NORTHERN HARDWOOD FORESTS

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NORTHERN HARDWOOD FORESTS THEME

Concept: Northern Hardwood Forests occur at high elevations in the Mountain Region and are dominated by several species of mesophytic hardwood trees, particularly *Betula alleghaniensis, Fagus grandifolia, Acer saccharum*, and *Aesculus flava*. Examples may be excluded from particular slope aspects but extend across a broad range of topography and are not confined to concave valleys as Mountain Cove Forests are.

Distinguishing Features: Northern Hardwood Forests are distinguished from Spruce–Fir Forests by the predominance of hardwoods over *Picea rubens* and *Abies fraseri* under long term natural conditions. They are distinguished from Mountain Oak Forests by the predominance of the mesophytic hardwoods over oaks in both cover and basal area. Some Mountain Oak Forests have developed mesophytic understories that resemble Northern Hardwood Forests and have greater stem density of mesophytic trees than oaks, while basal area remains dominated by oaks. Placing the boundary between Northern Hardwood Forests from Mountain Cove Forests is particularly difficult, because many mesophytic species are shared. In general, Northern Hardwood Forests contain a subset of the species typical of Mountain Cove Forests, with at least one of the characteristic species very abundant. These species are generally not dominant over more than local patches in Mountain Cove Forests. Northern Hardwood Forests generally have lower species richness and lack a number of low elevation species such as *Liriodendron tulipifera* and *Magnolia* spp.

Sites: Northern Hardwood Forests occur on ridges, open slopes, and upper coves at high elevations. Most examples are above 3600 feet, and they range to 5500 feet or higher, the highest elevations of any hardwood forests. In most of this elevational range they are primarily on the cooler slope aspects, but at the highest elevations they may occur on any aspect.

Soils: Northern Hardwood Forests occur on a range of high elevation Inceptisols, particularly Humic Dystrudepts, Typic Humadepts, and some Lithic Humadepts. A special case is the High Elevation Birch Boulderfield community, which occurs on very coarse colluvial deposits that are relict periglacial features.

Hydrology: Sites are well drained, but are mesic because of the cool temperatures, high rainfall, and frequent fog associated with high elevations.

Vegetation: Northern Hardwood Forests are dominated by varying mixtures of mesophytic tree species. *Betula alleghaniensis* or *Fagus grandifolia* may sometimes strongly dominate, almost to the exclusion of other species. In most places, one or both of these species is mixed with *Aesculus flava, Acer saccharum*, or minority amounts of *Quercus rubra*. *Tsuga canadensis* or *Picea rubens* may be present in small amounts. In the Basic Subtype, *Fraxinus americana, Prunus serotina, Tilia americana* var. *heterophylla*, *Carya ovata*, or other species of richer soils may also be abundant. The understory usually consists of the same set of species, but *Amelanchier arborea* and *Cornus alternifolia* are also characteristic. Shrubs layers are usually moderate in cover, but can range from dense to nearly absent. The herb layer usually is well developed, sometimes with moderate diversity but sometimes consisting of a dense carpet of a few, or only one, species. *Carex pensylvanica*, *Ageratina altissima* var. *roanensis, Oclemena acuminata, Eurybia chlorolepis,*

Athyrium asplenioides, Dennstaedtia punctilobula, Parathelypteris noveboracensis, Angelica triquinata, and in the spring, *Erythronium umbilicatum* var. *monostolum* and *Claytonia caroliniana* are frequent species that often are very abundant.

Dynamics: Northern Hardwood Forests are like most of North Carolina's hardwood forests in naturally occurring primarily as old-growth, uneven-aged stands. Most tree reproduction is in small canopy gaps created by the death of one or a few trees, resulting in a fine-scale mosaic of tree ages across the forest. Wind, lightning, and ice damage are important sources of mortality. Disease is now a source of mortality for *Fagus* in particular and may kill larger patches. Sites that were logged or severely burned in the past may have *Prunus pensylvanica*, *Robinia pseudoacacia*, or increased numbers of *Betula alleghaniensis*, which presumably will be replaced over time with the more typical canopy. Where the canopy has been partially disturbed by wind or ice, *Rubus canadensis* or *Rubus alleghaniensis* sometimes becomes abundant.

Fire was not frequent in these communities. The mesophytic hardwood litter is not very flammable and the moist conditions limit times when fire will spread. The characteristic trees have thin bark and are not well equipped to survive any but low intensity fires. Their prevalence over large areas even before the advent of effective fire suppression suggests little fire spread into these areas, despite frequent fire at lower elevations. Any fire that did occur might be a significant natural disturbance, much more than in oak forests, but the ability of the dominant hardwoods to sprout would limit changes in dominance resulting from rare fires.

The ecotones of Northern Hardwood Forests with adjacent communities may be affected by changing forest dynamics. The boundary with High Elevation Red Oak Forests likely was determined at least partly by fire behavior. Since the advent of effective fire suppression, many High Elevation Red Oak Forests have developed substantial mesophytic understories, which limit oak regeneration and appear poised to take over the canopy. If this trend continues, more areas that have been High Elevation Red Oak Forest may become indistinguishable from Northern Hardwood Forests.

