MOUNTAIN COVE FORESTS

Contents

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Concept: Mountain Cove Forests are mesic communities of low to middle elevations in the Mountain Region and foothills. They occur in broad to narrow valley bottoms, ravines, and on lower slopes. They are forested with mixtures of mesophytic hardwoods, usually containing moderate to large numbers of tree species and may or may not include *Tsuga canadensis*.

Distinguishing Features: Mountain Cove Forests are distinguished from drier forests by the dominance of mesophytic trees. Oaks, hickories, and occasionally pines are generally present but do not dominate. Mountain Cove Forests are distinguished from Piedmont and Mountain Floodplains, which may contain many of the same mesophytic tree and other plant species, by lacking species such as *Platanus occidentalis, Betula nigra*, and *Acer negundo*, which are characteristic of sites with regular flooding and alluvial deposition. Some of the tree-dominated communities of the Mountain Bogs and Fens theme also may share many species. Those communities are distinguished by containing additional species characteristic of acidic saturated wetlands, such as *Osmundastrum cinnamomeum, Juncus gymnocarpus, Carex folliculate, Carex leptalea, Vaccinium macrocarpon, Rosa palustris*, and *Sphagnum* spp.

The distinction between Mountain Cove Forests and Northern Hardwood Forests is particularly difficult, especially in the transitional elevation zone around 3500-4500 feet. Northern Hardwood Forests share most of their species with Mountain Cove Forests but are more strongly dominated by one or two species, generally *Betula alleghaniensis, Fagus grandifolia, Acer saccharum*, or *Aesculus flava*. A number of lower elevation species are common in Rich Cove Forests but rarely or never occur in Northern Hardwood Forests, including *Liriodendron tulipifera, Magnolia acuminata, Juglans nigra, Lindera benzoin*, *Rhododendron maximum*, and *Amphicarpaea bracteata*.

Within Mountain Cove Forests, Rich Cove Forests are distinguished by a diverse canopy and diverse herb layer that contains numerous species associated with richer soils. Tree species such as *Tilia americana* var. *heterophylla, Fraxinus americana, Prunus serotina, Acer saccharum*, *Magnolia acuminata*, and *Magnolia acuminata* are present in Rich Cove Forests but largely absent in Acidic Cove Forests. The characteristic species of Acidic Cove Forest, such as *Liriodendron tulipifera, Betula lenta*, *Acer rubum*, and *Halesia tetraptera,* are also present in Rich Cove Forest. Canada Hemlock Forests are distinguished by canopy dominance by *Tsuga canadensis*. Similar compositional distinctions occur in the herb layer. Species such as *Actaea racemosa, Caulophyllum thalictroides, Laportea canadensis, Osmorhiza claytonia, Sanguinaria canadensis,* and *Viola canadensis* are common to most Rich Cove Forests but largely absent in Acidic Cove Forests and Canada Hemlock Forests.

Sites: Mountain Cove Forests occur in mesic sites at low to moderate elevations, in small to large valley bottoms, in ravines, and on lower slopes. They more often occur on concave slopes but can be found on convex slopes that are sheltered. Most are below 4000 feet elevation, but a few range higher in specialized environments.

Soils: Mountain Cove Forests occur on a wide range of typical mountain soils, most often on Typic Dystrudepts or Typic Hapludults, sometimes on Lithic Dystrudepts, Typic Humadepts, or other types. Soils range from extremely acidic and infertile to circumneutral and rich.

Hydrology: Sites are mesic because of topographic sheltering and water accumulation on concave slopes and in lower slope positions.

Vegetation: Mountain Cove Forests are dominated by mixtures of mesophytic trees, with the mix varying among sites in response to soil chemistry as well as varying widely within and among comparable sites. Common to most are *Liriodendron tulipifera, Acer rubrum*, and *Betula lenta*, as well as *Quercus rubra* and formerly, *Castanea dentata*. *Halesia tetraptera, Fagus grandifolia*, *Tsuga canadensis, Pinus strobus*, *Quercus alba*, and *Quercus montana* are also fairly frequent across most communities. Acidic Cove Forests consist largely of these species. *Tsuga canadensis* dominates in Canada Hemlock Forests. Rich Cove Forests share a number of additional tree species, most frequently *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Aesculus flava, Prunus serotina*, and *Acer saccharum*. Lower strata vary. Acidic Cove Forests usually have dense shrub layers of evergreen Ericaceae but may have limited shrubs and have a well-developed herb layer consisting of a few acid-tolerant species. Rich Cove Forests usually have limited shrubs and have a lush herb layer. Herb species richness is high at both local and regional scales in Rich Cove Forests. Most examples have many species and some species are present in most examples, but there is a large pool of species that occur with moderate to low frequency.

Dynamics: Mountain Cove Forests are like most of North Carolina's hardwood forests in naturally occurring primarily as old-growth, uneven-aged stands. Trees up to several centuries old are common in uncut forests. Most tree reproduction is in small, less often medium size, canopy gaps created by the death of one or a few trees, resulting in a fine-scale mosaic of tree ages across the forest and relative stability of the forest cover over large areas. Lorimer (1980), working in virgin cove forests at Joyce Kilmer Memorial Forest, noted that trees are of multiple ages in areas as small as 1/10-1/2 hectare and that major tree species were present in most 10-year age classes up to 400 years old. However, he also noted that there were peaks of tree reproduction that suggest widespread disturbance. Wind, lightning, and ice damage are important sources of mortality. Lightning creates gaps at a relatively steady rate, but probably is less frequent in the sheltered settings of coves than it is on ridges. Large wind storms may create numerous gaps at once, while leaving the majority of canopy cover intact. Lorimer (1980) estimated that the average canopy mortality in a decade was 5.5%, with 3.8% in nondisturbance decades and up to 14% in decades with major disturbances. Runkle (1982) and Runkle and Yetter (1987) found that gaps formed at a rate of 1% of the land surface/year in their study areas. Runkle (1982) estimated for old-growth mesic forests in general that recognizable gaps occupied 17.3% of the canopy in Joyce Kilmer Memorial Forest and 8.9-24.2% in the Great Smokies.

Many of the characteristic trees of Mountain Cove Forests are tolerant of shade and regenerate readily beneath the canopy. However, other frequent trees, such as *Liriodendron*, are regarded as an early successional species intolerant of shade. *Liriodendron's* abundance in old-growth forests was regarded as a paradox, but Buckner and McCracken (1978), Lorimer (1980), and Clebsch and Busing (1989) all addressed this problem by noting that the single-tree and few-tree gaps in old-

growth forests are large enough to allow its regeneration. *Liriodendron* itself, as the largest of cove forest trees, is capable of forming gaps that allows its regeneration, but a number of other tree species can become almost as large and create large gaps.

Fire appears to be of limited importance in Mountain Cove Forests. The newly recognized frequency of fire in the low- and mid-elevation mountain landscapes suggests they were exposed to it regularly. However, the prevalence in coves of plant species not very tolerant of fire, a prevalence that is described in early studies and recorded in long-lived trees dating to before the time of fire suppression, indicates that fire was not an important ecological influence. The moist site conditions, shelter from wind, the tendency of mesophytic leaf litter to mat down and hold moisture, and the location downhill of most ignition points would all dampen fire behavior. Where present day prescribed fires are allowed to burn into coves or ravines, the fires sometimes go out and sometimes spread with low intensity that has little effect on even the thin-barked trees. Wild fires during droughts can have more effect but rarely are hot enough to cause widespread tree mortality in coves. The importance of fire in oak forests, despite their being dissected by bands of cove forest, suggests that fires usually crossed the coves. Ignition sources were not dense enough to create even moderate fire frequency without fires spreading over large areas. It is possible that the influence of topography and moisture on fire behavior was an important influence on the boundary between mesophytic forests and oak forests. Feedbacks created by the different flammability of oak and mesophytic leaf litter, as well as by different shrub and herb layers, may have sharpened and stabilized this boundary.

After heavy logging or clearing, Mountain Cove Forests usually regenerate in successional stands dominated by *Liriodendron tulipifera, Pinus strobus*, or *Robinia pseudo-acacia*, occasionally with yellow pines also becoming important. Logging also appears to increase abundance of other small-seeded trees such as *Betula lenta* and *Acer rubrum*, and sometimes may increase the amount of oak. Other species, such as *Aesculus flava*, frequently are scarce or lacking in second growth forests and may be very slow to return.

Much less is known about the dynamics of the lower strata of Mountain Cove Forests. Rich Cove Forests support dense and diverse herb layers of species that are shade-tolerant and do not depend on fire or other frequent disturbance to maintain diversity. Environmental heterogeneity and fine-scale niche differentiation may be important in the coexistence of so many species. Extensive spatial and ecological analysis by Tessell (2017) suggests that dispersal limitation is also an important factor in determining the presence of many species, not just on a regional scale but at individual sites within their ranges. Many herbs have no apparent adaptation for seed dispersal, and reproduction occurs only near parent plants. Dispersal limitation could explain the low constancy of many herb species and be an important influence on composition of individual community occurrences.

Herb layers appear stable over time, but little is known about stability on a fine scale. Most of the species probably are conservative, have long life spans, and reproduce by seed infrequently. Most examples that were cultivated in the past can be observed to have low herb density or to have higher density but low species richness even after many decades of recovery. A suggestion by Duffy and Meier (1992) that cove herb layers may also be very slow to recover from clearcutting sparked a rapid and heated response (e.g., Johnson, et al. 1993) but not a definitive answer.

