements of communities.
5. Establish native plant species assemblages typical of identified reference communities through planting, control or other means, and establish seed sources for these assemblages (viable reproducing populations of key species).
6. Support habitat elements for all functional groups in the ecosystem, including key habitat elements for particular species of concern.
7. Restore landscape connectivity and integrity so that the project site is integrated into a larger ecological matrix.

These objectives are broad enough to encapsulate the diverse conditions that exist on a variety of sites and allow for project-specific strategies to be developed to achieve the desired results as stated in each objective. A detailed discussion of each objective follows.

Objective 1. *Ameliorate threats where possible.*

CASRI and other stakeholders of the high elevation spruce-northern hardwoods forest have identified numerous serious threats to the ecosystem. Potential threats include the following (USFWS 2008):

- habitat loss and hydrologic alteration from mining, gas drilling, and construction of industrial wind turbine facilities;
- loss of forest buffer areas from second home development and logging;
- fragmentation from construction of new highways, other roads, and energy transmission rights-of-ways;
- invasive species and aggressive new pathogens and insect pests;
- excessive deer herbivory which eradicates palatable native species;
- airborne pollution, ozone damage, and acid deposition.

Planning for each project site evaluates, to the extent possible, the existing and potential threats to community and ecosystem integrity. Strategies to reduce or eliminate identified threats are built into the restoration plan as practical. For pervasive landscape-scale threats such as airborne pollution and climate change, the site-specific strategy may be to build ecosystem resilience through the community restoration action. When a site faces a severe threat from an adjacent activity that is beyond CASRI's influence, the strategy may be to re-allocate resources to a site that does not face such a threat.

Climate change is one of the newest and least understood threats to natural communities and biodiversity. The Central Appalachians are predicted to warm approximately 5 degrees Fahrenheit by mid-century under medium emissions scenarios (Gervitz et al. 2009). High elevation red spruce forest communities, which occupy the highest and coldest climate niche in the Central Appalachians, are clearly at risk due to climate change. Restoration sites will be prioritized according to analyses of potential resilience to climate change based on topography, elevation, and other factors developed for the ecoregion. One prediction of potentially resilient red spruce forest areas based on habitat suitability (Beane 2010) is shown in Figure 1. Another resource currently under development is a Central Appalachian climate change adaptive capacity analysis for forests by The Nature Conservancy (T. Minney, pers. comm., 2/8/11).

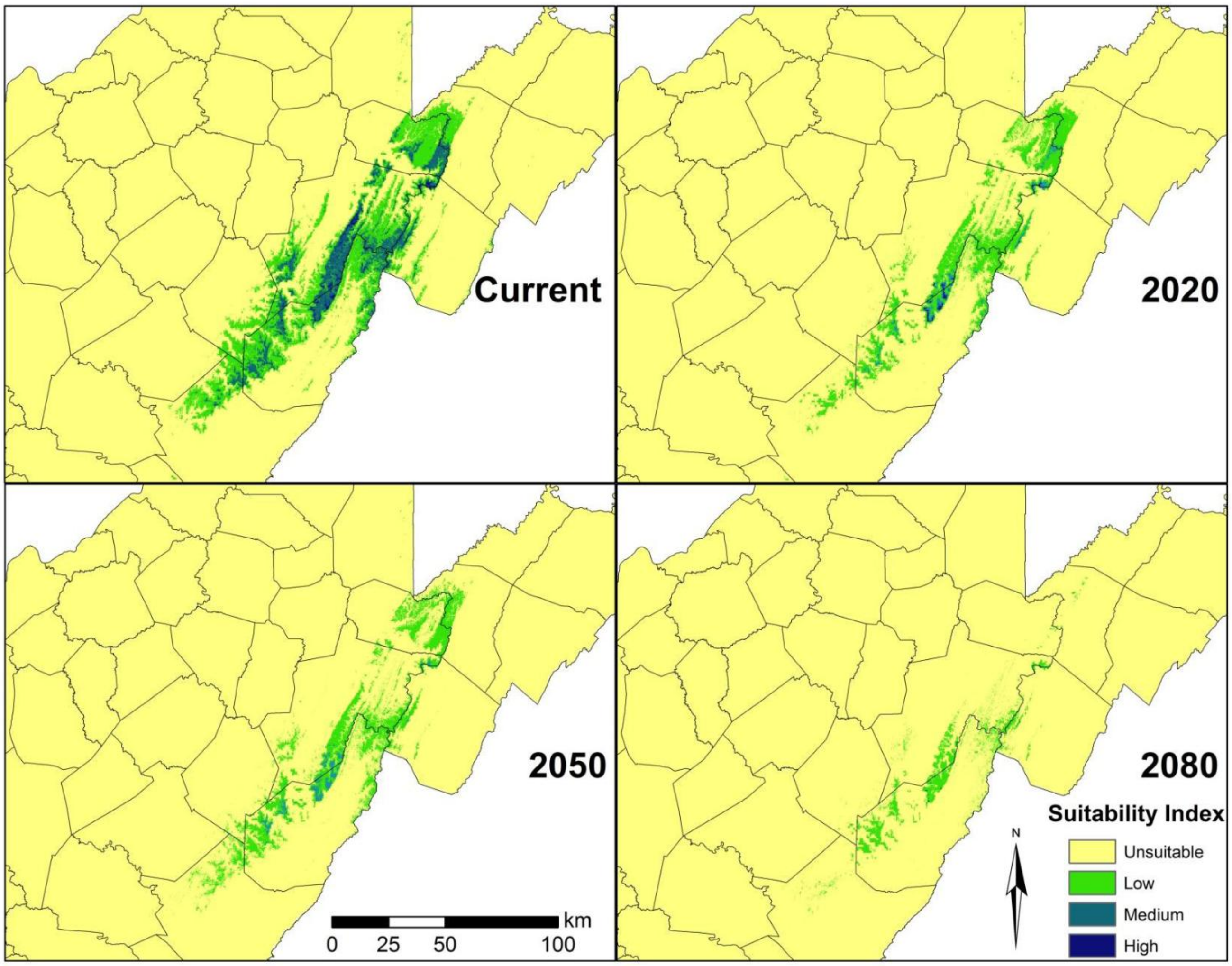

Figure 1. MaxEnt models of red spruce habitat suitability index in West Virginia by time steps under the SRES-B2 emissions model scenario (from Beane 2010, reproduced with permission).

Given model results indicating increased stress to the spruce ecosystem, the work of restoring functional forest communities becomes increasingly important. Increasing the historical spruce component of forests, particularly where climate models show persistence of spruce, will ensure continued habitat suitability for some of the state's rarest species as well as build resiliency through increased connectivity and functional habitat patch size. This is discussed further in Objective 7.

OBJECTIVE 2. *RESTORE HYDROLOGY AND SOILS.*

Hydrology

Many areas in the historic range of red spruce-northern hardwood forests have been altered through development of road systems for natural resource extraction and developments. Logging truck and skid roads not only fragment habitat and increase the potential of invasive species establishment, they may also create hydrologic barriers and channels that move surface water out of historic drainages and increase erosion. Road and trail restoration is necessary when these circumstances occur on a project site to repair hydrologic regimes and to prevent negative impacts to stream flows and vegetative communities.

CASRI hydrologic restoration activities aim to restore cool, moist microclimate forest conditions, where deep organic soil and structurally complex vegetation hold water in the ecosystem and release it slowly to organisms. Overland flows are minimized or eliminated, allowing most of the high rainfall of the spruce zone to be absorbed by the ecosystem and move very slowly toward streams as groundwater. Removal and restoration of unmaintained or retired logging truck roads, skid roads, inadequate culverts, and other features that disturb the local hydrology at restoration sites should reset natural flows and improve soil and organic matter retention there.

Soils

Soils that underlie the spruce-northern hardwoods forest ecosystem have been altered by extensive logging of the primary forest that started around 1880. Some spruce areas were severely burned from logging-associated fires and these soils were severely eroded or burned away. Some of these lands were converted to agriculture, but with the exception of high elevation farms on limestone soils, around the 1940's the agricultural lands were mostly abandoned or reforested to conifer plantations by the Civilian Conservation Corps. Other areas were impacted by surface mining activities during the 20^{th} Century. The topography and soils of mined areas have been severely altered from their natural state.

Intact soils have been found in pockets of spruce forest that were not impacted by intense fires. These are unique remnants of the historic forest and provide an important resource for restoration planning. Increment cores taken at some of these locations have documented rhododendrons and hemlocks that are hundreds of years old. Soils in these remnant pockets have thick organic surface horizons and spodic mineral subsoils (deeper horizons with iron oxide and organic matter moving down through them). These types of soils are desirable because given the very long interval (400-1200+ years) between natural stand-replacing fires (Lorimer and White 2003) and the near non-existence of small ground fires, they have the potential to store carbon in their mineral and organic horizons for several centuries.

In theory the thick organic horizons that may establish under currently maturing spruce stands will serve as potential future sinks of carbon. Similarly, these soils serve as a sink for excessive nitrogen as well, which is important in a region that receives high levels of nitrogen deposition.

The WVNFS exhibits a strong association and positive correlation with the red spruce ecosystem. Soil fungi provide a food source for the WVNFS, and deep organic horizons may enhance the growth of these fungi. The affiliation of the federally threatened Cheat Mountain Salamander (*Plethodon nettingi*) with deep organic horizons needs further investigation, but such soils may also provide a specialized niche for this species. Soils inventory data for the high elevation landscape of the Central Appalachians is incomplete, but the inventory data that exist help us better understand historic forest habitat conditions and present population dynamics of these specialized and habitat-sensitive animals.

Field investigations of soils on high elevations of the Monongahela National Forest lead us to hypothesize that spruce forests once existed on northern hardwood forest and old field sites with soils that currently exhibit remnant spodic horizons. Further soils research is needed to confirm this hypothesis, but for now we are tentatively using these data to assist us in targeting areas we believe will be most conducive to spruce forest conservation and restoration.

CASRI works to preserve locations of remnant occurrences of soil types that occurred under historic red spruce forests and to improve degraded soils through its vegetation restoration activities (i.e. establishing foundation vegetation, community structure, and additional core community species). CASRI does expect that soil conditions under maturing spruce forests will move closer to the deep organic soil conditions over time through restoration work, but understands that it may take centuries to see changes to soil systems.

OBJECTIVE 3. *ESTABLISH FOUNDATION VEGETATION.*

Dominant (or foundation) species are those that have substantial influences on community structure as a consequence of their high biomass, such as an abundant tree species in a forest (Molles 2010). Red spruce is the critical foundation species for CASRI activities. In specialized habitats such as circumneutral wetlands at high elevations, other foundation species including balsam fir (*Abies balsamea*) may share dominance with red spruce.

