The cover features a dark blue vertical bar on the left and a background of green foliage. A dark blue rectangular box is centered on the foliage, containing the title and subtitle. A small green square with the number '3' is positioned to the right of the title.

# Protecting Rare Species & Communities

3

Forest Operations Manual  
The Conservation Forestry Program

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# Protecting Rare Species & Communities

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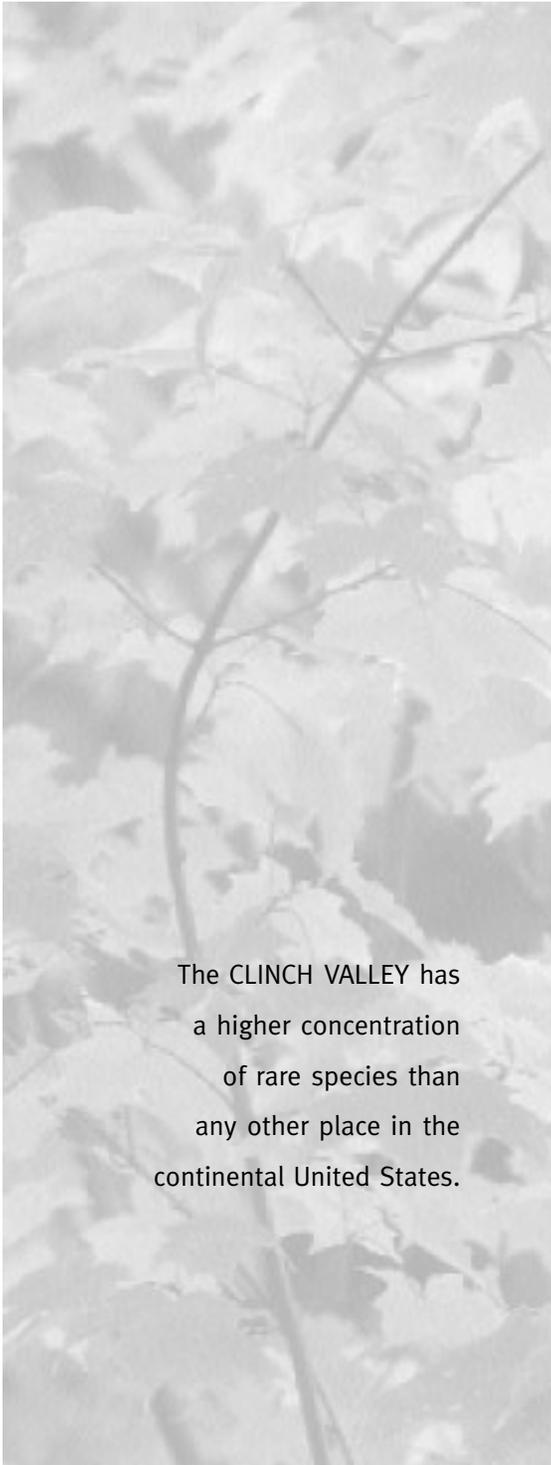
CHAPTER

3

## 3.1 The Nature Conservancy Philosophy

According to a joint study by the Association for Biodiversity Information (ABI) and The Nature Conservancy (TNC), the Clinch Valley is one of the nation's top hotspots for rare species. The Clinch Valley has a higher concentration of rare species than any other place in the continental United States. The watersheds of the Clinch and Powell Rivers contain 27 different imperiled species, 19 of which are associated directly with the area's streams and rivers. The other 8 inhabit caves in the area. The only area in the U.S. with more species at risk is Hawaii.

This study underscores what forest managers and conservationists in southwest Virginia have long known. The Virginia Division of Natural Heritage lists several rare species inhabiting the counties in the program area. Some, like running glade clover, exist nowhere else in the state. The majority are rare fish and mussels in the Clinch, Powell, and Holston Rivers noted in the biodiversity study. It is also possible that managed lands may also be home to imperiled species such as northern flying squirrels, Indiana bats, river otters, showy lady slippers, long-stalked hollies, yarrow-leaved ragworts, and alder-leaved buckthorns, as well to rare communities such as bogs, old-growth forests, and significant karst features.