The transition to Red Spruce–Fraser Fir Forest is a very gradual shift in tree dominance, generally occurring with increasing elevation but in a patchy, irregular pattern. There has been concern that the widespread logging of spruce forests in the early 1900s led to replacement of spruce with hardwoods, as happened over large areas in West Virginia. This is difficult to document at elevations much below 5800 feet, because the pattern of the transition is irregular and occurs over a range of elevations even in areas that were never logged. As the climate becomes warmer, this boundary between Northern Hardwood Forests and Spruce–Fir Forests presumably will shift to higher elevation; however, if frequent fog persists, warming may be less extreme at higher elevations than lower. Conversely, if warming leads to less fog and especially if it leads to severe drought, wild fire may cause rapid loss of spruce and lead to its replacement by Northern Hardwood Forests. At present, individual spruce trees may be observed establishing in Northern Hardwood Forests and High Elevation Red Oak Forests below the elevations where they dominate, suggesting they do not yet suffer from the present climate. Increased rainfall in the late 1900s, suggested by McEwan et al. (2011) as a driver of mesophication of oak forests, could possibly lead to such downhill expansion of spruce.

Comments: Northern Hardwood Forests are named for their resemblance to mesophytic hardwood forests of New England, the upper Midwest, and Canada. Like those northern forests, they occupy a climatic zone roughly between oak forests and spruce–fir forests. However, the analogy is only general. The Northern Hardwood Forests of the Southern Appalachians contain some regional endemic species and lack characteristic widespread northern species such as *Betula papyrifera* and *Populus tremuloides*. The catastrophic natural disturbances that favor such successional species also seem to be rare in the Southern Appalachians, giving our Northern Hardwood Forests a different ecological character from those in the north.

While the concept of Northern Hardwood Forests in our region has been widely used, it has also been widely considered problematic. Some authors of regional vegetation studies have specifically rejected the name or have not attempted to distinguish it from cove forests. Whittaker (1956) called it upper cove forest, even while describing numerous ways in which it differed from the classic cove forests. McLeod (1988) did not use the name and distinguished only the low diversity beech and birch forests above 4800 feet as distinct. Newell (1997), however, distinguished communities clearly comparable to these. Ulrey (2002) analyzed rich cove forests data that appear to include at least part of the concept of Northern Hardwood Forest (Rich Subtype), based on elevation ranges. While Northern Hardwood Forests and Rich Cove Forests do share much flora and extensively intergrade, the tremendous range in composition and environments between both, spanning some 5000 feet of elevation, calls for a division even if the transition is gradual. The reduced species richness, the shift in dominance, and the change in relationship to topography seem sufficient reason to create a break approximately where it is recognized here. It should be remembered, though, that the boundary is necessarily arbitrary, and examples on both sides of the boundary may closely resemble each other.

References:

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KEY TO NORTHERN HARDWOOD FORESTS

1. Ground nearly entirely covered by boulders, generally piled on deeper boulders, with abundant spaces beneath the rocks. Canopy strongly dominated by *Betula alleghaniensis*. Lower strata with few species, primarily *Acer spicatum, Ribes* spp., and ferns and bryophytes growing on rock. .... **High Elevation Birch Boulderfield Forest**

1. Ground not entirely covered by boulders; if rocky, rocks are embedded in soil and do not have large amounts of open space. Canopy various. *Betula alleghaniensis* not strongly dominant, though it may be abundant.

2. Forest strongly dominated by *Fagus grandifolia*, often stunted, with *Aesculus flava* the only other likely abundant species; herb layer generally a lawn-like bed of *Carex pensylvanica*; generally occurring at very high elevations, in concave areas adjacent to Spruce-Fir Forests or on open mountain tops. ....**Northern Hardwood Forest (Beech Gap Subtype)**

2. Forest not strongly dominated by *Fagus grandifolia*, though the species is often present and may be codominant; lawn-like areas of *Carex pensylvanica* absent or limited in extent; topographic settings various.

3. Forest containing tree species indicative of richer soils, such as *Tilia americana* var. *heterophylla, Fraxinus americana, Prunus serotina*, and *Carya ovata*; herb layer containing species indicative of richer soils or shared with Rich Cove Forests, such as *Collinsonia canadensis, Caulophyllum thalictroides, Actaea pachypoda, Actaea racemosa*, and *Hydrophyllum virginianum*. .... **Northern Hardwood Forest (Rich Subtype)**

3. Forest not containing trees or herbs indicative of richer soils as above; canopy a mix of *Betula alleghaniensis, Aesculus flava, Fagus grandifolia*, and *Acer saccharum*, herb layer sparse or dense but lacking the above species. .....**Northern Hardwood Forest (Typic Subtype)**

NORTHERN HARDWOOD FOREST (TYPIC SUBTYPE)

Concept: Northern Hardwood Forests are the mesophytic forests of higher elevations, occurring on exposed or somewhat sheltered sites and generally dominated by *Betula alleghaniensis, Fagus grandifolia, Acer saccharum*, or *Aesculus flava*. The Typic Subtype represents the most common examples, which lack the flora of rich sites and do not have the characteristics of the other subtypes.