Re-establishing red spruce as a dominant species over parts of its former range is a key element of CASRI's approach to restoration. Where spruce is currently absent, seedlings may be planted. Seedlings should be propagated from a local seed source to ensure that they are properly adapted to local conditions. Where spruce is present only in the suppressed understory layer of a forest, thinning or snag creation to release understory red spruce trees to the canopy may be the restoration action performed. The design of specific restoration treatments to increase foundation species will vary depending on site conditions and the composition of the target community (see Restoration Scenarios section below).

OBJECTIVE 4. *BUILD PHYSICAL STRUCTURE AND SPATIAL ARRANGEMENTS.*

Physical structure includes conditions such as coarse woody debris, snags, understory development, and the size and spatial distribution of trees and other community components. These components help produce the conditions necessary to ensure the restoration community will begin developing towards the target reference community. They are also important for ensuring specific wildlife habitat niches are met when implementing a restoration plan. Structural implications for wildlife habitat are discussed in Objective 6.

Key structural objectives, as described by Keaton (2006) in his paper on structural complexity enhancement, include the following:

- a vertically differentiated canopy,
- elevated large snag densities,
- elevated downed woody debris densities and volume,
- variable horizontal density (including small canopy gaps),
- basal area biased toward large diameter classes, and

- accelerated growth in the largest trees.

Stem size and density will drive the structure and species composition of the site. Understanding the goals for achieving desired stem densities at various stages of spruce forest restoration is important. One method to measure stand structural diversity is the diameter distribution, which plots the number of stems in each diameter class. Old growth spruce and spruce-northern hardwood stands typically show a characteristic rotated sigmoid diameter distribution, with high numbers of small diameter trees (typically seedlings). However, the bulk of the basal area occurs in the long tail of the curve, which represents the larger size classes (Figure 2). The generalized diameter distribution in Figure 2 can be used as a target to guide partial harvests for spruce release in mature northern hardwood stands, and it can serve as a long-term goal for development of stand structure in younger restoration stands.

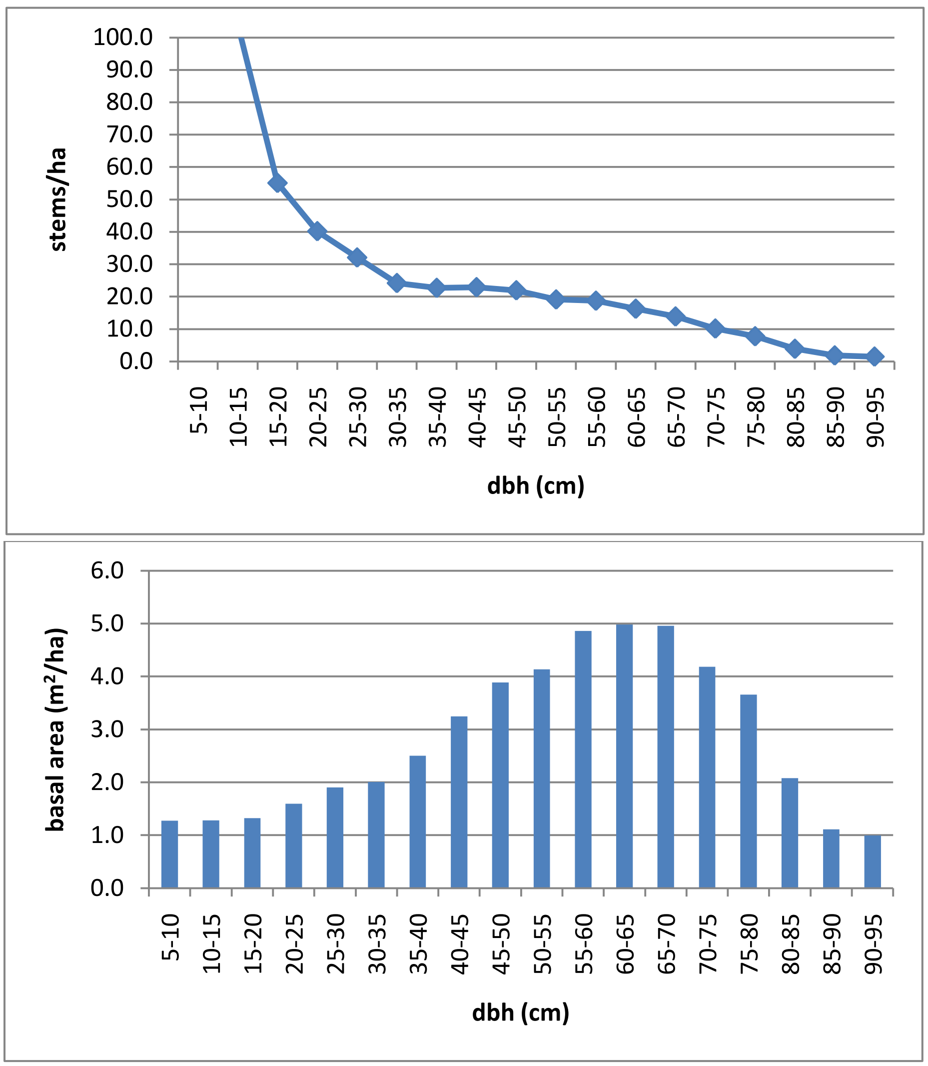

Figure 2. Generalized target diameter and basal area distributions for red spruce-northern hardwood restoration stands (based on data from Keeton 2006, Busing and Wu 1990, Adams and Stephenson 1989, and Nicholas et al. 1992).

CASRI projects aim to establish multi-layered/-aged/-species forest communities rather than single-layered/-aged/-species red spruce plantations. A common CASRI restoration activity is planting red spruce seedlings on old pasture or under second or third-growth northern hardwood forest. Seedlings are typically planted at densities of a few hundred per acre to insure some reach the overstory despite the natural mortality expected during stand development. Monitoring of planted red spruce densities will be necessary as restoration stands develop to insure that sufficient numbers reach the canopy to approximate the conifer component in the reference community. Monitoring can also help ensure that not too many are present, which could create an even-aged spruce plantation condition.

Objective 5. *Establish additional core community species.*

Core community plant species may be absent or poorly represented relative to reference communities in some restoration project sites. These core species are defined by NVC community type descriptions and include southern mountain cranberry, rhododendron, yellow birch, mountain holly and others. The natural community types within West Virginia's red spruce ecosystem are described by the WV Natural Heritage Program (Byers et al. 2007, 2010), and archived in the NVC system maintained by NatureServe (www. natureserve.org).

Each red spruce association defines the vegetation composition and environmental characteristics typical for that type. A summary of West Virginia's Natural Heritage plot data of high quality existing spruce stands provides a local list of species that may be considered when developing restoration plans (Appendix B). Species can be evaluated by their natural regeneration and dispersal methods, wildlife food value, wetland code, and other characteristics such as palatability to deer to guide selection of the best species to target in a site's plan. Important canopy species in each community type are shown in Appendix C. Any plants that are established through planting should be propagated from a local seed source to ensure that they are properly adapted to local conditions.

CASRI monitoring of restoration locations will describe present conditions and indicate deficits of species diversity. Restoration will strive to achieve appropriate species representation according to community targets through active or passive management actions which could include propagation and planting of core species, thinning and invasive species control. Using the defined associations, future monitoring can evaluate if restoration management actions are achieving the desired results, i.e. moving the forest ecosystem under management closer to the described reference conditions.

Objective 6. *Support habitat elements for wildlife.*

Wildlife Habitat Characteristics

Restoration objectives related to wildlife habitat are a key component of CASRI projects. Wildlife habitat restoration may support habitat elements for all functional groups in the ecosystem, or may focus on key habitat elements for particular species of concern. Individual restoration sites may drive habitat restoration towards a wildlife objective based upon land ownership. For example, projects on Federal lands may focus on enhancing habitat for the threatened Cheat Mountain salamander or the recently delisted WVNFS where appropriate. In general however, CASRI will strive to ensure wildlife and aquatic habitat values are considered when developing restoration plans for project sites.

Target characteristics for spruce forest restoration might include the following:

- increasing density of snags; ultimate goal is a snag basal area of at least 8 m^2/ha with approximately 8 snags/ha that are at least 50 cm dbh (Keeton et al. 2007, McGee et al. 1999, Adams and Stephenson 1989, Nicholas et al. 1992)
- increasing downed coarse woody debris, up to 100-200 m^3/ha (McGee et al. 1999, Keeton et al. 2007)
- increasing the density of large trees (>50cm dbh) up to 90 stems/ha (see Figure 2)
- increasing conifer canopy cover (variable depending on the target community) (Ford et al. 2004)
- increasing mid-story spruce stem density (1 – 12 cm dbh size class)

Improving late successional characteristics of forest stands will benefit a diversity of wildlife species. Increasing coarse woody debris and moving towards a more mature forest with a closed canopy will help improve micro-habitat conditions for the threatened Cheat Mountain salamander and other terrestrial woodland salamander species (Dillard et al. 2008). Increased coarse woody debris may also increase foraging opportunities for the WVNFS through increased presence of fungal (truffle) growth (Loeb et al. 2000). Larger trees with more interconnected branches, snag formation and promotion of spruce regeneration will improve general habitat conditions for the WVNFS. Migratory birds of concern such as saw-whet owl and brown creeper will benefit from increased cavity availability and sloughing bark for nesting opportunities. Other migratory birds of concern such as black-throated blue warbler and Canada warbler will benefit from targeted increased mid-story forest cover. Increasing or re-establishing forest cover of headwater streams will improve water quality for native brook trout populations.

Rare species conservation

Red spruce forests support at least 116 animal species, 159 plants and 29 slime molds listed by Central Appalachian states as species of conservation concern in state wildlife action plans. To maintain the rare elements of this ecosystem, it remains critically important to protect and manage existing intact habitat locations, including small pockets of refugia where there is adequate cover of red spruce in the overstory and deep organic soil horizons. Fridley's (2009) conclusions about mountain ecosystems and climate change suggest that if we want to protect biota in the Central Appalachians given anticipated climate change impacts, we need to keep forest cover as intact as possible (especially wetlands and coves which have more buffering capacity), pay attention to organic matter (ergo water-holding capacity) of substrates, and restore hydrology, especially where restoration increases the water retention of ecosystems.

OBJECTIVE 7. *RESTORE LANDSCAPE CONNECTIVITY AND INTEGRITY.*

Red spruce forests are home to many species that are impacted by fragmentation of habitat. Restoring landscape connectivity and integrity is key to restoring healthy communities and building ecosystem resilience. Project sites should be consciously integrated into the larger ecological matrix, through increasing the patch size and connectivity of natural communities and improving their ecological condition. Restoration should aim for patch sizes large enough to be resilient under natural periodic stresses and disturbance regimes.

Guidance for restoring important connections will be gathered through on-going mapping and modeling efforts to evaluate past locations where spruce forest dominated and provide suitable locations for future restoration efforts. Utilizing the best science available, CASRI will focus restoration actions in locations which increase functional patch size for key wildlife species, increase riparian cover for headwaters stream protection, and connect disjunct patches within and between landowners to improve the ecological integrity of the spruce ecosystem.