The CLINCH VALLEY has a higher concentration of rare species than any other place in the continental United States.

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Through careful management of land under its control, **The Nature Conservancy is committed to actively protecting and fostering rare species and communities throughout southwest Virginia.** Because the primary threat to these resources is habitat destruction caused by human interference, forest managers must pay strict attention to the needs of these species and communities in every phase of land management, from the initial surveys and management plans through timber harvests, recovery efforts, and ongoing monitoring.



We must pay strict attention to the **NEEDS** of species and communities in every phase of land management.



## Protecting Species

Check Conservation  
Databases

Conduct  
Specific Inventory

Develop  
Conservation Plans

Create Riparian  
Management Zones

Minimize Erosion  
and Sedimentation

Clean Up  
Accidental Spills

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## 3.2 Key Strategies

To adequately protect and foster rare species and communities on managed lands the managers will:

- ☛ Check the databases of the Virginia Department of Conservation and Recreation (DCR) Division of Natural Heritage Program, Virginia Department of Game and Inland Fisheries (VDGIF), the Tennessee Valley Authority (TVA), and the U.S. Fish and Wildlife Service to see if rare species or communities are likely to occur on the tract.
- ☛ If a search of the databases indicates the likelihood of an occurrence of rare species or communities, an inventory will be conducted.
- ☛ If surveys reveal a special habitat or rare species, develop specific conservation plans:
  - Contact the appropriate agency biologists for verification, information, and management assistance, and adhere to their management recommendations.
  - For location-specific species (i.e. species confined to a particular area on the site), at a minimum consider the species' habitat needs in all management decisions and buffer or remove that site from timber production and designate it as "off-limits" for any harvest-related activities if warranted.
  - For non-location-specific species, at a minimum consider the species' habitat needs in all management decisions.
- ☛ Designate adequate Riparian (Streamside) Management Zones and adhere to a no-harvest policy in these areas to protect aquatic communities.
- ☛ Minimize to the extent possible erosion and sedimentation from all forestry activities.
- ☛ Require logging contractors to have supplies on site to clean up accidental spills of oil or other chemicals from equipment.

Section 3.4 provides additional guidelines for specific rare species and communities.

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### 3.3 Terminology and Resources

In Virginia, the State Rank classification system is used by the Virginia DCR's Division of Natural Heritage to set protection priorities for rare plant and animal species, exemplary natural communities, and significant geologic formations.

**Rare species are those that are ranked as follows:**

**S1 SPECIES** are extremely rare; usually with 5 or fewer populations or occurrences in the state; or there may be a few remaining individuals; species is extremely vulnerable to extirpation

**S2 SPECIES** are very rare; usually between 5 and 20 populations or occurrences are in the state; or there may be many individuals in fewer occurrences; species is often susceptible to becoming extirpated

**S3 SPECIES** are rare to uncommon; usually between 20 and 100 populations or occurrences exist in the state; or there may be fewer occurrences, but with a large number of individuals in some populations; species may be susceptible to large-scale disturbances

**Rare species may also be assigned a legal status** as well.

They may fall into one of three legal categories:

**ENDANGERED SPECIES** are in danger of extinction throughout all or a significant portion of their range

**THREATENED SPECIES** are likely to become endangered within the foreseeable future throughout all or a significant portion of their range

**SPECIES OF CONCERN** merit special consideration according to state biologists

#### DESIGNATIONS S1, S2

**S1** (EXTREMELY RARE) and **S2** (RARE TO UNCOMMON) designations can apply either at the federal level or at the state level; that is, while a species may not be endangered nationally, it could be endangered in Virginia. Note, though, that if a species is endangered or threatened at the federal level, that designation applies in every state; the state listings add to, rather than replace, the federal ones. For each of these categories, a species may already be LISTED, or PROPOSED FOR LISTING. A species may also be a CANDIDATE FOR LISTING.