Distinguishing Features: Northern Hardwood Forests may be distinguished from High Elevation Red Oak Forests, Red Spruce, and Red Spruce–Fraser Fir Forests by the predominance of mesophytic hardwood species over *Quercus rubra, Picea rubens*, or *Abies fraseri*. High Elevation Birch Boulderfield Forest also is dominated by mesophytic hardwoods but has over 90% cover of boulders, with substantial open space beneath them. The ground cover vegetation in boulderfields is dominated by plants rooted on rock and shallow soil pockets rather than in deep soil. Though Northern Hardwood Forest sites may be very rocky, most plants are rooted in deep soil and the rocks do not visibly change the nature of the vegetation.

The boundary between the Rich Cove Forest and Northern Hardwood types is one of the most difficult to define. Many species in all strata may be shared, and the gradation is particularly gradual. The transition tends to occur around 4000 feet elevation but may be shifted considerably up or down in response to slope aspect, exposure, and latitude. The distinction is best made by the vegetation, based on the presence of species that are confined to high or low elevations. Typical cove species not expected in Northern Hardwood Forest include *Liriodendron tulipifera, Magnolia fraseri, Magnolia acuminata, Ostrya virginiana*, and *Cornus florida*. Northern Hardwood species uncommon in Rich Cove Forests are fewer, but include *Viburnum lantanoides*, *Rhododendron catawbiense,* and *Picea rubens*.

The Typic Subtype is distinguished most easily by lacking the characteristics of the other subtypes. The herb layer may be dense but is not highly diverse, and the species of rich soils which characterize the Rich Subtype are largely absent from all strata. While *Fagus grandifolia* may be codominant in the Typic Subtype, the Beech Gap Subtype has strong *Fagus* dominance in combination with a lawn-like herb layer dominated by *Carex pensylvanica*,

Synonyms: *Betula alleghaniensis - Fagus grandifolia - Aesculus flava / Viburnum lantanoides / Eurybia chlorolepis - Dryopteris intermedia* Forest (CEGL007285).
Ecological Systems: Southern Appalachian Northern Hardwood Forest (CES202.029).

Sites: Northern Hardwood Forest (Typic Subtype) occurs on convex to concave slopes and ridges at high elevations. Most examples are above 3600 feet, and they can range to 5600 feet or higher. At all but the highest elevations, most examples are on north or east-facing slopes, concave slopes, or otherwise sheltered sites.

Soils: Northern Hardwood Forests occur on a variety of Inceptisols. Common mapped soils include Typic Haplumbrepts (Plott, Wayah), Humic Dystrudepts (Balsam, Porters, Tusquitee), and Typic Humadepts (Burton).

Hydrology: Sites are well drained but are mesic due to cool temperatures and high rainfall at their high elevations. Northern Hardwood Forests are more moist than oak forests at the same elevations, because they occur on cooler slope aspects.

Vegetation: Northern Hardwood Forest (Typic Subtype) is dominated by varying combinations of *Betula alleghaniensis, Fagus grandifolia, Aesculus flava*, and *Acer saccharum*. Some forests are nearly pure *Betula*, while others are a mix of the other species with little *Betula*. *Quercus rubra* (presumably var. *ambigua*) is usually present in all but the highest elevation examples. Other canopy tree species are scarce, though some *Picea rubens* or *Abies fraseri* may be present at higher elevations and *Tsuga canadensis*, *Prunus serotina*, or other species may be present at the lower elevations. *Acer pensylvanicum* has high constancy and *Acer spicatum* is also frequent; the understory may be dominated by either or by canopy species. The shrub layer may be sparse or fairly dense. *Rubus canadensis* may be abundant where there has been widespread natural or artificial disturbance. *Viburnum lantanoides* and *Ilex montana* are frequent, and though less frequent, species such as *Vaccinium erythrocarpum, Vaccinium simulatum*, *Sambucus racemosa* var. *pubens*, and *Rhododendron catawbiense* indicate the high elevation affinities of this community. The herb layer generally is well developed and may be dense. High constancy species in CVS plot data are *Dryopteris intermedia, Athyrium asplenioides, Polystichum acrostichoides, Carex pensylvanica*, and *Arisaema triphyllum*, and all but the last may dominate substantial patches. Earlier in the spring, *Erythronium umbilicatum* var. *monostolum* and *Claytonia caroliniana* may dominate the herb layer. Other frequent and sometimes locally dominant species in plots include *Eurybia chlorolepis, Parathelypteris noveboracensis, Ageratina altissima* var. *roanensis*, *Angelica triquinata*, and *Maianthemum canadense*. Other frequent species include *Trillium erectum, Maianthemum racemosum, Dioscorea villosa, Tiarella cordifolia*, and *Viola* spp., while species such as *Clintonia borealis, Dryopteris campyloptera*, and *Carex intumescens* var. *intumescens* show the community's high elevation affinities.

Range and Abundance: Ranked G3G4. The Typic Subtype is the most abundant of the Northern Hardwood Forests. It is scattered throughout the mountain region at higher elevations. The equivalent association also occurs in Tennessee and southern Virginia.

