HIGH ELEVATION ROCK OUTCROPS

Contents

HIGH ELEVATION ROCK OUTCROPS THEME

Concept: High Elevation Rock Outcrops are sparsely or patchily vegetated communities of exposed bedrock occurring at higher elevations in the Mountain Region. They have less vegetation, less continuous soil, and more bare rock than Piedmont and Mountain Glades and Barrens, and, though they may contain local wet seepage areas, they lack the distinctive characteristics of the bedrock wetlands of Spray Cliff and Low Elevation Seep (Bedrock Subtype).

Distinguishing Features: High Elevation Rock Outcrop communities are distinguished from Low Elevation Cliffs and Rock Outcrops by the floristic differences associated with elevation. They often contain distinctive species confined to higher elevations, such as *Sibbaldiopsis tridentata, Carex brunnescens, Rhododendron (Menziesia) pilosum, Picea rubens*, and the suite of rare species such as *Houstonia montana*. They are more likely to have some additional species such as *Bryodesma* (*Selaginella*) *tortipilum, Danthonia compressa, Mononeuria groenlandica*, and *Rhododendron catawbiense*. Other species such as *Toxicodendron radicans, Gelsemium sempervirens, Rhododendron minus, Vaccinium arboreum, Vaccinium stamineum, Pinus virginiana, Juniperus virginiana*, and most *Quercus* species are more likely to occur on low elevation outcrops. All High Elevation Rock Outcrops occur in exposed topographic positions, on mid slope or higher; they may include vertical cliffs or more gently sloping surfaces. The transition from low to high elevation communities is different for the different communities, occurring around 3000 feet for High Elevation Granitic Dome but 4000 feet for High Elevation Rocky Summit.

High Elevation Rock Outcrops are distinguished from Piedmont and Mountain Glades and Barrens and Grass and Heath Balds, as well as from all forest and woodland themes, by their sparse vegetation, limited soil, and large amount of bare rock. High Elevation Rock Outcrops may have patches of denser herbaceous or woody vegetation, but these cover only a minority of the community extent, usually a small minority.

Within the theme, communities are divided into rocky summit and granitic dome communities based on rock structure. Granitic Domes are distinguished by smooth exfoliation surfaces with limited fractures and irregularities. Vegetation is therefore confined to unanchored shallow soil mats, without appreciable deeper crevices or pockets. Rocky Summits usually have substantial irregularities and fractures, but they may include areas of continuous smooth rock formed by bedding or foliation planes or massive beds. A few subtypes may consist largely of these smoother surfaces.

Sites: High Elevation Rock Outcrop communities occur on outcrops of rock that have very little soil cover, because of steepness, high topographic position, and resistance to weathering. They tend to be of weathering-resistant kinds of rock, such as quartzite, granite, gneiss, rhyolite, or related rocks but can also be of mafic or calc-silicate rocks. While High Elevation Granitic Domes are smooth and uniform, High Elevation Rocky Summits tend to be extremely heterogeneous at a fine scale, with expanses of rock often broken by ledges, chutes, overhangs, deep crevices, soil pockets, and aisles between slumped slabs of rock. Small accumulations of fallen boulders are common at the base of steeper outcrops, but larger areas of open talus are rare.

Soils: Soil is limited to shallow mats or accumulations on smooth surfaces or in local small depressions, and to occasional deeper accumulations in crevices. It presumably consists of a combination of marginally weathered rock and organic matter, perhaps with the addition of dust trapped by the vegetation and, potentially, material washed in from above.

Hydrology: Rock outcrop communities tend to be xeric overall, due to the lack of soil. Most rainfall runs off immediately, leaving the rock dry shortly afterward. However, moisture availability is extremely heterogeneous on a fine scale. Seepage areas may create small patches of wetland conditions. Slope aspect may also be important in determining moisture status of plants, as is the presence of overhangs. Overhangs and grottos can result from differential strength of rock layers. The climate of high elevations reduces drought stress, as evaporation is lower, rainfall is higher, and fog often bathes many sites.

Vegetation: All rock outcrop communities have limited cover of vascular plants, but their vegetation structure and composition tends to be extremely heterogeneous within occurrences as well as variable among the different communities and among their examples. Moister outcrops and sheltered microsites may have substantial cover of bryophytes, while drier outcrops may have substantial cover of crustose lichens, umbilicate lichens, or more xerophytic mosses. On the bare rock, vascular plants tend to be sparse. A suite of species that can grow on bare rock or minimal soil occurs across many of the communities. It includes several species of *Heuchera, Micranthes (Saxifraga), Asplenium, Bryodesma (Selaginella)*, and *Polypodium*. A further suite of herbs capable of surviving in shallow soil occurs on many outcrops, including drought-tolerant graminoids such as *Danthonia compressa, Schizachyrium scoparium*, and *Carex misera*, forbs such as several *Houstonia* species, *Krigia montana, Sibbaldiopsis tridentata*, and *Mononeuria groenlandica*, and highly specialized species such as *Liatris helleri* and *Solidago spithamea*. Other herbs of more general open habitats may be present, such as *Agrostis perennans, Angelica triquinata,* and *Solidago* spp., as well many species shared with surrounding forests. Herbs typical of Low Elevation Rocky Summits, such as *Campanula divaricata, Carex umbellata, Lysimachia quadrifolia,* and *Galax urceolata*, may occur but with lower frequency and mainly in lower elevation or more southerly examples. Trees or shrubs often take root in crevices or other areas with deeper soil. In more fractured outcrops, they may form substantial patches interspersed with the open rock. They may be of any species typical of the high elevations, but *Rhododendron catawbiense* is particularly characteristic. Granitic domes have distinctive vegetation representing stages of primary succession from *Grimmia laevigata* and *Bryodesma (Selaginella) tortipilum* to small herbs to larger grassy patches and eventually shrubs and small trees.

Dynamics: Most rock outcrop communities appear stable for long time periods, but they are undergoing a slow primary succession as rock weathers, soil accumulates, and plants establish. Outcrops tend to occur where these processes are particularly difficult and slow, due to resistant rock, steepness, and high erosion. Chemical weathering and plant growth are both slower in the cool climate at high elevation, slowing succession, but physical weathering by frost wedging enhances fracturing of rock. Resetting of weathering and primary succession may occur in some outcrops as rare collapse, breaking, or spalling exposes fresh rock. This is particularly important in granitic domes, where exfoliation leads to spalling of the surface. Granitic domes also have a distinctive dynamic because soil mats are not well anchored on the smooth rock and may easily fall, restarting primary succession. Though less dramatic than at lower elevations, maintenance of

open rock may also be aided by drought, which can kill established plants with limited rooting depth.

Fire is unlikely to be an important natural influence in most High Elevation Rocky Outcrop communities because of the sparse vegetation. Most are also surrounded by Spruce–Fir Forests or Northern Hardwood Forests, communities that do not naturally burn effectively. However, some are surrounded by High Elevation Red Oak Forest or other oak forests, and these might be exposed to fire more often.