Greenlee (1974) found that a cove that had been selectively logged had very different canopy structure and herb composition from a virgin cove forest. Even-aged, young canopies resulting from clearing or heavy logging may have reduced rate of gap formation and size of gaps. Such gaps may be necessary for maintaining high diversity. Observations readily made in second growth forests suggest that effects of past logging have been variable. Some successional cove forest stands have lush and diverse herb layers even though the canopy is young and heavily altered. Other successional coves have little herb cover or have low herb diversity even after many decades of recovery after logging. This appears to suggest that cove herb layers sometimes survive logging and survive the dense shade of young stands of regeneration, but they do not recover readily if they do not.

There is similar uncertainty about the dynamics of the shrub layer in Acidic Cove Forests and some Canada Hemlock Forests. The concerns about an increase in evergreen heath shrub layers in oak forests (Monk, et al. 1985) are less likely to be appropriate in these mesophytic sites. However, the ability of trees, even shade-intolerant *Liriodendron,* to coexist with dense shrub layers is interesting and would warrant further investigation.

There is also a question of possible interplay between shrubs and herbs. Occasional forests may be found with trees of Rich Cove Forests but with a dense *Rhododendron* shrub layer and few herbs. It is unclear if these mixtures are stable, nor, if they represent a recent transition, what caused it. *Rhododendron maximum* litter acidifies the soil, and a feedback mechanism may promote its persistence once established. It is unclear how readily this effect would be reversed by loss of the shrubs, such as might occur if they were destroyed by fire. *Rhododendron maximum* patches are often present as minor components in Rich Cove Forests, just as small numbers of Rich Cove Forest herbs can be present in Acidic Cove Forests. Logging may potentially lead to proliferation of shrubs, expanding shrubby conditions into herbaceous areas. However, such sites that suggest a transition between acidic and rich cove conditions are rare, and most examples appear to be stable in the long term.

Comments: Ulrey's (2002) analysis of mesophytic vegetation throughout the North Carolina mountains showed a distinct separation of Acidic Cove Forest and Rich Cove Forest in ordination space, with variables of soil fertility but not topography separating the two. The more mesic oak forests, also included in his analysis, were separated from both by variables related to topography and dryness but not by soil fertility. He noted that Acidic Cove Forests and Rich Cove Forests, in his experience, seldom graded into each other but that each more often graded into oak forest. Ulrey (2002) also noted that the measures of soil chemistry that are generally termed "richness" or "fertility" in ecological studies and that correlate with community patterns are quite different from measures of fertility in agriculture. Ecological gradients are usually correlated with pH and a variety of nutrient cations, while agricultural productivity is most often determined by nitrogen and phosphorus.

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KEY TO MOUNTAIN COVE FORESTS

1. Forest rich, containing at significant amounts of at least several of a suite of trees and herbs of richer soils, such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Aesculus flava, Prunus serotina, Lindera benzoin, Actaea* spp.*, Collinsonia canadensis, Sanguinaria canadensis, Asarum canadense, Osmorhiza* spp., *Laportea canadensis, Podophyllum peltatum, Phegopteris hexagonoptera, Phryma leptostachya*, *Hydrophyllum* spp., and a number of others. More broadly tolerant species listed below are also present and may dominate, but multiple rich-site species are present more than incidentally. *Rhododendron maximum* and *Leucothoe fontanesiana*, if present, are confined to patches in a minority of the area.

2. Forest additionally containing at least several species indicative of more extremely rich or calcareous soils, such as *Acer nigrum, Deparia acrostichoides, Diplaziopsis (Diplazium) pycnocarpa, Dryopteris goldieana,* and *Aquilegia canadensis*, and containing large amounts of species such as *Juglans nigra, Asarum canadense, Cryptotaenia canadensis*, and *Phryma leptostachya*. Sites are generally underlain by amphibolite, limestone, dolomite, or marble.

3. Community in the foothills or below 2000 feet in elevation; herb layer often only moderate in density ..... **Rich Cove Forest (Foothills Rich Subtype)**

3. Community in the Blue Ridge, above 2000 feet in elevation; herb layer very dense and lush. .... **Rich Cove Forest (Montane Rich Subtype)**

2. Forest not additionally containing any of the suite of species of more extremely rich soils. May be underlain by any common rock type but not associated with calcareous rock.

4. Community in a boulderfield, large boulders covering virtually all the ground, with open voids beneath many of them; canopy generally consisting of a smaller set of trees, usually predominantly *Betula alleghaniensis, Betula lenta*, and *Tilia americana* var. *heterophylla*; herb layer sparse or consisting mainly of moss and fern cover on rock but containing several of the species listed above. ..... **Rich Cove Forest (Boulderfield Subtype)**

4. Community not a boulderfield; rock cover may be substantial but almost all plants are rooted in deep soil and the herb layer cover is not greatly reduced by rock.

5. Canopy with *Quercus rubra* dominant, though *Tilia americana* var*. heterophylla* and species of other Rich Cove Forests are codominant or abundant; community on a steep, though still concave, slope in the upper end of a cove, generally very rocky but not a boulderfield. .... **Rich Cove Forest (Red Oak Subtype)**

5. Canopy not dominated by *Quercus rubra* more than locally, at least not in coincidence with a steep, rocky, upper cove setting.

6. Community in the foothills or below 2000 feet elevation; herb layer often only moderate in density, though containing rich-soil species; *Fagus grandifolia* more likely to be present .... **Rich Cove Forest (Foothills Intermediate Subtype)**

6. Community above 2000 feet elevation or within the interior of the Blue Ridge region and resembling communities at higher elevation; herb layer generally dense; *Fagus grandifolia* may be present but is less likely. ..... **Rich Cove Forest (Montane Intermediate Subtype)**

1. Forest lacking the above species of richer soils; trees and herbs consisting of a small suite of more broadly tolerant species such as *Liriodendron tulipifera, Betula lenta, Halesia tetraptera, Polystichum acrostichoides, Parathelypteris noveboracensis, Medeola virginiana*, and *Viola rotundifolia*; often, but not always, with a dense shrub layer of *Rhododendron maximum* or *Leucothoe fontanesiana*.

7. Forest dominated by *Tsuga canadensis*, at least weakly. Communities formerly dominated by *Tsuga* that has died recently because of hemlock woolly adelgid may be classified here but their future natural character is uncertain.

8. *Pinus strobus* codominant with *Tsuga canadensis*... **Canada Hemlock Forest (White Pine Subtype)**

8. *Pinus strobus* not codominant, normally not present; other hardwood species may be abundant, or *Tsuga* may strongly dominate..... **Canada Hemlock Forest (Typic Subtype)**

7. Forest not dominated by *Tsuda canadensis*; generally dominated by combinations of *Liriodendron tulipifera, Betula lenta, Betula alleghaniensis, Acer rubrum, Halesia tetraptera, Fagus grandifolia,* and *Quercus rubra*.

9. Forest dominated or codominated by *Betula alleghaniensis*, generally lacking *Liriodendron tulipifera*; generally at elevations above 3000 feet..... **Acidic Cove Forest (High Elevation Subtype)**

9. *Betula alleghaniensis* not dominant or codominant, generally absent; potentially at a broad range of elevations, including above 3000 feet.

10. Canopy dominated by *Halesia tetraptera*, often codominant with *Tsuga canadensis*, *Liriodendron tulipifera* generally absent..... **Acidic Cove Forest (Silverbell Subtype)**

10. Canopy not dominated by *Halesia*, though the species is often present; generally dominated by *Liriodendron* or with a mixed canopy of that species with *Betula lenta, Acer rubrum, Fagus grandifolia, Halesia tetraptera*, and *Quercus rubra*..... **Acidic Cove Forest (Typic Subtype)**

RICH COVE FOREST (MONTANE INTERMEDIATE SUBTYPE)

Concept: Rich Cove Forests are low to mid elevation mesophytic mountain and foothill forests with a diverse mix of trees that includes species of richer soils such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Prunus serotina,* and *Aesculus flava*, along with more widely tolerant mesophytic species. The herb layer also is diverse and contains many species of richer soils. The Montane Intermediate Subtype covers the most common examples, occurring in the Mountains at all but the lowest elevations and lacking the species characteristic of the richest sites such as *Deparia acrostichoides*, *Diplaziopsis (Diplazium) pycnocarpa*, and *Dryopteris goldeiana*.

Distinguishing Features: Rich Cove Forests are distinguished by having a diverse mix of mesophytic trees and a diverse mix of herbs, both of which include species of richer soils. Trees common in Rich Cove Forest and scarce to absent in Acidic Cove Forest include *Aesculus flava, Fraxinus americana, Tilia americana* var. *heterophylla*, and *Magnolia acuminata*, along with less common species such as *Juglans nigra, Carya ovata*, and *Cladrastis kentukea (= Cladrastis lutea). Liriodendron tulipifera, Acer rubrum, Tsuga canadensis*, and *Betula* spp. are shared by Rich Cove Forest and Acidic Cove Forest. Herbs present in Rich Cove Forest and absent or scarce in Acidic Cove Forest include *Actaea racemosa, Caulophyllum thalictroides, Prosartes lanuginosa, Aruncus dioicus, Adiantum pedatum, Collinsonia canadensis, Osmorhiza claytonii*, and *Laportea canadensis*. Acidic Cove Forests generally have a better developed shrub layer dominated by *Rhododendron maximum* or *Leucothoe fontanesiana*, which is often present but not abundant in Rich Cove Forests. Most of the small number of herbaceous species of Acidic Cove Forest (e.g., *Polystichum acrostichoides, Medeola virginiana*, and *Viola canadensis*) may also occur in Rich Cove Forest.

