MOUNTAIN DRY CONIFEROUS WOODLANDS

Contents

MOUNTAIN DRY CONIFEROUS WOODLANDS THEME

Concept: Mountain Dry Coniferous Woodlands are communities dominated or codominated by various species of *Pinus* or by *Tsuga caroliniana*, in upland settings. They may range from closed forests to open woodland or savanna structure in natural condition, but most are believed to be more open than typical hardwood forests.

Distinguishing Features: Mountain Dry Coniferous Woodlands are distinguished by being dominated by *Pinus* spp. or *Tsuga caroliniana* under natural conditions, occurring in dry to mesic upland sites. A few examples of Montane Alluvial Forest, and of Swamp Forest–Bog Complex or other Mountain Bogs and Fens may be codominated by some of the same conifer species but occur on floodplain terraces or in wetlands and have flora more similar to other communities in those themes.

Distinguishing natural communities of this theme from successional pine forests can sometimes be difficult. Any of the pine species are capable of taking advantage of severe human disturbances such as logging and clearing and dominating stands in what would otherwise be hardwood forest sites. For *Pinus pungens* and *Pinus rigida*, this is uncommon, but *Pinus virginiana* and *Pinus strobus* dominance more often indicate an artificial community than a natural one. In addition, *Pinus strobus* was widely planted. Successional and planted stands can often be recognized as floristically depauperate or as occurring in sites not characteristic of Mountain Dry Coniferous Woodland communities. Stands on flat ground or in easily accessible areas should generally be regarded as successional unless their history is known.

Synonyms:

Sites: Most Mountain Dry Coniferous Woodland communities occur on ridge tops and upper slopes, often with southerly or westerly aspect. Most slopes are convex in shape, generally the sharpest or most convex topography in the local area. Some may be on more planar slopes of dry aspect, and a few may be in more mesic settings such as valley bottoms.

Soils: Most Mountain Coniferous Woodlands occur on shallow or rocky soils, typically classified as Typic Dystrochrepts or Lithic Dystrochrepts. Fewer may occur on Ultisols or on other kinds of soil. Some may be inclusions in the soil map unit.

Hydrology: Mountain Dry Coniferous Woodland sites are typically the driest, most well-drained sites in the mountain landscape. However, high rainfall or cool temperatures at higher elevations may make them less xeric than similar topographic positions elsewhere.

Vegetation: Mountain Dry Coniferous Woodlands are dominated or codominated by various combinations of *Pinus rigida, Pinus pungens, Pinus virginiana, Pinus echinata, Pinus strobus*, and *Tsuga caroliniana* under natural conditions and when not recently disturbed. Codominant hardwoods are most often *Quercus montana, Quercus coccinea*, or at lower elevations, *Quercus alba, Quercus falcata,* or *Quercus stellata*. With the widespread alteration of fire regimes and impacts of southern pine beetles, *Acer rubrum* and typical understory species such as *Nyssa sylvatica* and *Oxydendrum arboreum* often are abundant in the canopy at present. *Castanea*

dentata was probably an important component of some communities in the past, but this is less well known than with the oak forests. The canopy in most examples probably was naturally at least somewhat open, though some probably had dense canopies. Most examples at present have dense shrub layers, usually dominated by *Kalmia latifolia* but potentially including a number of other species, such as *Gaylussacia baccata, Rhododendron* spp., *Clethra acuminata*, *Eubotrys recurva*, *Lyonia ligustrina* var. *ligustrina*, and *Vaccinium* spp. In the past, with more frequent fire, more communities are thought to have less shrub cover and to have had well-developed grassy herb layers.

Dynamics: The dynamics of Mountain Dry Coniferous Woodlands, especially the yellow pine communities, have been of great research interest for several decades, with an acceleration of interest in the last 20 years. The more recent focus coincides with an increased interest in the historical role of fire and in prescribed burning in the Central and Southern Appalachians in general. A number of dendrochronological and fire-scar studies have given evidence of past fire regimes (e.g., Aldrich et al. 2009; Cohen et al. 2007; Lafon et al. 2017), while widespread presence of charcoal in the soil also attests to the occurrence of fire (Welch 1999). Trees old enough to give evidence about pre-European times are sparse, making the picture of that time much less clear than in the time of heavy later human influence.

Nevertheless, it is clear that fire is the major ecological process in pine communities. These communities occur on the parts of the landscape most prone to lightning, most prone to ignition if exposed to fire, and most likely to burn intensely. Serotinous cones in *Pinus pungens* show that it is highly adapted to regeneration after fire. The other pines do not have serotinous cones, but readily seed into disturbed areas, including burns. Epicormic sprouting in *Pinus rigida* and seedling morphology in *Pinus echinata*, in addition to thick bark in all these species, suggests adaptation to surviving fire. *Pinus virginiana* is generally known to be intolerant of fire, but it is especially good at seeding into disturbed areas. Multiple field observations, demographic studies, and experimental prescribed burns have given information on the effects of fire in the present day. However, the picture in the literature to date appears to remain unclear, with contradictory results suggesting important aspects of variation are not yet understood.

A primary question is the mechanism of pine regeneration. Racine (1966) was one of several early authors who thought that pine communities were physiographic or edaphic climaxes, not dependent on widespread disturbance, and Barden (2000) noted that pines were reproducing in the absence of fire, though drought changed the ability of seedlings to survive across the time span of his study. There seems to be a widespread belief in general discussions that pine communities must be regenerated by catastrophic disturbance, a belief perhaps partially fueled by even-aged stands that regenerated after logging or field abandonment, which may or may not reflect natural conditions. However, Williams and Johnson (1992), Williams (1998), and Barden (2000) are among those who have noted that older natural pine communities are multi-aged, suggesting periodic recruitment without stand destruction. Barden (2000) noted that pines had successfully regenerated every decade from 1877-1976 in his study site.

There is a widespread belief that pine can not reproduce without bare mineral soil, and that fire is crucial for providing a suitable seedbed. Williams (1998) indicated that ice storms, producing canopy opening but not removing litter, favored oaks rather than pines. Pine stands killed by

southern pine beetles and not burned can often be observed to have little or no pine regeneration. But Williams et al. (1990), in experiments, found that pine seedlings did best with pine litter and that survival was low without daily watering in treatments with no litter, though oak litter was also harmful to seedling success. Williams and Johnson (1992) noted seedlings growing in up to 3 inches of duff and concluded that severe fire was not needed for reproduction. Reduction of competition, generally implied to be competition for light, is also suggest as important for pine regeneration. Williams (1998) indicated that regeneration was best after severe fire, such as that which followed insect mortality or occurred during drought, even though he acknowledged that presettlement fire was frequent and of low intensity. Waldrop et al. (2000) noted that experimental burns at three different intensities all failed to allow pines to regenerate because of dense hardwood sprouts, and that the most intense fire was the least successful. They suggested multiple low-intensity burning as a better solution.

These apparently contradictory understandings may be explainable by differences in the systems and circumstances under study. Canopy opening may be important where the canopy is dense but not in the driest sites or where it is kept open by abundant rock. Given the dense shrub layer in so many pine forests at present, fire may be more essential for reducing competition in that stratum than in the canopy. Canopy opening may be needed but, as in many other kinds of forest, the small single-tree gaps may be sufficient, or may have been sufficient in the more open canopies that prevailed when fire occurred more regularly. Reduction of litter and duff by fire may be crucial in some circumstances, when it is very thick or where it contains too much oak litter, but not otherwise. Hardwood sprouts may be an important limitation on pine recruitment where the pine was a minority of the previous stand and where hardwoods were dense in either the canopy or the understory. Some of these places may have been successional stands following logging or clearing, where pine would not dominate naturally. Others may be places where the effects of fire suppression have gone too far to be reversed quickly. With enough hardwood density, multiple fires at greater frequency may be needed, rather than a single fire, to bring the hardwoods under control. However, most pine seedlings are not likely to survive fires, so successful replacement of canopy pines may never occur if fire remains too frequent. In addition, since multiple fires and multiple seeding events may be needed to establish a new pine cohort, loss of too many of the canopy pines due to intense fire or to insect mortality may make regeneration of pines unlikely. It should also be noted that, if there is no catastrophic disturbance, sporadic regeneration in smaller canopy gaps is all that is needed to perpetuate pine dominance. However, pine communities appear to be more prone to catastrophic disturbance than most of our natural communities, so natural dynamics likely include a combination of disturbance intensities.

Besides the dominant role of fire, yellow pine community dynamics are potentially strongly affected by the southern pine beetle (*Dendroctonus frontalis*) and potentially by other insects. This species is native to the area and at normal endemic levels it is confined to preying on weakened and dying trees. In times of drought, and potentially other stresses, insect populations can build up to levels that can overwhelm and kill even healthy trees. While this is presumably a natural phenomenon in the region, it is possible that the increased extent of dense even-aged successional pine stands, with many trees reaching high susceptibility at the same time, has exacerbated the intensity of outbreaks. Southern pine beetle attacks during outbreaks act as catastrophic disturbances to yellow pine communities, killing all or most of the mature trees.

Less is known about the dynamics of the communities dominated by the other conifers in this theme. What is known is discussed within the descriptions of White Pine Forest and Carolina Hemlock Forest communities.

Comments:

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KET TO MOUNTAIN DRY CONIFEROUS WOODLANDS

1. Canopy dominated or codominated by *Tsuga caroliniana*, or dominated by it until recent hemlock wooly adelgid mortality.
   2. *Tsuga caroliniana* codominant with *Pinus rigida, Pinus pungens*, or *Pinus virginiana* ....**Carolina Hemlock Forest (Pine Subtype)**
   2. Pines a minor component or absent; *Tsuga caroliniana* solely dominant or codominant with *Tsuga canadensis* or other species.
      3. Community in a mesic site, generally on a lower slope or valley bottom; *Tsuga canadensis* or mesophytic hardwoods often codominant; shrub layer often dominated by *Rhododendron maximum*..... **Carolina Hemlock Forest (Mesic Subtype)**
      3. Community in a dry site, generally on upper slopes or ridge tops; shrub layer generally dominated by *Kalmia latifolia*..... **Carolina Hemlock Forest (Typic Subtype)**
1. Canopy dominated by *Pinus* spp., or codominated by *Pinus* with *Quercus* spp. or species other than *Tsuga*.
   4. Canopy naturally dominated by *Pinus strobus*.. .....**White Pine Forest**
   4. Canopy dominated by *Pinus virginiana, rigida, pungens*, or *echinata*, or codominated by these species along with *Quercus* spp.; if *Pinus strobus* is present, it is in small to moderate amounts or represents altered composition.
      5. Canopy dominated by *Pinus echinata*, at least weakly .... **Low Mountain Pine Forest (Shortleaf Pine Subtype)**
      5. Canopy not dominated by *Pinus echinata*, though the species may be present in small to moderate amounts.
         6. Canopy a relatively even mix of pines and oaks; canopy contains species indicative of low elevation dry conditions (*Pinus echinata, Quercus falcata, Quercus stellata, Quercus marilandica, Carya pallida*) or there is evidence that it did in the past.
            7. Canopy naturally very open and persistently small in stature. ....**Southern Mountain Xeric Pine–Oak Woodland**
            7. Canopy closed or somewhat open, normal in stature for its maturity. **..... .....Southern Mountain Pine–Oak Forest**
         6. Canopy dominated by *Pinus rigida, virginiana*, or *pungens*, with few oaks or with only *Quercus montana* and *Quercus coccinea* abundant; species indicative of low elevation dry conditions present or not.
            8. Canopy containing species indicative of low elevation dry conditions (*Pinus echinata, Quercus falcata, Quercus stellata, Quercus marilandica, Carya pallida*), at least in small numbers, though dominated by *Pinus virginiana, rigida*, or *pungens*; community occurring at low elevations, generally below 2500 feet ..... **Low Mountain Pine Forest (Montane Pine Subtype)**
            8. Canopy containing no species indicative of low elevation dry conditions, even in small numbers; canopy dominated by *Pinus virginiana, rigida*, or *pungens*; community generally occurring above 2000 feet but potentially lower in appropriate sites.
               9. Community occurring at higher elevations, above 3500 feet; shrub layer containing appreciable *Rhododendron catawbiense*, which is often codominant with *Kalmia latifolia*; *Eubotrys recurvus* often fairly abundant .....**Pine–Oak/Heath (High Elevation Subtype)**
               9. Community occurring at elevations below 3500 feet; *Rhododendron catawbiense* absent, or, if rarely present, low in abundant; *Eubotrys recurvus* abundant or not.
                  10. Community occurring in Linville Gorge or potentially in similar gorges with extremely acidic substrates; *Rhododendron carolinianum* generally abundant; *Eubotrys recurvus* and other species shared with the High Elevation Subtype (excluding *Rhododendron*

catawbiense) often abundant. .... **Pine–Oak/Heath (Linville Gorge Subtype)**

10. Community not occurring in Linville Gorge, but potentially anywhere else in the Mountains or foothills; shrub layer not as above, generally lacking *Rhododendron carolinianum* and *Eubotrys recurvus*. ..... **Pine–Oak/Heath (Typic Subtype)**

PINE–OAK / HEATH (TYPIC SUBTYPE)

Concept: Pine–Oak/Heath communities are naturally open-canopy woodlands of sharp ridges and dry slopes at moderate or higher elevations, dominated by yellow pines. They generally have a dense shrub layer but may have been more open and herb-dominated when regularly burned in the past. The Typic Subtype covers the common examples at lower to mid elevations, lacking high elevation species such as *Rhododendron catawbiense*.