There has been some concern raised by botanists monitoring rare plants that cover of woody vegetation has increased at the expense of rare herbs. It is not clear, however, that a natural process that would control woody growth is missing in most examples. With the exception of the minority that were readily exposed to fire, natural disturbances seem unaltered. Some disturbances, such as human trampling, have increased in many examples Johnson (1995) found that rare plants on outcrops do suffer from competition with woody plants and that competition seems to be what confines them to the rock outcrop. Johnson (1995) noted that high light levels are considered important, but that high elevation outcrops are frequently in fog, and some rare plants grow in microsites that are shaded by rock. He noted that dryness of outcrops is emphasized, but that rare species occur in the wettest as well as the driest microsites of rock outcrops. He also noted that herbs seem to suffer less from overhanging vegetation than from woody plants rooted in the same patch and suggested root competition may be more important than light competition. This appears reasonable, given the limited rooting volume.

The long-term dynamics of High Elevation Rocky Summit communities are interesting, in that many of their species appear to be remnants from an alpine tundra community that was widespread in the Southern Appalachians during the Pleistocene (Wiser 1993). Many of the rare species associated with them, both endemic and disjunct from the north, likely were once widespread alpine species in North Carolina. See the High Elevation Rocky Summit (Typic Subtype) for more details.

Comments: High Elevation Rock Outcrops are better studied than most sparsely vegetated communities, thanks to a comprehensive quantitative classification study (Wiser et al. 1996).

References:

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Wiser, S.K., R.K. Peet and P.S. White. 1996. High-elevation rock outcrop vegetation of the Southern Appalachian Mountains. Journal of Vegetation Science 7:703-722.

KEY TO HIGH ELEVATION ROCK OUTCROPS

1. Community on exfoliated granitic gneiss, granite, or related massive rocks; surface smooth, often curving from gentle to steep, with few or no deep fractures or crevices; vegetation, other than lichens and mosses on bare rock, consisting largely of plants in shallow soil mats, with *Bryodesma (Selaginella) tortipilum* usually dominant. Larger plants, where present, also rooted in shallow soil mats. (Consider also Low Elevation Granitic Dome if near 3000 feet elevation) .....**High Elevation Granitic Dome**

1. Community not on exfoliated gneiss, granite, or related massive rocks; if surface smooth and with limited deep fractures or crevices, then rock of other types and the surface a bedding plane or foliation surface, not smoothly curving; vegetation not consisting primarily of plants in shallow soil mats; vegetation a patchy mix of herbaceous and woody species rooted in deeper crevices and soil pockets along with plants on bare rock, or vegetation consisting solely of umbilicate lichens on bare rock.

2. Vegetation sparse overall but generally patchy, with lichens, bryophtyes, sparse herbs on bare rock, herbs in shallow soil mats, and herbs and woody species rooted in limited deeper soil patches; rock outcrop generally fractured and heterogeneous, and with abundant crevices, fractures, ledges, and other microsites, but possibly a smooth surface of amphibolite or related mafic rock with few fractures.

3. Rock outcrop a smooth, relatively unfractured surface of amphibolite or related rock; aspect generally south or west; vegetation containing a mix of typical high elevation rocky outcrop species such as *Sibbaldiopsis tridentata, Angelica triquinata*, and *Sorbus americana*, with species typical of lower elevations, such as *Schizachyrium scoparium* and *Coreopsis major*. (Consider High Elevation Mafic Glade if vegetation cover is high over the whole community). ....**High Elevation Rocky Summit (Little Bluestem Basic Subtype)**

3. Rock outcrop heterogeneous, generally moderately or highly fractured, with crevices, fractures, ledges, and other varying microsites; any type of rock and any aspect

4. Rock outcrop occurring at elevations above 5500 feet, or somewhat lower but with a limited flora that lacks species of lower elevations; typically dominated by *Heuchera villosa, Carex misera, Micranthes petiolaris*, *and* species shared with Spruce–Fir Forests..... ..... **High Elevation Rocky Summit (High Peak Subtype)**

4. Rock outcrop occurring at elevations below 5500 feet, or if somewhat higher, containing at least some plant species typical of lower elevations, such as *Kalmia latifolia, Amelanchier arborea, Vaccinium pallidum, Danthonia spicata, Krigia montana,* and *Dichanthelium acuminatum*.

5. Rock outcrop a steep slope or cliff facing north or east; composed of amphibolite; with vegetation contain abundant *Physocarpus opulifolius, Packera plattensis*, and *Phlox subulata*..... ..... **High Elevation Rocky Summit (Ninebark Basic Subtype)**

5. Rock outcrop steep or gentle; composed of any kind of rock; vegetation generally with a mix of species and growth forms, but without *Physocarpus, Packera*, and *Phlox* predominant; species of base-rich conditions are limited. ..... **High Elevation Rocky Summit (Typic Subtype)**

2. Rock outcrop vegetation consisting almost solely of the lichens *Lasallia papulosa* and *Lasallia caroliniana* on bare rock; vascular plants extremely limited or absent in most of the community; rock outcrop a smooth surface with few fractures, generally occurring on highly acidic rock such as quartzite.....**High Elevation Rocky Summit (High Peak Lichen Subtype)**

HIGH ELEVATION ROCKY SUMMIT (TYPIC SUBTYPE)

Concept: High Elevation Rocky Summits are communities of flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings, at high elevations, generally above 4000 feet. Vegetation of Rocky Summits is sparse or patchy, with substantial amounts of bare rock, and is generally characterized by a mix of growth forms or by predominantly forbs and sparse woody vegetation. The Typic Subtype covers most examples, lacking the distinctive characteristics of other subtypes. Their substrates range from felsic to mafic but they lack a strong component of flora associated with basic soils or with the highest elevations.

Distinguishing Features: High Elevation Rocky Summits are distinguished from forests, shrublands, and grasslands by a structure of sparse vegetation or herbaceous vegetation of moderate cover with extensive bare rock. Patches of shrub cover are generally present on edges or in pockets of deep soil, but large areas of shrub dominance should be considered Heath Balds. High Elevation Rocky Summits are distinguished from High Elevation Granitic Domes by having abundant fractured rock, in contrast to the largely smooth exfoliated bedrock of the domes. Montane Cliff communities generally occur at lower elevation than 4000 feet; they also are distinguished not by steepness but by a more topographically sheltered setting, below mid slope or protected by gorge walls or other topography.

High Elevation Rocky Summits are distinguished from Low Elevation Rocky Summits by the general absence of low elevation plants such as *Diodia teres, Phemeranthus (Talinum) teretifolius, Bryodesma (Selaginella) rupestre*, and *Quercus montana*. High elevation plants that are generally absent in Low Elevation Rocky Summits include *Sibbaldiopsis tridentata, Trichophorum cespitosum, Carex brunnescens, Geum radiatum, Liatris helleri, Solidago spithamaea, Houstonia montana, Rhododendron (Menziesia) pilosum, Abies fraseri, Picea rubens*, and *Sorbus americana*.