The distinction between Rich Cove Forest and Northern Hardwood Forest can be especially subtle, because Northern Hardwood Forests are often dominated by a subset of species found in Rich Cove Forest. However, Rich Cove Forests contain a number of species of lower elevation, which are absent or scarce in Northern Hardwood Forests. These include *Liriodendron tulipifera, Magnolia acuminata, Juglans nigra*, and *Ulmus rubra*, as well as many herbaceous species. A few species are more common in Northern Hardwood Forests, including *Viburnum lantanoides, Picea rubens*, and *Rhododendron catawbiense.*

Rich Cove Forests are distinguished from the Mesic Mixed Hardwood Forests and Basic Mesic Forests of the Piedmont by having a large component of montane flora; montane species may be present in Basic Mesic Forests, but generally only a few species at a given site and at low density. *Fagus grandifolia* is almost always a major component of the Piedmont communities, and *Tilia americana* var. *heterophylla, Aesculus flava, Magnolia acuminata, Betula alleghaniensis*, and *Betula lenta* are indicators of Rich Cove Forest.

Montane Alluvial Forest communities may share many species with Rich Cove Forests, but can be distinguished by the presence of characteristic species of floodplains, such as *Platanus occidentalis, Betula nigra*, and *Acer negundo*. Montane Alluvial Forests also tend to have a different mix of species, often including more from a broad range of moisture tolerances.

The Montane Intermediate Subtype is distinguished from the Montane Rich Subtype by the absence or scarcity of the most calciphilic species, such as *Diplaziopsis pycnocarpa, Asplenium rhizophyllum, Dryopteris goldieana, Aquilegia canadensis*, and *Acer nigrum*. It is distinguished from the Foothills Subtypes by occurring in the central parts of the Blue Ridge rather than on the periphery or in the foothills, and generally at elevations above 2000 feet. The Foothills Intermediate Subtype may be distinguished from lower elevation examples of the Montane Intermediate Subtype by the presence of a few lower elevation species, such as *Liquidambar styraciflua*, and by a less dense and somewhat less diverse herb layer.

Synonyms: *Liriodendron tulipifera - Fraxinus americana - (Tilia americana, Aesculus flava) / Actaea racemosa - Laportea canadensis* Forest (CEGL007710).
Ecological Systems: Southern and Central Appalachian Cove Forest (CES202.373).

Sites: Rich Cove Forests occur in sheltered mesic sites such as valley bottoms, ravines, lower slopes, and concave slopes. The Montane Intermediate Subtype usually occurs from 2000-4000 feet elevation, with a few examples higher and lower. The Montane Intermediate Subype may occur on any geologic substrate but is generally replaced by other subtypes on mafic or calcareous rocks.

Soils: The Montane Intermediate Subtype occurs on a wide range of soil map units, including Typic Dystrudepts (Ashe, Porters), Humic Dystrupepts (Tusquittee, Unaka), Typic Humadepts (Cullasaja, Tuckasegee), and Typic Hapludults (Chester, Watauga). Soils are acidic but are higher in pH, base saturation, and levels of nutritive cations than in most mountain communities, higher than in Acidic Cove Forests, but lower than in the Montane Rich Subtype.

Hydrology: Sites are well drained but mesic due to topographic sheltering, low slope position, and flow convergence. Local small seepages may be present.

Vegetation: The Montane Intermediate Subtype canopy is dominated by a varying mix of mesophytic trees, which may locally have one or a couple of predominant species but which usually contains many species within the stand. Canopy species in 50% or more in the numerous CVS plots, all sometimes dominant, are *Quercus rubra, Tilia americana* var. *heterophylla, Fraxinus americana, Aesculus flava, Liriodendron tulipifera, Acer saccharum, Betula lenta, Prunus serotina, Robinia pseudo-acacia, Magnolia acuminata, Tsuga canadensis*, and *Halesia tetraptera*. Also frequent are *Fagus grandifolia, Acer rubrum*, and *Carya glabra*. The understory consists primarily of canopy species but has *Acer pensylvanicum* as a constant component, frequently contains *Cornus florida, Cornus alternifolia*, and sometimes contains *Magnolia fraseri, Ostrya virginiana*, or *Carpinus caroliniana*. The shrub layer usually is open, with no species constant. *Hamamelis virginiana, Rhododendron maximum*, and *Lindera benzoin* are most frequent, but *Rhododendron* does not dominate large areas. The herb layer is dense, often extremely lush, with multiple layers and with different species predominating in different seasons. A few species, such as *Polystichum acrostichoides, Laportea canadensis, Eurybia divaricata*, or *Parathelypteris noveboracensis* may dominate patches, but usually there is no strong dominant. Species occurring in 50% or more of CVS plots include, besides the above, *Prosartes lanuginosa, Maianthemum racemosum, Actaea racemosa, Solidago curtissii, Botrypus virginianus, Caulophyllum thalictroides, Galium triflorum, Dioscorea villosa, Collinsonia canadensis,*

Stellaria pubera, Tiarella cordifolia, Sanguinaria canadensis, Trillium erectum, and *Osmorhiza claytonia*. Species only a bit less frequent (30-49%) include *Goodyera pubescens, Medeola virginiana, Dryopteris intermedia, Athyrium asplenioides, Amphicarpaea bracteata, Viola sororia, Adiantum pedatum, Polygonatum, Panax quinquefolius, Phegopteris hexagonoptera, Viola blanda, Viola canadensis, Eutrochium purpureum, Dryopteris marginalis, Polygonatum pubescens, Deparia acrostichoides, Hydrophyllum virginianum, Clintonia umbellule, Impatiens pallida*, and *Veratrum parviflorum*. A number of additional species are less frequent in plot data but are nevertheless characteristic of the community, including *Astilbe biternate, Uvularia perfoliata, Galium latifolium, Sanicula canadensis, Sanicula odorata, Podophyllum peltatum, Ranunculus recurvatus, Ageratina altissima, Phryma leptostachya, Cardamine diphylla, Hepatica acutiloba, Symphyotrichum cordifolium, Sedum ternatum, Actaea pachypoda, Osmorhiza longistylis, Arisaema triphyllum, Trillium grandiflorum, Dicentra canadensis, Dicentra cucullaria, Persicaria virginiana, Thaspium barbinode*, and several species of *Carex*. This community is rich in species at both the plot scale and the whole community scale. Plots averaged 71 species per 1/10 hectare. The species pool represented by the plots contains 490 species occurring in more than one plot, and 297 occurring in at least 5% of the plots.

Range and Abundance: Ranked G4. Rich Cove Forest (Montane Intermediate Subtype) is one of the most common communities in the Mountain region. It also occurs in Georgia, Tennessee, and Virginia, and the equivalent association has been questionably attributed to West Virginia.

Associations and Patterns: Rich Cove Forest (Montane Intermediate Subtype) is extensive and makes up a significant minority of the landscape mosaic in most places. It interfingers with various oak communities on the drier slopes. Ulrey (2002) indicated that he seldom saw Rich Cove Forests and Acidic Cove Forests co-occur, but such a pattern does sometimes occur. Rich Cove Forests fairly frequently contain embedded small patches of Montane Cliff, Rich Montane Seep, or Low Elevation Seep, and occasionally contain patches of Rich Cove Forest (Boulderfield Subtype).

Variation: With its large geographic and elevational range, the Montane Intermediate Subtype encompasses a tremendous range of variation. However, because of its large species pool and high local variability, it can be hard to sort out patterns suitable for recognition as variants. The large number of species with limited means for dispersal (Tessell 2017) contributes variability in composition that cannot be related to environmental variation. Ulrey (2002), in analysis focused on Rich Cove Forests, identified 5 groupings, four of which are tentatively recognized as variants here. (The fifth is equated to the Red Oak Subtype). More testing is needed to determine how well these variants can be distinguished. Though apparently distinct in multivariate analysis, distinguishing features among them are not easily articulated. An additional variant is recognized based on the author's experience.

1. Typic Variant occurs in the lower elevation range and is most characteristic of the Montane Intermediate Subtype as a whole. *Acer saccharum, Aesculus flava*, and *Tilia americana* var. *heterophylla* usually dominate.

2. High Elevation North Variant occurs at elevations above 3600 feet in areas north of the Asheville Basin. It has *Betula alleghaniensis* and *Fagus grandifolia* dominant in addition to the species of the Typic Variant. *Ostrya virginiana* often occurs in the understory. Particular herb

species may strongly dominate, including *Laportea canadensis, Stellaria pubera, Viola canadensis, Dryopteris intermedia*, and *Caulophyllum thalictroides*. This variant is transitional to Northern Hardwood Forest (Rich Subtype), Ulrey (2002) may not have placed the boundary in the same place the 4th Approximation does. *Liriodendron* and *Magnolia* both are present in his data for this group but at only low frequency.