**Section 3.5** provides a summary of the primary rare communities and species in Virginia. For the most current **federal listings**, check the *U.S. Fish and Wildlife Services' Endangered Species Program* web site at <http://endangered.fws.gov>. For **Virginia listings**, check the *Department of Conservation and Recreation's Natural Heritage Program* web site at <http://www.state.va.us/~dcr/vaher.html>. In addition, the *Virginia Wildlife Information Service* web site (<http://fwie.fw.vt.edu>) is an excellent resource for animal information (including a list of all species recorded for the state). Additional information may be found at the *Association for Biodiversity Information*, [www.natureserve.org](http://www.natureserve.org).

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The last one, Species of Concern, is used by the Virginia Department of Game and Inland Fisheries (VGDIF) for species in Virginia that, while not yet threatened, are rare enough to merit special consideration. In Virginia, VGDIF is the primary authority and leader for conserving all federally endangered and threatened species, as well for designating additional species as endangered, threatened, or of concern for the state. Rare species that are not legally classified are nonetheless deserving of special protection and management considerations.

### 3.4 A Description of Ecological Communities and their Rare Species



Diverse habitats of southwestern Virginia support a wide variety of natural community types. Rare types and exemplary examples of common types are important targets for conservation not only for the rare species they harbor, but also because they:

- ① Support myriad life forms too cryptic or poorly known to be catalogued and prioritized individually;
- ② Provide a nurturing environment for common as well as rare species;
- ③ Contribute to the maintenance of larger ecosystems; and
- ④ Possess unique intrinsic scientific, educational, and aesthetic values.

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To help forest managers recognize the major natural community types found in the program area, this section provides a brief description of many of the types and mentions globally-rare species which may be associated with each type. More detailed descriptions of each community type are found in *Fleming et al., 2000*.

## WETLAND COMMUNITIES

### Rivers and Streams

The Tennessee River drainage system in southwest Virginia and Tennessee (along with the neighboring Cumberland River system in Kentucky) is the nation's richest basin in species of endemic fish and among the richest in species of freshwater mussels. In particular, Virginia's Clinch River basin is home to the greatest diversity of aquatic fauna in the nation, containing **63 rare fish and mussel species**, including 21 that are listed as threatened or endangered under the Federal Endangered Species Act (Federal Act).

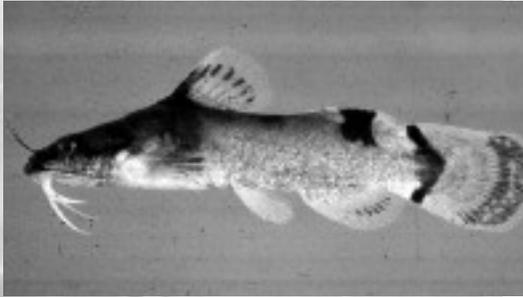
The freshwater mussel fauna in Virginia, which consists of about 73 species, is among the most diverse in the United States. However, largely due to human activities, five of these species are extirpated and many others have a significantly reduced range. This area is home to **17 species of mussels that are listed as endangered** under both the Federal Act and the Virginia Endangered Species Act (State Act). Nine additional species are listed as endangered and five species are listed as threatened under the State Act.

The Clinch and Powell river systems, and particularly Copper Creek and Little River, host the greatest diversity of fish species in Virginia. This area is home to the duskytail darter (*Etheostoma pernumum*, G1), listed as endangered under the Federal Act, and three species listed as threatened under that Act. A total of four species are listed as endangered under the State Act and nine species are listed as threatened.

Rivers and streams in southwestern Virginia host a variety of additional animal taxa that rely on the quality of the water and the riparian forest. Examples include the hellbender (*Cryptobranchus alleganiensis*), a large aquatic salamander, the river otter (*Lutra canadensis*), and the Cherokee clubtail dragonfly (*Gomphus consanguis*, G2G3).



Virginia's Clinch River basin is home to the greatest diversity of aquatic fauna in the nation.



The program area hosts 63 rare fish, including this endangered yellowfin madtom.