Distinguishing Features: Pine–Oak/Heaths are distinguished from various oak forests by a greater proportion of pine cover or basal area in the canopy under natural conditions. This can be a difficult distinction to make if southern pine beetles have killed the canopy pines long enough ago that snags are not visible, or if long absence of fire has led to proliferation of oaks in formerly open Pine–Oak/Heath. Beetle-killed stands generally are dominated by understory species such as *Nyssa sylvatica* and *Oxydendrum arboreum* rather than by oaks. Stands that have seen increases in oaks because of fire suppression or logging often have more abundant *Quercus coccinea* than *Quercus montana*, and they tend to have abundant *Acer rubrum*. However, it may not be possible to know if a *Quercus montana* forest with a minority component of pine might be pine-dominated under a more natural fire regime.

Carolina Hemlock Forest (Pine Subtype) is distinguished by a dominance or codominance of *Tsuga caroliniana*. If hemlock woolly adelgids have killed the hemlocks, it may be difficult to distinguish.

Vegetation similar to Pine–Oak/Heath may be present as patches in Low Elevation Rocky Summit, Low Elevation Granitic Dome, or High Elevation Granitic Dome communities. In general, these patches should be treated as part of the rock outcrop community unless they occupy an area several acres in extent or an area larger than the open zones of the rock outcrop.

The distinction between Pine–Oak/Heath and Low Mountain Pine Forest (Montane Pine Subtype) can be particularly subtle. Low Mountain Pine Forests always occur below 2000-2500 feet in elevation, are more likely to have abundant *Pinus virginiana*, and are indicated by the presence of species confined to low elevations, such as *Pinus echinata, Quercus falcata, Quercus stellata*, and *Quercus marilandica*. They also tend to have a greater diversity of shade-intolerant herbs, which are more abundant in burned examples. *Schizachyrium scoparium, Coreopsis major, Danthonia sericea, Pityopsis graminifolia, Solidago odora, Danthonia spicata, Lysimachia quadrifolia, Silphium reniforme, Tephrosia spicata, Eupatorium rotundifolium, Eupatorium album, Lespedeza hirta, Lespedeza repens, Symphyotrichum patens*, and *Scleria triglomerata/nitida* are species that are generally more frequent and abundant in Low Mountain Pine Forest, though many can also occur in Pine–Oak/Heath (Wentworth et al. in prep). *Quercus velutina, Carya pallida, Carya glabra, Carya tomentosa, Ilex montana, Ilex montana, Castanea pumila, Vaccinium stamineum, Rhus copallinum*, and *Magnolia fraseri* are also more frequent in Low Mountain Pine Forest. A few species are more typical of Pine–Oak/Heath, including *Rhododendron catawbiense*, *Eubotrys recurvus*, and *Clethra acuminata*. Nevertheless, many stands at low elevation have none of the definitive indicator species and appear indistinguishable from Pine–Oak/Heath communities at higher elevation. See the discussion in the Comments section below about this ambiguity. A careful search of the vicinity, including roadsides and forest edges, may reveal indicator species

that have been lost from the interior of the stand. However, some stands may not be able to be definitively classified with our current level of understanding.

The Typic Subtype is distinguished from the High Elevation Subtype by the absence or near absence of higher elevation species, especially *Rhododendron catawbiense*. *Eubotrys recurvus, Vaccinium simulatum,* and *Clethra acuminata* also tend to be more abundant in the High Elevation Subtype, while species shared with Low Mountain Pine Forest are generally completely absent in the High Elevation Subtype.

The Typic Subtype is easily distinguished from the Linville Gorge Subtype by location. That subtype is not known outside of Linville Gorge, and the Typic Subtype is not known within it. Vegetational distinctions of the Linville Gorge Subtype include abundant *Rhododendron carolinianum,* frequent *Eubotrys recurvus* at elevations below that of the High Elevation Subtype, and frequent *Symplocos tinctoria* at elevations above that of Low Mountain Pine Forest.

Synonyms: *Pinus pungens - Pinus rigida - (Quercus prinus) / Kalmia latifolia - Vaccinium pallidum* Woodland (CEGL007097).
Ecological Systems: Central and Southern Appalachian Montane Pine Forest and Woodland (CES202.331).

Sites: Pine–Oak/Heath communities occur on ridge tops, spur ridges, and convex upper slopes. Their topography often is notably sharper than nearby ridges. Small rock outcrops may be present but are not extensive. The Typic Subtype generally occurs below 3500 feet elevation, though it may range higher in more southerly areas. It generally occurs above 2000 feet in elevation, but occasional examples are lower. See the discussion below on the uncertain identity of some lower elevation stands.

Soils: Soils of the Typic Subtype are generally rocky and often shallow. Mapped series are widely variable. Many are mapped as Typic Dystrudepts (Ashe, Chestnut, Buladean, Soco, Edneyville) or Lithic Dystrudepts (Cleveland), but many are mapped as Typic Hapludults (Evard, Cowee, Tate, Brasstown, Junaluska, Sauratown).

Hydrology: Pine–Oak/Heaths are dry to xeric because of rapid drainage caused by their topography. They occur in the driest parts of the landscape.

Vegetation: The Typic Subtype usually has an open canopy. Canopies are thought to typically have less than 60 percent cover but may sometimes be denser, particularly if fire has not occurred for a long time. The canopy is dominated by varying combinations of *Pinus rigida* and *Pinus pungens*, sometimes with abundant *Pinus virginiana*. Other tree species that are highly constant in CVS plot data (Wentworth et al. in prep) and field observations, in either the canopy or understory, include *Quercus montana, Quercus coccinea, Oxydendrum arboreum, Nyssa sylvatica*, and *Acer rubrum*. Also fairly frequent are *Pinus strobus, Tsuga caroliniana, Tsuga canadensis, Quercus alba, Quercus velutina*, *Castanea dentata, Amelanchier* sp., and *Magnolia fraseri*. All of these species likely have increased significantly as a result of fire suppression, and it is possible that only the most fire-tolerant — *Quercus montana* and *Oxydendrum arboretum* — would be frequent under a natural fire regime. Virtually all examples have a dense shrub layer dominated by *Kalmia*

latifolia. *Vaccinium pallidum* is highly constant but not nearly as abundant. Other frequent shrubs include *Gaylussacia baccata, Symplocos tinctoria, Lyonia ligustrina, Eubotrys recurvus, Castanea pumila*, and, in the southern part of the state, *Gaylussacia ursina* and *Vaccinium hirsutum*. *Smilax glauca* and *Smilax rotundifolia* are frequent. The shrub layer likely would be less dense and probably less strongly dominated by *Kalmia* with more frequent fire. The herb layer is generally sparse in existing examples, with the only frequent species being *Galax urceolata, Chimaphila maculata, Pteridium latiusculum, Epigaea repens*, and *Iris verna*. Additional herbaceous species would likely be more abundant with more frequent fire, including *Danthonia spicata, Xerophyllum asphodeloides, Schizachyrium scoparium, Coreopsis major, Baptisia tinctoria*, and perhaps others considered more typical of lower elevation communities. [Examples in Linville Gorge also may have abundant *Rhododendron carolinianum*].

Range and Abundance: Ranked G3. The Typic Subtype is distributed across the interior of the Blue Ridge, throughout the Blue Ridge escarpment, and is present in the foothills. A few disjunct occurrences are present farther east, such as in the Sauratown Mountains. The NVC association is attributed to all of North Carolina's neighboring states and to Kentucky.

Associations and Patterns: Pine–Oak/Heath is treated as a small patch community. Occurrences are fairly small and are not predictable. It may once have occurred more regularly in mountain landscapes and have behaved as a matrix community. The Typic Subtype most often grades to Chestnut Oak Forest (Dry Heath Subtype), but it may be associated with other subtypes of Chestnut Oak Forest, Montane Oak–Hickory Forest, or other oak communities. Rock outcrop or glade communities may be embedded in it or occur nearby. Carolina Hemlock Forests, both the Typic and Pine Subtype, often occur in similar topographic settings and may be associated. In areas with a substantial range in elevation, the Typic Subtype may give way to the High Elevation Subtype or Low Mountain Pine Forest.

Variation: The Typic Subtype is highly heterogeneous, within and among stands. Preliminary data analysis by Wentworth et al. (in prep.) found a strong signal of geographic variation, but one that was too irregular to use as a basis for classification. The dominant pine species are often patchy within stands, with portions dominated by two or all three of the species. This does not appear to be a good basis for finer classification. There is also substantial variation in the shrub layer, which may be more useful. Density or cover of shrubs may be modified by fire history, but the dominant species is more likely to endure. Variants are tentatively recognized on this basis, to encourage further investigation of their stability and usefulness.

1. Evergreen Heath Variant is the most typical vegetation, with *Kalmia latifolia* dominating the shrub layer. Examples dominated by *Rhododendron minus* or *Rhododendron smokianum*, if found, may also be included here, but may warrant their own variant.
2. Typic Deciduous Heath Variant has limited *Kalmia* and has a shrub layer dominated by *Vaccinium pallidum* or *Gaylussacia baccata*. It may represent a geographic variant primarily north of Asheville, but this is uncertain. It may be widespread farther south.
3. Southern Deciduous Heath Variant has a shrub layer dominated by species confined to south of Asheville, usually *Gaylussacia ursina* but potentially *Vaccinium hirsutum*. This variant may be transitional to Low Mountain Pine Forest.

Dynamics: Dynamics for the Typic Subtype are likely similar to the general dynamics described for the theme. Because Pine–Oak/Heath communities occur on sharp ridge tops, they are particular targets for lightning and may be naturally ignited more often than any other community. Fire ignited there may or may not spread far downhill, making it possible for them to have a fire frequency greater than the surrounding landscape, though it is not entirely clear if they did.

There is widespread consensus that mountain pine communities have been changed as a result of fire suppression, though there is less consensus on precisely what they looked with a natural fire regime. More open canopies with less hardwood, especially less density and less cover of fire-intolerant trees such as *Acer rubrum* and *Quercus coccinea*, seem certain. How much the more fire-tolerant *Quercus montana* was reduced is less clear. Presumably the amount of *Pinus strobus* was less. However, established *Pinus strobus* can tolerate significant levels of fire, and it may have been a persistent component.

Despite acceptance of the importance and past frequency of fire, the environmental and dynamic factors that determine the boundary between Pine–Oak/Heath and Chestnut Oak Forest are not entirely understood. Predictive models often suggest Pine–Oak/Heath should cover all ridge tops but, as is readily observed and was noted by Racine (1966), its present occurrence can often be observed to be tied to particularly sharp ridges, a distinction not generally obvious in the digital elevation models used for terrain analysis. Pine–Oak/Heath often is confined to the sharpest ridges even where they occur below the main ridge line and would presumably be less exposed to lightning. However, in other places, patches can be found on broader ridge tops.

The extent of intact Pine–Oak/Heath has greatly declined in recent decades, and areas dominated by *Quercus coccinea,* and understory tree species often indicate places where they recently occurred. Evidence of replacement of Pine–Oak/Heath by mature *Quercus montana* stands is not clear. *Quercus montana* is a long-lived, fire-tolerant species; once established, it would likely survive fire frequencies nearly as great as those that support Pine–Oak/Heath. It is unclear if these communities existed as a shifting mosaic or as long-term patches stabilized by site characteristics and vegetation feedbacks.

Comments: Pine–Oak/Heath and Low Mountain Pine Forests as a whole are very distinctive and are recognized by most local vegetation studies such as Whittaker (1954), Dumond (1969), Cooper and Hardin (1970), McCurdy (1975), McLeod (1988), and Newell (1997). However, the finer distinctions within this grouping are difficult.

Some literature has suggested subdivisions of this type, particularly along a gradient from dominance by *Pinus virginiana* at lower elevations to *Pinus rigida* at intermediate elevations to *Pinus pungens* at the highest elevations (Whittaker 1954). This roughly corresponds to the gradient from Low Mountain Pine Forest to the Typic Subtype to the High Elevation Subtype. However, the pine species do not sort as well as suggested. *Pinus rigida* is abundant at all elevations and in all communities. *Pinus pungens* is more abundant in the High Elevation Subtype, but it occurs across the full range of elevation and can dominate at low elevations. *Pinus virginiana* is generally absent in the High Elevation Subtype and is more abundant in Low Mountain Pine Forest but may dominated in Pine–Oak/Heath (Typic Subtype).