3. High Elevation South Variant occurs above 3900 feet in areas south of the Asheville Basin. *Betula alleghaniensis* is a dominant canopy species, and *Betula lenta* is too, in addition to *Aesculus flava, Acer saccharum, Quercus rubra*, and *Tilia americana* var. *heterophylla*, *Ageratina altissima* and *Actaea racemosa* often dominate the herb layer. Also characteristic, compared to other variants, is *Prunus pensylvanica*.

4. Rich Variant occurs at elevations below 3500 feet and contains richer soils and species indicative of them. Part of the set of plots defined as this group by Ulrey (2002) probably represents the Montane Rich Subtype. See the description of that subtype for more discussion. Because some portion of this rich group does not appear to fit within the Montane Rich Subtype, it is accommodated in this variant. *Liriodendron tulipifera* apparently is more constant and abundant in this variant than in any of the others, but this may be not be universally true compared to the Typic Variant. *Ulmus rubra*, *Astilbe biternata,* and *Cystopteris protrusa* are noted as characteristic of this group, and *Asarum canadense* is more abundant in it.

5. Acidic Transition Variant is less diverse and contains a smaller subset of characteristic Rich Cove Forest species. The canopy generally contains *Fraxinus americana, Magnolia acuminata,* or *Prunus serotina*, as well as species shared with Acidic Cove Forest, but lacks most of the other characteristic species. The herb layer generally contains *Amphicarpaea bracteata, Brachyelytrum erectum, Phegopteris hexagonoptera, Dichanthelium boscii,* or *Ageratina altissima*, along with the species shared with Acidic Cove Forest, but lacks many other characteristic Rich Cove Forest species. This variant should only be recognized where it covers a significant area without being transitional between another variant and an adjacent community. It is scattered throughout the Mountain Region but appears to be much less common than the Typic Variant. A comparable variant occurs in the Foothills Intermediate Subtype.

Dynamics: The Montane Intermediate Subtype has dynamics similar to the Mountain Cove Forests theme as a whole. The importance of dispersal limitation in Rich Cove Forests (Tessell 2017) may create some interesting dynamics, with herb layer composition changing in response to infrequent dispersal and metapopulation processes in a way different from many other communities.

Comments: Rich Cove Forests as a whole constitute one of the most recognized and well-loved communities in the Mountains. Though many early studies did not distinguish between Acidic Cove Forest and Rich Cove Forest (see discussion under Acidic Cove Forest [Typic Subtype]), all described something recognizable as Rich Cove Forest. Where Rich Cove Forests were present. Acidic Cove Forests may have been ignored or viewed as a poorly developed versions.

Ulrey (2002) focused analysis on the distinction between Acidic Cove Forest and Rich Cove Forest, using plot data from across the North Carolina mountains and adjacent areas. His results

are similar to what was recognized in the 3rd and 4th Approximation. He also analyzed variation within Rich Cove Forests, and his results are the basis for the variants described here. His results are not as definitive for the subtypes of Rich Cove Forest because he didn't include data from the foothills and because his results were apparently different from previous concepts for the Rich Subtype. However, the variants based on his descriptions may become the basis for recognition of additional subtypes in this complex set of communities. Newell (1997) also recognized multiple community groupings within the range, but these varied among her three study areas in a way that is difficult to interpret on a regional scale.

Ulrey did demonstrate that even within the narrow range of moisture and soil nutrient status represented by Rich Cove Forests, soil chemistry as well as elevation play a recognizable role in structuring vegetation. He also noted that at least two of his groupings, adopted here as the High Elevation North and High Elevation South variants, did not have any recognizable environmental correlation. He suggested biogeography as a cause, though the possibility of unmeasured environmental variables remains a possibility. The Asheville Basin is a biogeographic break for many plant species, but the species that most strongly distinguish the variants occur on both sides of it. The biogeographic break between these variants is at a different geographic scale than the dispersal-related variation studied by Tessell (2017).

Both Whittaker (1956) and McLeod (1988) placed great emphasis on the broad transition between cove forests and drier oak forest communities. They noted that this transition zone is often more rich in species than the heart of the Rich Cove Forest. While this zone can sometimes be recognized in plots, it generally appears to be limited on the ground and too tightly tied to the Rich Cove Forest to classify as a separate community. The boundary between Rich Cove Forest and adjacent oak communities is placed where the diversity in the canopy and herb layer gives way to oak dominance and a sparser herb layer. Several of the characteristic Rich Cove Forest trees, especially *Magnolia acuminata, Prunus serotina*, and *Fraxinus americana*, can occur in oak forests as saplings or understory trees, while rarely being present in the canopy. This may be a recent phenomenon, the "mesophication" occurring as a result of removal of fire as a natural process. However, the observation of mixing and transition by Whittaker in 1956, not as far from the beginning of effective fire suppression, suggests such gradation has long been present.

Rare species:

References:

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

Tessell, S.M. 2017. Dispersal effects on species distribution and diversity across multiple scales in the Southern Appalachian mixed mesophytic flora. Ph.D. dissertation, University of North Carolina, Chapel Hill.

Ulrey, C.J. 2002. The relationship between soil fertility and the forests of the Southern Appalachian region. Ph.D. dissertation, North Carolina State University, Raleigh.

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

RICH COVE FOREST (MONTANE RICH SUBTYPE)

Concept: Rich Cove Forests are low to mid elevation mesophytic mountain and foothill forests with a diverse mix of trees that includes species of richer soils such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Prunus serotina,* and *Aesculus flava*, along with more widely tolerant mesophytic species. The herb layer also is diverse and contains many species of richer soils. The Montane Rich Subtype includes the less common examples occurring on the unusually rich substrates associated with mafic or calcareous rocks, in the Mountain region. They contain indicators of unusually rich soils, such as *Deparia acrostichoides*, *Diplaziopsis (Diplazium) pycnocarpa*, and *Dryopteris goldieana*.

Distinguishing Features: Rich Cove Forests are distinguished by having a diverse mix of mesophytic trees and a diverse mix of herbs, both of which include species of richer soils. Trees common in Rich Cove Forest and scarce to absent in Acidic Cove Forest include *Aesculus flava, Fraxinus americana, Tilia americana* var. *heterophylla*, and *Magnolia acuminata*, along with less common species such as *Juglans nigra, Carya ovata*, and *Cladrastis kentukea (= Cladrastis lutea).*

The Montane Rich Subtype is distinguished from the Montane Intermediate Subtype by differences in flora and vegetation that correlate with soil pH and fertility. The distinction can be subtle. Some members of a pool of calciphilic species such as *Cystopteris protrusa*, *Diplaziopsis (Diplazium) pycnocarpa, Asplenium rhizophyllum, Aquilegia canadensis, Dryopteris goldieana, Philadelphus hirsutus,* or *Acer nigrum* are generally present in a stand but may be sparse and not found in vegetation plots. Other species are more abundant in the Montane Rich Subtype but may still be found sometimes in other subtypes. These include *Carya cordiformis, Juglans nigra, Carpinus caroliniana, Toxicodendron radicans, Deparia acrostichoides, Asarum canadense, Astilbe biternata, Phryma leptostachya, Cryptotaenia canadensis,* and *Panax quinquefolius*. *Tsuga canadensis, Acer rubrum*, and *Oxydendrum arboreum* generally are absent in the Montane Rich Subtype.

The Montane Rich Subtype is distinguished from the Foothills Rich Subtype by occurring in the primary Blue Ridge region rather than in the foothills or low elevation periphery and generally at elevations above 2000 feet. The Foothills Rich Subtype may be distinguished from lower elevation examples of the Montane Rich Subtype by the presence of a few lower elevation species, such as *Liquidambar styraciflua*, and by an herb layer that is less dense even as it is generally highly diverse.

Synonyms: *Aesculus flava - Acer saccharum - (Fraxinus americana, Tilia americana* var. *heterophylla) / Hydrophyllum canadense - Solidago flexicaulis* Forest (CEGL007695).
Ecological Systems: Southern and Central Appalachian Cove Forest (CES202.373).

Sites: Rich Cove Forests occur in sheltered mesic sites such as valley bottoms, ravines, lower slopes, and concave slopes. The Montane Rich Subtype occurs on rocks such as amphibolite, hornblende gneiss, calc-silicate, dolomite, marble, that produce less acid, more fertile soils than typical. Many are on colluvial deposits. Most examples occur at 2000-4000 feet elevation, but a few examples are lower or higher.

Soils: The Montane Rich Subtype occurs on the same wide variety of Inceptisol and less common Ultisol soil map units as the Montane Intermediate Subtype. The Inceptisols are not classified by the chemical differences that distinguish the community subtypes, but it may be that some soils mapped as Ultisols are unrecognized Alfisols. The soils in the Montane Rich Subtype are acidic, but studies such as Ulrey (2002) and Newell (1997) find them less acidic than those in the other subtypes of Rich Cove Forest, and they are higher in base saturation and in most of the nutritive cations. They may be very rocky but do not have extreme boulder cover.

Hydrology: Sites are well drained but mesic due to topographic sheltering, low slope position, and flow convergence. Local small seepages may be present.