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### Rocky Bars and Shores

Influenced by a frequent regime of powerful flood scouring, these communities consist of the periodically flooded shrub and herbaceous vegetation of rock outcrops, boulders, and cobble bars along the shores and islands of large, high-gradient streams and rivers. Woody scrub, such as battered sycamore (*Platanus occidentalis*), willows (*Salix spp.*), silky dogwood (*Cornus amomum*), and buttonbush (*Cephalanthus occidentalis*) is typically dominant here. This is the habitat of Virginia spiraea (*Spiraea virginiana*, G2), which is listed as threatened under the Federal Act and as endangered under the Virginia Endangered Plant and Insect Act (Virginia Plant/Insect Act)

### Alluvial Floodplain Forests

These communities are temporarily to intermittently flooded bottomland forests occupying the floodplains of rivers and large streams. Characteristic trees include sycamore (*Platanus occidentalis*), boxelder (*Acer negundo*), American elm (*Ulmus americana*), and silver maple (*Acer saccharinum*). The Virginia endemic tree, Virginia round-leaf birch (*Betula uber*, G1Q) is found in this habitat. This species is listed as threatened under the Federal Act and as endangered under the Virginia Plant/ Insect Act.

### Calcareous Fens and Seeps

These communities are primarily found in valleys of the Ridge and Valley province that are underlain by limestone or dolomite. They typically occur where spring seeps emerge at the foot of calcareous hillsides or along the seepage zones of small stream bottoms. The vegetation is often a patch-mosaic of shrubs and herbaceous openings. Common shrubs include willows (*Salix spp.*), smooth alder (*Alnus serulata*), swamp rose (*Rosa palustris*), and chokeberries (*Aronia spp.*). Schweinitz's sedge (*Carex schweinitzii*, G3) and large-leaved grass-of-parnassus (*Parnassia grandifolia*, G3G4) are globally-rare plants found in calcareous wetlands.

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### Appalachian Bogs

These small wetlands (usually less than 0.4 hectare (1.0 acre) occur at gently sloping zones of groundwater discharge along valley floors and headwater streams. Soils are extremely acidic and support thick growths of sphagnum and other mosses. Bog vegetation is frequently a mosaic of shrub patches and herbaceous openings. Associated species include great-laurel (*Rhododendron maximum*), Catawba rhododendron (*R. catawbiense*), cinnamon fern (*Osmunda cinnamomea*), tawny cotton-grass (*Eriophorum virginicum*), Atlantic sedge (*Carex atlantica*), and brown beakrush (*Rhynchospora capitellata*). Long-stalked holly (*Ilex collina*, G3) is a globally-rare plant found here.

### High Elevation Seepage Swamps

Located at elevations above 900 m (3000 ft.), these saturated forest communities are found along gently sloping stream headwaters, large spring seeps, and ravine bottoms. They occur on various geologic substrates and soils, almost all of which are strongly to extremely acidic, and feature a pronounced hummock and hollow microtopography with braided streams, muck-filled depressions, and lush bryophyte cover. Eastern hemlock (*Tsuga canadensis*), yellow birch (*Betula alleghaniensis*), and red maple (*Acer rubrum*) are the most common trees found here.

### High Elevation Seeps

These saturated herbaceous wetlands are also found at elevations above 900 m (3000 ft.). They occur on relatively steep, usually bouldery upper slopes at sites of groundwater discharge, and are typically narrow in shape and partially shaded by tree species rooted in adjacent upland forests. Common species include oswego-tea (*Monarda didyma*), cut-leaved coneflower (*Rudbeckia laciniata*), spotted jewelweed (*Impatiens capensis*), rough goldenrod (*Solidago patula*), white turtlehead (*Chelone glabra*), golden ragwort (*Senecio aureus*), marsh blue violet (*Viola cucullata*), and umbrella-leaf (*Diphyllea cymosa*). These habitats can also be home to the shovelnose salamander (*Desmognathus marmoratus*), which are listed rare in the state.





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### Spray Cliffs

These communities occur on constantly wet rock faces within the spray or splash zone of waterfalls or on sheltered cliffs saturated with permanent seepage. Mosses and liverworts are usually the dominant plants, with vascular species more sparsely rooted in crevices and on moss or humus-covered shelves. Carolina saxifrage (*Saxifraga caroliniana*, G2) and Carey saxifrage (*Saxifraga careyana*, G3) are among the globally-rare plants found here.