The distinction between Pine–Oak/Heath (Typic Subtype) and Low Mountain Pine Forest (Montane Pine Subtype) remains particularly problematic. Occurrence of different pine species at lower elevations is irregular and is probably tied to community fire dynamics and the history of logging and southern pine beetle disturbance. Most examples of Pine–Oak/Heath and Low Mountain Pine Forest are dominated by a mixture of at least two of the same pine species. Certain tree species confined to lower elevations — *Pinus echinata, Quercus falcata, Quercus stellata*, and slightly less narrowly, *Quercus marilandica* — definitively indicate Low Mountain Pine Forest. A more diverse suite of shade-intolerant herbs (e.g., *Schizachyrium scoparium, Coreopsis major, Danthonia sericea, Pityopsis graminifolia, Solidago odora, Danthonia spicata, Lysimachia quadrifolia, Silphium reniforme, Tephrosia spicata, Eupatorium rotundifolium, Eupatorium album, Lespedeza hirta, Lespedeza repens,* and *Symphyotrichum patens*) is somewhat correlated with the presence of these trees. These species undoubtedly were much more abundant when fire was more frequent. However, many plots and site descriptions from elevations below 2000 feet are indistinguishable from examples of the Typic Subtype at middle elevations; they have none of the low elevation tree species and have no more diversity or abundance of the shade-intolerant herbs. Field observations by the author, site surveys by numerous biologists, and multiple approaches to plot data analysis by Wentworth et al. (in prep) have found overlap among vegetation groupings at lower elevations.

It is possible that the widespread lack of fire and other alterations have led to the loss of all plant species that might definitively separate these communities. However, it is also possible that some lower elevation sites, by virtue of slope aspect or other aspects of the physical environment, allow characteristic Pine–Oak/Heath vegetation to naturally exist. It is not clear that the ambiguous low elevation communities are more altered than other communities that fit the central concepts of the communities better. It is possible that the increase in prescribed burning will reveal additional differences, but this will take time. Single burns, and even several burns, can drastically change the vegetation structure of a stand, can induce proliferation of weedy species, but are slow to change the composition of more enduring species.

The NVC associations that represent Low Mountain Pine Forest (Montane Pine Subtype), especially *Pinus virginiana - Pinus (rigida, echinata) - (Quercus prinus) / Vaccinium pallidum* Forest (CEGL007119), also reflect some ambiguity. It appears to be described with a very wide range of vegetation and is attributed to a very large geographic, physiographic, and geologic range. This is discussed further in the Low Mountain Pine Forest description.

Rare species:
Vascular plants: *Dendrolycopodium hickeyi, Fothergilla major, Hexastylis contracta, Lysimachia fraseri, Monotropsis odorata, Quercus ilicifolia, Sisyrinchium dichotomum,* and *Thermopsis mollis*.
Nonvascular plants: *Macrocoma sullivantii*.
Vertebrate animals: *Neotoma magister*.
Invertebrate animals: *Patera clarki Nantahala.*

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LOW MOUNTAIN PINE FOREST (MONTANE PINE SUBTYPE)

Concept: Low Mountain Pine Forests are yellow-pine-dominated forests or woodlands containing both montane flora and low-elevation species such as *Pinus echinata*, occurring in the lower elevations of the Mountains and foothills. The Montane Pine Subtype encompasses those that are dominated by combinations of *Pinus virginiana, Pinus rigida*, and *Pinus pungens*, with *Pinus echinata* a minor component or absent.

Distinguishing Features: Low Mountain Pine Forests are distinguished from Pine–Oak/Heath by occurring at lower elevations and by containing characteristic low elevation species such as *Pinus echinata*, *Quercus stellata*, and *Quercus falcata*. The distinction between the Montane Pine Subtype and Pine–Oak/Heath is problematic in some examples. See the discussion of issues in the description of Pine–Oak/Heath (Typic Subtype). Low Mountain Pine Forests always occur below 2000-2500 feet in elevation, are more likely to have abundant *Pinus virginiana*, and are indicated by the presence of species confined to low elevations, such as *Pinus echinata, Quercus falcata, Quercus stellata*, and *Quercus marilandica*. They also tend to have a greater diversity of shade-intolerant herbs, which are more abundant in burned examples. *Schizachyrium scoparium, Coreopsis major, Danthonia sericea, Pityopsis graminifolia, Solidago odora, Danthonia spicata, Lysimachia quadrifolia, Silphium reniforme, Tephrosia spicata, Eupatorium rotundifolium, Eupatorium album, Lespedeza hirta, Lespedeza repens, Symphyotrichum patens*, and *Scleria triglomerata/nitida* are species that are generally more frequent and abundant in Low Mountain Pine Forest, though many can also occur in Pine–Oak/Heath (Wentworth et al. in prep). *Quercus velutina, Carya pallida, Carya glabra, Carya tomentosa, Ilex montana, Ilex montana, Castanea pumila, Vaccinium stamineum, Rhus copallinum*, and *Magnolia fraseri* are also more frequent in Low Mountain Pine Forest. Nevertheless, many stands at low elevation have none of the definitive indicator species and appear indistinguishable from Pine–Oak/Heath communities at higher elevation. A careful search of the vicinity, including roadsides and forest edges, may reveal indicator species that have been lost from the interior of the stand. However, some stands may not be able to be definitively classified with our current level of understanding.

The Montane Pine Subtype is distinguished from the Shortleaf Pine Subtype by having a canopy dominated by one of the above pines, with *Pinus echinata* either absent or a smaller component.

Synonyms: *Pinus virginiana - Pinus (rigida, echinata) - (Quercus prinus) / Vaccinium pallidum* Forest (CEGL007119). *Pinus virginiana - (Pinus rigida, Pinus pungens) / Schizachyrium scoparium* Forest (CEGL008500).
Ecological Systems: Southern Appalachian Low-Elevation Pine Forest (CES202.332).

Sites: Low Mountain Pine Forests occur on broad to sharp ridges, or on low elevation slopes, often facing south or west. Most examples of the Montane Pine Subtype are at 1200-2500 feet in elevation, but a couple apparent examples range higher.

Soils: Soils of the Montane Pine Subtype may be shallow and rocky or may be deeper. Most examples are mapped as Typic Dystrudepts (Ashe, Chestnut, Soco, Stecoah) or Typic Hapludults (Evard, Cowee, Edneyville), or Humic Dystrudepts (Whiteoak, Porters).

Hydrology: Low Mountain Pine Forests are dry, as a result of rapid drainage and warm slope aspects, along with the warm temperatures at low elevations.

Vegetation: The Montane Pine Subtype is a dense to open forest or woodland usually dominated by *Pinus virginiana, Pinus rigida,* or a mix of the two. *Pinus pungens* may rarely be codominant, and *Pinus echinata, Quercus montana, Quercus coccinea*, *Quercus falcata,* or *Pinus strobus* may be locally abundant. Other constant or frequent potential canopy tree species include *Quercus velutina, Carya glabra, Carya tomentosa*, and *Quercus alba*. Though less frequent in plots, *Quercus stellata* is often observed and is characteristic. Highly constant and sometimes codominant understory species in CVS plot data (Wentworth et al. in prep) are *Nyssa sylvatica, Oxydendrum arboreum,* and *Acer rubrum*. *Quercus marilandica* is also frequent and sometimes abundant. Other frequent understory species in plots include *Sassafras albidum, Diospyros virginiana, Magnolia fraseri, Amelanchier laevis,* and *Ilex opaca*. The shrub layer in present conditions ranges from moderate to dense. *Vaccinium pallidum* and *Kalmia latifolia* are highly constant and often dominant. Other highly constant or frequent shrubs that may have high cover are *Vaccinium stamineum* and *Gaylussacia baccata*. Other frequent shrubs in plots include *Castanea pumila,* and *Pyrularia pubera*. *Smilax rotundifolia* is highly constant and occasional can have high cover in patches. *Muscadinia rotundifolia* is also frequent. The herb layer under current conditions ranges from sparse to dense. *Galax urceolata* is the only species that occasionally has high cover. Other frequent herb layer species in plots include *Chimaphila maculata, Coreopsis major, Pteridium latiusculum, Epigaea repens, Dichanthelium commutatum, Tephrosia virginiana, Iris verna, Schizachyrium scoparium, Solidago odora, Hieracium venosum, Lysimachia quadrifolia*. It is presumed that with a more natural fire regime the less fire tolerant trees such as *Pinus virginiana, Quercus coccinea, Pinus strobus, Acer rubrum, Magnolia fraseri,* and *Ilex opaca* would be scarce, shrubs might be less dense, and many of less shade-tolerant of these herbs would be more abundant. Additional species found in the most open plots, which may indicate species that would be more constant and abundant with more frequent fire, include *Ceanothus americana, Arundinaria appalachiana, Hypericum stragulum, Pityopsis graminea, Eurybia surculosa, Lespedeza violacea, Lespedeza repens, Lespedeza hirta, Mimosa microphylla, Lilium michauxii, Sericocarpus asteroides, Sorghastrum nutans, Gillenia trifoliata, Helianthus microcephalus, Solidago erecta, Tephrosia spicata, Viola pedata*, and *Scutellaria elliptica*. Even when not present in stands, some of these species can often be found along edges or along forest roads or trails.

Range and Abundance: Ranked G3G4. The Montane Pine Subtype is scattered through the Mountain Region and foothills, with a few disjunct occurrences farther east in the Sauratown Mountains and Kings Mountains. There is somewhat of a cluster of known occurrences in the far southwestern area (Cherokee and Graham County) and in the South Mountains.

Associations and Patterns: Low Mountain Pine Forests occur now as remnants that are small patch communities. They probably once were large patch or even matrix communities. The Montane Pine Subtype is most often surrounded by Montane Oak–Hickory Forest or Chestnut Oak Forest. Montane Oak–Hickory Forest (Low Dry Subtype) and Southern Mountain Pine–Oak Forest are closely related in their environment and patches may occur in the same sites. Low Mountain Pine Forest (Shortleaf Pine Subtype) is not commonly associated but the two subtypes may once have co-occurred.

Variation: Analysis of plot data (Wentworth et al. in prep.) finds two vegetation groups corresponding to the Montane Pine Subtype, which differ primarily in the relative amounts and diversity of shrubs and herbs. It is unclear how much these differences reflect enduring site differences and how much they represent only recent management and disturbance history. They are recognized as variants to encourage further study. They are discussed further in the Comments section below.

1. Shrub Variant has high shrub cover and limited herb cover and diversity. It is widespread in the Mountains and foothills.
2. Grass Variant has a higher, though still generally low, cover and diversity of herbs, including grasses. Shrubs are still moderate. This variant is generally more open, possibly because of fire history but also possibly because of more rock cover in its sites. It is much rarer, and most of the few known plots are from the lower Chattooga River in South Carolina and Georgia.

Dynamics: The general discussion of dynamics in the theme description applies well to this community, especially the importance of fire. Many impressions of historical fire frequency and beliefs about the appropriate structure for Low Mountain Pine Forests are based on times with heavy influence by modern human activities. However, it is clear that regular fire has been a natural part of these communities for much longer. More frequent fire would remove or greatly reduce some of the less fire-tolerant species in the present-day vegetation. This might include *Pinus virginiana* as well as *Acer rubrum, Quercus coccinea*, potentially *Pinus strobus*, and some of the understory trees. *Kalmia latifolia* does not recover quickly from fire, and presumably was less abundant in the past. However, *Vaccinium pallidum*, *Gaylussacia baccata*, and other shrubs recover quickly from burning and can be seen to spread after contemporary fires. Herbs presumably were dense and more diverse with regular burning. The tree species used as indicators of this community presumably were also more common.

Comments: As discussed in the comments of Pine–Oak/Heath (Typic Subtype), mountain pine communities as a group are distinctive but the boundary between Pine–Oak/Heath and Low Mountain Pine Forest is blurred. Many plots and some whole stands at low elevation contain none of the indicator species and have no recognizable evidence in the vegetation to distinguish them from Pine–Oak/Heath at higher elevation. It is unclear if this is solely because the indicator species have been lost with the long absence of fire and with other land use, or if there are sites that naturally support Pine–Oak/Heath vegetation at these low elevations.

The two variants appear to correspond to the two NVC associations listed in synonymy, with *Pinus virginiana - Pinus (rigida, echinata) - (Quercus prinus) / Vaccinium pallidum* Forest (CEGL007119) approximating the Shrub Variant and *Pinus virginiana - (Pinus rigida, Pinus pungens) / Schizachyrium scoparium* Forest (CEGL008500) the Grass Variant. Interpretation of the concepts of these association is uncertain. The first, in particular, is described with a wide range of vegetation and a very large geographic range. Beside the Southern Appalachian states, it is attributed to states from Alabama to Ohio and Indiana, spanning the Ridge and Valley, Cumberland Plateau, and Interior Low Plateaus physiographic regions. As described, it could apply to successional forests as well as natural pine forests and woodlands. Given a general belief that fire was naturally more frequent and that it led to more herbaceous and less shrub vegetation, the natural state of Low Mountain Pine Forest would match more closely to the Grass Variant.