Vegetation: The Montane Rich Subtype is dominated by a varying mix of mesophytic trees, which may locally have one or a couple of predominant species but which usually include many species within the stand. Canopy species in 50% or more of CVS plots are *Acer saccharum* (probably including some *Acer nigrum*), *Aesculus flava, Fraxinus americana, Tilia americana* var. *heterophylla, Carya cordiformis, Quercus rubra, Prunus serotina, Liriodendron tulipifera*, and *Betula alleghaniensis*. Also frequent are *Fagus grandifolia, Halesia tetraptera*, *Magnolia acuminata*, and *Betula lenta*. Less frequent, but notable, trees include *Juglans nigra*, *Ulmus rubra*, and *Cladrastis kentukea*. In addition to canopy species, the understory usually includes *Acer pensylvanicum* and *Ostrya virginiana*, and fairly frequently includes *Cornus alternifolia*. The shrub layer usually is sparse, but moderate cover of *Hydrangea arborescens, Lindera benzoin*, or *Hamamelis virginiana* may be present. The vines *Isotrema macrophyllum, Parthenocissus quinquefolius*, and *Smilax rotundifolia* are highly constant or frequent, though their cover usually is limited. The herb layer generally is extremely dense and diverse, but patches may be strongly dominated by a single species and therefore be less diverse. High constancy species that sometimes dominate patches include *Caulophyllum thalictroides, Laportea canadensis*, *Hydrophyllum canadense*, *Asarum canadense*, and *Viola canadensis*. Other species occurring in 50% or more of CVS plots or of Ulrey's (2002) plots are *Arisaema triphyllum, Actaea racemosa, Prosartes lanuginosa, Dryopteris marginalis, Maianthemum racemosum, Osmorhiza claytonia, Deparia acrostichoides, Dryopteris intermedia, Botrypus virginianus, Galium triflorum, Stellaria pubera* (probably including *Stellaria corei*), *Trillium erectum, Solidago curtissii, Eurybia divaricata, Impatiens pallida, Sanguinaria canadensis*, and *Polygonatum pubescens*. Other frequent species in plots include *Adiantum pedatum, Uvularia grandiflora, Collinsonia canadensis, Solidago flexicaulis, Tiarella cordifolia, Astilbe biternata, Cystopteris protrusa, Thalictrum dioicum, Dioscorea villosa, Panax quinquefolius, Sanicula odorata, Podophyllum peltatum, Cryptotaenia canadensis, Lilium superbum, Veratrum parviflorum, Actaea podocarpa, Hepatica acutiloba, Athyrium asplenioides,* and *Arnoglossum reniforme*. Additional characteristic species, though less frequent in plots, include *Uvularia perfoliata, Ageratina altissima*, *Amphicarpaea bracteata, Allium tricoccum, Dryopteris goldieana, Galearis spectabilis, Persicaria virginiana, Phryma leptostachya, Thalictrum dioicum, Diplaziopsis pycnocarpa, Carex (Cymophilus) fraseriana, Carex plantaginea, Dicentra canadensis, Delphinium tricorne, Hydrophyllum macrophyllum, Aquilegia canadensis*, and several species of *Carex*. Many of these species that are less frequent in plot data are more frequently observed in surveys of whole stands. Compared to the Montane Intermediate Subtype, the greater number of species with high constancy in plots reflects that greater density and abundance of many species in stands.

Range and Abundance: Ranked G3G4, but probably appropriately G4. The overall abundance is somewhat uncertain because of difficulty and varying criteria used in distinguishing this subtype from others. Numerous occurrences are known, but the overall area of occurrence is much less than for the Montane Intermediate Subtype. The equivalent NVC association is attributed to Alabama, Georgia, Tennessee, and Virginia, as well as North Carolina. The association may be more broadly conceived than the subtype defined here.

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Associations and Patterns: The Montane Rich Subtype generally occurs in small patches, occasionally large patches, corresponding to the distinctive underlying rock. It may grade to Montane Oak–Hickory Forest (Basic Subtype) on drier slopes and may contain embedded small patches of Montane Cliff (Mafic or Calcareous Subtype), Rich Montane Seep, or Rich Cove Forest (Boulderfield Subtype). The Montane Rich Subtype may sometimes grade to, or sharply border, the Montane Intermediate Subtype, and may occasionally grade to Northern Hardwood Forest (Rich Subtype) at higher elevations.

Variation: No variants are recognized, but further analysis may distinguish biogeographic or elevational variants analogous to those found by Ulrey (2002) in the range of the Montane Intermediate Subtype.

Dynamics: The Montane Rich Subtype presumably has dynamics similar to the Mountain Cove Forest theme as a whole. As in the Montane Intermediate Subtype, the importance of dispersal limitation in Rich Cove Forests (Tessell 2017) may create some interesting dynamics, with herb layer composition changing in response to infrequent dispersal and metapopulation processes in a way different from many other communities.

Comments: Botanists have long highlighted sites with the Rich Subtype as unusually rich by several meanings of the term – in having long lists of species present on the site, having high abundance of species associated with rich soils, having a high potential for finding rare species, containing species absent even in less rich Rich Cove Forests, and, to use Ulrey's (2002) term, aesthetic lavishness. It is the presence of the most restricted "base-loving" species that is used to conceptually define the Rich Subtype here, but examples also differ in the quantitative abundance of many other species.

Nevertheless, the distinction between the Montane Rich and Montane Intermediate subtypes is subtle and somewhat confused. The majority of frequent and abundant species are shared among all Rich Cove Forest subtypes, though some tend to be more abundant in different subtypes. Though there is a substantial pool of species that distinguish the Montane Rich Subtype, many occur in only a minority of sites. Individual sites thus vary substantially in flora. The problem is magnified in plot data, because many of these species occur at low density or are patchy when they are present and may be missed in standard 1/10 hectare plots. Ulrey (2002) noted that most of the species suggested as indicative of the Rich Subtype at the time of his study were not found in any of the plots in his analysis. Nevertheless, those species can be found on whole-site species lists from the same locations, and the sites often were targeted for sampling on that basis.

It appears that different conceptual boundaries may have been used by different authors or that analysis of different sets of plots may have led to different impressions of which species are dominant or frequent. For example, Ulrey (2002) found *Liriodendron tulipifera, Carya cordiformis, Juglans nigra*, and *Ulmus rubra* to be character species, present at high frequency in his rich grouping of plots and distinguishing it from other groups. Adding more recent CVS plot data attributed this subtype suggests that all of these species but *Carya cordiformis* have low frequency in the Rich Subtype. The NVC description mentions only *Carya cordiformis* among these species, and Fleming and Patterson (2009) cited there have *Tilia* and *Aesculus* among the most diagnostic species. All of these analyses used large numbers of plots – numbers considered suitable for characterization of communities.

Rare species:

References:

Fleming, G.P., and K.D. Patterson. 2009. A vegetation classification for the Appalachian Trail: Virginia south to Georgia. Virginia Department of Conservation and Recreation, Division of Natural Heritage. In-house analysis, March 2009.

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.

Tessell, S.M. 2017. Dispersal effects on species distribution and diversity across multiple scales in the Southern Appalachian mixed mesophytic flora. Ph.D. dissertation, University of North Carolina, Chapel Hill.

Ulrey, C.J. 2002. The relationship between soil fertility and the forests of the Southern Appalachian region. Ph.D. dissertation, North Carolina State University, Raleigh.

RICH COVE FOREST (FOOTHILLS INTERMEDIATE SUBTYPE)

Concept: Rich Cove Forests are low to mid elevation mesophytic mountain and foothill forests with a diverse mix of trees and herbs that includes species of richer soils such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Prunus serotina,* and *Aesculus flava*, along with more widely tolerant mesophytic species. The Foothills Intermediate Subtype covers examples in the foothills and periphery of the Blue Ridge, generally below 2000 feet, lacking a significant component of high pH, rich-site flora. The herbaceous layer of this subtype is fairly diverse, much more diverse than that of Acidic Cove Forest, but is often not as dense as it is in the other subtypes.

Distinguishing Features: Rich Cove Forests are distinguished by having a diverse mix of mesophytic trees and a diverse mix of herbs, both of which include species of richer soils. They are distinguished from the Mesic Mixed Hardwood Forests and Basic Mesic Forests of the Piedmont by having a large component of montane flora; montane species may be present in Basic Mesic Forests but generally only a few species at a given site and at low density. *Fagus grandifolia* is almost always a major component of the Piedmont communities, and *Tilia americana* var. *heterophylla, Aesculus flava, Magnolia acuminata, Betula alleghaniensis*, and *Betula lenta* are indicators of Rich Cove Forest. Montane Alluvial Forest communities may share many species with Rich Cove Forests, but they can be distinguished by the presence of characteristic species of floodplains, such as *Platanus occidentalis, Betula nigra*, and *Acer negundo*. Montane Alluvial Forests also tend to have a different mix of species, often including more from a broad range of moisture tolerances.

The Foothills Intermediate Subtype is distinguished from the Montane subtypes most easily by location and elevation. There are a few species largely confined to lower elevations, such as *Liquidambar styraciflua*, which distinguish the Foothills Subtype. Otherwise it is distinguished by a generally lower diversity, with its flora being a subset of the characteristic species of the Montane Intermediate Subtype. The herb layer, though fairly diverse, is generally not dense as it is in the Montane Intermediate Subtype. The characteristic Rich Cove Forest herbs may be present only at low density. Among species usually absent from the Foothills Intermediate Subtype include *Acer saccharum, Acer pensylvanicum, Impatiens pallida, Polygonatum pubescens, Clintonia umbellulata,* and *Maianthemum canadense.*

The Foothills Intermediate Subtype is distinguished from the Foothills Rich Subtype by the absence of strongly calciphilic species, such as *Aquilegia canadensis, Trillium simile, Asplenium rhizophyllum*, and *Cystopteris protrusa*. Some species shared by the Montane Intermediate and Foothills Rich subtypes, such as *Laportea canadensis*, are also absent or scarce.