The Typic Subtype is distinguished from the High Peak Subtype by the presence of plants generally absent at the highest elevations. These include *Kalmia latifolia, Amelanchier arborea, Vaccinium pallidum, Danthonia spicata, Krigia montana, Carex umbellata*, and *Dichanthelium acuminatum*. The Typic Subtype is distinguished from the Little Bluestem Basic Subtype by the absence or minor role of warmer site plants characteristic of that subtype, such as *Schizachyrium scoparium* and *Coreopsis major*; it also has more typical cool site plants such as *Sibbaldiopsis tridentata, Angelica triquinata*, and *Sorbus americana*. It is distinguished from the Ninebark Basic Subtype by the absence or scarcity of *Phlox subulata ssp. subulata, Packera plattensis (= Senecio plattensis)*, and *Physocarpus opulifolius*.

Synonyms: Synonyms: *Saxifraga michauxii - Carex misera - Danthonia spicata - Krigia montana* Herbaceous Vegetation (CEGL004279).
Ecological Systems: Southern Appalachian Rocky Summit (CES202.327).

Sites: High Elevation Rocky Summits occur on peaks, ridge tops, upper slopes, and potentially mid slopes that are not topographically sheltered. They may consist of any kind of rock. The rock lacks the continuous smooth surface created by exfoliation. It generally is fractured or irregular, but areas of smooth surface created by bedding planes, foliation, or joints may occasionally be extensive. Fractures and varying hardness of rock layers can create complex structure, including

surfaces that are flat, sloping, vertical, or overhanging, and microsites such as ledges, crevices, chutes, and pockets of deeper soil.

Soils: Soil is limited to local small depressions and to occasional deeper accumulations in crevices or pockets. It presumably consists mainly of marginally weathered rock and accumulated organic matter but may locally include soil washed in from above.

Hydrology: Rock outcrop communities tend to be xeric overall, due to the lack of soil. Most rainfall runs off immediately, leaving the rock dry shortly afterward. However, moisture availability is extremely heterogeneous on a fine scale. Local microsites may concentrate or trap rainwater and runoff, creating moist conditions. Seepage areas may create small patches of wetland conditions. Overhangs may create moist sheltered microsites even in exposed sites. The climate of high elevations reduces drought stress, as evaporation is lower, rainfall is higher, and fog often bathes many sites.

Vegetation: High Elevation Rocky Summit vegetation tends to be patchy and mixed in structure. The extensive rock areas may include herbs able to root on bare rock and species of shallow soils. Deeper soil patches often have shrubs or even trees. Herbs found by Wiser et al. (1996) to have moderate to high constancy in one or both of the clusters that are equivalent to the Typic Subtype include *Micranthes (Saxifraga, Hydatica) petiolaris, Athyrium asplenioides, Danthonia spicata, Carex misera, Hylotelephium telephioides, Sibbaldiopsis tridentata, Heuchera villosa, Krigia montana, Polypodium appalachianum, Agrostis perennans, Rumex acetosella,* and *Angelica triquinata*. Site reports show largely the same set of species occurring frequently. Several rare species are also fairly high in frequency, at least in examples in the northern part of the state, including *Houstonia montana,* and *Geum radiatum*. Other species that may occur with lower frequency include *Solidago glomerata, Deschampsia cespitosa* ssp. *glauca, Danthonia compressa, Oreojuncus trifidus, Sanguisorba canadensis, Mononeuria (Arenaria, Minuartia) groenlandica, Liatris helleri,* and *Trichophorum cespitosum*. Herbs typical of Low Elevation Rocky Summits, such as *Schizachyrium scoparium, Campanula divaricata, Carex umbellata, Lysimachia quadrifolia,* and *Galax urceolata*, may occur but with lower frequency and mainly in lower elevation or more southerly examples. Shrubs that occur with at least fairly high frequency include *Rhododendron catawbiense, Sorbus americana, Vaccinium corymbosum, Vaccinium erythrocarpum*, *Rhododendron pilosum*, and *Diervilla sessilifolia.* Less frequent are *Physocarpus opulifolius, Aronia arbutifolia, Hypericum buckleyi, Viburnum cassinoides, Clethra acuminata, Gaylussacia baccata*, and species more typical of lower elevations such as *Kalmia latifolia*. Frequent trees also reflect the high elevation, with *Sorbus americana* and *Betula alleghaniensis* with high frequency and *Picea rubens* and *Abies fraseri* sometimes present. *Pinus* spp, *Quercus* species other than *rubra*, and other species of lower elevations are uncommon.

Range and Abundance: Ranked G2. Examples are scattered in the higher mountain ranges of North Carolina but are more abundant in the northern mountains. This community also occurs in Tennessee but is not known in the other Southern Appalachian states. Different associations represent the rocky summits in Virginia.

Associations and Patterns: High Elevation Rocky Summits are small patch communities. Most examples of the Typic Subtype are a few acres, but larger complexes may add up to more than 10 acres. They may be associated with Heath Bald or Grassy Bald communities, but otherwise are

surrounded by high elevation forests of the Spruce-Fir Forest and Northern Hardwood Forest themes, or by High Elevation Red Oak Forest or the highest extents of Montane Oak–Hickory Forest.

Variation: Two variants are recognized, to call attention to a distinctive specialized environment that needs further study and may warrant higher level recognition. Further variants may need to be recognized.

1. Typic Variant has the characteristics described above. It remains heterogeneous and may warrant further subdivision. It includes two plot clusters recognized by Wiser, et al. (1996) as *Paronychia-Polypodium* and *Deschampsia-Angelica*. Both are associated with mafic rock but do not have flora suggestive of strong basic influence. Additional examples of the Typic Variant, not sampled by Wiser or not distinguished in analysis, occur on felsic rock, including several that are transitional to Low Elevation Rocky Summit and have a component of lower elevation species. These could potentially be recognized as variants.
2. Ice/Rock Fall Variant is a distinctive open community that rarely forms at the base of vertical Rocky Summit or Granitic Dome cliffs where substantial amounts of ice form in the winter and fall to the base of the cliff. This variant is analogous in ecological process to the ice pond community of South Carolina (Hill 1999) but is much higher in elevation and consequently is rather different floristically. Its environment is a relatively level terrace of fallen boulders and soil at the base of the cliff, with small areas of water impounded by the accumulation of the terrace. Its flora includes boulderfield and wetland species as well as typical Rocky Summit species, some of which apparently established after falling from the rock above. It may warrant recognition as a distinct subtype, with further study.

Dynamics: High Elevation Rocky Summits are generally among the most stable of rocky outcrop communities. They are less likely to experience undercutting and collapse than cliffs, though some examples are still prone to it. With their deep rooting sites in crevices and deeper soil pockets, they are less likely to have vegetation mats slough off than are granitic domes. They are subject to stress and potential mortality of established vegetation caused by drought, though less so than lower elevation rock outcrops. Extreme cold and ice also are potential disturbances. In the Ice/Rock Fall Variant, and potentially in lower parts of some Typic Subtype examples, battering by falling material may be a chronic disturbance.