Projects will also design ecosystem restoration in blocks of sufficient size and configurations to meet suitable habitat requirements for red spruce forest focal species of the Central Appalachians. Recommendations of minimum patch sizes for focal species' habitats can be used to inform restoration site design.

Enhancing connectivity within the forest landscape also plays a role in supporting resiliency of the ecosystem to climate change. Restoring connectivity will maintain or improve the permeability of land and water for the movement of both individuals and ecological processes (e.g. hydrological flows) (Game et. al. 2010). Both vertical connectivity (elevation) and north-south (latitudinal) landscape-scale connectivity provide movement corridors for wildlife and dispersal options for forest species depending on their capabilities.

Additionally, larger intact blocks of forest should better withstand some climate change-related impacts. For example, the predicted increase in extreme weather events could change the frequency of disturbance events on an ecosystem (Aldous et al. 2007). More frequent disturbances may lead to a shift to forests that are younger and of species that are more fast-growing, short-lived, and disturbance-tolerant (including invasive plants). A large, intact forest landscape has the area to absorb the severe weather events that might lead to the destruction of a smaller forest patch.

RESTORATION SCENARIOS BY INITIAL CONDITION

CASRI restoration projects start from a variety of initial site conditions:

- Northern hardwood forest with red spruce in the understory
- Northern hardwood forest with little to no red spruce in understory
- Surface mine
- Anthropogenic pasture (grassland and shrubland)
- Plantation forest (native and non-native species)
- Degraded riparian areas and wetlands
- Dense spruce monocultures

For each initial site condition, CASRI is developing strategies for different stages of restoration so that our 'lessons learned' may benefit other projects and adaptive management is practiced. The starting point for any restoration project will be affected by the existing ecological limitations and be defined by the targeted forest community type. The following site conditions and strategies are listed as general conditions and actions which may be taken to address a site restoration project, but they are not intended to be all inclusive. Each site will offer unique restoration challenges that will require careful planning and strategy development in order to set the area on a trajectory towards the desired future forest community. Additionally, the starting point for each restoration project will help define the required continued involvement of area managers to ensure the appropriate development of desired forest characteristics.

Brief strategies for different initial site conditions are outlined below. These strategies are works in progress, and will be improved and refined as the experience of the CASRI partners grows.

NORTHERN HARDWOOD FOREST WITH RED SPRUCE IN THE UNDERSTORY

- Utilize reference plant community and structural references such as the rotated sigmoid diameter distribution curve to develop canopy species composition and structural targets, including the number of spruce in canopy/acre. Overstory spruce targets will vary by site location and natural community and will be based on the NVC type identified as the restoration target.
- Protect any existing small remnant patches of mature spruce from disturbance during activities
- Use noncommercial methods (snag creation, large woody debris creation) to thin the hardwood canopy. Alternatively, use accepted silvicultural practices to selectively harvest an appropriate number of canopy hardwoods to release spruce in the understory and move toward the targeted final forest community. Intensity of the harvest will vary depending on the amount and condition of advanced spruce regeneration, the amount of shade needed to prevent regeneration of undesirable species, and the amount of hardwood overstory that needs to be retained to maintain desired mature forest habitat structure. Snags and coarse woody debris retention should be maximized to enhance wildlife habitat.
- Retain canopy hardwood species as necessary to reflect targeted final forest community description. Suggested thinning is no more than 1/3 of canopy at a time.
- Use targeted herbicide applications or mechanical methods as needed to control excessive competition from midstory and understory saplings.
- Identify associated species in mid and understory layers. If necessary, plant seedlings or broadcast seed of appropriate species based upon targeted final forest community.
- Restore any unneeded roads or skid trails to prevent hydrologic disruption and spread of invasive species. Any access routes that will be needed for future management entries should be stabilized and properly drained to prevent erosion and sedimentation.
- Control invasive species.
- As the stand develops, evaluate the need for additional management actions to achieve the desired species composition and structure.
- Minimize or eliminate new road construction for silvicultural operations.

NORTHERN HARDWOOD FOREST WITH LITTLE OR NO RED SPRUCE IN THE UNDERSTORY

- Determine appropriateness of spruce restoration on site and verify through historic mapping or current modeling efforts.
- Determine target reference spruce community based upon site conditions.
- Restore any unneeded roads or skid trails to prevent hydrologic disruption and spread of invasive species. Any access routes that will be needed for future management entries should be stabilized and properly drained to prevent erosion and sedimentation.
- Underplant forest with spruce seedlings – density of planting determined by site conditions and targeted final future forest community. Current restoration projects have used seedling densities between 100 and 300 seedlings per acre.
- Identify associated species in mid and understory layers. If necessary, plant seedlings or broadcast seed of appropriate species based upon targeted final forest community.
- Use targeted herbicide applications or mechanical methods as needed to control excessive competition from midstory and understory saplings.
- Control invasive species.
- As the planted seedlings reach the sapling stage, use noncommercial methods (snag creation, large woody debris creation) to thin the hardwood canopy. Alternatively, use accepted silvicultural practices to selectively harvest an appropriate number of canopy hardwoods to release spruce in the understory and move toward the targeted final forest community. Intensity of the harvest will vary depending on the amount and condition of

advanced spruce regeneration, the amount of shade needed to prevent regeneration of undesirable species, and the amount of hardwood overstory that needs to be retained to maintain desired mature forest habitat structure.

- Thin understory spruce as necessary to ensure future composition is on target with desired future forest community.
- Minimize or eliminate new road construction for silvicultural operations.

SURFACE MINE

- Use deep tillage and re-contouring as necessary to aerate soil and restore microtopography or surface roughness.
- Ensure seasonal and permanent water flows are restored and are not causing excessive erosion.
- Depending on the need as dictated by site conditions, implement measures to ameliorate acidic drainage and heavy metal pollution.
- Plant seedlings, ensuring that the mixture of spruce and hardwood species reflects the targeted final forest community. Current restoration projects have planting in densities ranging 300 to 600 per acre.
- Identify associated species in mid and understory layers. Plant seedlings or broadcast seed of appropriate species based upon targeted final forest community (e.g. planted aspen seedlings can serve as 'pioneer' forest cover and provide early successional wildlife habitat). See Appendix D for suggested species.
- Control invasive species, sod grasses, and other vegetation that may outcompete planted vegetation.
- Control vehicular access.

GRASSLAND AND SHRUBLAND

- Prepare the site to enhance seedling establishment –use tree mats, scalp, disc or till as necessary to break sod layer.
- Plant seedlings – ensure mixture of spruce and hardwood species in a composition which reflects targeted final forest community. Current restoration projects have planting in densities ranging 300 to 600 per acre.
- Identify associated species in mid and understory layers. Plant seedlings or broadcast seed of appropriate species based upon targeted final forest community.
- Control invasive species.
- Control native and non-native grass species through grass-selective herbicide application when practical and beneficial.

PLANTATION FOREST (NON-NATIVE SPECIES)

- Use accepted silvicultural practices to harvest part of the plantation overstory. The intensity of the harvest will depend on the amount of increased light needed on the forest floor to stimulate existing spruce seedling growth or to support newly planted seedling growth, the amount of shade needed to prevent regeneration of undesirable species, and the degree to which the existing plantation canopy provides desirable habitat structure. Minimize any potential adverse impacts to rare species, such as the WVNFS.
- Alternatively, noncommercial methods (snag creation, large woody debris creation) can be used to thin the plantation canopy.
- Use targeted herbicide applications or mechanical methods as needed to control excessive competition from midstory and understory saplings.

- Restore any unneeded roads or skid trails to prevent hydrologic disruption and spread of invasive species. Any access routes that will be needed for future management entries should be stabilized and properly drained to prevent erosion and sedimentation.
- If adequate advanced regeneration does not already exist, plant canopy species seedlings to ensure mixture of spruce and hardwood species in a composition which reflects targeted final forest community.
- Identify associated species in mid and understory layers. If necessary, plant seedlings or broadcast seed of appropriate species based upon targeted final forest community.
- Control invasive species.
- As planted vegetation and/or advanced regeneration develops, implement additional partial harvests or noncommercial treatments to release the desirable regeneration. The intensity of these partial harvests will depend on the degree of release that is needed and the degree to which the plantation overstory provides desirable habitat structure.
- Minimize or eliminate new road construction for silvicultural operations.

PLANTATION FOREST (NATIVE SPECIES)

- Utilize reference plant community and structural references such as the rotated sigmoid diameter distribution curve to develop canopy species composition and structural targets, including the number of spruce in canopy/acre.
- Use noncommercial methods (snag creation, large woody debris creation) to thin the plantation canopy, create vertical and horizontal habitat structure, and release spruce regeneration.
- Alternatively, use accepted silvicultural practices to harvest identified % of canopy trees (or # of trees per acre) to meet the restoration community description, keeping in mind the need for snags and coarse woody debris. Use selective harvesting or thinning to create canopy gaps and reduce evenness of plantation forest. In designing the intensity of the harvest, make allowances for expected natural mortality and future management actions. Be mindful of the potential for increased wind throw in thinned spruce stands. This method should be used only when any potential adverse impacts to rare species, such as the WVNFS, can be minimized.
- Use targeted herbicide applications or mechanical methods as needed to control excessive competition from midstory and understory saplings.
- Restore any unneeded roads or skid trails to prevent hydrologic disruption and spread of invasive species. Any access routes that will be needed for future management entries should be stabilized and properly drained to prevent erosion and sedimentation.
- If adequate advanced regeneration does not already exist, plant canopy species seedlings in newly created canopy gaps to accelerate growth. Seedlings will match targeted species composition.
- Identify associated species in mid and understory layers. If necessary, plant seedlings or broadcast seed of appropriate species based upon targeted final forest community.
- Control invasive species.
- As the stand develops, evaluate the need for additional management actions to achieve the desired species composition and structure.
- Minimize or eliminate new road construction for silvicultural operations.

DEGRADED RIPARIAN AND WETLAND AREAS

- Restore hydrology. Time hydrology restoration such that saturated conditions do not interfere with other restoration activities.

- Reduce sources of sedimentation through erosion control practices.
- Identify appropriate forested corridor width along riparian zone, locate deficiencies. Appropriate width may be based on water quality goals, wildlife goals or a combination.
- Plant canopy species seedlings to ensure future adequate riparian forest width. Design planting such that canopy trees do not impact naturally open wetland communities.
- Identify and plant/broadcast seed understory-mid story layers based upon targeted final forest community.
- Control invasive species.

DENSE RED SPRUCE MONOCULTURES <70 YEARS OLD

- Utilize reference plant community and structural references such as the rotated sigmoid diameter distribution curve to develop canopy species composition and structural targets, including the number of spruce in canopy/acre.
- Use non-commercial methods such as snag creation and large woody debris creation to thin the canopy, create vertical and horizontal habitat structure, and release regeneration of spruce and other desirable species.
- Alternatively, use accepted silvicultural practices to thin identified % of canopy trees (or # of trees per acre) to meet the restoration community description, keeping in mind the need for snags and coarse woody debris. Be mindful of the potential for increased wind throw in thinned spruce stands. This method should be used only when any potential adverse impacts to rare species, such as the WVNFS, can be minimized.