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Associations and Patterns: The Typic Subtype occurs as a large patch community, often occupying the cooler slope aspects while High Elevation Red Oak Forest covers the warmer aspects. The Typic Subtype may grade upslope to Red Spruce–Fraser Fir Forest. It may grade downslope to Rich Cove Forest in sheltered topography or to Chestnut Oak Forest or Montane Oak–Hickory Forest in more exposed areas. High Elevation Birch Boulderfield, Grassy Bald, Heath Bald, High Elevation Rocky Summit, Rich Montane Seep, High Elevation Boggy Seep, or other small patch communities may be embedded. The Typic Subtype may grade to the Rich Subtype or Beech Gap Subtype.

Variation: The Typic Subtype is a very broad category, with much variation in species composition, structure, and overall diversity. Several variants can be recognized:

1. Birch Variant occurs at the highest elevations. *Betula alleghaniensis* usually strongly dominates, but *Picea rubens* may be abundant in the transition to Red Spruce–Fraser Fir Forest.

2. Ridge variant occurs on other high, exposed ridgetops or peaks, where *Fagus grandifolia* is dominant. This variant is transitional to the Beech Gap Subtype but has a full stature canopy.

3. Typic Variant occurs at lower elevations and generally has a more mixed canopy containing three or four of the characteristic tree species.

4. Mesic Variant occurs in the transition to Acidic Cove Forest, where *Tsuga canadensis, Rhododendron maximum*, and other species of lower elevations may occur.

Dynamics: Dynamics of the Typic Subtype are similar to those of the theme as a whole.

Comments: In the southern part of the mountains, beyond the geographic range of spruce and fir, Northern Hardwood Forests of the Birch or Beech Variants may occupy large areas on high peaks. A similar pattern appears in several areas within the range of spruce and fir, where mountains reach high enough elevations to support these conifers but lack them. The Craggy Mountains and Elk Knob are examples. The trees in the Northern Hardwood Forest are often small or stunted in these areas. It has been noted that these mountain ranges are slightly lower in elevation than those that do support spruce and fir, and it has been suggested that the species were eliminated from them in a time of warmer climate several thousand years ago. The suggestion is that the spruce–fir forests were "pushed off the top of the mountain" by the shifting of vegetation zones in that warmer climate. An underlying assumption is that these species lack the ability to disperse back to these ranges. It must be noted, however, that the Craggy Mountains are connected at high elevation to the extensive spruce–fir forests of the Black Mountains, and that spruce appears to be dispersing into them at present. At Elk Knob, an anomalous population of spruce occurs in the valley downslope of the stunted Northern Hardwood Forest.

Rare species: Vascular plants – *Aconitum reclinatum, Betula cordifolia, Brachyelytrum aristosum, Cardamine clematitis, Dendrolycopodium dendroideum,Geum geniculatum, Glyceria nubigena, Lilium grayi, Meehania cordata, Pyrola elliptica, Rhododendron vaseyi, Scutellaria saxatilis, Spiranthes ochroleuca.* Nonvascular plants – *Drepanoleujeunea appalachiana, Gymnoderma lineare, Metzgeria temperata, Plagiochila austinii.*

Animals – *Aegolius acadicus, Certhia americana, Coccyzus erythropthalmus, Empidonax alnorum, Glaucomys sabrinus coloratus, Plethodon aureolus, Plethodon cheoah, Plethodon welleri, Sorex dispar blitchi, Sphyrapicus varius*.

References:

NORTHERN HARDWOOD FOREST (RICH SUBTYPE)

Concept: Northern Hardwood Forests are the mesophytic forests of higher elevations, occurring on exposed or somewhat sheltered sites, and generally dominated by *Betula alleghaniensis, Fagus grandifolia, Acer saccharum*, or *Aesculus flava*. The Rich Subtype encompasses the rare examples on mafic or calcareous rock substrates, which contain flora of rich soils, including many species shared with Rich Cove Forest.

Distinguishing Features: Northern Hardwood Forests may be distinguished from High Elevation Red Oak Forests, Red Spruce, and Red Spruce–Fraser Fir Forests by the predominance of mesophytic hardwood species over *Quercus rubra, Picea rubens*, or *Abies fraseri*. High Elevation Birch Boulderfield Forest also is dominated by mesophytic hardwoods but has over 90% cover of boulders, with substantial open space beneath them. The ground cover vegetation in boulderfields is dominated by plants rooted on rock and shallow soil pockets rather than in deep soil. Though Northern Hardwood Forest sites may be very rocky, most plants are rooted in deep soil and the rocks do not visibly change the nature of the vegetation.

The Rich Subtype is distinguished from the other subtypes of Northern Hardwood Forest by having several canopy and herbaceous species indicative of richer soil conditions. *Fraxinus americana, Tilia americana* var. *heterophylla*, *Prunus serotina*, *Carya ovata*, and *Magnolia acuminata* are typically indicative. Herbs characteristic of the Rich Subtype and not of other subtypes include *Actaea racemosa, Actaea pachypoda, Caulophyllum thalictroides, Collinsonia canadensis, Osmorhiza claytonia, Hydrophyllum virginianum*, and a number of other species.