However, the NVC description of the association corresponding to the Grass Variant is also unclear, suggesting the openness might be due to fire, other disturbance, or to site rockiness. It might thus include natural vegetation in good condition, excessively burned vegetation, or communities that might be better regarded as glades or at least as being transitional to them. Because it is unclear if these two kinds of vegetation represent different enduring natural vegetation, they are not recognized as subtypes. Further investigation may clarify the distinction, or an increase in fire management of lower elevation pine forests may eventually lead to more natural vegetation that may yield answers.

Similar questions remain for the relationship of Low Mountain Pine Forest to Southern Mountain Pine-Oak Forest. It is also unclear how it is related to Southern Mountain Xeric Pine–Oak Woodland and Southern Mountain Pine–Oak Forest. Southern Mountain Xeric Pine–Oak Woodland, and Montane Oak–Hickory Forest (Low Dry Subtype). Several of these communities are included only provisionally. All share the same suite of indicator species for warm low elevation climate, influence of fire, and more plentiful sunlight. The differences between them are also in proportions of species which might be modified by historical events. All of these communities need substantial study, preferably of examples with restored natural fire regimes.

Rare species:
No rare species known.

References:
Wentworth, T.R., Schafale, M.P., Peet, R.K., and Weakley, A.S. in prep. Coniferous vegetation of the Southern Blue Ridge Mountains.

SOUTHERN MOUNTAIN PINE–OAK FOREST

Concept: Southern Mountain Pine–Oak Forests are mixed, potentially open forests of low elevation mountain slopes and ridges, where *Pinus echinata* and dry-site oaks characteristic of lower elevations codominate. They occur in lower elevation valleys and basins, and in the foothills.

Distinguishing Features: Southern Mountain Pine–Oak Forests are distinguished by canopies that are naturally codominated by *Pinus echinata*, other pines, and combinations of dry-site oaks that include some *Quercus falcata* or *Quercus stellata,* as well as *Quercus alba*, *Quercus montana,* and *Quercus coccinea*. At the edges of the foothills, they grade into Dry Oak–Hickory Forest of the Piedmont. They are distinguished by a significant presence of Blue Ridge flora such as *Kalmia latifolia, Gaylussacia baccata, Gaylussacia ursina, Rhododendron calendulaceum*, and *Castanea dentata* sprouts. They are differentiated from Low Mountain Pine Forest by a greater component of oaks and from Montane Oak–Hickory Forest (Low Dry Subtype and Low Dry Basic Subtype) by a greater pine component. Because the ratios of pines to oaks can be widely altered by both logging and fire suppression, as well as altered by chestnut blight, distinguishing this community can be particularly difficult, requiring judgment of what conditions would develop over time with regular fire. In general, even a small presence of *Pinus echinata, Quercus stellata*, or *Quercus falcata* likely indicate that more was once present, while abundant *Quercus montana* or *Quercus alba* likely suggest they were naturally abundant. *Quercus coccinea* and *Pinus virginiana*, along with other hardwood genera, likely give little information on the natural dominants of the community.

Synonyms: *Pinus echinata - Quercus (prinus, falcata) / Oxydendrum arboreum / Vaccinium pallidum* Forest (CEGL007493). *Pinus echinata - Quercus alba / Vaccinium pallidum / Hexastylis arifolia - Chimaphila maculata* Forest (CEGL008427)
Ecological Systems: Southern Appalachian Low-Elevation Pine Forest (CES202.332).

Sites: Southern Mountain Pine–Oak Forests occur on slopes, spur ridges, and ridge tops, usually convex and usually facing south or west. Ridge-top occurrences tend to be on broader ridges than Low Mountain Pine Forest or Pine–Oak/Heath. Most examples are 1000-2000 feet in elevation, but a few occur higher on steep slopes with dry aspect.

Soils: Southern Mountain Pine–Oak Forests may potentially occur on a wide variety of mountain upland soils, but most are probably the Typic Hapludults that are widespread at lower elevations. Evard and Cowee are frequently mapped series in the foothills.

Hydrology: Southern Mountain Pine–Oak Forests are dry and well-drained.

Vegetation: Southern Mountain Pine–Oak Forests are presently often dense forests but likely were fairly open with a natural fire regime. The canopy is dominated by a varying mix of *Quercus montana, Quercus coccinea*, *Quercus alba, Pinus virginiana*, and other pines, including *rigida, pungens*, and *strobus*. *Pinus echinata, Quercus falcata*, and *Quercus stellata* are indicators of the community and likely would codominate with regular fire, but at present usually occur only in small numbers. *Carya glabra, Carya pallida, Acer rubrum*, *Quercus velutina*, and other species may also be present. Highly constant species in the understory in CVS plot data and site

descriptions are *Oxydendrum arboreum, Acer rubrum,* and *Nyssa sylvatica*, and frequent species include *Sassafras albidum, Amelanchier arborea*, *Diospyros virginiana, Cornus florida, Magnolia fraseri,* and uncharacteristic mesophytic species such as *Magnolia acuminata* and *Ilex opaca*. The shrub layer may be dense, moderate, or sparse. *Vaccinium pallidum* is highly constant and often dominant, and *Kalmia latifolia* and *Gaylussacia baccata* are frequent and sometimes dominant. Infrequent but occasionally dominant is *Gaylussacia ursina*. Other frequent shrubs include *Corylus cornuta, Castanea dentata* sprouts, *Vaccinium stamineum, Arundinaria appalachiana, Rhododendron calendulaceum,* and *Euonymus americanus*, while *Hypericum stragulum, Vaccinium arboreum*, and *Amorpha glabra* are infrequent but may once have been more abundant. *Smilax glauca* and *Smilax rotundifolia* are highly constant, and *Muscadinia rotundifolia* is frequent. The herb layer is usually sparse in present-day examples that have not burned, but likely was fairly dense when burned. Frequent herbs in plots include *Coreopsis major, Carex nigromarginata, Dichanthelium boscii, Dichanthelium commutatum, Galium circaezans, Hexastylis arifolia, Lysimachia quadrifolia, Polystichum acrostichoides, Polygonatum biflorum, Chimaphila maculata, Endodeca serpentaria, Galax urceolata, Hylodesmum nudiflorum, Lespedeza violacea, Solidago odora, Solidago arguta, Goodyera pubescens*, and *Viola hastata*. Other herbs that are not frequent in plots but are found in occurrences and are likely characteristic of the community when burned include *Piptochaetium avenaceum, Schizachyrium scoparium, Iris verna, Danthonia spicata, Danthonia sericea, Silphium reniforme, Baptisia tinctoria, Scleria oligantha, Tephrosia virginiana, Pityopsis graminifolia, Liatris spicata, Mimosa microphylla, Clitoria mariana, Desmodium rotundifolia, Dichanthelium dichotomum, Hypoxis hirsuta, Helianthus* spp., *Solidago erecta, Solidago nemoralis, Viola pedata, Viola hastata, Eupatorium rotundifolium, Ionactis linariifolia, Sericocarpus asteroides, Sericocarpus linifolius, Cunila origanoides Sorghastrum nutans,* and *Eryngium yuccifolium*.

Range and Abundance: Ranked G3G4. In North Carolina, this community is very rare, with only a dozen occurrences known. Most are in the far southwestern mountains of Graham and Cherokee County and in the South Mountains. It is possibly unrecognized in other areas of the Blue Ridge escarpment, the Asheville Basin, or other lower elevation valleys, or has been lost from these areas. The related NVC associations range widely, from South Carolina, Georgia, and Alabama to Kentucky, but may be conceived overly broadly.

Associations and Patterns: Southern Mountain Pine–Oak Forests now occur as small patch communities, absent from most landscapes and, when present, in small patches. However, a couple of large clusters are 25 acres or more exist. It likely was once more widespread, and unrecognizable altered examples may still be present. Examples may grade into Montane Oak–Hickory Forest (Low Dry Subtype) or Low Mountain Pine Forest, but more often appear to be surrounded by Chestnut Oak Forest (Dry Heath or White Pine Subtype) or Montane Oak–Hickory Forest (Acidic or White Pine Subtype).

Variation: Examples are highly variable, but it is difficult to tell natural variation from alteration. It is not clear that the two related NVC associations can be distinguished in North Carolina, but variants are defined to encourage investigation of this question.
1. Chestnut Oak Variant has *Quercus montana* as the predominant oak and is generally drier.
2. White Oak Variant has *Quercus alba* as the predominant oak and is generally somewhat more mesic, though still containing the other drier oaks characteristic of the community.

Quercus montana and *Quercus alba* both are highly constant in site descriptions and in the few plots that have been sampled in North Carolina, but *Quercus montana* dominates all the plots.

Dynamics: Southern Mountain Pine Oak Forests, like most pine and oak forests, are believed to depend on regular fire to maintain their natural composition and structure. They presumably lie between the pine-dominated and oak-dominated communities of the Mountains in the effects of fire, but it is unclear what aspects of the fire regime are most important for allowing a more even mix of these genera. If we presume most of the fires that burned a given area had spread from some distance, fire frequency likely was similar to that of the oak forests, with the dry slope aspect and convex topography serving to increase fire intensity at times. As with other oak and pine communities, in the long absence of fire, canopies, understories, and often shrub layers have become denser, herbs have been greatly reduced, and many characteristic herbs have probably been lost from each example.

Comments: Southern Mountain Pine–Oak Forest remains a poorly understood community, and its classification and interpretation need further study. Given the rarity and heavy alteration of Low Mountain Pine Forests, which contain some oaks, and of the dry, low elevation oak forest communities, which contain some pines, it is difficult to determine what the natural state of a stand would be. If Southern Mountain Xeric Pine–Oak Woodland also occurs in North Carolina, it too would be difficult to distinguish from this community. The classification may be too finely divided to be readily applied to the natural state of communities. However, further study, especially in areas that are now receiving prescribed fire, may allow for better understanding.

Southern Mountain Pine Oak Forest was initially believed to be a peripheral community to North Carolina, more characteristic of Tennessee and Georgia and only rarely present in Cherokee County. However, vegetation attributable to it was later found in the South Mountains, and recognized occurrences are now as abundant there as anywhere in the state. It may exist unrecognized elsewhere in the state. However, the abundance of plots attributed to it in the lower Chattooga River valley of Georgia and South Carolina suggest that its primary range is peripheral to North Carolina.

The relationship of North Carolina's examples to the NVC also remains uncertain. It is unclear how widely the association is applied to altered, partly successional vegetation. The two NVC associations that appear to overlap it conceptually are fairly distinguishable in analysis of CVS plots in other states, with one being generally more mesic than the other. However, the differences beyond dominant oaks are not dramatic, and most of the species distinguishing the more mesic association are ones that could be expected to have increased with fire suppression (e.g., *Ilex opaca, Liriodendron tulipifera, Magnolia acuminata,* and *Kalmia latifolia*). These species are fairly abundant in North Carolina examples that are dominated by *Quercus montana* and have little *Quercus alba*, blurring the distinction here. However, the few plots in North Carolina are all attributed to the *Quercus montana*-dominated association and statistically resemble those attributed to it in other states. A couple of the known North Carolina sites, where no plots have been sampled, have been described as having *Quercus alba* dominant.

Rare species:

References:

SOUTHERN MOUNTAIN XERIC PINE–OAK WOODLAND

Concept: Southern Mountain Xeric Pine–Oak Woodland is an open woodland dominated by *Pinus echinata, Quercus stellata*, and *Quercus marilandica*, occurring on the driest low elevation slopes. It is not documented in North Carolina but may possibly occur as extant or degraded examples.

Distinguishing Features: Southern Mountain Xeric Pine–Oak Woodland would be distinguished from Southern Mountain Pine–Oak Forest by a more open canopy, more xerophytic composition, and occurrence in the driest sites. It is distinguished from Low Mountain Pine Forest, which might be similarly open and on similarly dry sites, by the codominance of oaks.

Synonyms: *Pinus echinata - Quercus stellata - Quercus marilandica / Vaccinium pallidum* Woodland (CEGL003765).
Ecological Systems: Southern Appalachian Low-Elevation Pine Forest (CES202.332).

Sites: Southern Mountain Xeric Pine–Oak Woodland occurs on steep slopes that face south or west, at low elevations in the foothills or Mountains.

Soils: Soils likely would be one of the Typic Hapludults common in the foothills or low mountains.

Hydrology: Sites are very dry due to steepness, convex slopes, and warm slope aspect.