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APPENDIX A: EXCERPT FROM SER PRIMER

From http://www.ser.org/content/ecological_restoration_primer.asp

This section addresses the question of what is meant by “recovery” in ecological restoration. An ecosystem has recovered – and is restored – when it contains sufficient biotic and abiotic resources to continue its development without further assistance or subsidy. It will sustain itself structurally and functionally. It will demonstrate resilience to normal ranges of environmental stress and disturbance. It will interact with contiguous ecosystems in terms of biotic and abiotic flows and cultural interactions.

The nine attributes listed below provide a basis for determining when restoration has been accomplished. The full expression of all of these attributes is not essential to demonstrate restoration. Instead, it is only necessary for these attributes to demonstrate an appropriate trajectory of ecosystem development towards the intended goals or reference. Some attributes are readily measured. Others must be assessed indirectly, including most ecosystem functions, which cannot be ascertained without research efforts that exceed the capabilities and budgets of most restoration projects.

1. The restored ecosystem contains a characteristic assemblage of the species that occur in the reference ecosystem and that provide appropriate community structure.
2. The restored ecosystem consists of indigenous species to the greatest practicable extent. In restored cultural ecosystems, allowances can be made for exotic domesticated species and for non-invasive ruderal and segetal species that presumably co-evolved with them. Ruderals are plants that colonize disturbed sites, whereas segetals typically grow intermixed with crop species.
3. All functional groups necessary for the continued development and/or stability of the restored ecosystem are represented or, if they are not, the missing groups have the potential to colonize by natural means.
4. The physical environment of the restored ecosystem is capable of sustaining reproducing populations of the species necessary for its continued stability or development along the desired trajectory.
5. The restored ecosystem apparently functions normally for its ecological stage of development, and signs of dysfunction are absent.
6. The restored ecosystem is suitably integrated into a larger ecological matrix or landscape, with which it interacts through abiotic and biotic flows and exchanges.
7. Potential threats to the health and integrity of the restored ecosystem from the surrounding landscape have been eliminated or reduced as much as possible.
8. The restored ecosystem is sufficiently resilient to endure the normal periodic stress events in the local environment that serve to maintain the integrity of the ecosystem.
9. The restored ecosystem is self-sustaining to the same degree as its reference ecosystem, and has the potential to persist indefinitely under existing environmental conditions. Nevertheless, aspects of its biodiversity, structure and functioning may change as part of normal ecosystem development, and may fluctuate in response to normal periodic stress and occasional disturbance events of greater consequence. As in any intact ecosystem, the species composition and other attributes of a restored ecosystem may evolve as environmental conditions change.

Appendix B: NVC Key and Summary Descriptions

How do I choose an NVC reference unit for my restoration project?

Use the rough key below to determine which National Vegetation Classification (NVC) unit is likely to fit your project area. If you are not sure based on the key, you may wish to choose the "Red spruce – Yellow birch" type, which is the most common and widespread of our red spruce forests in West Virginia. You can also read the brief descriptions of the types below to verify your choice, or check the more detailed tables and descriptions in the references listed at the end. If you have intact red spruce communities adjacent to and in the same environmental setting as your site, then you can use the floristic keys in the references at the end to make a more accurate choice regarding the best NVC unit to use as a restoration target. The West Virginia Natural Heritage Program at WVDNR can provide assistance as needed.

1. My project is on an upland site. **2**
1. My project is in a wetland. **8**

<u>Uplands</u>

2. My site is at an elevation below 850 m (2800 ft): (stop here: you are probably too low for an upland red spruce forest to grow)
2. My site is at an elevation above 850 m (2800 ft) **3**
3. The bedrock at my site is shale or limestone: **Red spruce – hemlock – beech forest**
3. The bedrock at my site is sandstone **4**
4. My site is on exposed rock or talus along the Allegheny Front: **Red spruce – heath rocky woodland**
4. My site is not on exposed rock or talus along the Allegheny Front **5**
5. My site is at an elevation above 1340 m (4400 feet): **Red spruce – southern mountain cranberry forest**
5. My site is at an elevation below 1340 m (4400 feet) **6**
6. My site is at an elevation above 1180 m (3870 ft): **Red spruce – yellow birch forest**
6. My site is at an elevation below 1180 m (3870 ft) **7**
7. My site is in a sheltered, moist cove: **Red spruce – rhododendron forest**
7. My site is not in a sheltered, moist cove: **Red spruce – hemlock – beech forest**

<u>Wetlands</u>

8. My site is a peatland (stop here: peatlands are rare habitats with many sensitive species and should be assessed by a conservation ecologist prior to any restoration work)
8. My site is not a peatland **9**
9. My site is at an elevation below 770 m (2800 ft): (stop here: you are probably too low for a red spruce wetland to grow)
9. My site is at an elevation above 770 m (2800 ft) **10**
10. The bedrock at my site is shale or limestone AND my site is either in Canaan Valley, Gandy Creek headwaters, the headwaters of the East Fork of the Greenbrier, or near Blister Run on the Upper Shavers Fork **11**
10. The bedrock at my site is sandstone, or I am not in the places listed above **13**
11. The bedrock at my site is limestone, or the soil pH is greater than 5.0: **Balsam fir – black ash swamp**
11. The bedrock at my site is shale, or the soil pH is between 4.0-5.0 **12**
12. My site is dry enough that my feet don't get wet in regular hiking boots. White-edge sedge,

clubmosses, partridgeberry, and bracken fern may be abundant: **Balsam fir – oatgrass swamp**

12. My site is wetter, with some obligate wetland sedges or grasses present: **Balsam fir – winterberry swamp**

13. My site is at an elevation above 1140 m (3740 feet): **Red spruce – southern mountain cranberry swamp**

13. My site is at an elevation below 1140 m (3740 feet) **14**

14. The soil pH at my site is greater than 4.0: **Red spruce – yellow birch – mannagrass swamp**

14. The soil pH at my site is less than 4.0: **Red spruce – hemlock – rhododendron swamp**

UPLAND RED SPRUCE COMMUNITIES

Red Spruce – Heath Rocky Woodland
West Virginia Scientific Name: *Picea rubens / Vaccinium angustifolium* Rocky Woodland
NVC Code and Name: CEGL006254 *Picea rubens / Vaccinium angustifolium* High Allegheny Plateau Woodland
Conservation Status: G2 S1

Geographic extent: This red spruce rocky woodland occurs in a linear band along the Allegheny Front at high elevations in the drier northeastern part of the red spruce range in West Virginia.

Characteristic species: This upland spruce type has a low, stunted, open woodland canopy averaging 41% cover. The canopy is strongly dominated by Picea rubens, with much lower cover of *Pinus rigida, Acer rubrum, Betula alleghaniensis* var. *alleghaniensis, Amelanchier laevis, Sorbus americana,* and *Tsuga canadensis.*

The tall shrub layers averages 43% cover and is dominated by *Kalmia latifolia* with *Nemopanthus mucronatus, Rhododendron maximum,* and regenerating tree saplings. The short shrub layer is diverse, averaging 35% cover, and often includes *Vaccinium angustifolium, Menziesia pilosa, Gaylussacia baccata, Nemopanthus mucronatus, Photinia melanocarpa, Rhododendron maximum,* and *Vaccinium erythrocarpum.* Occasional shrubs include *Ribes rotundifolium, Prunus pensylvanica* var. *pensylvanica, Gaultheria procumbens, Ribes glandulosum, Vaccinium myrtilloides, Ilex montana, Acer pensylvanicum, Acer spicatum, Hamamelis virginiana, Rhododendron prinophyllum,* and *Viburnum nudum* var. *cassinoides.*

The herbaceous layer is sparse, with only 3% average cover. *Maianthemum canadense, Pteridium aquilinum,* and *Polypodium appalachianum* have constancy >40%. Additional herbaceous species may include *Deschampsia flexuosa* var. *flexuosa, Aralia nudicaulis, Epigaea repens,* and *Carex brunnescens.* The non-vascular stratum has significant diversity, much of which occurs as abundant crustose lichens on the rocky substrate. The crustose lichens have not been thoroughly documented for this type. Non-vascular cover averages 21% and in addition to crustose lichens, often includes *Cladonia rangiferina, Umbilicaria muehlenbergii, Hypnum imponens, Leucobryum glaucum, Pleurozium schreberi* and *Lasallia papulosa.*

Red Spruce – Hemlock – Beech Forest
West Virginia Scientific Name: *Picea rubens – Tsuga canadensis – Fagus grandifolia* / Dryopteris *intermedia* Forest

NVC Code and Name: CEGL006029 *Picea rubens - Tsuga canadensis - Fagus grandifolia / Dryopteris intermedia* Forest
NatureServe Conservation Status: G3 S3

West Virginia Description: This forest type occupies relatively warmer, lower elevations within the red spruce zone in West Virginia, at elevations above 850 m (2800 feet). A less common variant of this type extends into the middle and upper elevations of the spruce zone along slightly richer substrates underlain by shale and limestone.

Characteristic species: The canopy averages 62% cover and is dominated by *Picea rubens* with *Tsuga canadensis, Betula alleghaniensis* var. *alleghaniensis,* and *Acer rubrum.* Less common are *Fagus grandifolia, Prunus serotina* var. *serotina,* and *Betula lenta,* and occasional canopy species include *Acer saccharum* var. *saccharum, Magnolia fraseri, Liriodendron tulipifera,* and *Magnolia acuminata.* The subcanopy is relatively lush, with average 38% cover, and exhibits co-dominance by several species including *Picea rubens, Betula alleghaniensis* var. *alleghaniensis, Tsuga canadensis, Acer pensylvanicum, Acer rubrum, Fagus grandifolia,* and *Acer saccharum* var. *saccharum.* Less common subcanopy species are *Magnolia acuminata, Betula lenta, Magnolia fraseri, Prunus serotina* var. *serotina, Crataegus* spp.*, Amelanchier laevis, Fraxinus americana,* and *Tilia americana.*

The shrub layers are relatively sparse in this community compared to other upland spruce communities. The tall shrub layer, averaging 16% cover, is dominated by regenerating tree saplings, especially *Picea rubens, Fagus grandifolia, Tsuga canadensis,* and *Acer pensylvanicum.* Shrubs that are occasionally present include *Ilex montana, Rhododendron maximum, Kalmia latifolia,* and *Viburnum lantanoides.* The short shrub layer is sparse at 5% cover and consists largely of regenerating tree species, with occasional presence of *Vaccinium erythrocarpum, Ilex montana, Smilax rotundifolia, Kalmia latifolia,* and *Menziesia pilosa.*

This community has the richest herbaceous layer of any of the upland spruce communities in West Virginia. Averaging 23% cover, it is strongly dominated by *Dryopteris intermedia*. Other common species include *Maianthemum canadense, Oxalis montana, Mitchella repens, Dennstaedtia punctilobula, Trillium undulatum, Medeola virginiana, Oclemena acuminata, Dryopteris campyloptera, Anemone quinquefolia, Lycopodium dendroideum, Arisaema triphyllum, Carex debilis* var. *rudgei, Danthonia compressa, Galium triflorum, Huperzia lucidula, Lycopodium clavatum, Lycopodium obscurum, Platanthera orbiculata, Polypodium appalachianum,* and *Tiarella cordifolia.* The non-vascular stratum averages 20% cover, the lowest bryophyte cover among upland red spruce communities in West Virginia. *Bazzania trilobata* and *Hypnum imponens* are the dominant species, followed by *Dicranum scoparium*, *Thuidium delicatulum, Brotherella recurvans,* and *Dicranodontium denudatum.*

Red Spruce – Rhododendron Forest
West Virginia Scientific Name: *Picea rubens / Rhododendron maximum* Forest
NVC Code and Name: CEGL006152 *Picea rubens - (Tsuga canadensis) / Rhododendron maximum* Forest
NatureServe Conservation Status: G2G3 S2

Geographic extent: This species-poor forest type occurs primarily at low and middle elevations within the red spruce zone of West Virginia. It generally grows on moist, protected landforms and can include slope forests, boulderfields, ravines, and occasional ridges.