## **HIGH-ELEVATION TERRESTRIAL COMMUNITIES**

High-elevation communities such as Southern Appalachian Red Spruce Forests or Northern Hardwood Forests provide critical habitat for species that may have had a much wider distribution in Virginia during the Pleistocene Epoch (Ice Age). These communities and their rare species are generally found at elevations of 900 m (3000 ft.) or higher.

### Fraser Fir-Red Spruce Forests

Coniferous forests dominated by Fraser fir (*Abies fraseri*) or combinations of Fraser fir and red spruce (*Picea rubens*) are found in Virginia only above 1700 m (5400 ft.) on Mount Rogers in Grayson and Smyth Counties. This community type is considered globally rare by TNC and the Natural Heritage network. Globally-rare plants found in this community include Fraser fir (G3) and mountain bittercress (*Cardamine clematitis*, G2G3).

### Southern Appalachian Red Spruce Forests

Coniferous and mixed forests dominated or co-dominated by red spruce (*Picea rubens*) are restricted to elevations above 1300 m (4300 ft.). They are found in the Blue Ridge (Grayson, Smith, and Washington Counties) and on Clinch Mountain (Russell and Tazwell Counties). This is considered to be a globally-rare to uncommon community type. Mountain bittercress (G2G3) and long-stalked holly (*Ilex collina*, G3) are found here. Spruce forests are also home to the federally endangered Northern flying squirrel subspecies (*Glaucomys sabrinus volans*, G5T2 S1) and the globally rare Weller's salamander (*Plethodon welleri*, G3).

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### **Southern Appalachian Northern Hardwood Forests**

These mixed hardwood forests, typically dominated by sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), yellow birch (*Betula alleghaniensis*), and yellow buckeye (*Aesculus flavà*), are found in southwest Virginia at elevations above 1200 m (3900 ft.). They are currently known from the Mount Rogers-Whitetop Mountain area of the Blue Ridge, the Iron Mountains, Clinch Mountain, and Stone Mountain.

### **High-Elevation Boulderfield Forests and Woodlands**

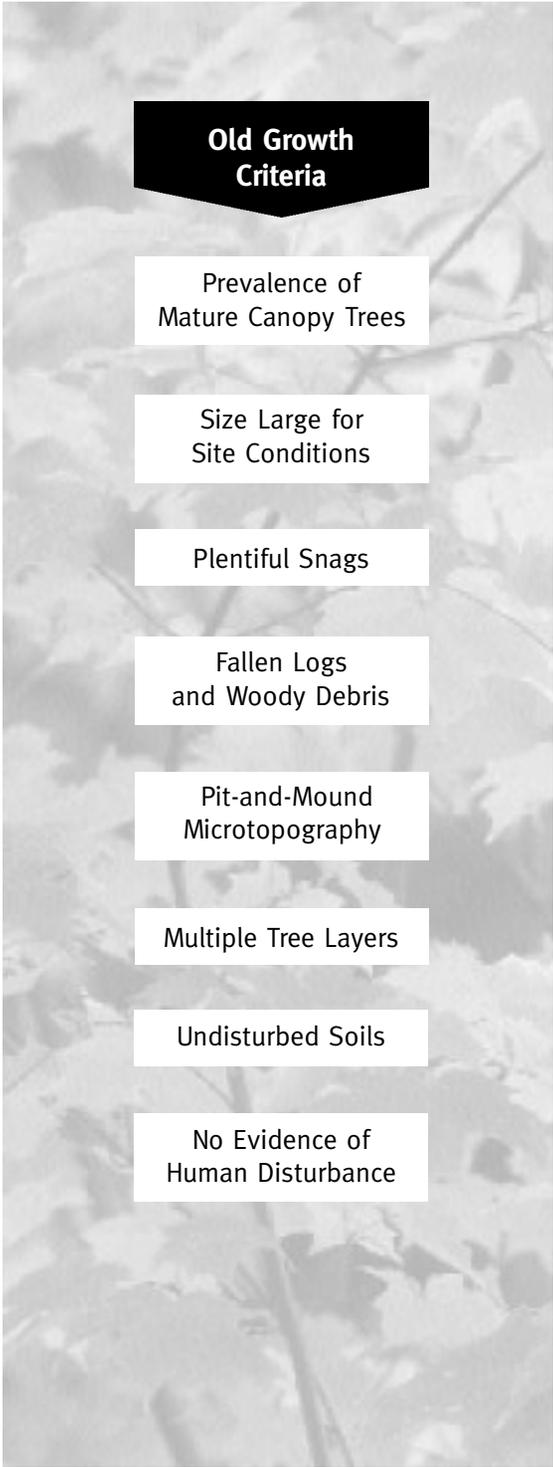
These open forests and woodlands occupying relatively unweathered boulderfields are believed to be a globally rare to uncommon community type. Located at elevations above 900 m (3000 ft.), characteristic species of these communities include yellow birch (*Betula alleghaniensis*), American mountain-ash (*Sorbus americana*), mountain maple (*Acer spicatum*), gooseberries (*Ribes spp*) and red-berried elder (*Sambucus racemosa ssp. pubens*)