The boundary between the Rich Cove Forest and Northern Hardwood types is particularly difficult to define for the Rich Subtype. The overlap of species is much greater than for other subtypes. Some of the species that are confined to lower elevations on more typical acidic substrates, such as *Magnolia acuminata* and *Ostrya virginiana*, extend to higher elevation in the Rich Subtype. *Liriodendron tulipifera* is confined to Rich Cove Forest, while the presence of high elevation species such as *Picea rubens, Viburnum lantanoides*, or *Sambucus racemosa* var. *pubens* is indicative of Northern Hardwood Forest. Further analysis is needed to clarify additional indicators to distinguish these communities. The transition tends to occur around 4000 feet elevation but may be shifted uphill or downhill in response to slope aspect, exposure, and latitude.

Synonyms: *Aesculus flava - Betula alleghaniensis - Acer saccharum / Acer spicatum / Caulophyllum thalictroides - Actaea podocarpa* Forest (CEGL004973).
Ecological Systems: Southern Appalachian Northern Hardwood Forest (CES202.029).

Sites: Northern Hardwood Forest (Rich Subtype) occurs on high elevation convex to concave slopes and ridges which are underlain by mafic or calcareous rock. Most examples are above 3600 feet, and they can range to 5600 feet or higher. At all but the highest elevations, most examples are on north or east-facing slopes, concave slopes, or otherwise sheltered sites.

Soils: Soils in the Rich Subtype are influenced by mafic or, much less frequently, calcareous rock. They have higher pH and base saturation than typical soils in the region. Most are mapped as the

same series of Typic Haplumbrepts, Humic Dystrudepts, and Typic Humadepts as in the Typic Subtype.

Hydrology: Sites are well drained but are mesic due to cool temperatures and high rainfall at their high elevations. Northern Hardwood Forests are more moist than oak forests at the same elevations, because they occur on cooler slope aspects.

Vegetation: The Rich Subtype has a diverse canopy that contains the characteristic Northern Hardwood Forest species *Acer saccharum, Aesculus flava,* and *Betula alleghaniensis* along with several other species shared with Rich Cove Forests. Additional trees with high constancy in CVS plots data are *Prunus serotina, Fagus grandifolia, Tilia americana* var. *heterophylla*, and *Fraxinus americana*. Also at least fairly frequent are *Quercus rubra, Carya cordiformis*, *Betula lenta*, and *Magnolia acuminata*. The understory may be dominated by *Acer pensylvanicum* or, less often, *Acer spicatum* or *Ostrya virginiana*. *Cornus alternifolia* is also frequent. The shrub layer is sparse to moderate in density. *Hydrangea arborescens* is the only species with fairly high frequency in plot data, but *Viburnum lantanoides, Ilex montana*, and *Sambucus racemosa* var. *pubens* sometimes occur. The herb layer is diverse and often dense and lush and shares a large pool of species with Rick Cove Forest. *Laportea canadensis* can dominate in late summer, but otherwise there usually are not clear dominant species. Highly constant species in CVS plot data are *Arisaema triphyllum, Polystichum acrostichoides, Maianthemum racemosum, Laportea canadensis, Prosartes lanuginosa, Caulophyllum thalictroides, Trillium erectum, Actaea racemosa, Impatiens pallida, Stellaria pubera, Tiarella cordifolia, Polygonatum biflorum, Dryopteris intermedia, Eurybia divaricata, Solidago curtisii*, and *Osmorhiza claytonia*. Additional frequent species include *Angelica triquinata, Athyrium asplenioides, Lilium superbum, Viola rotundifolia, Allium tricoccum, Hydrophyllum canadense, Viola canadensis, Huperzia lucidula, Oclemena acuminata, Galium triflorum, Carex pensylvanica, Anemone quinquefolia, Parathelypteris noveboracensis, Actaea podocarpa, Streptopus lanceolatus* var. *lanceolatus, Collinsonia canadensis, Dioscorea villosa, Dryopteris marginalis, Monarda didyma, Botrypus virginianus, Actaea pachypoda, Ageratina altissima* var. *roanensis, Festuca subverticillata*, and *Veratrum parviflorum*. A large number of additional species are present at frequencies below 30%.

Range and Abundance: Ranked G3. The Rich Subtype is scattered throughout the high mountain of North Carolina, but with fewer sites and much less acreage than the Typic Subtype. The related association, as defined, ranges not only Georgia, Tennessee and Virginia, but into West Virginia.
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Associations and Patterns: The Rich Subtype occurs as a large patch or small patch community. It may be associated with the Typic Subtype and may give way to High Elevation Red Oak Forest or Montane Oak–Hickory Forest on warmer slope aspects. As with the Typic Subtype, it may grade upslope to Red Spruce–Fraser Fir Forest. It may potentially contain embedded High Elevation Birch Boulderfield, Grassy Bald, Heath Bald, High Elevation Rocky Summit, Rich Montane Seep, High Elevation Boggy Seep, or other small patch communities, though no cases are known for some of these associations. The Rich Subtype may grade the Typic Subtype with a change in substrate.