Characteristic species: The canopy layer averages 58% cover and is dominated by *Picea rubens* with lower cover by *Tsuga canadensis, Acer rubrum,* and *Betula alleghaniensis* var. *alleghaniensis*. Occasionally *Betula lenta* and *Amelanchier arborea* var. *arborea* are also present in the canopy. The subcanopy averages 35% cover and is dominated by *Betula alleghaniensis* var. *alleghaniensis* and *Picea rubens,* with lower cover of *Tsuga canadensis* and *Acer rubrum*. Other subcanopy trees may include *Sorbus americana, Amelanchier arborea* var. *arborea, Betula lenta,* and *Magnolia fraseri.*

The tall shrub layer is dense, averaging 63% cover and strongly dominated by *Rhododendron maximum*. Low cover of *Ilex montana* and various tree seedlings may intermix, and occasionally a few shrubs of *Kalmia latifolia or Rhododendron catawbiense* occur. The short shrub layer is much less dense, averaging 13% cover and with the same dominance and species distribution as the tall shrubs. Occasional low cover of *Vaccinium erythrocarpum, Menziesia pilosa,* and *Vaccinium angustifolium* may occur in the short shrub stratum.

The herbaceous layer is extremely sparse, averaging only 1% cover. There are no herbaceous species other than tree seedlings that have constancy >20%. Those that do occur with low constancy and cover include *Dryopteris intermedia, Dryopteris campyloptera, Oclemena acuminata, Oxalis montana,* and *Polypodium appalachianum*. The bryophyte layer averages 28% cover and is strongly dominated by *Bazzania trilobata,* with much lower cover of *Hypnum imponens, Leucobryum glaucum, Brotherella recurvans,* and *Dicranum scoparium.*

Red Spruce – Southern Mountain Cranberry Forest
West Virginia Scientific Name: *Picea rubens / Vaccinium erythrocarpum / Dryopteris campyloptera* Forest
NVC Code and Name: CEGL007131 *Picea rubens - (Abies fraseri) / Vaccinium erythrocarpum / Oxalis montana - Dryopteris campyloptera / Hylocomium splendens* Forest
NatureServe Conservation Status: G2 S1

Geographic extent: This forest type is restricted to the highest elevations and coldest climate niche within the red spruce zone in West Virginia, occurring primarily on ridgetops at elevations above 1350 m (4400 feet).

Characteristic species: This spruce forest has a dense canopy (70% cover) that is strongly dominated by *Picea rubens,* with much lower cover by *Betula alleghaniensis* var. *alleghaniensis* and *Acer rubrum. Prunus serotina* var*. serotina* and *Sorbus americana* are occasionally present in the canopy. The subcanopy (20% cover) is much less dense with *Betula alleghaniensis* var. *alleghaniensis, Picea rubens,* and *Acer rubrum* as co-dominants, and occasional low cover by *Sorbus americana* or *Fagus grandifolia*.

The tall and short shrub strata are dominated by *Vaccinium erythrocarpum,* which generally grows as a short shrub but can reach heights of more than 2 meters where growing conditions are favorable. The tall shrub layer averages 20% cover and may also include *Ilex montana, Acer pensylvanicum,* and regenerating canopy saplings. Occasionally, *Menziesia pilosa, Rhododendron maximum, Rhododendron prinophyllum*, and *Viburnum lantanoides* may be present in the tall shrub stratum. The short shrub stratum averages 18% cover, with species distribution very similar to the tall shrub layer, including occasional trace amounts of *Vaccinium angustifolium*.

The herbaceous layer is sparse, averaging only 7% cover. Herbaceous species with constancy >50% include *Dryopteris intermedia, Dryopteris campyloptera, Maianthemum canadense, Oxalis montana, Clintonia borealis,* and *Trillium undulatum.* Less common herbaceous species include

Dennstaedtia punctilobula, Lycopodium dendroideum, Polypodium appalachianum, Lycopodium clavatum, Lycopodium obscurum, Oclemena acuminata, and *Osmunda 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. Non-vascular cover is high (averaging 54%) in this forest type, with *Bazzania trilobata* dominant, followed by *Hypnum imponens, Dicranum scoparium,* and *Brotherella recurvans.* Other common bryophytes include *Leucobryum glaucum, Cladonia furcata, Polytrichum pallidisetum,* and *Dicranodontium denudatum.*

Red Spruce – Yellow Birch Forest
West Virginia Scientific Name: *Picea rubens – Betula alleghaniensis* var*. alleghaniensis / Bazzania trilobata* Forest
NVC Code and Name: CEGL008501 *Picea rubens / Betula alleghaniensis / Bazzania trilobata* Forest
NatureServe Conservation Status: G2 S2

Geographic extent: This community occurs primarily in the Allegheny Mountains of Greenbrier, Pendleton, Pocahontas, Randolph, and Tucker Counties. This is the typical forest encountered in the heart of red spruce habitat in West Virginia, with widespread distribution in the middle and upper elevations (1070-1400 m [3500-4600 feet]) of the red spruce zone in the state. The community occurs on both gentle slopes bordering high-elevation valley floors and on more exposed ridge crests and rocky summits.

Characteristic species: The canopy averages 61% cover and is strongly dominated by *Picea rubens,* with lower cover of *Betula alleghaniensis* var. *alleghaniensis* and *Acer rubrum.* Other trees that occasionally occur with low cover in the canopy include *Tsuga canadensis, Betula lenta, Acer pensylvanicum, Pinus strobus, Sorbus americana, Amelanchier laevis,* and *Quercus rubra*. The subcanopy averages 28% cover and is very similar in dominance and composition to the canopy, with the occasional addition of *Magnolia fraseri, Acer spicatum, Amelanchier arborea* var. *arborea,* and *Fagus grandifolia.*

The tall shrub stratum averages 23% cover and is strongly dominated by saplings of the regenerating canopy species, especially *Picea rubens* and *Betula alleghaniensis* var. *alleghaniensis. Ilex montana, Kalmia latifolia,* and *Rhododendron maximum* occur frequently in the tall shrub layer. Rarely, a small amount of *Hamamelis virginiana, Menziesia pilosa,* or *Nemopanthus mucronatus* may be present. The short shrub stratum averages only 8%, again dominated by regenerating canopy species, with *Ilex montana, Vaccinium erythrocarpum, Kalmia latifolia,* and *Rhododendron maximum.* Occasional very low cover of *Menziesia pilosa, Vaccinium angustifolium, Vaccinium myrtilloides, Gaylussacia baccata, Smilax rotundifolia,* and *Viburnum lantanoides* may be present.

The herbaceous stratum averages 6% cover and often includes Dryopteris intermedia, Oxalis montana, and Dennstaedtia punctilobula. Less common are Trillium undulatum, Maianthemum canadense, Dryopteris campyloptera, Lycopodium obscurum, Monotropa uniflora, Carex debilis var. rudgei, Mitchella repens, and Oclemena acuminata. The non-vascular stratum averages 53% cover and is strongly dominated by Bazzania trilobata, with lesser amounts of Hypnum imponens, Dicranum scoparium, Polytrichum pallidisetum, Brotherella recurvans, and Leucobryum glaucum.

WETLAND RED SPRUCE COMMUNITIES

Balsam Fir – Black Ash Swamp

West Virginia Scientific Name: *Fraxinus nigra - Abies balsamea / Alnus incana* ssp*. rugosa / Rhamnus alnifolia / Carex bromoides* ssp. *bromoides* Rich Swamp
NVC Code and Name: CEGL006003: *Fraxinus nigra - Abies balsamea / Rhamnus alnifolia* Forest
NatureServe Conservation Status: G1 S1

Geographic extent: The known distribution of this community is restricted to frost-pocket, high-elevation wetlands on the Mississippian Greenbrier limestone in Canaan Valley, in the Allegheny Mountains region of West Virginia, at elevations between 960 and 1000 m above sea level. This type may have historically occurred at a second site with similar geologic and climatic conditions at Blister Swamp in Pocahontas County, WV.

Characteristic species: The canopy is open to closed and dominated by stunted, inundation-stressed *Abies balsamea* (balsam fir), *Fraxinus nigra* (black ash), and *Tsuga canadensis* (eastern hemlock). Other tree species occurring in the canopy include *Acer rubrum* (red maple), *Picea rubens* (red spruce), and *Betula alleghaniensis* var. *alleghaniensis* (yellow birch). The subcanopy ranges from 5-30% cover and is dominated by *Abies balsamea* (balsam fir) with varying amounts of *Betula alleghaniensis* var. *alleghaniensis* (yellow birch), *Tsuga canadensis* (eastern hemlock), *Picea rubens* (red spruce), and *Fraxinus nigra* (black ash). *Acer rubrum* (red maple), *Amelanchier* (serviceberry) spp., *Crataegus* (hawthorn) spp., and *Sorbus americana* (American mountain ash) may be present with very low cover in the subcanopy.

The tall-shrub layer ranges from 10-100% cover and is dominated by *Alnus incana* ssp. *rugosa* (speckled alder) with locally abundant *Ilex verticillata* (common winterberry) and sometimes vigorous *Picea rubens* (red spruce) regeneration in this stratum. *Rhododendron maximum* (great laurel) may be present with low cover. The short-shrub layer covers 5-30% and is dominated by *Rhamnus alnifolia* (alderleaf buckthorn) or rarely by *Cornus amomum* (silky dogwood).