Vegetation: Southern Mountain Xeric Pine–Oak Woodlands are open-canopy woodlands dominated by a mix of *Pinus echinata, Quercus stellata*, and *Quercus marilandica*. In the several plots in Georgia that are the basis of the NVC association, other highly constant canopy trees are *Quercus velutina* and *Quercus coccinea*, while *Quercus falcata, Carya tomentosa, Quercus montana, Quercus falcata, Quercus marilandica, Carya pallida, Pinus strobus, Pinus virginiana*, and *Quercus alba* are at least fairly frequent. Dominant understory tree species are *Cornus florida, Nyssa sylvatica,* and *Oxydendrum arboreum*, and frequent species are *Diospyros virginiana* and *Sassafras albidum*. *Vaccinium pallidum* is constant and usually dominant in the shrub layer, and *Smilax glauca* and *Muscadinia rotundifolia* are highly constant. The only other frequent shrub is *Symplocos tinctoria,* but *Vaccinium arboreum, Kalmia latifolia,* and *Vaccinium stamineum* also occur and may be characteristic. No herbs appear strongly dominant in the plot data, and only *Pteridium latiusculum, Euphorbia corollata/pubentissima, Goodyera pubescens, Iris verna, Asclepias amplexicaulis*, and *Coreopsis major* occur with even moderate frequency. However, other herbs that occur occasionally and likely were more abundant in the past include *Baptisia tinctoria, Chamaecrista fasciculata, Chamaecrista nictitans, Chrysopsis mariana, Clitoria mariana, Coreopsis tripteris, Crotalaria sagittalis, Desmodium rotundifolium, Erianthus giganteum, Helianthus atrorubens, Helianthus microcephalus, Pityopsis graminifolia, Polygala verticillata, Rudbeckia hirta, Schizachyrium scoparium, Mimosa microphylla, Silphium reniforme, Sorghastrum nutans, Stylosanthes biflora*, and *Tephrosia virginiana*.

Range and Abundance: Ranked G4? This community has not been documented in North Carolina but may occur. The NVC association is attributed to South Carolina, Tennessee, and potentially Kentucky as well as Georgia and North Carolina, and is said to "probably extend into the southern

Ridge and Valley, Cumberland Plateau, and Piedmont." Given the extreme nature of the community, and its presumed dependence on fire, it probably is rarer than the G4 rank suggests.

Associations and Patterns: Where it is documented in Georgia, this community appears to be associated with Southern Mountain Pine–Oak Forest and perhaps Low Mountain Pine Forest.

Variation:

Dynamics: This community presumably is dependent on fire in the same way the Southern Mountain Pine–Oak Forest is. The distinctive character is probably due to drier site conditions.

Comments: This community is included in the 4th Approximation on the basis of the NVC and the strong possibility that it might occur here, but no occurrences are known and no plots in North Carolina have been attributed to it. It is also possible that it once occurred but that only unrecognizable altered areas remain. However, the most xeric slopes known in the foothills of North Carolina appear to support Low Mountain Pine Forest or Southern Mountain Pine–Oak Forest. The nearest known occurrence is 11 miles from North Carolina in the lower Chattooga River valley.

It is somewhat unclear how this community would be distinguished from Xeric Piedmont Slope Woodland if it were defined to range more broadly than the fringes of the Southern Blue Ridge.

Rare species:

References:

PINE–OAK / HEATH (HIGH ELEVATION SUBTYPE)

Concept: Pine-Oak/Heath communities are naturally open-canopy woodlands of sharp ridges and dry slopes at moderate or higher elevations, dominated by yellow pines. They generally have a dense shrub layer but may have been more open and herb-dominated when regularly burned in the past. The High Elevation Subtype covers higher elevation examples, generally above 3500 feet, containing *Rhododendron catawbiense*.

Distinguishing Features: Pine-Oak/Heaths are distinguished from various oak forests by a greater proportion of pine cover or basal area in the canopy under natural conditions. This can be a difficult distinction to make if southern pine beetles have killed the canopy pines long enough ago that snags are not visible, or if long absence of fire has led to proliferation of oaks in formerly open Pine–Oak/Heath. Beetle-killed stands generally are dominated by understory species such as *Nyssa sylvatica* and *Oxydendrum arboreum* rather than by oaks. Stands that have seen increases in oaks because of fire suppression or logging often have more abundant *Quercus coccinea* than *Quercus montana*, and they tend to have abundant *Acer rubrum*. However, it may not be possible to know if a *Quercus montana* forest with a minority component of pine might be pine-dominated under a more natural fire regime.

Carolina Hemlock Forest (Pine Subtype) is distinguished by a dominance or codominance of *Tsuga caroliniana*. If hemlock woolly adelgids have killed the hemlocks, it may be difficult to distinguish.

Vegetation similar to Pine–Oak/Heath may be present as patches in Low Elevation Rocky Summit, Low Elevation Granitic Dome, or High Elevation Granitic Dome communities. In general, these patches should be treated as part of the rock outcrop community unless they occupy an area several acres in extent or an area larger than the open zones of the rock outcrop.

The High Elevation Subtype is distinguished from the Typic Subtype and Linville Gorge Subtype by the presence of characteristic high elevation species, particularly *Rhododendron catawbiense*. The canopy may be dominated by either *Pinus rigida* or *Pinus pungens*. A high frequency of several other species, including *Eubotrys recurvus*, also distinguishes the High Elevation Subtype from the Typic Subtype but is shared with the Linville Gorge Subtype.

Synonyms: *Pinus rigida - (Pinus pungens) / Rhododendron catawbiense - Kalmia latifolia / Galax urceolata* Woodland (CEGL004985).
Ecological Systems: Central and Southern Appalachian Montane Pine Forest and Woodland (CES202.331).

Sites: The High Elevation Subtype occurs in sites similar to the Typic Subtype, primarily sharp ridge tops and, less often, shallow-soil areas near rock outcrops. It typically occurs at elevations from 3500 feet to as high as 4800 feet.

Soils: As in other Pine–Oak/Heaths, soils of the High Elevation Subtype are generally rocky and often shallow. Mapped soils include Tyic Dystrudepts (Ashe, Chestnut), Lithic Dystrudepts (Cleveland), Typic Humadepts (Wayah, Plott) and Humic Dystrudepts (Porters).

Hydrology: The High Elevation Subtype occurs in the driest parts of the landscape, with sites well drained because of sharply convex slopes. Sites are presumably less xeric than the Typic Subtype because of the cooler high elevation climate and possibly higher rainfall.

Vegetation: The High Elevation Subtype is most often dominated by *Pinus rigida*, but *Pinus pungens* is frequent and may dominate patches. *Pinus virginiana* is moderately frequent but seldom has much cover. *Quercus montana* occurs with high constancy and *Quercus coccinea* and *Pinus strobus are* frequent and sometimes abundant. *Tsuga caroliniana* and *Tsuga canadensis* are also fairly frequent. Dominant understory trees with high constancy in CVS data (Wentworth et al. in prep) are *Acer rubrum, Nyssa sylvatica*, and *Amelanchier laevis*, while *Oxydendrum arboreum* is almost as frequent and potentially abundant. Other frequent understory tree species include *Sassafras albidum* and *Castanea dentata* sprouts. Even *Picea rubens* occasionally occurs. The shrub layer is usually dense under present conditions. It is typically codominated by *Kalmia latifolia* and *Rhododendron catawbiense*. *Eubotrys racemosus* is also highly constant and occasionally abundant. Other frequent shrubs include *Clethra acuminata, Vaccinium corymbosum, Gaylussacia ursina, Gaylussacia baccata, Vaccinium pallidum, Hamamelis virginiana, Symplocos tinctoria,* and *Ilex montana*. *Lyonia ligustrina, Vaccinium corymbosum,* and *Rhododendron carolinianum* may also be present. *Smilax rotundifolia* is highly constant though seldom with high cover. The herb layer is generally sparse, but *Galax urceolata* is highly constant and sometimes has very high cover. *Gaultheria procumbens, Epigaea repens, Chimaphila maculata, Goodyera pubescens, Schizachyrium scoparium*, *Pteridium latiusculum*, and *Melampyrum lineare* are also present.

Range and Abundance: Ranked G2. The High Elevation Subtype is much rarer than the Typic Subtype, with fewer than 20 occurrences widely scattered throughout the Mountain region. It may be endemic to North Carolina but is questionably attributed by the NVC to Tennessee. The High Elevation Subtype appears to be rarer not only because there is less acreage at higher elevations but also to be less likely to occur in intact landscapes in its elevational range.

Associations and Patterns: Pine–Oak/Heath is treated as a small patch community. Occurrences are fairly small and are not predictable, but sometimes occur with multiple patches that occasionally add up to dozens of acres.

Variation: The High Elevation Subtype is more narrowly defined and less heterogeneous than the Typic Subtype, but some of the variations in the shrub layer reflected in the variants of the Typic Subtype might occur in it.

Dynamics: The general dynamics of pine communities discussed for the theme apply to the High Elevation Subtype. The reasons why the High Elevation Subtype is rarer than the Typic Subtype are unclear. It may be that the cooler temperatures and higher rainfall at higher elevations lead to fewer fires or to more rapid growth of hardwoods when fire is suppressed. Given the lower herb diversity, it is unclear if the High Elevation Subtype would have as much herb cover as lower elevation pine communities if burned more frequently. However, the slow recovery of *Kalmia latifolia* and likely *Rhododendron catawbiense* after fire make it likely it would be less shrubby.

Comments: Some authors, such as Whittaker (1956) have discussed variation in pine communities with elevation. However, the patterns of vegetation mentioned, such as an elevation gradient from *Pinus virginiana* to *Pinus rigida* to *Pinus pungens,* does not appear to work in general. While *Pinus virginiana* is uncommon in the High Elevation Subtype, the other two primary pines may dominate anywhere in the elevational range of pine communities.

Rare species:
Vascular plants: *Rhododendron vaseyi* and *Robinia hartwigii*.

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

PINE–OAK/HEATH (LINVILLE GORGE SUBTYPE)

Concept: Pine–Oak/Heath communities are naturally open-canopy woodlands of sharp ridges and dry slopes at moderate elevations, dominated by yellow pines. They generally have a dense shrub layer but may have been more open and herb-dominated when regularly burned in the past. The Linville Gorge Subtype encompasses the distinctive communities occurring in Linville Gorge and potentially in other gorge settings with quartzite substrate, which share characteristics of both the Typic Subtype and High Elevation Subtype.

Distinguishing Features: Pine–Oak/Heaths are distinguished from various oak forests by a greater proportion of pine cover or basal area in the canopy under natural conditions. This can be a difficult distinction to make if southern pine beetles have killed the canopy pines long enough ago that snags are not visible, or if long absence of fire has led to proliferation of oaks in formerly open Pine–Oak/Heath. Extreme wildfires also can confuse the distinction.

Vegetation similar to Pine–Oak/Heath may be present as patches in Low Elevation Rocky Summit and other rock outcrop communities. In general, these patches should be treated as part of the rock outcrop community unless they occupy an area several acres in extent or an area larger than the open zones of the rock outcrop.

The Linville Gorge Subtype is easily distinguished from the Typic Subtype by its occurrence in Linville Gorge at elevations below 3500 feet. It has not been found elsewhere, but it could occur in other topographically sheltered sites with quartzite subtypes. Vegetational characteristics that are distinctive to it include abundant *Rhododendron carolinianum,* frequent *Eubotrys recurvus* at elevations below that of the High Elevation Subtype, and frequent *Symplocos tinctoria* at elevations above that of Low Mountain Pine Forest.

The High Elevation Subtype also occurs in Linville Gorge at elevations above 2500 feet. It may be distinguished by a codominance or substantial presence of *Rhododendron catawbiense*.

Synonyms: A new NVC association will be created but has not been named.
Ecological Systems: Central and Southern Appalachian Montane Pine Forest and Woodland (CES202.331).

Sites: The Linville Gorge Subtype occurs on spur ridges and convex slopes within the gorge, probably most on a substrate of quartzite. The combination of local topographic exposure with broader scale topographic sheltering may be distinctive.

Soils: Soils are rocky, often thin, and probably are more extremely acidic than in other subtypes. They are mapped as various Typic Dystrudepts (Soco, Ditney, Ashe, Chestnut, Buladean, Stecoah) or Lithic Dystrudepts (Unicoi, Cleveland).

Hydrology: Sites are very well drained and dry.