High Elevation Rocky Summits are interesting for their potential long-term dynamics. The Southern Appalachians are believed to have had a broad alpine tundra zone during the Pleistocene glaciation, with a timberline around 4400 feet (Delcourt and Delcourt 1985, 1988). Wiser (1993) noted that the treeline likely would have been lower in highly exposed sites. The 4000 foot lower elevation range for High Elevation Rocky Summit corresponds to this. Her analysis of biogeographic affinities and growth forms suggests that 17% of the 288 vascular plant species she found on high elevation rock outcrops are likely relicts of alpine tundra that has otherwise been replaced by forests. This includes a number of species shared with northern alpine communities, such as *Deschampsia cespitosa* and *Oreojuncus trifidus*, and endemic species such as *Carex misera, Carex biltmoreana, Solidago glomerata*, and *Geum radiatum*. Many of these species are now confined to High Elevation Rocky Summits, while others occur largely in them in combination with Grassy Balds or High Elevation Boggy Seeps. The exceptionally large number

of rare species associated with High Elevation Rocky Summits is at least partly a result of this history and of their role as refugia of once-abundant species of alpine tundra.

Comments: This subtype is based primarily on two plot clusters distinguished by quantitative analysis by Wiser (1993). However, the two clusters are the most closely related in the analysis, and most of the highly constant species in each are also at least frequent in the other. A third cluster, called *Aronia/Kalmia* appears to represent more shrubby zones in the Typic Subtype, and is described as transitional to Heath Bald.

Photinia melanocarpa - *Gaylussacia baccata* / *Carex pensylvanica* Shrubland (CEGL008508) is a G1? rock outcrop association defined in Virginia and stated to potentially be in North Carolina. It is described as a mosaic of shrub patches, herb patches, and bare rock. If something like it occurs, it might fit as a subtype of High Elevation Rocky Summit or might be a kind of glade.

In addition to the large number of rare plants and handful of rare animals listed below, High Elevation Rocky Summits may share with Spruce-Fir Forests a number of globally rare beetle species in genera such as *Trechus* and *Arianops*, some of them endemic to single North Carolina mountain ranges.

Rare species:
Vascular plants: *Allium allegheniense, Alnus viridis* ssp. *crispa, Arabidopsis lyrata, Betula cordifolia, Campanula rotundifolia, Cardamine clematitis, Chelone cuthbertii, Clematis occidentalis, Geum radiatum, Gymnocarpium appalachianum, Houstonia montana, Huperzia appalachiana, Oreojuncus trifidus, Liatris helleri, Lilium grayi, Lilium philadelphicum* var. *philadelphicum, Micranthes caroliniana, Mononeuria groenlandica, Phlox subulata, Rhododendron vaseyi, Robinia hispida* var. *kelseyi, Packera millefolium, Solidago spithamea, Triantha glutinosa, Trichophorum cespitosum, Woodsia appalachiana,* and *Woodsia ilvensis*
Nonvascular plants: *Anaptichya crinalis, Campylopus atrovirens, Cetraria arenaria, Ephebe americana, Gymnoderma lineare, Melanelia stygia, Rhytidium rugosum,* and *Xanthoparmelia monticola*.
Vertebrate animals: *Falco peregrinus* and *Neotoma magister*

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Wiser, S.K., R.K. Peet and P.S. White. 1996. High-elevation rock outcrop vegetation of the Southern Appalachian Mountains. Journal of Vegetation Science 7:703-722.

HIGH ELEVATION ROCKY SUMMIT (HIGH PEAK SUBTYPE)

Concept: High Elevation Rocky Summits are communities of flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings, at high elevations. Vegetation is sparse or patchy, with substantial amounts of bare rock, and is generally characterized by a mix of growth forms or by predominantly forbs and sparse woody vegetation. The High Peak Subtype covers examples in topographically exposed settings at the highest elevations, where even mid-elevation species are largely absent. Most are above 5500 feet.

Distinguishing Features: The High Peak Subtype is distinguished from other subtypes of High Elevation Rocky Summit and from all other open communities by occurring at the highest elevation locations, generally above 5500 feet, surrounded by Spruce–Fir Forests or Heath Balds, combined with limited flora that lacks species of lower elevation rock outcrops. Species typically completely lacking in this subtype include *Kalmia latifolia, Amelanchier arborea, Vaccinium pallidum, Danthonia spicata, Krigia montana,* and *Dichanthelium acuminatum*, while a small number of rock outcrop species such as *Heuchera villosa, Carex misera, Micranthes petiolaris*, and species shared with Spruce–Fir Forests are prominent.

Synonyms: *Saxifraga michauxii - Carex misera - Oclemena acuminata - Solidago glomerata* Herbaceous Vegetation (CEGL004277).
Ecological Systems: Southern Appalachian Rocky Summit (CES202.327).

Sites: The High Peak Subtype occurs near the tops of peaks and ridge tops, at elevations generally above 5500 feet. The rock is generally highly resistant felsic rock or quartzite. In known examples the rock tends to be highly fractured.

Soils: Soil is limited to local small depressions and to deeper accumulations in fractures. It presumably consists mainly of marginally weathered rock and accumulated organic matter.

Hydrology: This subtype may be less dry than most rock outcrops. The high elevation locations are subject to frequent fog as well as high rainfall and have limited evaporation in the cool temperatures. The fractured rock also may provide places for water to accumulate or be retained.

Vegetation: Vegetation of the High Peak Subtype is the typical mix of sparse vegetation on bare rock with patches of shrubs and trees in deeper soil pockets. Herbs with high constancy in Wiser, et al. (1996) include *Micranthes petiolaris, Carex misera, Oclemena acuminata, Solidago glomerata*, and *Heuchera villosa*. Other fairly frequent species include *Houstonia serpyllifolia, Athyrium asplenioides, Chelone lyonii, Angelica triquinata, Polypodium appalachianum,* and *Carex brunnescens*. Shrubs and trees with high constancy include *Sorbus americana, Rhododendron (Menziesia) pilosum,* and *Abies fraseri*, while *Vaccinium erythrocarpum* is fairly frequent. Only a few other species were found in the plots, including *Vaccinium corymbosum, Rhododendron catawbiense, Aronia arbutifolia, Rubus idaeus* ssp. *strigosus, Phegopteris connectilis, Trichophorum cespitosum, Eurybia cordifolia,* and *Houstonia serpyllifolia*.

Range and Abundance: Ranked G1. This community is limited to a handful of occurrences on high peaks, primarily on Grandfather Mountain, Roan Mountain, and in the Black Mountains. It also occurs in the Tennessee, probably solely at Roan Mountain and the Great Smoky Mountains.

Associations and Patterns: The High Peak Subtype is a small patch community. Though individual patches are mostly small, larger clusters may add up to 10 acres or more. It is generally surrounded by Fraser Fir Forest, Red Spruce–Fraser Fir Forest, or Heath Bald.

Variation: The High Peak Subtype is a relatively narrowly defined community with limited variation.

Dynamics: The dynamics of the High Peak Subtype are probably similar to the Typic Subtype and to High Elevation Rocky Summits in general.