The herbaceous ground layer is extensive and diverse, ranging from 50-100% cover and typically including over 50 species. The most abundant species are *Carex bromoides* ssp. *bromoides* (bromelike sedge) and *Glyceria striata* (fowl mannagrass). Other common species include *Arisaema triphyllum* (Jack in the pulpit), *Caltha palustris* var. *palustris* (yellow marsh marigold), *Carex gynandra* (nodding sedge), *Dryopteris cristata* (crested woodfern), *Impatiens capensis* (jewelweed), *Juncus effusus* (common rush), *Lycopus uniflorus* (northern bugleweed), *Maianthemum canadense* (Canada mayflower), *Osmunda cinnamomea* var. *cinnamomea* (cinnamon fern), *Packera aurea* (golden ragwort), *Polygonum sagittatum* (arrowleaf tearthumb), *Rubus hispidus* (bristly dewberry), and *Solidago rugosa* (wrinkleleaf goldenrod). *Poa alsodes* (grove bluegrass) is locally abundant. Nonvascular plants have 3-50% cover in this community. Dominant bryophytes are *Sphagnum* spp., *Hypnum imponens*, *Thuidium delicatulum*, and *Bazzania trilobata*, with 12 other bryophyte species occasionally noted.

Balsam Fir – Oatgrass Swamp
West Virginia Scientific Name: *Abies balsamea - Picea rubens / Danthonia compressa - Lycopodium* spp. */ Sphagnum* spp. Forested Swamp
NVC Code and Name: CEGL006592: *Abies balsamea - Picea rubens / Danthonia compressa - Lycopodium* spp. */ Sphagnum* spp. Forest
NatureServe Conservation Status: G2 S2

Geographic extent: The known distribution of this community is restricted to the Allegheny Mountains region of West Virginia, at elevations between 960 and 1130 m. Within this region, the community is known only from Canaan Valley, Blister Run Swamp, and Dolly Sods.

Characteristic species: The canopy is open to closed and dominated by *Abies balsamea* (balsam fir) and *Picea rubens* (red spruce), with occasional presence of *Prunus serotina* var. *serotina* (black cherry). Mean canopy cover is 30%. The subcanopy averages 19% cover and is dominated by *Abies balsamea* (balsam fir) with smaller amounts of *Picea rubens* (red spruce), *Acer rubrum* (red maple), and *Betula alleghaniensis* var. *alleghaniensis* (yellow birch). *Tsuga canadensis* (eastern hemlock), *Amelanchier arborea* var. *arborea* (common serviceberry), and *Crataegus* (hawthorn) spp. may be present with very low cover in the subcanopy.

The tall-shrub layer averages 31% cover and is also dominated by *Abies balsamea* (balsam fir) and *Picea rubens* (red spruce). The short-shrub layer averages 18% cover, with locally abundant *Vaccinium myrtilloides* (velvetleaf huckleberry) and *Hypericum densiflorum* (bushy St. Johnswort). Regeneration of canopy species is present in this stratum.

The herbaceous ground layer is fairly diverse, with mean 48% cover and typically including 25-50 species. The most abundant species are *Danthonia compressa* (flattened oatgrass), *Lycopodium obscurum* (rare clubmoss), and *Rubus hispidus* (bristly dewberry). Other herbaceous species with high constancy include the canopy species, *Lycopodium clavatum* (running clubmoss), *Carex folliculata* (northern long sedge), *Dennstaedtia punctilobula* (eastern hayscented fern), *Pteridium aquilinum* (western brackenfern), and *Oclemena acuminata* (whorled wood aster). Nonvascular plants average 17% cover in this community, dominated by *Sphagnum* species and *Polytrichum* species; *Leucobryum glaucum* is also common.

Balsam Fir – Winterberry Swamp
West Virginia Scientific Name: *Abies balsamea - Picea rubens / Ilex verticillata / Sphagnum* spp. Woodland Swamp
NVC Code and Name: CEGL006591: *Abies balsamea - Picea rubens / Ilex verticillata / Sphagnum* spp. Forest
NatureServe Conservation Status: G2 S1

Geographic extent**:** The known distribution of this evergreen woodland swamp is restricted to frost-pocket headwater basins in the Allegheny Mountains of West Virginia, at elevations between 980 and 1120 m. Within this region, the community is known from Canaan Valley, Blister Run Swamp, and Blister Swamp.

Characteristic species**:** The canopy is open and dominated by stunted, inundation-stressed *Abies balsamea* (balsam fir) and *Picea rubens* (red spruce), with occasional presence of *Betula alleghaniensis* var. *alleghaniensis* (yellow birch) and *Acer rubrum* (red maple). Mean canopy cover is 25%. The subcanopy averages 20% cover and is dominated by *Abies balsamea* (balsam fir) and *Tsuga canadensis* (eastern hemlock) with smaller amounts of *Picea rubens* (red spruce) and *Acer rubrum* (red maple). *Amelanchier* (serviceberry) spp. may be present with very low cover in the subcanopy.

The shrub strata average 30% cover and are dominated by *Ilex verticillata* (common winterberry), the regenerating canopy species, and *Alnus incana* ssp. *rugosa* (speckled alder). Low cover of *Rhododendron maximum* (great laurel), *Hypericum densiflorum* (bushy St. Johnswort), and *Vaccinium myrtilloides* (velvetleaf huckleberry) may be present.

The herbaceous ground layer is fairly diverse, with mean 80% cover and typically including 30-40 species. The most abundant species are *Carex gynandra* (nodding sedge), *Carex folliculata* (northern long sedge), and *Rubus hispidus* (bristly dewberry). Other herbaceous species with high constancy include regenerating woody species and *Polygonum sagittatum* (arrowleaf tearthumb), *Osmunda cinnamomea* var*. cinnamomea* (cinnamon fern), *Galium tinctorium* (stiff marsh bedstraw), *Dryopteris cristata* (crested woodfern), *Carex trisperma* var*. trisperma* (threeseeded sedge), *Impatiens capensis* (jewelweed), *Viola cucullata* (marsh blue violet), *Triadenum fraseri* (Fraser's marsh St. Johnswort), *Juncus effusus* (common rush), *Carex stipata* (owlfruit sedge), *Glyceria striata* (fowl mannagrass), *Polygonum punctatum* (dotted smartweed), *Glyceria grandis* var*. grandis* (American mannagrass), *Oxalis montana* (mountain woodsorrel), *Dryopteris intermedia* (intermediate woodfern), and *Maianthemum canadense* (Canada mayflower). Nonvascular plants are dominated by *Sphagnum* spp. (*Sphagnum fallax*, *Sphagnum palustre*, *Sphagnum flexuosum*, *Sphagnum magellanicum*, *Sphagnum fuscum*, *Sphagnum girgensohnii*) and average 35% cover in this community.

Red Spruce – Hemlock – Rhododendron Swamp
West Virginia Scientific Name: *Picea rubens - Tsuga canadensis / Rhododendron maximum / Sphagnum* spp. - *Bazzania trilobata* Forested Swamp
NVC Code and Name: CEGL006277: *Picea rubens - (Tsuga canadensis) / Rhododendron maximum* Saturated Forest

NatureServe Conservation Status: G2? S2

Geographic extent: This conifer swamp is restricted to the Allegheny Mountains region of West Virginia, at elevations between 770 and 1150 m, with most occurrences between 800 and 1000 m elevation. Within this region, the community is known from Cranesville Swamp, Laurel and Glady Forks of the Cheat River, Desert Branch, Falls Run on Cheat Mountain, Yellow Creek in Otter Creek Wilderness, Odey Run Swamp, Piney Swamp, Whitmeadow Run, Canaan Valley State Park, Cranberry Glades, Glade Run below Gaudineer Knob, Helmick Run, Little Laurel Creek of the Cherry River, Sinks of Gandy, and the Williams River.

Characteristic species: This evergreen swamp is characterized by an open to closed canopy dominated by *Picea rubens* (red spruce) and *Tsuga canadensis* (eastern hemlock), with lower cover of *Acer rubrum* (red maple) and *Betula alleghaniensis* var. *alleghaniensis* (yellow birch), and occasional presence of *Nyssa sylvatica* (blackgum), *Larix laricina* (tamarack), or *Pinus strobus* (eastern white pine). Mean canopy cover is 45%. The subcanopy averages 30% cover and is dominated by *Tsuga canadensis* (eastern hemlock) with *Betula alleghaniensis* var. *alleghaniensis* (yellow birch), *Acer rubrum* (red maple), and *Picea rubens* (red spruce). Species that may be present with low cover in the subcanopy include *Fraxinus americana* (white ash), *Betula lenta* (sweet birch), *Nyssa sylvatica* (blackgum), *Magnolia acuminata* (cucumber-tree), *Amelanchier laevis* (Allegheny serviceberry), *Lindera benzoin* (northern spicebush), *Liriodendron tulipifera* (tuliptree), and *Sorbus americana* (American mountain ash).

The tall-shrub layer averages 35% cover and is dominated by *Rhododendron maximum* (great laurel). Other commonly occurring species in the tall-shrub layer include *Ilex verticillata* (common winterberry), *Tsuga canadensis* (eastern hemlock), *Picea rubens* (red spruce), and *Sorbus americana* (American mountain ash). Low cover of *Nemopanthus mucronatus* (catberry) and *Kalmia latifolia* (mountain laurel) may be present. The short-shrub layer averages 10% cover, with species composition similar to that of the tall-shrub stratum, and the occasional addition of *Viburnum nudum* var. *cassinoides* (northern wild raisin).

The herbaceous ground layer is sparse and variable, with mean 8% cover and often including *Carex trisperma* (three-seeded sedge), *Osmunda cinnamomea* var. *cinnamomea* (cinnamon fern), *Acer rubrum* (red maple), *Symplocarpus foetidus* (skunk cabbage), *Dennstaedtia punctilobula* (eastern hay-scented fern), *Glyceria melicaria* (melic mannagrass), and *Mitchella repens* (partridgeberry). Nonvascular plants average 50% cover and are dominated by *Sphagnum* spp. (*Sphagnum palustre*, *Sphagnum fallax*, *Sphagnum girgensohnii*, *Sphagnum recurvum*, *Sphagnum magellanicum*, *Sphagnum papillosum*), *Bazzania trilobata*, and *Hypnum imponens*.

Red Spruce – Southern Mountain Cranberry Swamp
West Virginia Scientific Name: *Picea rubens / Vaccinium erythrocarpum / Sphagnum* spp. - *Bazzania trilobata* High Elevation Swamp
NVC Code and Name: CEGL006593: *Picea rubens / Vaccinium erythrocarpum / Sphagnum* spp. - *Bazzania trilobata* Forest
NatureServe Conservation Status: G2 S2

Geographic extent: The known distribution of this community is restricted to the Allegheny Mountains region of West Virginia, at elevations between 1140 and 1400 m. Within this region, the community is known from Mt. Porte Crayon, Glade Run below Gaudineer Knob, Odey Run Bog, First Fork of the Upper Shavers, and the Upper Shavers Fork.