Synonyms: *Liriodendron tulipifera - Tilia americana* var. *heterophylla - (Aesculus flava) / Actaea racemosa* Forest (CEGL007291).
Ecological Systems: Southern and Central Appalachian Cove Forest (CES202.373).

Sites: Rich Cove Forests occur in sheltered mesic sites such as valley bottoms, ravines, lower slopes, and concave slopes. The Foothills Intermediate Subtype can occur on any geologic substrate, though it rarely occurs over mafic rocks.

Soils: The Foothills Intermediate Subtype occurs on a wide variety of soils. Occurrences are most often mapped as Typic Hapludults (Fannin, Cowee, Evard, Brasstown, Junaluska, Rion, Pacolet, and others), some are mapped as Typic Dystrudepts (Porters, Chestnut, Ashe) or Humic Dystrudepts (Tusquittee, Whiteoak). Soils are acidic but are presumed to be higher in pH, based saturation, and nutritive cations than those of Acidic Cove Forests and most drier forests, though lower than in the Foothills Rich Subtype.

Hydrology: Sites are well drained but mesic due to topographic sheltering, low slope position, and flow convergence. Most examples of the Foothills Subtype are in areas with drier climate than most of the Mountain Region.

Vegetation: The Foothills Intermediate Subtype forest is generally dominated by *Liriodendron tulipifera*, with a variety of other tree species abundant to scarce. *Fraxinus americana* and *Quercus rubra* are usually present. *Magnolia acuminata, Carya glabra, Prunus serotina, Carya cordiformis, Acer rubrum*, and even *Quercus montana* are frequent. *Tilia americana* var. *heterophylla* and *Aesculus flava* are frequent, but often sparse or only in the understory. *Fagus grandifolia* and *Magnolia acuminata* also often occur. The understory usually includes *Halesia tetraptera* and *Cornus florida*, as well as canopy species. The shrub layer is sparse to moderate. *Calycanthus floridus* and *Lindera benzoin* are usually present, and *Hydrangea arborescens* sometimes occurs. *Parthenocissus quinquifolius, Smilax rotundifolia*, and *Toxicodendron radicans* usually are present, along with small individuals of *Smilax glauca*. The herb layer is moderate to sparse in total cover and density. *Polystichum acrostichoides, Parathelypteris noveboracensis*, *Athyrium asplenioides, Eurybia divaricata*, or *Amphicarpaea bracteata* may dominate patches and be dense locally. Other high constancy species include *Actaea racemosa, Galium latifolium, Sanguinaria canadensis, Arisaema triphyllum, Botrypus virginianus, Dioscorea villosa, Maianthemum racemosum, Dichanthelium boscii, Endodeca serpentaria, Hylodesmum nuydiflorum, Muhlenbergia tenuiflora, Phegopteris hexagonoptera, Prosartes lanuginosa, Tradescantia subaspera* and *Uvularia perfoliate*. Other frequent species include *Uvularia perfoliata, Adiantum pedatum, Caulophyllum thalictroides, Galium circaezans, Houstonia purpurea, Monarda clinopodia, Nabalus latissimus, Phryma leptostachya, Solidago curtisii, Stellaria pubera, Tiarella cordifolia, Trillum catesbaei, Viola canadensis, Viola sororia*, and *Galearis spectabilis*. Other characteristic species include *Arnoglossum reniforme, Circaea canadensis, Collinsonia canadensis, Galium triflorum, Iris cristata, Osmorhiza claytonia, Sanicula canadensis, Sanicula smallii*, and *Thalictrum dioicum*.

Range and Abundance: Ranked G4?, but perhaps better treated as G3G4. In North Carolina, the Foothills Intermediate Subtype is uncommon in the foothills ranges and in a few gorges and lower elevation areas in the Blue Ridge itself. Rich Cove Forest occupies a much smaller part of the landscape in these areas than in the higher mountains. The equivalent association is attributed to South Carolina, Georgia, and uncertainly to Tennessee. Because most of the acreage of low elevation fringe and foothills on the west and south are in other states, this association probably is more abundant outside of North Carolina.

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Associations and Patterns: The Foothills Intermediate Subtype occurs as small to large patches. Patches generally are smaller than those of the Montane Intermediate Subtype, possibly because

the drier low elevation conditions require more topographic sheltering to support it. Acidic Cove Forest appears to also be more abundant in the foothills than Rich Cove Forest. Occurrences grade to various oak forests on drier slopes. They may grade to Acidic Cove Forest in other mesic areas. Small patches of Montane Cliff, Rich Montane Seep, or Low Elevation Seep may be embedded.

Variation: Two variants are recognized, based on the author's experience. Variation should also be sought between the eastern foothills and those occurrences on the west side of the Blue Ridge.
1. Typic Variant best fits the description above.
2. Acidic Transition Variant is less diverse and contains a smaller subset of characteristic Rich Cove Forest species. The canopy generally contains *Fraxinus americana, Magnolia acuminata,* or *Prunus serotina*, as well as species shared with Acidic Cove Forest, but it lacks most of the other characteristic species. The herb layer generally contains *Amphicarpaea bracteata, Brachyelytrum erectum, Phegopteris hexagonoptera, Dichanthelium boscii,* or *Ageratina altissima*, along with the species shared with Acidic Cove Forest, but the herb layer lacks many other characteristic Rich Cove Forest species. This variant should only be recognized where it covers a significant area without being transitional between another variant and an adjacent community. It is scattered throughout the foothills but appears to be much less common than the Typic Variant. A comparable variant occurs in the Montane Intermediate Subtype.

Dynamics: Dynamics probably are similar to those of other Rich Cove Forests. Fire was more frequent at lower elevations, but, as in other cove forests, the sheltered moist sites where these communities occur reduce fire effects.

Comments: The foothills have generally been less studied than the core of the Blue Ridge, at least in North Carolina. Ulrey (2002) did not include these lower elevation areas in his broad analysis of mesic forests. The NVC description notes that the equivalent association was first distinguished in analysis of plot data in the Chattooga River basin and lists several species that distinguish it from higher elevation cove forests.

The cause of the distinction between Acidic Cove Forest and Rich Cove Forest is not well known. Acidic Cove Forest predominates more in the foothills and Blue Ridge escarpment than in the higher mountains. Occurrences of Rich Cove Forest may partly depend on underlying rock type, even where the rock is not distinctive enough to support the Foothills Rich Subtype.

Rare species:

References:

Ulrey, C.J. 2002. The relationship between soil fertility and the forests of the Southern Appalachian region. Ph.D. dissertation, North Carolina State University, Raleigh.

RICH COVE FOREST (FOOTHILLS RICH SUBTYPE)

Concept: Rich Cove Forests are low to mid elevation mesophytic mountain and foothill forests with a diverse mix of trees that includes species of richer soils such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Prunus serotina,* and *Aesculus flava*, along with more widely tolerant mesophytic species. The Foothills Rich Subtype covers examples in the foothills and periphery of the Blue Ridge, generally below 2000 feet, containing a significant component of high pH, rich-site flora.

Distinguishing Features: Rich Cove Forests are distinguished by having a diverse mix of mesophytic trees and a diverse mix of herbs, both of which include species of richer soils. They are distinguished from the Mesic Mixed Hardwood Forests and Basic Mesic Forests of the Piedmont by having a large component of montane flora; montane species may be present in Basic Mesic Forests, but generally only a few species at a given site and at low density. *Fagus grandifolia* is almost always a major component of the Piedmont communities, and *Tilia americana* var. *heterophylla, Aesculus flava, Magnolia acuminata, Betula alleghaniensis*, and *Betula lenta* are indicators of Rich Cove Forest. Montane Alluvial Forest communities may share many species with Rich Cove Forests, but can be distinguished by the presence of characteristic species of floodplains, such as *Platanus occidentalis, Betula nigra*, and *Acer negundo*. Montane Alluvial Forests also tend to have a different mix of species, often including more from a broad range of moisture tolerances.

The Foothills Rich Subtype is distinguished from the Foothills Intermediate Subtype by the presence of species associated with the highest pH, rich soils, such as *Asplenium rhizophyllum, Aquilegia canadensis, Cystopteris protrusa*, and *Trillium simile*. Some additional species common in both Montane subtypes are present in the Foothills Rich Subtype and absent or scarce in the Foothills Intermediate Subtype, including *Laportea canadensis, Asarum canadense*, and *Hydrophyllum canadense*. In addition, the Foothill Rich Subtype has greater abundance and local richness of most of the characteristic herbs of the Montane Intermediate Subtype.

The Foothills Intermediate Subtype is distinguished from the Montane subtypes most easily by location and elevation. Otherwise it is distinguished by floristic differences. It is generally less diverse than the Montane Rich Subtype, with its flora a subset. Among species usually absent from the Foothills Intermediate Subtype are *Acer saccharum, Acer pensylvanicum, Impatiens pallida, Polygonatum pubescens, Clintonia umbellulata,* and *Maianthemum canadense.*

Synonyms: *Tilia americana* var. *heterophylla - Fraxinus americana - (Ulmus rubra) / Sanguinaria canadensis - (Aquilegia canadensis, Asplenium rhizophyllum)* Forest (CEGL007711).
Ecological Systems: Southern and Central Appalachian Cove Forest (CES202.373).