### **Low-Elevation Terrestrial Forest And Woodland Communities**

Seventeen different low-elevation terrestrial forest and woodland community types have been identified as occurring or potentially occurring within the program area. These types are described in Fleming et al. (2001) and are as follows:

- |                                     |   |
|-------------------------------------|---|
| <i>Rich Cove and Slope Forests</i>  | <i>Chestnut Oak Forests</i>                             |
| <i>Basic Mesic Forests</i>          | <i>Eastern White Pine-Hardwood Forests</i>              |
| <i>Acidic Cove Forests</i>          | <i>Carolina Hemlock Forests</i>                         |
| <i>Mesic Mixed Hardwood Forests</i> | <i>Pine-Oak/Heath Woodlands</i>                         |
| <i>Eastern Hemlock Forests</i>      | <i>Montane Acidic Woodlands</i>                         |
| <i>Arborvitae Slope Forests</i>     | <i>Piedmont/Mountain Basic Woodlands</i>                |
| <i>Acidic Oak-Hickory Forests</i>   | <i>Montane Dry Calcareous Forest and Woodlands</i>      |
| <i>Montane Oak-Hickory Forests</i>  | <i>Low Elevation Boulderfield Forests and Woodlands</i> |
| <i>Mixed Oak/Heath Forests</i>      |   |





## Old Growth Criteria

Prevalence of  
Mature Canopy Trees

Size Large for  
Site Conditions

Plentiful Snags

Fallen Logs  
and Woody Debris

Pit-and-Mound  
Microtopography

Multiple Tree Layers

Undisturbed Soils

No Evidence of  
Human Disturbance

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Two of these community types, **Arborvitae Slope Forests** and **Carolina Hemlock Forests** are believed to be globally rare:

### Arborvitae Slope Forests

These are mixed, largely coniferous forests in which arborvitae (*Thuja occidentalis*) is a dominant or co-dominant tree. Habitats are on steep, rocky west to north-facing slopes undercut by streams. Bedrock is usually limestone or dolomite, but one Virginia site is underlain by calcareous Silurian sandstone. Eastern white pine (*Pinus strobus*) and Eastern hemlock (*Tsuga canadensis*) are the most frequent tree associates.

### Carolina Hemlock Forests

These are forests dominated or co-dominated by Carolina hemlock (*Tsuga caroliniana*). They are typically found on steep, rocky sites with shallow, nutrient-poor soils. Common associates include chestnut oak (*Quercus prinus*), white oak (*Quercus alba*), scarlet oak (*Quercus coccinea*), pines (*Pinus spp*), blackgum (*Nyssa sylvatica*), and various ericaceous shrubs.