Characteristic species: The canopy is open to closed and strongly dominated by *Picea rubens* (red spruce). Mean canopy cover is 50%. The subcanopy averages 35% cover and is also dominated by *Picea rubens* (red spruce), with lower cover by *Acer rubrum* (red maple) and *Betula alleghaniensis* var. *alleghaniensis* (yellow birch). *Acer pensylvanicum* (striped maple) and *Amelanchier laevis* (Allegheny serviceberry) may be present with very low cover in the subcanopy.

The tall-shrub layer averages 25% cover and is similar in composition to the subcanopy, with the occasional addition of *Ilex montana* (mountain holly), *Rhododendron maximum* (great laurel), or *Sorbus americana* (American mountain ash). The short-shrub layer averages 18% cover and is dominated by *Vaccinium erythrocarpum* (southern mountain cranberry), with locally abundant *Kalmia latifolia* (mountain laurel).

The herbaceous ground layer is variable and sparse, with mean 13% cover. *Dryopteris intermedia* (intermediate woodfern) or *Thelypteris noveboracensis* (New York fern) may be locally abundant. Species with high constancy but low cover include *Osmunda cinnamomea* var. *cinnamomea* (cinnamon fern), *Maianthemum canadense* (Canada mayflower), *Clintonia* (bluebead lily) spp., and *Carex trisperma* var. *trisperma* (three-seeded sedge). Nonvascular plants average 60% cover in this community, dominated by *Bazzania trilobata*, which blankets the abundant downfall, and *Sphagnum* ssp. (*Sphagnum girgensohnii*, *Sphagnum fallax*, *Sphagnum palustre*, and *Sphagnum rubellum*), which carpet the mucky hollows; *Polytrichum* spp. and *Hypnum imponens* are also common.

Red Spruce – Yellow Birch – Mannagrass Swamp
West Virginia Scientific Name: *Picea rubens – Betula alleghaniensis* var*. alleghaniensis – Tsuga canadensis / Glyceria melicaria / Sphagnum* spp. Swamp
NVC Code and Name: CEGL006556: *Picea rubens - Acer rubrum / Ilex verticillata* Forest
NatureServe Conservation Status: G3 S2S3

Geographic extent: This community is restricted to the Allegheny Mountains region of West Virginia, at elevations between 770 and 1220 m. Within this region, the community is known from

Canaan Valley, Cranberry Glades, Cranesville Swamp, Difficult Creek, Dolly Sods, Glady Fork and Laurel Fork of the Shavers, Little River and Old Road Run on West Fork Greenbrier, Laurel Fork Wilderness South, Piney Swamp, Red Creek Plains, and Glade Run below Gaudineer Knob.

<u>Characteristic species:</u> This mixed swamp is characterized by an open to closed canopy of *Picea rubens* (red spruce), *Tsuga canadensis* (eastern hemlock), and *Betula alleghaniensis* var. *alleghaniensis* (yellow birch), with occasional additions of *Acer rubrum* (red maple), *Fraxinus nigra* (black ash), *Abies balsamea* (balsam fir), *Pinus strobus* (eastern white pine), or *Nyssa sylvatica* (blackgum). Mean canopy cover is 40%. The subcanopy is similar in composition to the canopy and averages 25% cover.

The tall-shrub layer averages 30% cover and is characterized by *Alnus incana* ssp. *rugosa* (speckled alder), *Rhododendron maximum* (great laurel), the regenerating canopy species, and occasionally *Ilex verticillata* (common winterberry). The short-shrub layer is sparse, averaging only 5% cover, with species composition similar to the tall-shrub layer.

The herbaceous layer, with mean 45% cover, is diverse and variable, with a number of characteristic seep species. Herbaceous species with high constancy include *Glyceria melicaria* (melic mannagrass), *Impatiens capensis* (jewelweed), *Osmunda cinnamomea* var. *cinnamomea* (cinnamon fern), *Chrysosplenium americanum* (American golden saxifrage), *Polygonum sagittatum* (arrowleaf tearthumb), *Leersia oryzoides* (rice cutgrass), *Chelone glabra* (white turtlehead), *Symplocarpus foetidus* (skunk cabbage), *Maianthemum canadense* (Canada mayflower), *Caltha palustris* var. *palustris* (yellow marsh marigold), *Onoclea sensibilis* (sensitive fern), *Carex leptalea* ssp. *leptalea* (bristlystalked sedge), *Oxalis montana* (mountain woodsorrel), and *Dryopteris intermedia* (intermediate woodfern). Nonvascular plants average 45% cover and are dominated by *Sphagnum* spp. (*Sphagnum palustre*, *Sphagnum fallax*, *Sphagnum squarrosum*, *Sphagnum magellanicum*, *Sphagnum girgensohnii*) carpeting the mucky hollows, *Rhizomnium appalachianum* in the seepy areas, and *Hypnum imponens* and *Dicranum scoparium* blanketing the woody hummocks.

References

Detailed descriptions and tables of environmental characteristics within West Virginia for each of the NVC communities summarized above are included in the following publications, which are available on-line. The NatureServe Explorer website has additional rangewide information about each NVC community.

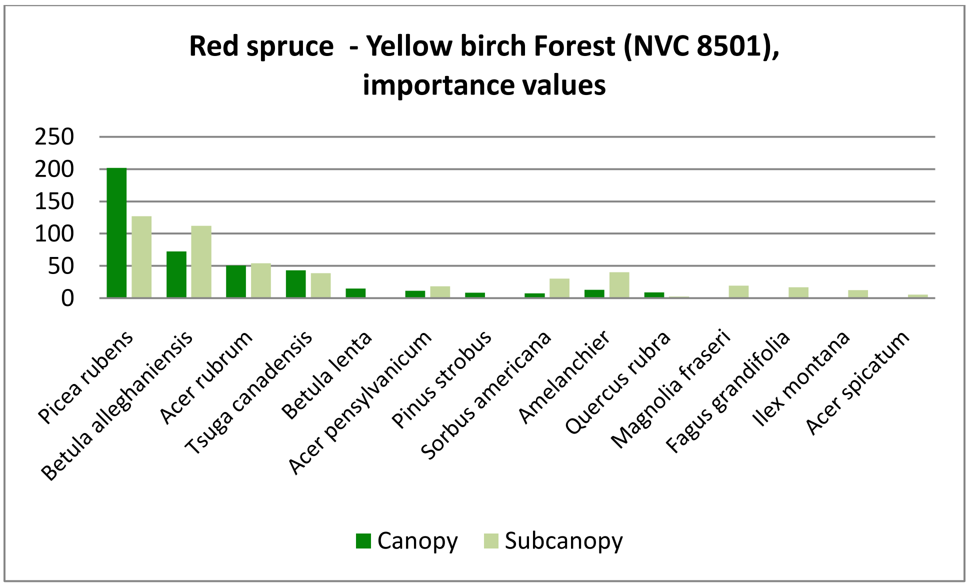
Byers, E. A., J. P. Vanderhorst, and B. P. Streets. 2007. Classification and Conservation Assessment of High Elevation Wetland Communities in the Allegheny Mountains of West Virginia. West Virginia Natural Heritage Program, WVDNR. Elkins, WV. http://wvdnr.gov/publications/publications.shtm

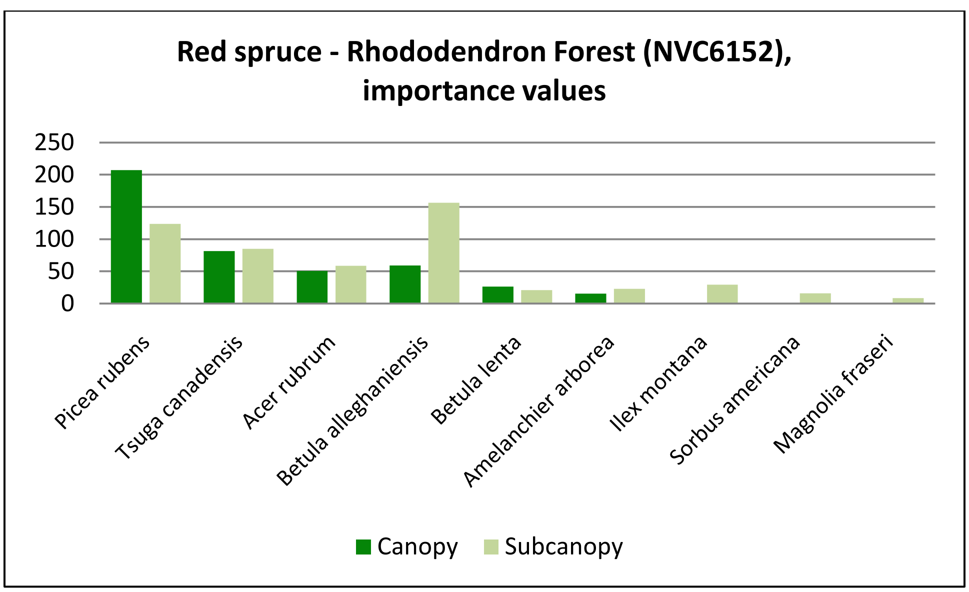
Byers, E. A., J. P. Vanderhorst, and B. P. Streets. 2010. Classification and Conservation Assessment of Upland Red Spruce Communities in West Virginia. West Virginia Natural Heritage Program, WVDNR. Elkins, WV. http://wvdnr.gov/publications/publications.shtm

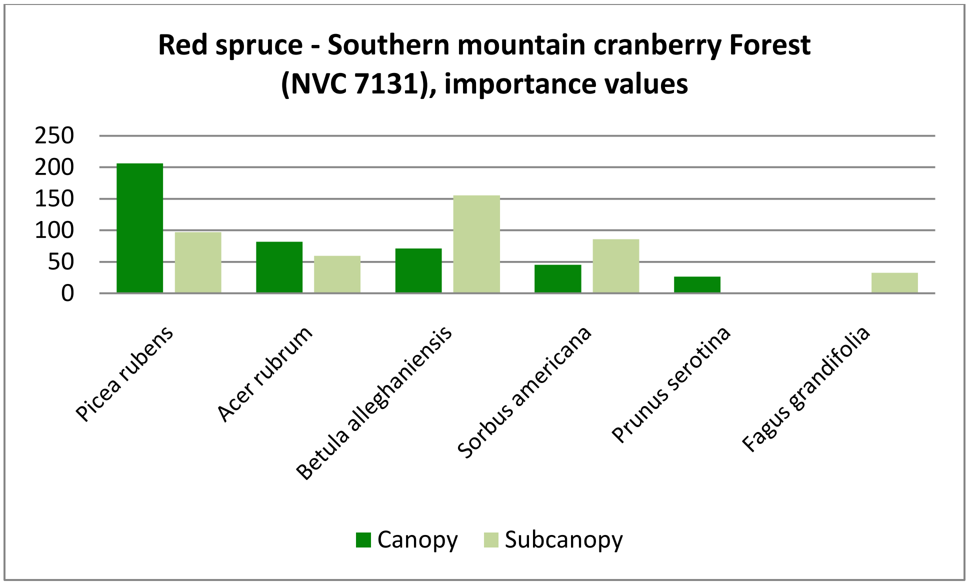
NatureServe. 2010. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer.