Sites: Rich Cove Forests occur in sheltered mesic sites such as valley bottoms, ravines, lower slopes, and concave slopes. The Foothills Rich Subtype occurs on rocks such as amphibolite, hornblende gneiss, calc-silicate, dolomite, marble, or calcite-cemented siltstone that produce less acid, more fertile soils than typical. Most examples occur below 2000 feet elevation.

Soils: The Foothills Rich Subtype occurs on the same range of soil map units as the Foothills Intermediate Subtype. The Inceptisols are not classified by the chemical differences that distinguish the community subtypes, but it may be that some soils mapped as Ultisols are unrecognized Alfisols. The soils in the Montane Rich Subtype are acidic, but where tested, have been found to have higher pH, higher base saturation, and higher levels of nutritive cations than those in the Montane Intermediate Subtype.

Hydrology: Sites are well-drained but mesic due to topographic sheltering, low slope position, and flow convergence. Most examples of the Foothills Subtype are in areas with drier climate than most of the Mountain Region. The more clay-rich soils derived from mafic rocks may have higher moisture-holding capacity than those of the Foothills Intermediate Subtype.

Vegetation: The Foothills Rich Subtype canopy is generally dominated by *Liriodendron tulipifera*. In CVS plots, *Carya cordiformis* is uniformly present, and *Quercus rubra, Fraxinus americana, Carya glabra, Acer rubrum, Betula lenta, Prunus serotina, Robinia pseudo-acacia, Juglans nigra*, and *Ulmus rubra* occur in more than half of the plots. *Aesculus flava* and *Tilia americana* var. *heterophylla* are frequent in plots and are more constant in whole-site descriptions. Besides canopy species, the understory contains *Cornus florida* and *Halesia tetraptera* with high constancy, and frequently contains *Magnolia fraseri, Asimina triloba*, and *Carpinus caroliniana*. The shrub layer is open to sparse. *Lindera benzoin* occurs with high constancy and *Calycanthus floridus, Cornus alternifolia, Sambucus canadensis*, *Hamamelis virginiana*, and *Philadelphus inodorus* are frequent. The herb layer is diverse and generally at least fairly dense. Species occurring in more than half the CVS plot data are *Collinsonia canadensis, Sanguinaria canadensis, Prosartes lanuginosa, Polystichum acrostichoides, Arisaema triphyllum, Eurybia divaricata, Actaea racemosa, Maianthemum racemosum, Laportea canadensis, Caulophyllum thalictroides, Adiantum pedatum, Botrypus virginianus, Cryptotaenia canadensis, Dioscorea villosa, Ranunculus recurvatus, Solidago curtisii, Deparia acrostichoides, Stellaria pubera, Viola canadensis, Hydrophyllum canadense, Sanicula odorata, Ageratina altissima, Astilbe biternata, Galium circaezans, Osmorhiza claytonia, Persicaria virginiana, Phryma leptostachya,* and *Sanicula canadensis*. Other frequent species in CVS plot data include *Amphicarpaea bracteata, Cystopteris protrusa, Tiarella cordifolia, Hepatica acutiloba, Dryopteris marginalis, Lysimachia quadrifolia, Panax quinquefolius, Phacelia bipinnatifida, Podophyllum peltatum, Polygonatum biflorum, Tradescantia subaspera, Boechera laevigata, Asarum canadense*, and *Phegopteris hexagonoptera*. Less frequent but characteristic species include *Carex austro-caroliniana, Carex plantaginea, Actaea pachypoda, Symphyotrichum cordifolium, Asplenium rhizophyllum, Cubelium concolor, Hylodesmum glutinosum¸ Iris cristata, Trillium simile,* and *Aquilegia canadensis*. Compared to the Foothills Intermediate Subtype, the number of species with high constancy in plots reflects the greater density and cover of these species within stands. As in the Montane Rich Subtype, many of the most distinctive characteristic species for this subtype occur at low density in stands and appear in few or no plots.

Range and Abundance: Ranked G2G3. In North Carolina, clusters of examples occur where mafic rocks are most abundant – in the Blue Ridge escarpment from Hickorynut Gorge to the Tryon Peak area, and in parts of the South Mountains, with examples sparsely scattered over the rest of the foothills and the western periphery of the Blue Ridge. The equivalent association also occurs in Georgia, South Carolina, and possibly Tennessee.

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Associations and Patterns: The Foothills Rich Subtype occurs as small to large patches. Patches generally are smaller than those of the Montane Intermediate Subtype, possibly because the drier low elevation conditions require more topographic sheltering to support it. Acidic Cove Forest appears to also be more abundant in the foothills than Rich Cove Forest. Occurrences grade to oak forests on drier slopes, generally to Montane Oak–Hickory Forest (Basic Subtype) if the underlying geology does not change. Small patches of Montane Cliff (Basic Subtype) or, rarely, Rich Montane Seep or Rich Cove Forest (Boulderfield Subtype) may be embedded.

Variation: No variants are recognized, but further analysis may distinguish biogeographic or elevational variants analogous to those found by Ulrey (2002) in the range of the Montane Intermediate Subtype. Examples potentially may also vary with degree of richness.

Dynamics: Dynamics probably are similar to those of other Rich Cove Forests. Fire was more frequent at lower elevations, but as in other cove forests, the sheltered moist sites where these communities occur reduce fire effects.

Comments: The foothills have generally been less studied than the core of the Blue Ridge, at least in North Carolina. Ulrey (2002) did not include these lower elevation areas in his broad analysis of mesic forests. The NVC description notes that the broad scale regional analyses done for the Appalachian Trail corridor, Fleming and Patterson (2009), found only a handful of plots fitting the equivalent association. The CVS plot data used as the primary source for description of the vegetation are also limited, and the characterizations of species as highly constant, frequent, or less frequent may not be quite the same as the more numerous site-specific descriptions.

Rare species: Vascular plants – *Trillium simile*, *Trillium discolor*, a number of others.

References:

Fleming, G.P., and K.D. Patterson. 2009. A vegetation classification for the Appalachian Trail: Virginia south to Georgia. Virginia Department of Conservation and Recreation, Division of Natural Heritage. In-house analysis, March 2009.

Ulrey, C.J. 2002. The relationship between soil fertility and the forests of the Southern Appalachian region. Ph.D. dissertation, North Carolina State University, Raleigh.

RICH COVE FOREST (RED OAK SUBTYPE)

Concept: Rich Cove Forests are low to mid elevation mesophytic mountain and foothill forests with a diverse mix of trees and herbs that includes species of richer soils such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Prunus serotina,* and *Aesculus flava*, along with more widely tolerant mesophytic species. The Red Oak Subtype covers uncommon forests of intermediate-elevation, steep, rocky upper coves, where *Quercus rubra* weakly dominates the canopy but the composition is otherwise similar to Rich Cove Forest. While the composition is intermediate between typical Rich Cove Forest and oak forests, these communities are tied to specialized rocky sites rather than simply being ecotonal communities.

Distinguishing Features: Rich Cove Forests are distinguished by having a diverse mix of mesophytic trees and a diverse mix of herbs, both of which include species of richer soils. The Red Oak Subtype has much in common with High Elevation Red Oak Forest (Rich Subtype) and Montane Oak–Hickory Forest (Basic Subtype). It is distinguished by occurring in more concave and sheltered sites (though more exposed than most Rich Cove Forests), in having only marginal dominance by *Quercus rubra*, and by overall differences in dominant vegetation.
The floristic distinctions need further clarification, but they appear to be real. While *Fraxinus americana*, *Acer saccharum*, and other species of Rich Cove Forests occur in the richer oak forest communities, Rich Cove Forest (Red Oak Subtype) is most often codominated by *Liriodendron tulipifera* or *Tilia americana* var. *heterophylla* and has a greater diversity of mesophytic hardwoods. The other strata show a similar difference. The basic/rich oak forests share a number of herb species with Rich Cove Forest, but they lack many others, and the herb layer is more often dominated by *Solidago, Tradescantia*, or other species of drier sites. *Tilia americana* var. *heterophylla, Carya cordiformis, Astilbe biternata, Osmorhiza* spp., *Monarda didyma, Thalictrum clavatum*, and *Arnoglossum muehlenbergii* are some species characteristic of this subtype that are not typical of the rich oak forest communities.

The Red Oak Subtype is distinguished from other Rich Cove Forest subtypes by the abundance of *Quercus rubra* (though it is widespread and may be locally abundant in other subtypes), by occurrence in higher concave topography, by less diverse composition than the Montane Intermediate or Montane Rich Subtype, and by a less dense herb layer than in those subtypes. As in the Foothills subtypes, the herb layer is fairly diverse but cover is often sparse. The Boulderfield Subtype may occur in similar topographic settings but has near complete boulder cover and, though often rich in *Tilia*, has limited *Quercus rubra*.

Synonyms: *Quercus rubra - Tilia americana* var. *heterophylla - (Halesia tetraptera var. monticola) / Collinsonia canadensis - Prosartes lanuginosa* Forest (CEGL007878).
Ecological Systems: Southern and Central Appalachian Cove Forest (CES202.373).