### Old Growth

Other exemplary stands of the other 15 forest and woodland community types should also be targeted for protection. Criteria for old growth have been set forth by Leverett (1991, 1996) as follows:

- The prevalence of mature canopy trees  $\geq$  150 years old with asymmetrical shapes, flattened crowns, old-age bark characteristics, trunks free of low branches, and frequent heartwood decay;
- Trees of large size relative to site conditions;
- Plentiful snags;
- Fallen logs in all stages of decomposition and high volume of woody debris on the ground and in streams;
- Pit-and-mound microtopography caused by windthrow;
- Multiple tree layers indicating all-age composition;
- Undisturbed soils; and
- Little or no evidence of human disturbance (e.g., cut stumps, roads).

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Exemplary old growth stands are those of excellent quality (mid to late successional stage, lack of disturbance, lack of invasive species) and sufficient size. The sufficient size criterion is variable, depending on whether the community is a matrix, large patch, or small patch type. For a discussion of these community categories and target sizes for community protection by type, see [TNC's Cumberland/Ridge and Valley Ecoregional Plan](#).

Globally-rare plants found in terrestrial forest and woodland communities include small whorled pogonia (*Isotria medeoloides*, G2G3) Appalachian bugbane (*Cimicifuga rubifolia*, G3), and small spreading pogonia (*Cleistes bifaria*, G3G4). Small whorled pogonia is listed as threatened under the Federal Act and as endangered under the Virginia Plant/Insect Act. Within the program area, it is most likely to be found in Acidic Oak-Hickory Forests, Eastern White Pine-Hardwood Forests, or Mesic Mixed Hardwood Forests. Appalachian bugbane is most likely to be found in Basic Mesic Forests and small spreading pogonia in Pine-Oak/Heath Woodlands.

American ginseng (*Panax quinquefolius*) while not considered globally-rare, is also listed as threatened under the Virginia Plant/Insect Act. Within the program area, this species is primarily found in Acidic Cove Forests and Rich Cove and Slope Forests.

## ROCK OUTCROPS AND BARRENS

### Limestone and Dolomite Barrens

These communities of woody scrub and herbaceous vegetation occur on carbonate rock outcrops and adjacent dry rocky slopes. While these barrens are typically found on steep, south to west-facing slopes, in The Cedars region of Lee County, “flatrock” limestone barrens are present on gently rolling topography. Warm season prairie grasses are characteristic of these barrens. These include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), side-oats grama (*Bouteloua curtipendula*), and rough dropseed (*Sporobolus clandestinus*). Woody species include chinkapin oak (*Quercus muhlenbergii*), eastern red cedar (*Juniperus virginiana*), and Carolina buckthorn (*Frangula caroliniana*). These communities are state-rare and, in





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some cases, globally rare. They also support the globally-rare plants running glade clover (*Trifolium calcaricum*, G1) and yarrow-leaved ragwort (*Packera millefolia*, G2). The Cedars region is also home to the globally rare cedar millipede (*Brachoria cedra*, G1G2), found nowhere else in the world.

### **Acidic Outcrop Barrens**

These communities consist of woody scrub and herbaceous vegetation on exposed outcrops of sandstone, quartzite, or granite. Habitats typically have a high cover of exposed bedrock, with vascular plants restricted to crevices and locally developed organic mats. Soil environments are minimal and highly nutrient-poor, while lithophytic lichens are prevalent. A high-elevation type on a rhyolite substrate in the Mount Rogers area is believed to be globally rare.

### **Xeric Calcareous Cliffs**

These are communities of sparse shrub and herbaceous vegetation on very steep to precipitous, south to west-facing limestone and dolomite outcrops, cliffs, and rock escarpments. A high cover of exposed bedrock and associated edaphic stresses limit overall vegetation cover, woody growth, and species richness. Woody species include eastern red cedar (*Juniperus virginiana*), chinkapin oak (*Quercus muhlenbergii*) and hairy mock-orange (*Philadelphus hirsutus*). Characteristic herbs include moss phlox (*Phlox subulata*), cliff-brakes (*Pellaea spp.*), wall-rue (*Asplenium ruta-muraria*), and ebony sedge (*Carex eburnea*). The globally-rare shrub, Canby's mountain-lover (*Paxistima canbyi*, G2), is found here.