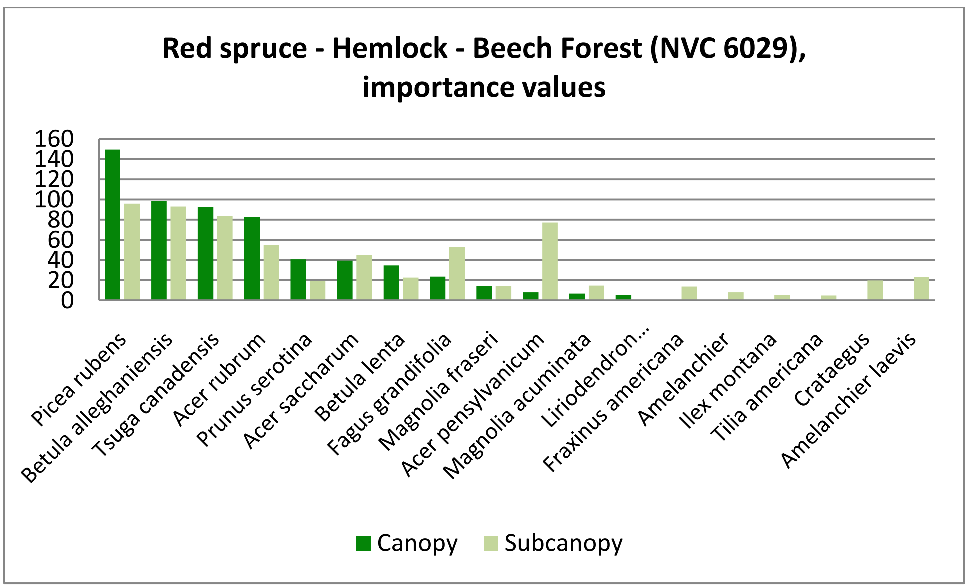
APPENDIX C: IMPORTANT CANOPY AND SUBCANOPY SPECIES BY TYPE

The charts below show the species distribution of canopy and subcanopy species for West Virginia's four upland spruce forest types, based on Natural Heritage plot data for good quality, but mostly second growth, existing forest stands. Importance is calculated as relative frequency + 2 (relative percent cover), on a base of 300. The first chart shows the most common forest type (red spruce-yellow birch), followed by the rhododendron type, the high elevation southern mountain cranberry type, and finally the lower elevation spruce-hemlock-beech type with more hardwoods.






Red spruce - Southern mountain cranberry Forest (NVC 7131), importance values
250
200
150
100
50
0
Picea rubens
Acer rubrum
Betula alleghaniensis
Sorbus americana
Prunus serotina
Fagus grandifolia
Canopy
Subcanopy


Red spruce - Hemlock - Beech Forest (NVC 6029), importance values
160
140
120
100
80
60
40
20
0
Picea rubens
Betula alleghaniensis
Tsuga canadensis
Acer rubrum
Prunus serotina
Acer saccharum
Betula lenta
Fagus grandifolia
Magnolia fraseri
Acer pensylvanicum
Magnolia acuminata
Liriodendron...
Fraxinus americana
Amelanchier
Ilex montana
Tilia americana
Crataegus
Amelanchier laevis
Canopy
Subcanopy

APPENDIX D: POTENTIAL SPECIES FOR RESTORATION OF SURFACE MINE SITES

MOWER TRACT ON CHEAT MOUNTAIN: RECOMMENDATIONS FOR NATIVE SPECIES RESTORATION ON OLD STRIP MINE BENCHES

Compiled in part by Elizabeth Byers, WVDNR, 15 July for 28 August field review

Plants ***bolded are good for wildlife. Plants bolded and denoted with asterisk are most preferable for ruffed grouse. Highlighted ones are high priority for seed trials***

All habitats

Red Spruce (Picea rubens)
Yellow Birch (Betula alleghaniensis var. alleghaniensis)
Eastern Hemlock (Tsuga canadensis)
***Big-tooted Aspen (Populus grandidentata)**
***Allegheny Serviceberry (Amelanchier laevis)**
Great Laurel (Rhododendron maximum)
Mountain Laurel (Kalmia latifolia)
***Southern Mountain Cranberry (Vaccinium erythrocarpum)**
Alternate leaved dogwood (Cornus alternifolia)
Black Cherry (Prunus serotina)
American Beech (Fagus grandifolia) – immune to Beech Bark Disease

Upland areas
Mountain Holly (Ilex montana)
Hillside Blueberry (Vaccinium pallidum)
Flattened Oatgrass (Danthonia compressa)
Intermediate Woodfern (Dryopteris intermedia)
White-Edge Sedge (Carex debilis)
Greater Bladder Sedge (Carex intumescens)

Wetlands: existing ponds

Pond margin:
Common Winterberry (Ilex verticillata)
***Speckled Alder (Alnus incana ssp. rugosa)**
Catberry (Nemopanthus mucronatus)
***Northern Wild Raisin (Viburnum nudum var. cassinoides)**
***Northern Arrowwood (Viburnum recognitum)**
***Swamp Rose (Rosa palustris) –these are coming**
***Silky Willow (Salix sericea)**
***Black Chokeberry (Photinia melanocarpa)**
Bushy St. John's-Wort (Hypericum densiflorum)
Velvetleaf Blueberry (Vaccinium myrtilloides)
Bristly Dewberry (Rubus hispidus)

Wrinkleleaf Goldenrod (Solidago rugosa)
Flat-Top Goldentop (Euthamia graminifolia var. graminifolia)
Whorled Wood Aster (Oclemena acuminata)
Deer-Tongue Witchgrass (Dichanthelium clandestinum)
Stalk-Grain Sedge (Carex stipata)
Broom Sedge (Carex scoparia var. scoparia)
Tussock Sedge (Carex stricta)

Mudflat or a few inches of water:
American Bur-Reed (Sparganium americanum)
Small Bur-Reed (Sparganium chlorocarpum)
American Water-Plantain (Alisma subcordatum)
Nodding Beggarticks (Bidens cernua)
Marsh Seedbox (Ludwigia palustris)
Northern Bugleweed (Lycopus uniflorus var. uniflorus)
Broadleaf Arrowhead (Sagittaria latifolia)
Rattlesnake Mannagrass (Glyceria canadensis)
Fowl Mannagrass (Glyceria striata)
Rice Cutgrass (Leersia oryzoides)
Candlewick Rush (Juncus effusus var. solutus)
Woolgrass Bulrush (Scirpus cyperinus)
Softstem Bulrush (Schoenoplectus tabernaemontani)
Threeway Sedge (Dulichium arundinaceum)
Blunt Spikerush (Eleocharis obtusa)

Wetlands: vernal pool creation

Nodding Beggarticks (Bidens cernua)
Northern Bugleweed (Lycopus uniflorus var. uniflorus)
Orange Jewelweed (Impatiens capensis)
Fowl Mannagrass (Glyceria striata)
Rice Cutgrass (Leersia oryzoides)
Candlewick Rush (Juncus effusus var. solutus)
Green Bulrush (Scirpus atrovirens)
Threeway Sedge (Dulichium arundinaceum)
Blunt Spikerush (Eleocharis obtusa)
Stalk-Grain Sedge (Carex stipata)
Sallow Sedge (Carex lurida)

Wetlands: shaded seepage areas

Hobble bush – Viburnum alnifolia
Common Winterberry (Ilex verticillata)
***Speckled Alder (Alnus incana ssp. rugosa)**
Catberry (Nemopanthus mucronatus)
***Northern Arrow-Wood (Viburnum recognitum)**
Canadian Wood-Nettle (Laportea canadensis)
Orange Jewelweed (Impatiens capensis)

Marsh Blue Violet (Viola cucullata)
Heartleaf Foamflower (Tiarella cordifolia)
Crinkleroot (Cardamine diphylla)
Quaker Bittercress (Cardamine pensylvanica)
White Turtlehead (Chelone glabra)
Northern Bugleweed (Lycopus uniflorus var. uniflorus)
Scarlet Beebalm (Monarda didyma)
Golden Ragwort (Packera aurea)
Crooked-Stem Aster (Symphyotrichum prenanthoides)
American Golden-Saxifrage (Chrysosplenium americanum)
Cinnamon Fern (Osmunda cinnamomea var. cinnamomea)
Melic Manna Grass (Glyceria melicaria)
Fowl Mannagrass (Glyceria striata)
Grove Bluegrass (Poa alsodes)
Upland Bentgrass (Agrostis perennans)
Eastern Rough Sedge (Carex scabrata)
Nodding Sedge (Carex gynandra)
Bristlystalked Sedge (Carex leptalea ssp. leptalea)
Stalk-Grain Sedge (Carex stipata)

Wetlands: sunny seepage areas

Elderberry (Sambucus canadensis)
Common Winterberry (Ilex verticillata)
***Speckled Alder (Alnus incana ssp. rugosa)**
Catberry (Nemopanthus mucronatus)
***Northern Wild Raisin (Viburnum nudum var. cassinoides)**
***Northern Arrow-Wood (Viburnum recognitum)**
***Swamp Rose (Rosa palustris)**
Silky Willow (Salix sericea)
***Black Chokeberry (Photinia melanocarpa)**
Bushy St. John's-Wort (Hypericum densiflorum)
Velvetleaf Blueberry (Vaccinium myrtilloides)
Orange Jewelweed (Impatiens capensis)
Northern Bugleweed (Lycopus uniflorus var. uniflorus)
Arrowleaf Tearthumb (Polygonum sagittatum)
Bog Goldenrod (Solidago uliginosa)
Wrinkleleaf Goldenrod (Solidago rugosa)
Deer-Tongue Witchgrass (Dichanthelium clandestinum)
Flat-Top Goldentop (Euthamia graminifolia var. graminifolia)
Whorled Wood Aster (Oclemena acuminata)
Golden Ragwort (Packera aurea)
Bristly Dewberry (Rubus hispidus)
Rattlesnake Mannagrass (Glyceria canadensis)
Fowl Mannagrass (Glyceria striata)
Bluejoint Grass (Calamagrostis canadensis var. canadensis)
Candlewick Rush (Juncus effusus var. solutus)
Green Bulrush (Scirpus atrovirens)
Woolgrass Bulrush (Scirpus cyperinus)

Tawny Cotton-Grass (Eriophorum virginicum)
Nodding Sedge (Carex gynandra)
Stalk-Grain Sedge (Carex stipata)
Broom Sedge (Carex scoparia var. scoparia)
Prickly Bog Sedge (Carex atlantica)
Tussock Sedge (Carex stricta)
Northern Long Sedge (Carex folliculata)