Variation: Examples may vary in the apparent richness of the site as reflected by the flora. It is possible that there could be variants analogous to those in the Typic Subtype, but these have not been clarified.

Dynamics: Dynamics of the Typic Subtype are similar to those of the theme as a whole.

Comments: Rohrer (1983) noted that substrate (metabasalt vs. arkose) shifted the boundary between Northern Hardwood Forest (this subtype) and High Elevation Red Oak Forest. This suggests that the soil nutrient status or soil texture may interact with moisture conditions and the effects of topography.

It is particularly difficult to distinguish the Rich Subtype from Rich Cove Forest in literature, as it is in the field. Many regional study areas, such as the Joyce Kilmer-Slickrock Wilderness and Shining Rock Wilderness studied by Newell (1997), and the Great Smoky Mountains (Whittaker 1956), have little of the appropriate geology to support the Rich Subtype. The Black and Craggy Mountains do have a broad range of geology, and the presence of the Rich Subtype may have contributed to McLeod's (1988) choice not to distinguish distinct Northern Hardwood Forest. Ulrey (2002) distinguished two high elevation groupings of rich cove forest plots, which appear to partially overlap this subtype of Northern Hardwood Forest.

Rare species: Vascular plants – *Aconitum reclinatum, Brachyelytrum aristosum, Cardamine clematitis, Dendrolycopodium dendroideum, Geum geniculatum, Glyceria nubigena, Lilium grayi, Lonicera canadensis, Meehania cordata, Platanthera grandiflora, Pyrola elliptica, Rhododendron vaseyi, Saxifraga caroliniana, Scutellaria saxatilis, Spiranthes ochroleuca, Streptopus amplexifolius.* Nonvascular plants – *Drepanoleujeunea appalachiana, Gymnoderma lineare, Metzgeria temperata, Plagiochila austinii.*

Animals – *Aegolius acadicus, Certhia americana, Coccyzus erythropthalmus, Desmognathus organi, Empidonax alnorum, Glaucomys sabrinus coloratus, Inflectarius downieanus, Inflectarius downieanus, Paravitrea andrewsae, Plethodon aureolus, Plethodon cheoah, Plethodon welleri, Sorex dispar blitchi, Sphyrapicus varius, Ventridens collisella*.

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NORTHERN HARDWOOD FOREST (BEECH GAP SUBTYPE)

Concept: The Beech Gap Subtype encompasses forests strongly dominated by *Fagus grandifolia* at very high elevation, usually as small areas around ridge top gaps surrounded by spruce–fir forest, but sometimes on open peaks in areas that lack spruce and fir.

Distinguishing Features: The Beech Gap subtype is distinguished from other high elevation forests by having a canopy strongly dominated by *Fagus grandifolia*, with *Aesculus flava* being the only other common species. The trees are generally stunted, sometimes strikingly so, and the overall floristic composition is low in diversity. The herb layer may be either a lawn of *Carex pensylvanica* or a moderate to dense bed of forbs. The Beech Variant of Northern Hardwood Forest (Typic Subtype) is generally less strongly dominated by *Fagus*, has larger tree stature, and is somewhat more diverse. The Beech Gap Subtype is a narrowly defined extreme community with distinctive structure and appearance.

Synonyms: *Fagus grandifolia / Carex pensylvanica - Ageratina altissima var. roanensis* Forest (CEGL006130).
Ecological Systems: Southern Appalachian Northern Hardwood Forest (CES202.029).

Sites: The Beech Gap Subtype characteristically occurs in south-facing ridge top gaps or on exposed peaks and open ridges in mountain ranges that lack spruce and fir. Most examples are above 5000 feet in elevation, but a few occurrences attributed to the subtype occur at to 4000 feet or lower. Russell (1953) noted that Great Smoky Mountains beech gaps had more severe microclimate, with larger temperature extremes, than surrounding forests.

Soils: The Beech Gap Subtype likely has soils similar to those of the Typic Subtype and is generally mapped as the same series of Typic Haplumbrepts, Humic Dystrudepts, and Typic Humadepts. Russell (1953) noted that beech gaps had less litter accumulation and high pH than surrounding spruce-fir forests. This probably results from the lack of coniferous litter rather than being a cause of vegetation differences.

Hydrology: Sites are mesic due to cool temperatures and high rainfall at their high elevations. They presumably are well drained but those on concave slopes and in gaps may be less so than the other subtypes of Northern Hardwood Forest.

Vegetation: Beech Gap Subtype forests have short canopies, often gnarled and appearing stunted. *Fagus grandifolia* generally strongly dominates, but small numbers of *Aesculus flava, Betula alleghaniensis, Picea rubens*, or *Acer saccharum* may be present. These forests generally have limited understory cover, which most often includes *Acer spicatum* and as well as species from the canopy. Shrubs generally are sparse, with saplings of *Fagus* and other trees typically most abundant in the stratum. If the canopy has been disturbed, *Rubus alleghaniensis* or *Rubus canadensis* may be abundant. The herb layer generally is dense. *Carex pensylvanica* characteristically strongly dominates. Other frequent species reported by Russell (1953) include *Laportea canadensis, Poa alsodes, Athyrium asplenioides, Carex debilis,* other *Carex* spp,, *Stellaria pubera*, and *Trillium erectum*. Additional herbs highly constant or frequent in CVS plot data include *Arisaema triphyllum, Solidago curtisii, Dryopteris intermedia, Eurybia chlorolepis,*

Oclemena acuminata, Angelica triquinata, *Maianthemum racemosum, Maianthemum canadense*, *Smilax herbacea*, and *Epifagus virginiana*.