Vegetation: The Linville Gorge Subtype is presumed to naturally have an open canopy similar to other Pine–Oak/Heaths, but at present the canopy can range from closed to open to sparse, or most

trees may have been recently killed by wildfire or southern pine beetles. The canopy is usually dominated by a mix of *Pinus pungens* and *Pinus rigida*. In CVS plots, *Quercus montana* and *Pinus strobus* presently are highly constant and occasionally locally codominant. Other frequent canopy species in plots include *Pinus virginiana, Quercus coccinea,* and *Tsuga caroliniana*. Highly constant or frequent understory trees that may be abundant include *Acer rubrum, Nyssa sylvatica,* and *Oxydendrum arboreum. Amelanchier arborea/laevis* and *Sassafras* albidum are also frequent. The shrub layer is generally dense, sometimes extremely so. *Kalmia latifolia* is constant and usually dominates, but *Rhododendron caroliniana* dominates or codominates in about half of plots and *Vaccinium pallidum* is also highly constant and sometimes locally dominant. Other constant or frequent shrubs include *Eubotrys recurvus, Gaylussacia baccata,* and *Symplocos tinctoria*, all of which may be fairly abundant. *Lyonia ligustrina, Castanea pumila, Hamamelis virginiana, Vaccinium stamineum, Vaccinium simulatum, Rhododendron maximum,* and *Fothergilla major* are also frequent in plots, but some of these might be not be characteristic under a more natural fire regime. Also perhaps characteristic is *Clethra acuminata*. *Smilax rotundifolia* and *Smilax glauca* are highly constant. The herb layer is generally sparse, but dense patches of *Galax urceolata* may occur. Other frequent species include *Gaultheria procumbens, Epigaea repens, Xerophyllum asphodeloides, Iris verna, Hexastylis shuttleworthii, Hexastylis virginica, Chimaphila maculata,* and *Pteridium latiusculum*. At lower elevations, *Coreopsis major, Schizachyrium scoparium, Danthonia sericea*, and *Hieracium venosum* also become more frequent.

Range and Abundance: This subtype is known only from Linville Gorge, an area of roughly 10,000 acres. It is fairly abundant there but makes up a fairly small minority of the landscape. No G-rank has been assigned, but this community would be G1 or G2 in light of its narrow endemic range and limited acreage.

Associations and Patterns: The Linville Gorge Subtype is a small patch community, but one which may have many patches within the site, so that the acreage is substantial. It is associated primarily with Chestnut Oak Forest (Dry Heath and White Pine Subtypes). Low Elevation Rocky Summit and Montane Cliff communities are often adjacent or nearby. Canada Hemlock Forest, Acidic Cove Forest, and Carolina Hemlock Forest may also be adjacent or nearby.

Variation: Two variants are recognized on the basis of analysis of plot data.
1. Typic Subtype occurs from roughly 2000 feet to 3500 feet in elevation and best fits the vegetation described above. It has limited *Pinus virginiana* and more abundant *Pinus pungens*.
2. Low Elevation occurs below roughly 2000 feet. It has similar vegetation but has high constancy of *Pinus virginiana*, limited *Pinus pungens*, and sometimes has a few species more associated with Low Mountain Pine Forest. These include *Quercus marilandica, Coreopsis major, Schizachyrium scoparium,* and *Pityopsis graminifolia*. However, it has less of the characteristic species of lower elevation than does typical pine forest at similar elevations.

Dynamics: Dynamics are probably generally similar to those for other Pine–Oak/Heath subtypes, but the topography of Linville Gorge may modify the fire regime. Though the rim appears to be highly prone to lightning fire ignition, but steep slopes and abundant rock outcrops may limit spread of fires downhill. Recent wildfires have shown some extreme behavior when spreading uphill when they have spread to the bottom of the gorge. The fire regime may thus be one of less frequent but more catastrophic natural fire. This needs further investigation. As in other dry

mountain communities, modern fire suppression has undoubtedly modified the fire regime and led to changes in the vegetation.

It is not entirely clear what factors lead to the distinctness of Pine–Oak/Heath in Linville Gorge, nor why it appears to have species of high elevations extending farther downhill. The topographic sheltering by the gorge walls or the different fire regime may be responsible.

Comments: Linville Gorge has the most intensively sampled pine vegetation, thanks to the work of Claire Newell (1997). The Linville Gorge Subtype was newly recognized during the final stages of preparation of 4th Approximation community descriptions. Intensive analysis of CVS plot data (Wentworth et al. in prep) identified anomalies in vegetation patterns that were associated almost exclusively with plots from Linville Gorge. These plots, though at middle elevations, clustered with plots of the High Elevation Subtype, yet it lacked the characteristic abundance of *Rhododendron catawbiense*. Other species that increase with higher elevation, such as *Eubotrys recurvus*, were nevertheless abundant. *Rhododendron carolinianum*, absent in most pine communities, was abundant. These characteristics led to the decision to recognize this subtype. There remains some uncertainty how to treat the lower elevation portions of this community. Plots in the normal lower elevational range of Low Mountain Pine Forest in Linville Gorge separate from the middle elevation Linville Gorge plots but also separate from other Low Mountain Pine Forest plots. They are included provisionally in the Linville Gorge Subtype.

Rare species:
Vascular plants: *Dicentra eximia* and *Fothergilla major.*

References:
Newell, C.L. 1997. Local and regional variation in the vegetation of the Southern Appalachian Mountains. Ph.D. dissertation, University of North Carolina, Chapel Hill.

Wentworth, T.R., Schafale, M.P., Peet, R.K., and Weakley, A.S. in prep. Coniferous vegetation of the Southern Blue Ridge Mountains.

CAROLINA HEMLOCK FOREST (TYPIC SUBTYPE)

Concept: Carolina Hemlock Forest communities are forests or woodlands where *Tsuga caroliniana* dominates the canopy at least weakly. The Typic Subtype consists of examples where *Pinus* spp. and *Tsuga canadensis* are both absent or minor components, generally occurring on ridge tops or upper slopes. Small groves of *Tsuga caroliniana* in oaks forests are not included here.

Distinguishing Features: Carolina Hemlock Forests are distinguished from all other upland communities by the dominance or codominance of *Tsuga caroliniana* in the canopy. (A single occurrence of Swamp Forest–Bog Complex is known to have *Tsuga caroliniana* codominant). The Typic Subtype is distinguished from the Pine Subtype by the dominance of *Tsuga caroliniana* and the absence of an appreciable pine component. Some oaks or other hardwoods may occasionally be codominant. The Typic Subtype is distinguished from the Mesic Subtype by occurrence in dry, topographically exposed environments, and by a shrub layer dominated by *Kalmia latifolia, Rhododendron catawbiense*, or *Rhododendron minus* with little or no *Rhododendron maximum*.

Synonyms: Carolina Hemlock Bluff (Third Approximation). *Tsuga caroliniana / Kalmia latifolia - Rhododendron catawbiense* Forest (CEGL007139).
Ecological Systems: Central and Southern Appalachian Montane Pine Forest and Woodland (CES202.331).

Sites: Carolina Hemlock Forest (Typic Subtype) usually occurs on upper slopes, occasionally on spur ridges or higher ridges. A few examples occur on lower sites on river bluffs. This community is often on the edges of rock outcrops or on very steep slopes. Most occurrences are at 2000-4000 feet, but foothills examples range to under 1000 feet and higher ones up to at least 4700 feet.

Soils: Carolina Hemlock Forests occur on rocky Typic or Lithic Dystrudepts such as Ashe and Porters. Some foothills and lower elevation examples may occur on various Typic Hapludults or even Typic Kanhapludults.

Hydrology: The Typic Subtype occurs in dry, well-drained upland sites. Because many sites are convex slopes or have shallow soil, they are particularly prone to drought stress.

Vegetation: Carolina Hemlock Forests are dominated by *Tsuga caroliniana*, with this species making up at least half of the canopy. Pines do not codominate, but *Pinus rigida, Pinus pungens*, or *Pinus virginiana* may be present in smaller numbers. Various hardwoods may be abundant, especially *Quercus montana* and *Quercus coccinea*. Frequent understory trees in CVS plots, local vegetation studies, and site descriptions are *Nyssa sylvatica, Acer rubrum*, *Oxydendrum arboreum, Amelanchier laevis*, *Sassafras albidum*, and *Castanea dentata*. *Kalmia latifolia* is nearly constant and usually dominates the shrub layer, but *Rhododendron catawbiense* and *Gaylussacia baccata* are also highly constant in CVS plot data. Other shrubs that are frequent include *Vaccinium pallidum, Eubotrys recurva, Rhododendron carolinianum, Hamamelis virginiana Vaccinium corymbosum, Clethra acuminata*, and *Ilex montana*. *Smilax rotundifolia* and *Smilax glauca* are also frequent. Herbs are generally low in density and in diversity, though *Galax urceolata* sometimes may have high cover. In addition to widespread species of highly acidic sites, such as *Chimaphila maculata* and *Goodyera pubescens*, fairly frequent species include *Xerophyllum*

asphodeloides and *Cypripedium acaule*. Species such as *Asplenium montanum* may be present locally on rocks within the community.

Range and Abundance: Ranked G2, however, the rank may soon become G1 in light of the severe damage and ongoing threat caused by the hemlock woolly adelgid (*Adelges tsugae*) to the dominant tree species. The NVC association shows a Southern Blue Ridge endemic pattern, ranging into Virginia, Tennessee, and South Carolina. In North Carolina, the Typic Subtype ranges throughout the interior Blue Ridge and foothills, with a couple of disjunct examples in the upper Piedmont. Examples are most abundant along the Blue Ridge escarpment; they also appear to be more abundant north of Asheville in the interior.

Associations and Patterns: Carolina Hemlock Forests are small patch communities. A few occurrences are reported to be more than 50 acres, but most are just a few acres. The Typic Subtype is often associated with rock outcrops, which may support Low Elevation Rocky Summit or Low Elevation Granitic Dome communities. Because it occurs in sites similar to Pine–Oak/Heath, it is often associated with that community. Otherwise, examples are usually surrounded by dry forest communities such as Chestnut Oak Forest or Montane Oak–Hickory Forest. A few examples grade into more mesic sites with Carolina Hemlock Forest (Mesic Subtype), Acidic Cove Forest, or Canada Hemlock Forest.

Variation: No patterns of variation have been identified, other than the gradation to adjacent communities. Otherwise, the shrub layer is the most variable part of the community, and examples dominated by *Rhododendron catawbiense* or *Rhododendron carolinianum* rather than *Kalmia latifolia* should be investigated for whether they warrant recognition as variants.

Dynamics: All aspects of the dynamics of Carolina Hemlock Forests are now in question because of the impact of the introduced hemlock woolly adelgid (*Adelges tsugae*). This insect is lethal to adult and young hemlocks. It initially appeared that *Tsuga caroliniana* might be less susceptible than *Tsuga canadensis*, but many stands have since suffered severe mortality. Slower initial mortality may have been due solely to general small size and isolated occurrence of Carolina Hemlock Forests. It is unclear if any examples of this community will remain distinct and viable in the future. While the immediate fate of affected stands is to become dominated by the associated canopy and understory tree species, it is unclear if they will ultimately develop into Pine–Oak/Heath, become indistinguishable from the surrounding oak forests, or form a different distinct community.

Relatively little is known about the dynamics of Carolina Hemlock Forests, compared to the intensive study of pine and oak forests. Two studies that have addressed population dynamics of the hemlocks in specific sites (Humphrey 1989 and Rentch, et al. 2000) have described a pattern indicative of a stress-tolerating life history, with multi-aged stands that seemed to be self-sustaining and typical of old-growth forests of other types. Trees exceeding 300 years old were found in both sites.

A crucial question for these communities is the role of fire. *Tsuga caroliniana* has thicker bark than *Tsuga canadensis*, and may be more tolerant of fire, though it seems unlikely to match the fire tolerance of pines or most oaks. The dry, topographically exposed sites where these

communities occur would seem prone to fire, but the frequent association with rock outcrops hints at a possible need for some natural sheltering from fire. The persistence of older trees that pre-date modern fire suppression suggests either that they are protected from fire or tolerate it well, though they may be survivors of fires that killed some part of the canopy. Newell (1997) noted that there was evidence of fire in 55% of the *Tsuga caroliniana* cluster sites, which appears to combine all three subtypes, but that fire was less recent than in the pine communities and that the community did not appear to depend on fire.

Given that the Typic Subtype and Pine Subtype of Carolina Hemlock Forest occur in sites similar to those that support Pine–Oak/Heath, it is a question why Carolina Hemlock Forests occupy certain sites instead. One possibility is a shifting mosaic, with Carolina Hemlock Forests, Pine–Oak Heath, and perhaps Chestnut Oak Forests having a successional relationship, probably with Carolina Hemlock Forests taking over if enough time passes without severe disturbance. Another possibility is chance establishment followed by persistence. *Tsuga caroliniana* individuals may be observed as scattered groves in oak forests in some areas. These often appear to have a single or small group of founder trees, with younger trees surrounding them, as if the grove is expanding slowly. If there is a vegetation-mediated feedback, perhaps with hemlock litter reducing fire effects, a stand, once established, might persist for multiple tree generations. It remains a possibility, however, that sites for the communities differ in ways that are not perceived, perhaps in ways that are only apparent under the fire regime of the past. These same questions likely are important for the relationship between the Typic Subtype and the Pine Subtype. The answers to these questions may be crucial to the future of Carolina Hemlock Forest communities after hemlock woolly adelgid mortality.

Comments: Carolina Hemlock Forests have had limited focused study, and they are a rare part of the landscape, but they have been recognized in several local vegetation studies (e.g., McLeod 1988, Newell and Peet 1995, Newell 1997). Newell (1997) recognized a *Tsuga caroliniana* type that appears to combine all three subtypes.