### **Mesic Calcareous Cliffs**

Consisting of sparse woodland, shrub, and herbaceous vegetation, these communities are located on very steep to precipitous, somewhat sheltered north to east-facing limestone and dolomite outcrops. Habitats are exposed, but have limited solar exposure because of their northerly aspects. Local zones of ephemeral seepage are frequent. Woody vegetation is more diverse and often achieves larger size than on xeric calcareous cliffs. Typical species

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include American arborvitae (*Thuja occidentalis*), basswood (*Tilia americana*), slippery elm (*Ulmus rubra*), and wild hydrangea (*Hydrangea arborescens*). Herbs include bulblet fern (*Cystopteris bulbifera*), fernleaf phacelia (*Phacelia bipinnatifida*), lyre-leaf rockcress (*Arabis lyrata*), and walking fern (*Asplenium hizophyllum*). Canby's mountain-lover (*Paxistima canbyi*, G2) and Carolina saxifrage (*Saxifraga caroliniana*, G2) are globally-rare plants which may be found in this community.

### Acidic Cliffs

Located on steep to precipitous sandstone, acidic shale, and quartzite outcrops, cliffs, and rocky escarpments, these are communities of sparse woodland, shrub, and herbaceous vegetation. The vegetation is generally dominated by lichens, with vascular plants confined to crevices and humus-covered shelves. On drier, south to west-facing cliffs, vascular plants may be very sparse and consist of stunted pines (*Pinus spp*), shrubs in the heath family, and occasional rock-loving herbs such as mountain spleenwort (*Asplenium montanum*), silverling (*Paronychia argyrocoma*), and wild bleeding heart (*Dicentra eximia*). Sheltered, north to east-facing cliffs often support a more diverse flora, including Eastern hemlock (*Tsuga canadensis*), evergreen rhododendrons (*Rhododendron spp*), rock polypodies (*Polypodium spp*), Michaux's saxifrage (*Saxifraga michauxii*), and rock alumroot (*Heuchera villosa*). Shaded grottoes and "rock houses" on cliffs of the Cumberland Mountains support little-leaved alumroot (*Heuchera parviflora*) and the state-rare round-leaved catchfly (*Silene rotundifolia*).

### Caves

Much of the landscape of southwestern Virginia exhibits karst topography, a landform of water-soluble limestone and dolomite bedrock that has led to the formation of sinkholes, springs, and caves. The Clinch River valley contains over 1250 caves, roughly half of the caves known to Virginia. The Nature Conservancy and the Virginia Division of Natural Heritage have designated over 110 of these caves as biologically significant.





The Virginia big-eared bat, an endangered bat species, lives in caves in southwestern Virginia.

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Caves found throughout Virginia host a wide variety of specialized and localized faunas; often these cave populations are very restricted geographically and thus highly vulnerable to extinction due to habitat disturbance. Caves in the Clinch valley are home to over 50 globally-rare species of invertebrates, in particular isopods, amphipods, beetles, and millipedes. Many of these invertebrates are vulnerable to changes in the groundwater quality in and around the cave.

Three federally endangered bat species, the Virginia big-eared bat (*Corynorhinus townsendii virginianus*, G4T2), Gray bat (*Myotis grisescens*, G2G3) and the Indiana bat (*Myotis sodalis*, G2), use caves in southwestern Virginia. The Indiana bat concentrates its hibernation in a few caves, while the Virginia big-eared bat uses caves both for hibernation and maternity colonies, making these caves critical environments to protect. The Indiana bat forms maternity colonies under the loose bark of trees such as shagbark hickories, oaks, and maples, and feeds over tree-lined streams on insects. An additional rare bat species known to the caves of the region is the eastern small-footed bat (*Myotis leibii*, G3).

### 3.5 Related Management Practices

Applying the strategies listed in Section 3.3 and adequately protecting rare species and communities involves a broad range of practices, including:

- Developing a management plan that takes these species and communities into account (see Chapter 7.)