Range and Abundance: Ranked G1. Examples are scattered in the higher mountains. The equivalent association also occurs in Tennessee and possibly in Georgia.

Associations and Patterns: The Beech Gap Subtype may occur either as small patch community surrounded by spruce-fir forest or as a large patch community occupying the tops of mountains and grading downslope to other subtypes of Northern Hardwood Forest or to High Elevation Red Oak Forest.

Variation: Two variants are recognized, based on the two characteristic landscape patterns more than vegetation, and warranting further study of differences:

1. Gap Variant occurs in ridge top gaps surrounded by spruce–fir forest. This is the original concept of beech gap, as described by Russell (1953) and Whittaker (1956).

2. Ridge Variant occurs on peaks and ridge top, generally in areas without spruce–fir forest. It may occupy a larger range of environments because of the lack of competition with spruce and fir.

Dynamics: These communities are apparently stable climaxes under current climatic conditions. Trees may be quite old, although small. The forest may be periodically damaged by severe wind or ice storms. These sites are marginal environments for the occurrence of the dominant tree species, and growth and reproduction are relatively slow. Most reproduction may be by clonal sprouts rather than seeds. In the last decade or two, beech bark disease has killed patches of *Fagus* canopy. Such stands appear to be regenerating from root sprouts, but the long term fate of these areas is uncertain.

The question of why these high elevation sites are not occupied by spruce and fir has been of interest to ecologists. Pavlovic (1981), sampling across a red spruce – beech gap ecotone, found a relatively sharp boundary and found that the Beech Gap received spruce and birch seed rain. Russell (1953) concluded that cold and high winds were responsible for the occurrence of Beech Gaps and that their sites experienced more extreme temperature fluctuations than surrounding sites. Fuller (1977) suggested several other factors, including allelopathic effects of beech litter on spruce and seed predation under beech litter.

Comments: The concept of the beech gap community appears to have originated in the Great Smoky Mountains and to have been limited to what is here called the Gap Variant. As with many narrowly defined, extreme communities, there is a risk of losing sight of a distinctive phenomenon by broadening its concept. The addition of what is here called the Ridge Variant recognizes another extreme community but one that is more difficult to distinguish from other Northern Hardwood Forests. Further investigation is needed into whether these two variants belong together.

A separate forb-dominated Beech Gap community was recognized in earlier versions of the 4th approximation guide, as well as in the NVC. This distinction has been dropped, as most examples

appear to be mixes of sedges and forbs. The former association, *Fagus grandifolia / Ageratina altissima var. roanensis* Forest (CEGL006246), has been lumped into this one.

Rare species: Vascular – *Lilium grayi, Platanthera grandiflora, Spiranthes ochroleuca*.

References:

Fuller, F.D. 1977. Why does spruce not invade the high elevation beech forests of the Great Smoky Mountains? M.S. Thesis, University of Tennessee, Knoxville.

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Whittaker, R.H. 1956. Vegetation of the Great Smoky Mountains. Ecological Monographs 26: 1-80.

HIGH ELEVATION BIRCH BOULDERFIELD FOREST

Concept: High Elevation Birch Boulderfield Forests are vegetated boulderfields at high elevations (generally above 4000 feet), with canopies strongly dominated by *Betula alleghaniensis*. Well-developed boulderfields have nearly 100 percent ground cover of large rocks, with void present beneath the rocks, and with the structure and composition of the lower strata determined by rock cover.

Distinguishing Features: High Elevation Birch Boulderfield Forests are distinguished from the Boulderfield Subtype of Rich Cove Forest by higher elevation and lower species richness. High Elevation Birch Boulderfield Forests have virtually no other canopy trees other than *Betula alleghaniensis*. Rich Cove Forest boulderfields may have *Betula alleghaniensis* as a codominant species, but also contain a variety of species of Rich Cove Forests, particularly *Tilia americana var. heterophylla*, but also including *Fraxinus americana, Liriodendron tulipifera*, and other species. High Elevation Birch Boulderfields are generally above 4000 feet; Rich Cove Forests (Boulderfield Subtype) may extend above 4000 feet, higher than other Rich Cove Forest subtypes, but most are at lower elevation. High Elevation Birch Boulderfields lack lower elevation species such as *Isotrema macrophylla* and *Ribes cynosbati* and often have minor amounts of higher elevation species such as *Picea rubens, Sorbus americana, Sambucus racemosa (= Sambucus pubens)*, and *Viburnum lantanoides*.