As a species, *Tsuga caroliniana* appears to have an odd, patchy distribution. Where it is present in the landscape, besides occurring in Carolina Hemlock Forest communities, it may occur as scattered individuals and small groves in several oak forest communities, but this is only a small fraction of the landscapes where those oak communities occur. These groves often appear to have been founded by the colonization of a single individual, and to be growing slowly by its reproduction. It is possible that this is an artifact of the absence of regular fire in the last century. It is similar to the pattern evidenced by *Tsuga canadensis* and by *Picea rubens* in ranges where it occurs, but *Tsuga caroliniana* appear more likely to mature and produce offspring in these isolated groves.

Rare species:
Vascular plants: *Mononeuria groenlandica, Monotropsis odorata, Packera millefolium,* and *Quercus ilicifolia*.

References:
Humphrey, L. David. 1989. Life history traits of Tsuga caroliniana Engelm. (Carolina hemlock) and its role in community dynamics. Castanea 54:172-190.

McLeod, D.E. 1988. Vegetation patterns, floristics, and environmental relationships in the Black and Craggy Mountains of North Carolina. Ph.D. dissertation, University of North Carolina, Chapel Hill.

Newell, C.L. and R.K. Peet. 1995. Vegetation of Linville Gorge Wilderness, North Carolina. Unpublished report to USDA Forest Service. University of North Carolina, Department of Biology, Chapel Hill.

Newell, C.L. 1997. Local and regional variation in the vegetation of the Southern Appalachian Mountains. PhD dissertation, University of North Carolina, Chapel Hill.

Rentch, J.S., H.S. Adams, R.B. Coxe, and S.L. Stephenson. 2000. An ecological study of a Carolina hemlock (Tsuga Caroliniana) community in southwestern Virginia. Castanea 65:1-8.

CAROLINA HEMLOCK FOREST (PINE SUBTYPE)

Concept: Carolina Hemlock Forest communities are forests or woodlands where *Tsuga caroliniana* dominates the canopy at least weakly. The Pine Subtype covers examples with yellow pines abundant or codominant.

Distinguishing Features: Carolina Hemlock Forests are distinguished from all other upland communities by the dominance or codominance of *Tsuga caroliniana* in the canopy. The Pine Subtype is distinguished from the other subtypes by an appreciable component of yellow pines, which may be codominant. Some oaks and other hardwoods may be present.

Synonyms: Carolina Hemlock Bluff (Third Approximation). *Tsuga caroliniana - Pinus (rigida, pungens, virginiana*) Forest (CEGL006178).
Ecological Systems: Central and Southern Appalachian Montane Pine Forest and Woodland (CES202.331).

Sites: The Pine Subtype usually occurs on upper slopes, occasionally on spur ridges or higher ridges. This community is often on the edges of rock outcrops or on very steep slopes. Most occurrences are at 2000-4000 feet, but foothills examples range to under 1000 feet and higher ones up to at least 4700 feet. Examples are known from 1600-4200 feet in elevation.

Soils: Most examples of the Pine Subtype are likely on Lithic or Typic Dystrudepts such as Ashe or Porters, with some on Typic Hapludults such as Cliffield. Some examples are included in rock outcrop map units.

Hydrology: The Pine Subtype occurs in dry, well-drained upland sites. Because many sites are convex slopes or have shallow soil, they are particularly prone to drought stress.

Vegetation: Carolina Hemlock Forests are dominated by *Tsuga caroliniana*, with this species making up at least half of the canopy. The Pine Subtype has *Pinus virginiana, Pinus rigida*, or *Pinus pungens* as a canopy codominant or at least abundant associated species. Limited CVS plot data and site descriptions show other frequent canopy species include *Quercus montana, Quercus coccinea*, *Betula lenta*, and *Pinus strobus*. Frequent understory trees include *Acer rubrum, Oxydendrum arboreum, Nyssa sylvatica, Amelanchier laevis*, and *Castanea dentata*. The shrub layer is moderate to dense. *Kalmia latifolia* may dominate but other species are almost as frequent with high cover, including *Rhododendron carolinianum, Gaylussacia baccata*, and *Vaccinium pallidum*. Other frequent shrubs include *Vaccinium stamineum, Eubotrys racemosa, Ilex montana,* and *Vaccinium corymbosum*. *Smilax rotundifolia* is highly constant. The herb layer is sparse. Species tolerant of very acidic conditions, such as *Galax urceolata* and *Gaultheria procumbens*, prevail, but other species that are fairly frequent are probably associated with small rock outcrops: *Polypodium appalachianum, Danthonia spicata, Asplenium montanum, Schizachyrium scoparium*, and *Coreopsis major*.

Range and Abundance: Ranked G2, but may soon become G1 in light of the severe damage and ongoing threat caused by the hemlock woolly adelgid (*Adelges tsugae*) to the dominant tree species.. This community is known only in North Carolina and Tennessee. It is difficult to tell how

abundant it is in the state. It is a fairly new concept, recognized only in early drafts of the 4th Approximation. It is difficult to distinguish in existing site reports, because the Typic Subtype often has at least some pine in it. It is unclear if some sites contain both subtypes, and, if so, what their relative amounts are. The Pine Subtype appears to be somewhat rarer than the Typic Subtype. Known occurrences range through the mountains and foothills but are most concentrated along the Blue Ridge escarpment.

Associations and Patterns: The Pine Subtype is a small patch community. Most occurrences are a few acres. The few acreage figures over 20 acres are highly uncertain. The Pine Subtype is often associated with rock outcrops, perhaps more than the Typic Subtype. It may thus grade into Low Elevation Rocky Summit or Low Elevation Granitic Dome communities. It is unclear how much it is associated with the Typic Subtype. Because it occurs in sites similar to Pine–Oak/Heath, it is often associated with that community. Otherwise, examples are usually surrounded by dry forest communities such as Chestnut Oak Forest or Montane Oak–Hickory Forest.

Variation: No patterns of variation have been identified, other than the gradation to adjacent communities. Otherwise, the shrub layer is the most variable part of the community, and examples dominated by *Rhododendron catawbiense* or *Rhododendron carolinianum* rather than *Kalmia latifolia* should be investigated for whether they warrant recognition as variants.

Dynamics: See the discussion of dynamics for the Typic Subtype. The dynamics of the Pine Subtype are even more uncertain, because it consists of two genera of trees which appear to have very different life histories and different relationships with fire. It is possible they represent an intermediate stage of succession, with the pines having once been dominant but now in decline as hemlocks take over. It is possible they represent an accident of tree establishment after some historical event, representing an additional patch type in a shifting mosaic. Especially if they are in rocky sites, it is possible the sites are heterogeneous and contain a mix of microsites optimal for both genera, either in soil properties or in typical fire behavior.

Future dynamics, and even future existence of the Pine Subtype in the face of hemlock woolly adelgid (*Adelges tsugae*) are as uncertain as for the Typic Subtype, but the trajectory may be different. It is reasonable to expect that, with abundant associated pines and with occurrence in similar sites, that *Tsuga* mortality will lead to pine dominance and create a community indistinguishable from Pine–Oak/Heath. However, because yellow pines have difficulty reproducing under current conditions without fire, long-term pine dominance in these communities is a tenuous as it is for hemlock.

Comments: The Pine Subtype is one of the less distinctive communities in the 4th approximation. It is included only provisionally. Newell (1997) recognized only a single *Tsuga caroliniana* community in Linville Gorge, one that appears to combine the Typic, Pine, and Mesic Subtypes. It may be arguable that recognizing a separate association and subtype for it is simply a result of the "conifer bias" that affects many forest classifications. However, pine and Carolina hemlock communities may have very different dynamics, and a community that combines elements of both may be interesting. In addition, the abundant of pines suggests a different possible future for the community if Carolina hemlock is permanently lost as a dominant species.

Rare species:
Vascular plants: *Buckleya distichophylla, Monotropsis odorata, Quercus ilicifolia,* and *Sisyrinchium dichotomum.*
Vertebrate animals: *Crotalus horridus.*
Invertebrate animals: *Hypochilus coylei.*

References:
Newell, C.L. 1997. Local and regional variation in the vegetation of the Southern Appalachian Mountains. PhD dissertation, University of North Carolina, Chapel Hill.

CAROLINA HEMLOCK FOREST (MESIC SUBTYPE)

Concept: Carolina Hemlock Forest communities are forests or woodlands where *Tsuga caroliniana* dominates the canopy at least weakly. The Mesic Subtype covers examples in moister, more sheltered sites, with more mesic composition transitional to Canada Hemlock Forest.

Distinguishing Features: Carolina Hemlock Forests are distinguished from all other upland communities by the dominance or codominance of *Tsuga caroliniana* in the canopy. The Mesic Subtype is distinguished by occurrence in topographically sheltered or valley bottom environments (but not wetlands), by having a shrub layer dominated by *Rhododendron maximum* rather than less mesic species, and often by having *Tsuga canadensis* codominant.

Synonyms: *Tsuga caroliniana - (Tsuga canadensis) / Rhododendron maximum* Forest (CEGL007138). Carolina Hemlock Bluff (Third Approximation).
Southern and Central Appalachian Cove Forest (CES202.373).

Sites: The Mesic Subtype occurs in valley bottoms and on lower slopes, often in gorges. Known examples range from 2000-4100 feet in elevation.

Soils: Soils associated with the subtype are not well known, but probably can include a range of Lithic and Typic Dystrudepts, Typic Humadepts, and Typic Hapludults. They presumably are deeper and less rocky than the other subtypes.

Hydrology: The Mesic Subtype occurs in well-drained upland sites that are mesic because of lower slope positions and topographic sheltering.

Vegetation: The Mesic Subtype canopy is dominated by *Tsuga caroliniana*. *Tsuga canadensis*, *Acer rubrum*, *Pinus strobus, Quercus coccinea*, or *Quercus montana* may be abundant or occasionally codominant. In CVS plot data, understory species that are constant or at least moderately frequent include *Oxydendrum arboreum, Nyssa sylvatica, Acer rubrum, Amelanchier laevis, Acer pensylvanicum, Ilex opaca, Sassafras albidum*, and *Betula lenta*. The shrub layer is generally moderate to dense. *Rhododendron maximum* is highly constant and often strongly dominant. *Kalmia latifolia* is highly constant and may be dominant or abundant. Other frequent shrubs include *Hamamelis virginiana, Ilex montana, Leucothoe fontanesiana,* and *Viburnum cassinoides*. *Smilax rotundifolia* and *Smilax glauca* are frequent. *Galax urceolata* may have high cover in the herb layer. Otherwise, herbs are sparse and are largely confined to very acid-tolerant species such as *Chimaphila maculata* and *Goodyera pubescens*.

Range and Abundance: Ranked G1G2, but the rank may soon become G1 in light of the severe damage and ongoing threat caused by the hemlock woolly adelgid (*Adelges tsugae*) to the dominant tree species. The Mesic Subtype is rarer than the other subtypes. Examples are scattered in the Blue Ridge escarpment and mountain interior. None are known in the foothills, but occurrence is possible. The NVC association is reported only for North Carolina and Tennessee.

Associations and Patterns: The Mesic Subtype is a small patch community. All known occurrences are just a few acres. It may grade uphill to the Typic Subtype. Otherwise, it is likely

to be associated with Acidic Cove Forest or Canada Hemlock Forest, potentially with Rich Cove Forest or various oak forests.

Variation: No patterns of variation have been identified, other than the gradation to adjacent communities.

Dynamics: See the discussion of dynamics for the Typic Subtype. It is uncertain how similar the dynamics of the Mesic Subtype are. Given the moister conditions and lower topographic position, fire and drought are less likely to be important. Dynamics may be more similar to Acidic Cove Forest or Canada Hemlock Forest. However, the factors that lead to establishment and persistence of Carolina Hemlock Forest rather than one of those communities are not known.

Future dynamics and even future existence of the Mesic Subtype in the face of hemlock woolly adelgid (*Adelges tsugae*) are as uncertain as for the Typic Subtype, but the trajectory may be different. Because of the mesic location and general proximity to seed sources, it is reasonable to expect that, with *Tsuga caroliniana* mortality, they most likely will come to resemble Acidic Cove Forests.

Comments: The Mesic Subtype is one of the less distinctive communities in the 4th approximation, though it differs more in sites and composition than the Pine Subtype. Newell (1997) recognized only a single *Tsuga caroliniana* community in Linville Gorge, one which appears to combine the Typic, Pine, and Mesic Subtype.

Rare species: No rare species are known to be associated with this community.

References:

Newell, C.L. 1997. Local and regional variation in the vegetation of the Southern Appalachian Mountains. PhD dissertation, University of North Carolina, Chapel Hill.