Comments: The High Peak Subtype was distinguished from the Typic Subtype by quantitative analysis in Wiser (1993). Besides the primary cluster that is equivalent to this subtype, called *Aster acuminatus/Menziesia pilosa*, there was a woody-dominated cluster that appears to represent shrub patches in this subtype, called *Picea rubens/Leiophyllum buxifolium*.

Rare species:
Vascular plants: *Calamagrostis cainii, Geum radiatum, Houstonia montana, Huperzia appalachiana, Oreojuncus trifidus, Rubus idaeus* ssp. *strigosus, Phegopteris connectilis, Solidago spithamea,* and *Trichophorum cespitosum.*
Nonvascular plants: *Gymnoderma lineare.*
Vertebrate animals: *Desmognathus wrighti.*

References:
Wiser, S.K. 1993. Vegetation of high-elevation rock outcrops of the Southern Appalachians: Composition, environmental relationships, and biogeography of communities and rare species. PhD. Dissertation, University of North Carolina, Chapel Hill.

Wiser, S.K., R.K. Peet and P.S. White. 1996. High-elevation rock outcrop vegetation of the Southern Appalachian Mountains. Journal of Vegetation Science 7:703-722.

HIGH ELEVATION ROCKY SUMMIT (LITTLE BLUESTEM BASIC SUBTYPE)

Concept: High Elevation Rocky Summits are communities of flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings, at high elevations, generally above 4000 feet. The Little Bluestem Basic Subtype is a very rare community on southern or western exposures of base-rich rock — amphibolite, other mafic rock, or other basic substrates or influenced by base-rich seepage. While not strongly calciphilic, the flora contains species not otherwise common in High Elevation Rocky Summits. The warm exposure allows some lower elevation plants to mix with high elevation species. It thus shares characteristics with both High Elevation Mafic Glade and Low Elevation Rocky Summit.

Distinguishing Features: High Elevation Rocky Summits are distinguished from forests, shrublands, and grasslands by a structure of sparse vegetation or herbaceous vegetation of moderate cover with extensive bare rock. Patches of shrub cover are generally present on edges or in pockets of deep soil but are limited. High Elevation Rocky Summits are distinguished from High Elevation Granitic Domes by having abundant fractured rock, in contrast to the largely smooth exfoliated bedrock of the domes. Montane Cliff communities generally occur at lower elevation than 4000 feet; they also are distinguished not by steepness but by a more topographically sheltered setting, below mid slope or protected by gorge walls or other topography.

The Little Bluestem Basic Subtype is distinguished from other subtypes of High Elevation Rocky Summit by the occurrence of abundant *Schizachyrium scoparium, Coreopsis major*, and other species more typical of lower elevations. It is distinguished from Low Elevation Rocky Summit and Low Elevation Basic Glade by the presence of typically high elevation species such as *Sibbaldiopsis tridentata, Angelica triquinata*, and *Sorbus americana*. It is distinguished from High Elevation Mafic Glade by lower vegetation cover and more extensive bare rock. While the flora suggests basic soil conditions and research has shown soils to be high in base cations, not all examples are on mafic rocks. Some occur on normally acidic rocks which have some seepage, presumably because the seepage brings higher concentrations of base cations.

Synonyms: *Schizachyrium scoparium - Saxifraga michauxii - Coreopsis major* Herbaceous Vegetation (CEGL004074).
Ecological Systems: Southern Appalachian Rocky Summit (CES202.327).

Sites: The High Peak Subtype occurs on ridgetops or uppermost slopes. Examples are known from 4100 to over 5000 feet. Most examples known are in the Amphibolite Mountains area in the northwestern corner of the state. Outcrops are generally surfaces of slab-like fractured rock that slope to face south or west. While fractures are more abundant than in High Elevation Granitic Domes, there is fairly extensive continuous rock. The rock is usually amphibolite, but other kinds of rock in the vicinity of amphibolite can support the community, apparently influenced by movement of cation-rich water from the amphibolite.

Soils: Soil is limited to local small depressions and to deeper accumulations in fractures. It presumably consists mainly of marginally weathered rock and accumulated organic matter. Soils sampled in Wiser (1993) plots were higher in pH, magnesium, and manganese than other High Elevation Rocky Summits.

Hydrology: Rock outcrop communities tend to be xeric overall, due to the lack of soil. Most rainfall runs off immediately, leaving the rock dry shortly afterward. The extensive continuous rock surface limits the amount of water accumulation and seepage, and dry slope aspect of the Little Bluestem Basic Subtype makes it drier than other subtypes. However, small seepage areas with saturated conditions may still be present.

Vegetation: Vegetation of the Little Bluestem Basic Subtype is a mix of sparse vegetation on bare rock, herb-dominated shallow soil mats, and some woody vegetation in deeper pockets or crevices. More of the vegetation is herbs than in other subtypes. The flora includes both species common to most Elevation Rocky Summits and species shared with Low Elevation Rocky Summits. Herbs with constancy over 50% in Wiser (1993) and Wiser et al. (1996) plots are *Schizachyrium scoparium, Coreopsis major, Krigia montana, Dichanthelium acuminatum, Danthonia spicata, Paronychia argyrocoma*, and *Micranthes petiolaris*. Other herbs with fairly high frequency include *Allium cernuum, Viola sagittata, Solidago bicolor, Campanula divaricata, Houstonia caerulea, Carex umbellata, Hylotelephium telephioides, Heuchera villosa, Polypodium appalachianum, Avenella (Deschampsia) flexuosa,* and *Agrostis perennans*. Other notable herbs include *Danthonia sericea, Sibbaldiopsis tridentata, Houstonia longifolia* var. *glabra, Carex brunnescens, Carex misera,* and *Asplenium montanum*. Seeps may contain species such as *Sanguisorba canadensis, Oxypolis rigidior, Thalictrum clavatum*, and *Drosera rotundifolia*. The highest constancy woody species, all generally with low cover in plots, are *Rhododendron catawbiense, Kalmia latifolia*, and *Quercus rubra*, while *Physocarpus opulifolius, Vaccinium pallidum*, and *Vaccinium corymbosum* also are frequent. Additional high elevation species such as *Betula alleghaniensis* and *Sorbus americana* may occur.

Range and Abundance: Ranked G1. The Little Bluestem Basic Subtype is largely limited to the Amphibolite Mountains in Ashe County, but may be found in a few other places. Only a handful of well-developed occurrences is known. The NVC association is also attributed to Tennessee.

Associations and Patterns: The Little Bluestem Basic Subtype is a small patch community. Occurrences may be up to a few acres in size. They may occur near other subtypes of High Elevation Rocky Summit. They are usually surrounded by High Elevation Red Oak Forest (Rich Subtype) or Northern Hardwood Forest (Rich Subtype).

Variation: This is a narrowly defined community. It varies primarily in transitions to adjacent communities.

Dynamics: The dynamics of the Little Bluestem Basic Subtype are similar to High Elevation Rocky Summits in general. Because of their drier site conditions, drought may be an important natural disturbance. Fire may be a natural influence in the peripheral parts, but fire is unlikely to carry through the sparse vegetation.