Synonyms: Boulderfield Forest. *Betula alleghaniensis / Ribes glandulosum / Polypodium appalachianum* Forest (CEGL006124). Boulderfield Forest (3rd Approximation).
Ecological Systems: Southern Appalachian Northern Hardwood Forest (CES202.029).

Sites: High Elevation Birch Boulderfield Forests occur on coarse colluvial deposits. Large rocks cover virtually the entire ground surface and are piled on top of each other so that there is a substantial amount of large voids beneath them. Most boulderfields are believed to be relict Pleistocene periglacial features. They typically occur on north-facing slopes, usually in upper coves or other steep concave slopes but occasionally on steep open slopes. A smaller number of boulderfields appear to be talus on steep slopes below rock outcrops.

Soils: Soil consists of accumulations of organic matter on and among the boulders (Lithic Dystrochrepts).

Hydrology: Conditions are mesic due to cool microclimate, high rainfall, and frequent fog of high elevations, but soil moisture may vary drastically at a very fine scale. Shallow soil pockets maybe become dry very quickly. Some boulderfields have seepage that creates moist conditions locally. In some, water may be heard flowing rapidly beneath the rocks, and some of this may be accessible to plant roots.

Vegetation: High Elevation Birch Boulderfields have a closed to somewhat open canopy, strongly dominated by *Betula alleghaniensis*. Often no other canopy trees are present, but *Aesculus flava, Picea rubens*, or *Fagus grandifolia* may sometimes occur. *Acer spicatum* usually forms an understory with low to moderate cover. *Ribes glandulosum* is the most frequent and characteristic shrub, sometimes having substantial cover but sometimes absent or sparse. Other shrubs, sparser

and at lower frequency, include *Ribes rotundifolium, Ribes cynosbati, Viburnum lantanoides*, *Euonymus obovatus*, and *Hydrangea arborescens*. The herb layer is dominated by species that can grow bare rock. There usually is extensive cover of mosses, more than all vascular herbs. *Polypodium appalachianum* or *Polypodium virginianum* may have extensive cover, and *Dryopteris marginalis* or *Dryopteris intermedia* may be abundant. Other herbs typical of Northern Hardwood Forests are often rooted in the deeper soil pockets. The abundance of such species is difficult to quantify in plot data, because inclusion of even small amounts of an adjacent community can substantially increase their cover in a plot. Frequent species include *Eurybia chlorolepis, Tiarella cordifolia, Athyrium asplenioides, Arisaema triphyllum, Oclemena acuminata*, and *Ageratina altissima*. If seepage or flowing water is present at the surface, *Impatiens pallida, Monarda didyma*, and *Diphylleia cymose* may occur in pockets.

Range and Abundance: Ranked G3,but likely should be G2. High Elevation Birch Boulderfield Forest is scattered through the higher mountains. It also occurs in adjacent Tennessee, Virginia, and possibly Georgia. The equivalent association has also questionably been attributed to West Virginia.

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Associations and Patterns: High Elevation Birch Boulderfield Forest occurs in small patches, surrounded by Northern Hardwood Forest (Typic Subtype), High Elevation Red Oak Forest, Red Spruce–Fraser Fir Forest, or other high elevation communities.

Variation: Examples vary with the amount of water seeping or flowing among the rocks and with gradation to adjacent communities.

Dynamics: While stand dynamics likely are similar to Northern Hardwood Forest, canopy gaps last longer because of the difficulty of tree establishment. Chafin and Jones (1989) found windthrow to be more common and canopy gaps more abundant in Boulderfield Forests than in nearby Rich Cove Forests. The ability of *Betula alleghaniensi*s to germinate and establish on top of logs and rocks, with its roots wrapping around these features and continuing downward until they reach soil, allows it to dominate in this unique environment.

The Southern Appalachian boulderfields apparently are relict features created by periglacial action during the Pleistocene. Though the boulders presumably once moved downhill, they do not appear to move at present. Weathering and sediment accumulation might be expected to eventually develop more typical soils in them, but their apparent persistence for thousands of years suggests that they may be stable for a long time to come. The rapid drainage of rainwater through the boulders presumably limits chemical weather of the rocks and carries away any weathering products.

Comments: High Elevation Birch Boulderfield Forests are rare communities of a distinctive extreme environment. They are clearly related to Northern Hardwood Forest but have a consistent composition and structure distinct enough to treat as a separate type. Other Boulderfield communities are treated as subtypes of Rich Cove Forest and Red Spruce–Fraser Fir Forest, because they are somewhat less distinct. While rocky soils and substantial rock cover occur in many mountain communities, only at this extreme, where multiple layers of rock are present and voids beneath the rocks are abundant, do distinctive communities develop. When well developed,

the aspect of large trees and moss-covered boulders is striking, as is the distinctive species composition.

Rare species: Vascular plants – *Aconitum reclinatum, Cardamine clematitis, Conioselinum chinense, Geum geniculatum, Meehania cordata, Stellaria corei*.

Animals – *Sorex dispar blitchi, Plethodon ventralis.*

References:

Chafin, L.G. and S.B. Jones, Jr. 1989. Community structure of two southern Appalachian boulderfields. Castanea 54: 230-237.