LOW MOUNTAIN PINE FOREST (SHORTLEAF PINE SUBTYPE)

Concept: Low Mountain Pine Forests are yellow-pine-dominated forests or woodlands containing both montane flora and low-elevation species such as *Pinus echinata*, occurring in the lower elevations of the Mountains and foothills. The Shortleaf Pine Subtype encompasses communities dominated by *Pinus echinata*, with other pines and hardwoods collectively less than 50% of the canopy in natural condition.

Distinguishing Features: Low Mountain Pine Forests are distinguished from Pine–Oak/Heath by occurring at lower elevations and by containing characteristic low elevation species such as *Pinus echinata*, *Quercus stellata*, and *Quercus falcata*. The Shortleaf Pine Subtype is distinguished from the Montane Pine Subtype by being dominated by *Pinus echinata*. *Pinus echinata* is generally present in the Montane Pine Subtype, and likely once was more abundant in it, but did not dominate.

Synonyms: *Pinus echinata / Vaccinium (pallidum, stamineum) - Kalmia latifolia* Forest (CEGL007078).
Ecological Systems: Southern Appalachian Low-Elevation Pine Forest (CES202.332).

Sites: Low Mountain Pine Forests occur on low elevation slopes and broad to sharp ridges. Most examples of the Shortleaf Pine Subtype are at 1200-2000 feet in elevation, but a couple range higher.

Soils: The Shortleaf Pine Subtype may potentially occur on a wide variety of mountain upland soils. Soils mapped at examples include Typic Kanhapudults such as Hayesville and Sauratown, Typic Hapludults such as Brevard, and Typic Dystrudepts such as Ashe, Cleveland, and Chestnut.

Hydrology: Low Mountain Pine Forests are dry, as a result of rapid drainage and warm slope aspects, along with the warm temperatures at low elevations.

Vegetation: The Shortleaf Pine Subtype is a dense to open forest dominated, at least weakly, by *Pinus echinata* in natural condition. Stands more altered by fire exclusion or southern pine beetles may have less *Pinus echinata* but will show evidence of it being abundant. Highly constant canopy tree species, in CVS plots or site descriptions, include *Quercus falcata, Quercus coccinea,* and *Acer rubrum*, while *Pinus strobus, Pinus rigida, Quercus alba, Quercus stellata, Carya glabra,* and *Carya tomentosa* are frequent. The dominant understory trees are *Oxydendrum arboreum, Nyssa sylvatica*, and *Ilex opaca*, the latter presumably increased due to lack of fire. *Cornus florida* and uncharacteristic *Tsuga canadensis* and *Liriodendron tulipifera* are also frequent. *Vaccinium pallidum* is highly constant in the shrub layer and often dominant. *Kalmia latifolia* is frequent and may be abundant. Other frequent shrubs in plots or site reports include *Gaylussacia ursina, Symplocos tinctoria, Vaccinium arboreum, Ceanothus americanus*, and *Euonymus americanus*. Herbs are generally sparse. *Coreopsis major, Pteridium latiusculum, Danthonia spicata, Iris verna*, *Chimaphila maculata, Polystichum acrostichoides, Stenanthium gramineum*, and *Antennaria plantaginea* are at least fairly frequent in plots. A number of different species are frequent in site descriptions, presumably because they occur at lower density and are seldom encountered in plots, but many are probably more abundant when sites are regularly burned,

including *Schizachyrium scoparium, Pityopsis graminifolia, Solidago odora, Tephrosia virginiana, Desmodium viridiflorum, Desmodium rotundifolia, Ageratina aromatica, Mimosa microphylla,* and *Silphium reniforme*. Other herbs that are infrequent but may be characteristic include *Danthonia sericea, Rudbeckia hirta, Gillenia trifoliata, Nabalus serpentaria, Lespedeza hirta, Baptisia tinctoria, Helianthus microcephalus,* and *Chamaecrista* spp.

Range and Abundance: Ranked G4? In North Carolina, this community is very rare, with only a dozen occurrences known. Most are in the far southwestern mountains of Graham and Cherokee counties and in the South Mountains. It apparently once was extensive in the southwestern mountains. The NVC association is said to range from South Carolina and Georgia to Kentucky.

Associations and Patterns: The Shortleaf Pine Subtype is a large patch community, with most known occurrences in the range of 20-75 acres but a few larger and smaller. It is believed to have once been more extensive in Cherokee County and in adjacent states, though it is difficult to tell whether all of the reported extensive stands were natural long-term communities. The Shortleaf Pine Subtype may be associated with Southern Mountain Pine–Oak Forest or Montane Oak–Hickory Forest (Low Dry Subtype).

Variation: Examples vary with the gradation to adjacent communities.

Dynamics: Dynamics of the Shortleaf Pine Subtype are probably similar to other yellow-pine-dominated Mountain Dry Coniferous Woodlands. *Pinus echinata* is tolerant of frequent fire and appears to have dominated savanna-like communities farther west, but it is unclear that such frequent fire regimes occurred natural in North Carolina.

Comments: *Pinus echinata / Schizachyrium scoparium* Appalachian Woodland (CEGL003560) is an association defined for South Carolina and Georgia, which appears to be a more frequently burned version of this.

Rare species:
Vascular plants: *Fothergilla major*.

References:

WHITE PINE FOREST

Concept: The White Pine Forest natural community encompasses rare upland forests that are strongly dominated by *Pinus strobus* in natural condition. *Pinus strobus* forests that result from planting, from past land clearing, or from logging of other types of forest are not included. Forests where *Pinus strobus* is naturally codominant with oaks, *Tsuga canadensis*, or other species characteristic of other natural communities, or that are in floodplain or wetland natural communities, are not included.

Distinguishing Features: White Pine Forests are distinguished from the White Pine Subtype of Chestnut Oak Forest, the White Pine Subtype of Montane Oak–Hickory Forest, and all other forests that may contain a mixture of *Pinus strobus* by having *Pinus strobus* naturally making up more than 66 percent of the canopy over an area more than 1 acre. Distinguishing natural from unnatural successional white pine forests can be difficult. In general, natural White Pine Forests are on slopes of gorges or on ridges, while successional white pine forests are on valley flats or gentle lower slopes. However, clearcutting may allow white pine to become dominant in Montane Oak–Hickory Forests or Chestnut Oak Forests in some parts of the state.

Synonyms: *Pinus strobus / Kalmia latifolia - (Vaccinium stamineum, Gaylussacia ursina)* Forest (CEGL007100).
Ecological Systems: Southern Appalachian Low-Elevation Pine Forest (CES202.332).

Sites: White Pine Forests are typically on open slopes, generally at lower elevations. Many are within gorges, but some are on more exposed mountain ridges. Slopes are generally planar or convex, but not sharp. Elevations generally are 1200-3500 feet, but at least one example extends to 4000 feet.

Soils: White Pine Forests generally occur on the widespread soils of mountain slopes, usually Typic Dystrudepts such as Ashe, Edneyville, Chestnut, Cleveland, and Buladean. A few are mapped as Tusquitee (Humic Dystrudept) or Toecane (Humic Hapludult). Pinchot and Ashe (1897) noted that *Pinus strobus* prefers loamy soil, but this is typical of most soils in the region.

Hydrology: White Pine Forests occur in dry-mesic to dry upland conditions. Soils are generally well drained, and sites may be topographically sheltered or exposed.

Vegetation: White Pine Forests, by definition, are dominated by *Pinus strobus*. Associated canopy species most frequently are *Quercus coccinea* and *Quercus montana*, but they may also include *Pinus virginiana, Pinus rigida*, *Quercus alba, Quercus rubra, Betula lenta*, *Tsuga canadensis,* or other species. In both CVS plot data and site descriptions, the understory species with high constancy to medium frequency and sometimes high cover are *Acer rubrum, Oxydendrum arboreum*, and *Nyssa sylvatica*, with *Ilex opaca* having lesser cover. Other understory species may include *Magnolia fraseri, Tsuga canadensis, Castanea dentata*, or *Diospyros virginiana*. *Kalmia latifolia* is highly constant in the shrub layer and often is very dense. *Vaccinium pallidum* or *Gaylussacia ursina* may also dominate patches. Other shrubs with high frequency include *Symplocos tinctoria, Rhododendron maximum*, and *Hamamelis virginiana*, while *Rhododendron minus* is codominant in at least one example. *Smilax rotundifolia*, *Smilax glauca*, and *Muscadinia*

rotundifolia are frequent. Herbs are generally sparse and consist mainly of species of shaded acidic sites, such as *Chimaphila maculata, Epigaea repens, Mitchella repens,* and *Goodyera pubescens*, but *Iris verna, Pteridium latiusculum*, and *Cypripedium acaule* also occur with moderate frequency.

Range and Abundance: Ranked G2G3. Only about ten occurrences are known in North Carolina, most of them south of Asheville but a few farther north. The abundance of *Pinus strobus* in mixed communities and in successional communities makes it difficult to recognize natural examples. Some additional occurrences may be overlooked or may be in less explored areas. The NVC association ranges into South Carolina, Georgia, and Tennessee.

White pine has an odd native range in North Carolina. Pinchot and Ashe (1897) noted: "The woodland in which white pine is the dominant coniferous tree is not extensive, but lies in isolated, small bodies along the crest, and southern and eastern slopes of the Blue Ridge or on the low hills on the west." They go on to list these areas as the South Fork New River valley of Ashe and Watauga Counties, the upper valley of the Linville River in Mitchell County, the valley of the French Broad River in Transylvania County, and the southern parts of Macon and Jackson Counties. They also note the escarpment in Wilkes and McDowell Counties as a place where both white and yellow pines occur together. This range corresponds better to the range of the White Pine Subtypes of oak forests than it does to known White Pine Forests, but the community should be sought in these other areas.

Associations and Patterns: White Pine Forests are usually associated with oak forests, particularly the White Pine Subtype of Montane Oak–Hickory Forest and Chestnut Oak Forest. It may also grade to Acidic Cove Forest or Canada Hemlock Forest, and potentially to other communities.

Variation: Little is known about the variation in this community.

Dynamics: Dynamics of White Pine Forests in North Carolina are less studied than those of the yellow pine forests. In the Northeast and upper Midwest, naturally occurring white pine forests are generally considered to be the result of catastrophic fire. They can survive to 350-400 years of age (Pinchot and Ashe 1897). Though *Pinus strobus* is considered poorly adapted to surviving fire, it readily invades areas disturbed by severe fire. Such stands can then mature to become large-stature old-growth forests. In this view, northern white pine forests act as part of a shifting mosaic, as is more common in the West, establishing as a result of rare events in somewhat random places, then persisting until long-term succession naturally leads to a different community. In the South, where fire was more frequent but less severe, such dynamics would be rare, if not absent. Pinchot and Ashe (1897) noted that *Pinus strobus* is susceptible to fire until it is 10 inches dbh. However, one of the characteristic settings for White Pine Forest — in gorges — is sheltered from much of the fire in the surrounding landscape yet can burn intensely on the rare occasions when fire reaches the gorge bottom and then runs up steep slopes. Nevertheless, recent severe fires in Linville Gorge do not appear to have resulted in creation of pure *Pinus strobus* in what had been other communities.

If White Pine Forest patches do depend on catastrophic disturbances to establish, they might then persist for 100-200 years or more. Since *Pinus strobus* is about as shade tolerant as oaks, either genus could establish in canopy gaps once the canopy is mature enough that gaps start forming, but known occurrences have not been examined for evidence of the future trajectory. The tendency to develop a more shade-tolerant understory might make it difficult for either genus to regenerate until fire again occurs. DeYoung (1979), in his study on the Tennessee side of the Great Smoky Mountains, describes some forests containing *Pinus strobus* as apparently self-sustaining, but these were mixed forests resembling the White Pine Subtype of Chestnut Oak Forest and Montane Oak–Hickory Forest. Purer pine forests in that area appeared to be anthropogenic successional communities.

Comments: The historical and natural abundance and distribution of White Pine Forest is more difficult to discern than for most natural communities. Since the species is both readily able to invade disturbed areas and is a highly desired timber tree that might be selectively removed, past logging may have either increased or decreased its abundance in any given site. Since young individuals are susceptible to fire while seedling establishment is also potentially enhanced after fire, the modern change in fire regime also had uncertain effects. Descriptive literature is confused by the abundance of anthropogenic successional forests established on former fields and clearings, as well as by the apparently more widespread distribution of the species in mixed forests. Pinchot and Ashe (1897) described *Pinus strobus* as often forming large patches of nearly pure forest, but it is unclear if these are natural communities or old field stands, but elsewhere they said that the species typically occurred dispersed in hardwood forests as single trees or small groups.

Rare species: No rare species are known to be associated with this community.

References:

DeYoung, H.R. 1979. The white pine-hardwood vegetation types of the Great Smoky Mountains National Park. M.S. Theses. University of Tennessee–Knoxville. 190 pp.

Pinchot, G. and Ashe, W.W. 1897. Timber trees and forests of North Carolina. North Carolina Geological Survey Bulletin No. 6.