Comments: This subtype was distinguished in analysis by Wiser (1993). It was the most distinct cluster in her analysis, but likely would appear less distinct if Low Elevation Rocky Summits had been included. It appears only marginally distinct from High Elevation Mafic Glade, but the lower plant cover and greater importance of bare rock tie it to High Elevation Rocky Summit. The

influence of higher base richness makes it somewhat analogous to the Basic Subtype of Low Elevation Rocky Summit.

Rare species:
Vascular plants: *Allium allegheniense, Campanula rotundifolia, Clematis occidentalis* var. *occidentalis, Geum radiatum, Gymnocarpium appalachianum, Houstonia montana, Huperzia appalachiana, Oreojuncus trifidus, Liatris helleri, Lilium grayi, Micranthes caroliniana, Phlox subulata, Sanguisorba canadensis, Trichophorum cespitosum, Woodsia appalachiana,* and *Woodsia ilvensis*.
Nonvascular plants: *Cetraria arenaria, Gymnoderma lineare,* and *Rhytidium rugosum.*

References:
Wiser, S.K. 1993. Vegetation of high-elevation rock outcrops of the Southern Appalachians: Composition, environmental relationships, and biogeography of communities and rare species. PhD. Dissertation, University of North Carolina-Chapel Hill.

Wiser, S.K., R.K. Peet and P.S. White. 1996. High-elevation rock outcrop vegetation of the Southern Appalachian Mountains. Journal of Vegetation Science 7:703-722.

HIGH ELEVATION ROCKY SUMMIT (NINEBARK BASIC SUBTYPE)

Concept: High Elevation Rocky Summits are communities of flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings, at high elevations. Vegetation is sparse or patchy, with substantial amounts of bare rock, and is generally characterized by a mix of growth forms or by predominantly forbs and sparse woody vegetation. The Ninebark Basic Subtype encompasses very rare examples on vertical amphibolite cliffs of cool slope aspect, with sparse vegetation characterized by vertical amphibolite cliffs with sparse vegetation dominated by *Physocarpus opulifolius, Phlox subulata*, and *Packera (Senecio) plattensis*. This subtype lacks many of the typical Rocky Summit plants and is conceptually transitional to Montane Cliff. It is known from Bluff Mountain, and this may be the only well-developed example.

Distinguishing Features: The Ninebark Basic Subtype is distinguished by amphibolite substrate and sparse vegetation dominated by *Physocarpus opulifolius, Packera plattensis*, and *Phlox subulata*.

Synonyms: *Physocarpus opulifolius / Campanula divaricata* - *Tradescantia subaspera* - (*Packera plattensis)* Sparse Vegetation (CEGL004759). Montane Mafic Cliff (in part).
Ecological Systems: Southern Appalachian Montane Cliff and Talus (CES202.330).

Sites: The Ninebark Basic Subtype occurs on steep, cliff-like outcrops of amphibolite, on upper slopes, facing north or east.

Soils: Soil is limited to local small depressions and to deeper accumulations in fractures. It presumably consists mainly of marginally weathered rock and accumulated organic matter but may include some material washed in from above.

Hydrology: The Ninebark Basic Subtype has extensive dry area because of the lack of soil, but the northerly slope aspect reduces evaporation and creates less xeric conditions than in most High Elevation Rocky Summits. Some seepage areas may be present.

Vegetation: Vegetation in the Ninebark Basic Subtype is sparse overall, but may have patches dominated by herbs or shrubs, both as shallow soil mats on flatter surfaces and plants rooted in fractures. Herbs include *Tradescantia subaspera, Packera plattensis, Phlox subulata*, *Houstonia purpurea, Houstonia longifolia* var. *glabra*, *Deschampsia cespitosa* var. *glauca, Carex misera, Corydalis sempervirens, Campanula divaricata, Coreopsis major, Polygala senega, Arabidopsis lyrata* ssp. *lyrata*, *Schizachyrium scoparium, Helianthus divaricatus, Danthonia compressa, Solidago bicolor*, and *Polygala senega*. Woody species include *Physocarpus opulifolius, Kalmia latifolia, Rhododendron catawbiense*, and *Tsuga caroliniana*.

Range and Abundance: Ranked G1? but the G1 status is clearer than many other communities. No more than a handful of examples exist, perhaps only one. The NVC association, however, is attributed to Tennessee as well as North Carolina.

Associations and Patterns: The Ninebark Basic Subtype is a small patch community, with patches potentially up to several acres. They may have more vertical surface than horizontal. The well-known example is associated with Carolina Hemlock Forest and Montane Oak-Hickory Forest, but other forest communities are possible.

Variation: This is a very narrowly defined community. Nothing is known about variation other than the normal heterogeneity of rock outcrop communities.

Dynamics: Nothing specific is known about the dynamics of this subtype. The steepness presumably makes it more susceptible to rock falls.

Comments: This community type is not well understood, and it is included only provisionally because the basis for its distinctness is not entirely clear. It was recognized as an association in the NVC, clearly based on the Bluff Mountain occurrence but is now attributed to Tennessee as well. Wiser (1993) did not find it distinct, though, with only two plots in it, data may not have been sufficient. The plots clustered with the Little Bluestem Basic Subtype. However, its vegetation reflects the cooler microclimate of the northeast-facing slope.

Rare species:
Vascular plants: *Allium alleghnsiense, Calamagrostis canadensis* var. *canadensis, Houstonia montana, Liatris aspera, Muhlenbergia glomerata, Packera paupercula* var. *appalachiana,* and *Phlox subulata*.
Nonvascular plants: *Campylopus atrovirens* var. *atrovirens*, *Dichodontium pellucidum,* and *Leptodontium flexifolium*

References:
Wiser, S.K. 1993. Vegetation of high-elevation rock outcrops of the Southern Appalachians: Composition, environmental relationships, and biogeography of communities and rare species. PhD. Dissertation, University of North Carolina, Chapel Hill.

HIGH ELEVATION ROCKY SUMMIT (HIGH PEAK LICHEN SUBTYPE)

Concept: High Elevation Rocky Summits are communities of flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings, at high elevations. The High Peak Lichen Subtype covers rare examples of steep to gently sloping, dry, smooth outcrops at high elevations, where shallow soils mats are nearly absent and vegetation consists almost entirely of the umbilicate lichens *Lasallia papulosa* or *Lasallia caroliniana*, along with crustose lichens. They are conceptually intermediate between High Elevation Rocky Summit and High Elevation Granitic Dome in having smooth, minimally fractured rock surfaces.

Distinguishing Features: The High Peak Lichen Subtype is distinguished from all other communities by the dominance of *Lasallia papulosa* or *Lasallia caroliniana*, the scarcity of vascular plants, and the absence or near absence of both crevices and shallow soil herb mats.

Synonyms: *Lasallia papulosa* - *Umbilicaria caroliniana* Nonvascular Vegetation (CEGL004386). High Elevation Granitic Dome (High Peak Lichen Subtype) (earlier 4th Approximation drafts). Ecological Systems: Southern Appalachian Granitic Dome (CES202.297).

Sites: The High Peak Lichen Subtype occurs on outcrops that are relatively continuous and unfractured but that are not exfoliated granitic rock. They occur on upper slopes or spur ridges at high elevations. The rock is quartzite in known examples, but other kinds of rock are possible.

Soils: Almost no soil is present. Even shallow accumulations of material in crevices or pockets are scarce or absent.

Hydrology: The High Peak Lichen Subtype is dry because of the lack of soil and exposure to wind and sun. However, the cool moist climate, high rainfall, and frequent fog at high elevation ameliorates the dry conditions to some degree. Generally little or no seepage is present.

Vegetation: The High Peak Lichen Subtype is vegetated almost solely by the lichens *Lasallia papulosa* and *Lasallia caroliniana* growing on bedrock. Vascular plants are largely absent.

Range and Abundance: Ranked G2? but probably rarer. The number of occurrences is not well known, and depends on uncertainties of circumscription, but no more than a handful of occurrences are likely. The NVC association is also attributed to Tennessee.

Associations and Patterns: The High Peak Lichen Subtype is a small patch community. Because some examples are steep, their vertical extent may be greater than their map extent. Associations are not well known. This subtype may occur in association with other subtypes. Otherwise, it may be surrounded by various kinds of high elevation forests, or potentially Heath Bald.

Variation: This is a narrowly defined community that has little known variation.

Dynamics: Nothing specific is known of the dynamics of the High Peak Lichen Subtype. They likely are very stable. The lichens are extremely vulnerable to trampling, so any examples that are not steep and are accessible may be among the most sensitive of communities to visitation.

Comments: The High Peak Lichen Subtype remains one of the most poorly understood of the communities in the 4th Approximation. It is not well known to the author and is not well described in site reports. Only a single CVS plot is known to represent it; Wiser (1993) and CVS did not generally distinguish lichen species. The limited number of people who can distinguish and who report on the different species of umbilicate lichens makes collecting information difficult.

This subtype was treated as a subtype of High Elevation Granitic Dome in early drafts, based on its NVC characterization as occurring on exfoliation slopes. But it was initially defined on Grandfather Mountain and indicated to likely occur in the Roan Mountain area. Neither mountain has well-developed granitic domes, though smooth surfaces that resemble exfoliation faces are locally present. Additional vertical, smooth quartzite cliffs covered with umbilicate lichens in the Black Mountains may also be this community. While the large High Elevation Granitic Domes farther south in the mountains sometimes have extensive faces dominated by umbilicate lichens, these do not represent this community, which is confined to higher peaks north of Asheville. The move from High Elevation Granitic Dome remains somewhat uncertain, but their association with rocky summits and higher elevation appear to make it a better fit.

Rare species: It is unclear if any rare species are associated with this subtype.

References:

HIGH ELEVATION GRANITIC DOME

Concept: High Elevation Granitic Domes are communities of large, smooth, exfoliation surfaces of granitic rock, occurring at higher elevations than Low Elevation Granitic Domes, generally above 3000 feet. Vegetation consists primarily of lichens on bare rock or of shallow mats generally dominated by *Bryodesma (Selaginella) tortipilum*.

Distinguishing Features: High Elevation Granitic Domes are distinguished from Low Elevation Granitic Domes by elevation and vegetation. The elevational boundary is around 3000 feet, but the types may overlap somewhat. Species that occur in High Elevation Granitic Domes but seldom in Low Elevation Granitic Domes include *Carex misera, Carex biltmoreana, Trichophorum cespitosum, Danthonia compressa, Hypericum buckleyi, Packera millefolium,* and *Robinia hartwigii*. Species that occur in Low Elevation Granitic Domes but seldom or less often in High Elevation include *Bryodesma rupestre, Danthonia spicata, Hypericum gentianoides, Hexasepalum (Diodia) teres, Phemeranthus teretifolius, Phlox nivalis ssp. hentzii, Rhododendron minus, Chionanthus virginicus, Juniperus virginiana*, *Pinus virginiana*, and *Carya* spp.

Granitic Domes are distinguished from other rock outcrop communities by a near absence of crevices and deep soil pockets, so that the vegetation is strongly dominated by shallow mats. In contrast, glades have extensive areas of deeper soil where herb or shrub cove is high. Rocky summits may have local areas of shallow soil mats, but also support substantial plant cover rooted in crevices or deeper pockets. Low Elevation Rocky Summit (Quartzite Ledge Subtype) can have substantial shallow soil mats but occurs on quartzite and has distinctive vegetation with abundant *Kalmia (Leiophyllum*) *buxifolia* and *Rhododendron carolinianum*. Cliffs are located in more topographically sheltered situations, generally on lower slopes or gorge walls, and generally also are more fractured. Smooth, exfoliated rock faces that extend onto lower slopes or gorge walls should be treated as High Elevation Granitic Domes if the rock is largely free of fractures and the vegetation is similar to that described above.

High Elevation Granitic Domes may grade conceptually with higher elevation examples of Low Elevation Basic Glade (Montane Subtype), which have a different threshold for low versus high elevation types. Glades are distinguished by more continuous soils and vegetation, though their soils are still shallow and their vegetation of low stature and often of similar composition. Often glades are on rocks that appear to be exfoliation surfaces that are more irregular, with undulating surfaces and more weathering pits. Both communities can contain patches that resemble the other, and in such cases, classification may need to be decided by the preponderance of cover. Only if there are substantial contiguous areas of both should both types be recognized on a single outcrop complex.

Two other communities may occur on the same rock outcrops as Low Elevation Granitic Domes. Low Elevation Seep (Bedrock Subtype) is a wetland community that occurs where seepage areas are extensive and have well-developed bryophyte mats or distinctive wetland flora. Low Elevation Acidic Glade (Biltmore Sedge Subtype) is a dense graminoid-dominated community, generally of *Carex biltmoreana*. Both of these communities should be recognized only for large, well-

developed patches, while small seeps and patches of *Carex biltmoreana* should be treated as part of the Low Elevation Granitic Dome community.

Low Elevation Granitic Domes sometimes have zones along their edges with vegetation that resembles Pine–Oak/Heath. These areas should be considered part of the Granitic Dome community unless they cover a substantial area or extend far from the rock outcrop.

Synonyms: *Selaginella tortipila - Krigia montana - Houstonia longifolia* Herbaceous Vegetation (CEGL004283).
Ecological Systems: Southern Appalachian Granitic Dome (CES202.297).

Sites: High Elevation Granitic Domes occur on outcrops of exfoliated massive rocks, usually granite or related rocks or granitic gneiss. Slopes may be gentle or steep, but large examples often curve gradually from nearly flat to nearly vertical. Domes are usually in upper slope positions and most often face south. Examples are known from 2900 feet to 4900 feet in elevation.

Soils: Soils are generally absent, except for patchy mats of shallow organic or mineral matter, usually of a sandy texture. Shallow continuous soils occur at the periphery. Wiser et al. (1996) noted that soils tended to be lower in major cations and micronutrients than all the different subtypes of High Elevation Rocky Summit.

Hydrology: High Elevation Granitic Domes tend to be xeric overall. With little soil, rainfall runs off immediately, leaving the rock dry most of the time. However, many examples occur in areas with high rainfall. The cooler temperatures and greater frequency of fog at higher elevations also makes them somewhat less xeric. Small seeps are common on the edges of domes, where moisture percolating through forest soil meets the bare rock. Occasionally a more persistent small stream may flow down the rock. Where domes have flatter tops, they may have small weathering pits that can trap water for a while after rains.

Vegetation: High Elevation Granitic Domes include large areas of rock that is bare or covered with crustose lichens. Areas of *Umbilicaria* sp. or *Lasallia papulosa* may be present. Mosses described as important by Oosting and Anderson (1939) include *Racomitrium heterostichum, Grimmia laevigata, Polytrichum* spp., and, in seeps, *Sphagnum* spp., *Andreaea rupestris*, and *Hedwigia ciliata*. *Cladonia* spp. also often are present. Vegetation mats of *Bryodesma tortipilum* dominate the portions with vascular vegetation. Wiser et al. (1996), a larger set of CVS plot data, and site descriptions don't consistently identify any other plant species as highly constant, but a number of herbs are at least fairly frequent in one or more of these sources. These include *Krigia montana*, *Houstonia longifolia* var. *glabra*, *Danthonia compressa, Danthonia sericea, Andropogon virginicus*, *Carex umbellata, Dichanthelium acuminatum, Solidago puberula, Danthonia spicata, Avenella flexuosa, Schizachyrium scoparium*, *Corydalis sempervirens, Micranthes petiolaris* var. *petiolaris, Eurybia surculosa*, *Solidago simulans*, and *Viola* spp. Additional notable herbaceous species that occur less frequently include *Sibbaldiopsis tridentata, Heuchera villosa, Carex misera, Agrostis perennans, Andropogon gerardii, Carex biltmoreana, Lobelia spicata,* and *Pycnanthemum* spp. Woody species occur primarily on the edges, though they may be present on thicker soil mats. Fairly frequent shrub species include *Kalmia latifolia, Diervilla sessilifolia, Vaccinium pallidum, Gaylussacia baccata, Vaccinium corymbosum,* and

Hypericum buckleyi. Frequent trees include *Acer rubrum, Amelanchier arborea*, *Quercus rubra, Quercus montana*, *Pinus pungens*, and *Pinus strobus*.

Range and Abundance: Ranked G2G3 but perhaps G3. North Carolina examples are concentrated in Jackson and Macon counties, with only a few examples scattered elsewhere in the Mountains. This community extends to South Carolina and Georgia and is questionably attributed to Tennessee, but a large majority of occurrences are in North Carolina.

Associations and Patterns: High Elevation Granitic Domes are best considered small patch communities, but the largest complexes can exceed 100 acres in size. They tend to be bordered by various oak forests or by Pine–Oak/Heath. Lower edges may grade to Acidic Cove Forest. Patches of the rare Low Elevation Seep (Bedrock Subtype) or Low Elevation Acidic Glade (Biltmore Sedge Subtype) may be associated with them.

Variation: Examples vary with configuration of the rock. Steeper outcrops have more bare rock while gentler slopes have more developed soil mats. Relative amounts of bare rock and vegetation mats may also vary with time and with amount of visitation. Two variants are recognized, to call attention to a distinct zone that is present in some examples.

1. Typic Variant covers most parts of all examples and fits the description above.
2. Ice/Rock Fall Variant is a distinctive open community that forms rarely at the base of vertical Granitic Dome faces where substantial amounts of ice form in the winter and fall from the cliff. This variant is analogous in ecological process to the ice pond community of South Carolina (Hill 1999) but is at somewhat higher elevation. More study is needed to characterize this variant, which was reported by Ed Schwartzman in the course of county natural area inventories. It appears as a relatively level terrace of fallen boulders and soil at the base of the cliff, with small areas of water impounded by the accumulation of the terrace. It has a cold and wet microclimate created by accumulation of fallen ice and has chronic disturbance that keeps forests from developing. Its flora includes boulderfield and wetland species as well as typical High Elevation Granitic Dome and Rocky Summit species, some of which apparently survive after falling from the rock above. This variant may prove distinctive enough to warrant a subtype or even a full type. However, occurrences are apparently all small, very heterogeneous, and seem to be tightly associated with High Elevation Granitic Domes.

Dynamics: Granitic Dome communities are primary successional communities like other rock outcrops, but they display a distinctive kind of successional dynamics (Oosting and Anderson 1937). Bare rock is colonized by mosses, particularly *Grimmia laevigata*, and by *Bryodesma tortipilum*. These pioneer mats trap sand grains and wind-blown dust, and accumulate organic matter, forming shallow soil that eventually can be colonized by other plants. As mats expand at their edges and become thicker, larger herbs, and eventually shrubs and trees, can root in them. Because the mats are not well anchored to the smooth rock beneath, most mats slough off under their own weight before they become very old. This tendency is greater on the steeper slopes and is exacerbated both by the death of the shallowly rooted trees and shrubs and by saturation of the mats during heavy rains. This cyclic succession maintains a predominance of bare rock and early successional mats despite the occurrence of most examples in areas with very high rainfall. Spalling of the rock surface may also occasionally renew the unweathered rock surface. The

overall complex of vegetation zones appears relatively stable over time. However, flatter upper edges of domes are less susceptible to sloughing, and a more continuous zone of shallow soil shrubland can develop there. Most of the sparse vegetation of the community would not carry fire and probably is little affected by fire in surrounding communities. However, it is possible that the upper edge may shift in response to fire dynamics or climatic cycles.

Comments: Plot analysis by Wiser (1993) found a distinct cluster representing High Elevation Granitic Domes, called *Selaginella/Carex umbellata*. The most closely related cluster was one called *Aronia/Kalmia*, which appears to be more closely related to High Elevation Rocky Summit (Typic Subtype).

Earlier drafts of the 4th Approximation included a High Peak Lichen Subtype. This poorly known community has been moved to treatment as a subtype of High Elevation Rocky Summit. Though that subtype occurs on smooth rock surfaces, its locations more resemble rocky summit conditions.

Rare species:
Vascular plants: *Crocanthemum bicknellii, Huperzia porophila, Juniperus communis* var. *depressa*, *Rhododendron vaseyi, Robinia hartwigii, Trichophorum cespitosum, Sedum glaucophyllum, Packera millefolium, Solidago simulans,* and *Solidago uliginosa* var. *uliginosa*.
Nonvascular plants: *Barbilophozia barbata, Campylopus atrivirens* var. *atrovirens*, *Gymnoderma lineare, Sphagnum pylaesii, Sphagnum tenellum,* and *Usnea angulata.*
Vertebrate animals: *Aneides aeneus* and *Eumeces anthracinus*

References:
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Oosting, H.J., and L.E. Anderson. 1937. The vegetation of a bare-faced cliff in western North Carolina. Ecology 8:280-292.

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