Sites: The Red Oak Subtype occurs on steep mid slopes at the head of coves, generally with high cover of rock but not well-developed boulderfields. Most examples are at 3000-4000 feet, but they may occur somewhat lower or higher.

Soils: The Red Oak Subtype probably generally occurs as inclusions within soil map units. As with other Rich Cove Forests, soils are higher in pH, base saturation, and nutritive cation levels

than most mountain communities. Within the range of Rich Cove Forests, Ulrey (2002) found them, on average, intermediate in these factors between the Montane Rich and Montane Intermediate Subtype but not statistically different from the latter.

Hydrology: Sites are well drained but are mesic due to topographic sheltering and flow convergence, but they appear to be somewhat drier than other Rich Cove Forests at similar elevations.

Vegetation: The Red Oak Subtype canopy is dominated by *Quercus rubra,* in combination with *Tilia americana* var. *heterophylla, Liriodendron tulipifera*, *Betula lenta*, and *Acer rubrum*. In Ulrey (2002), the latter three species are the most abundant associations, while those seen by the author have been codominated by *Tilia*. Other frequent canopy species reported include *Acer saccharum, Carya glabra, Halesia tetraptera, Fraxinus americana, Magnolia acuminata, Tsuga canadensis, Prunus serotina, Robinia pseudo-acacia*, and *Aesculus flava*. The NVC notes that *Halesia* can be an important part of the canopy in the Great Smoky Mountains. The understory frequently includes *Acer pensylvanicum, Castanea dentata, Cornus alternifolia*, and *Magnolia fraseri*, as well as canopy species. The shrub layer is low in density, with no species very constant. Frequent species include *Hamamelis virginiana, Hydrangea arborescens*, and *Rhododendron maximum*. The herb layer is moderate to low in density and is only moderately diverse. Widespread species such as *Parathelypteris noveboracensis, Polystichum acrostichoides*, and *Viola* spp. tend to dominate, but a variety of characteristic Rich Cove Forest species are present. Frequent species reported by Ulrey (2002) include *Arisaema triphyllum, Athyurium asplenioides, Prosartes lanuginosa, Botrypus virginianus, Maianthemum racemosum, Laportea canadensis, Medeola virginiana, Polygonatum biflorum, Dioscorea villosa, Nabalus* sp., *Caulophyllum thalictroides, Amphjicarpaea bracteata, Euryubia divaricata, Collinsonia canadensis, Actaea racemosa, Sanaguinaria canadensis, Solidago curtisii, Stellaria pubera, Goodyera pubescens, Galium triflorum, Ageratina altissima, Drypteris marginalis*, and *Eupatorium purpureum.*

Range and Abundance: Ranked G3, but perhaps G2. This subtype appears to largely limited to the western part of the Mountain region south of Asheville. The overall abundance is confused by differing concepts and limited inventory. The equivalent association also occurs in Tennessee and perhaps in Georgia.

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Associations and Patterns: The Red Oak Subtype occurs as small patches. It may grade to other Rich Cove Forest subtypes in lower coves or on more concave slopes. It grades to various oak forests on drier slopes.

Variation: No recognized pattern of variation is known.

Dynamics: Dynamics presumably are similar to cove forests in general, but the location higher on slopes may lead to more frequent penetration by fire. However, the frequent abundance of rock may reduce fire spread and intensity.

Comments: The concept and circumscription of this subtype need further clarification, as does its distribution and abundance. It is accepted somewhat provisionally here, as a narrowly circumscribed community of specialized topographic sites. It should be applied where it represents

a distinct patch of at least several acres, in a concave upper cove setting. It is not useful for conservation purposes to apply it either to groves of oak within the normal variation of cove forests or to narrow transition zones between typical cove forest and oak forest. The author has observed a few distinctive, well developed community patches, but further clarification is needed on whether other areas are similarly well developed. The number of plots attributed to the equivalent association, by Ulrey (2002), Fleming and Patterson (2009), and in the CVS database, is substantially larger than the number of sites that have been otherwise identified as this community, the reverse of the situation for most communities. It is unclear if this is because many well-developed occurrences have been overlooked or if many plots do not represent larger communities.

A red oak grouping was recognized in analysis by Ulrey (2002) and something like it was recognized by Fleming and Patterson (2009) in their analysis of Appalachian Trail corridor data. It was also recognized in analysis of plot data in the Great Smoky Mountains. In all cases, despite the abundance of oak, plots grouped more closely with cove forests than with oak forests.

Rare species:

References:

Fleming, G.P., and K.D. Patterson. 2009. A vegetation classification for the Appalachian Trail: Virginia south to Georgia. Virginia Department of Conservation and Recreation, Division of Natural Heritage. In-house analysis, March 2009.

Ulrey, C.J. 2002. The relationship between soil fertility and the forests of the Southern Appalachian region. Ph.D. dissertation, North Carolina State University, Raleigh.

RICH COVE FOREST (BOULDERFIELD SUBTYPE)

Concept: Rich Cove Forest (Boulderfield Subtype) communities are forests of well-developed boulderfields, comparable to High Elevation Birch Boulderfield Forests, but occurring at lower elevations and having a more diverse canopy dominated by species of Rich Cove Forests in combination with *Betula alleghaniensis*.

Distinguishing Features: The Boulderfield Subtype of Rich Cove Forest, like the High Elevation Birch Boulderfield Forest community, is distinguished by occurring on well-developed boulderfields, with near complete cover by large rocks, substantial open space beneath the rocks, soil limited to accumulations on top of and between rocks, and lower strata substantially influenced by the rock cover. The Rich Cove Forest subtype is distinguished by lower elevation and a richer flora, which overall is very similar to other Rich Cove Forest subtypes. *Betula alleghaniensis* often is the most abundant tree in both, but in the Boulderfield Subtype of Rich Cove Forest other mesophytic tree species, most often *Tilia americana* var. *heterophylla* or *Aesculus flava*, are also present. Several species of herbs characteristic of Rich Cove Forests are also present, though usually with low cover. Woody vines often are abundant. High Elevation Birch Boulderfield Forests generally occur at higher elevations; however, the Boulderfield Subtype can occur at higher elevations than other Rich Cove Forests subtypes and may be bordered by Northern Hardwood Forest on adjacent exposed slopes.

The Boulderfield Subtype of Rich Cove Forest is distinguished from the Boulderfield subtypes of Chestnut Oak Forest and Montane Oak—Hickory Forest by having canopy dominance or codominance by mesophytic species; oaks, particularly *Quercus rubra*, may be present but form a minority of the canopy.

This subtype should be used only for well-developed boulderfields. Many Rich Cove Forests of all subtypes occur on colluvial soils with abundant boulders, but most do not have enough boulder cover to affect community composition.

Synonyms: *Betula alleghaniensis - Tilia americana* var. *heterophylla / Acer spicatum / Ribes cynosbati / Dryopteris marginalis* Forest (CEGL004982).

Sites: Rich Cove Forest (Boulderfield Subtype) occurs on coarse colluvial deposits. Large rocks cover virtually the entire ground surface and are piled on top of each other so that there is a substantial number of large voids beneath them. Boulderfields may be relict Pleistocene periglacial features on concave north-facing slopes, or they may be talus on steep slopes below rock outcrops. Most examples occur at 2500-4500 feet, but a few occur at substantially higher or lower altitudes.

Soils: Soil consists of accumulations of organic matter on and among the boulders (Lithic Dystrochrepts), but patches are generally small and are inclusions in soil map units.

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

Vegetation: The Boulderfield Subtype canopy may be closed or somewhat open. It is generally dominated by varying combinations of *Betula alleghaniensis, Tilia americana* var. *heterophylla*, and *Aesculus flava*. Other species of Rich Cove Forests may be present, usually in much smaller numbers but occasionally abundant, including *Acer saccharum, Fraxinus americana, Tsuga canadensis, Fagus grandifolia, Halesia tetraptera, Quercus rubra, Liriodendron tulipifera*, and *Betula lenta*. The understory generally is dominated by *Acer pensylvanicum* or *Acer spicatum*. Shrubs are often sparse, but *Hydrangea arborescens, Ribes cynosbati*, *Euonymus obovatus*, or rarely other species may have substantial cover. Vines, most often *Isotrema macrophyllum* or *Parthenocissus quinquefolia*, sometimes have significant cover. The herb layer often includes substantial cover of *Dryopteris intermedia, Dryopteris marginalis, Polypodium appalachianum*, *Heuchera villosa*, *Cystopteris protrusa*, or other species that can root on rocks, as well as substantial bryophyte cover. Where there is seepage through the rocks but near the surface, patches may be dominated by dense *Laportea canadensis*, *Impatiens pallida*, or *Impatiens capensis*. Usually several other species typical of Rich Cove Forests are present with low cover. Frequent species include *Polystichum acrostichoides, Arisaema triphyllum, Actaea racemosa, Tiarella cordifolia, Galium triflorum, Prosartes lanuginosa, Solidago curtisii, Trillium erectum, Eurybia chlorolepis, Caulophyllum thalictroides, Stellaria pubera, Veratrum parviflorum, Allium tricoccum*, *Clintonia umbellulata, Collinsonia canadensis*, and *Osmorhiza claytonia*.

Range and Abundance: Ranked G3. The Boulderfield Subtype is scattered throughout the Mountain region, but only very rarely in the foothills. The equivalent association also occurs in Georgia, Tennessee, and possibly Virginia and Kentucky.

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Associations and Patterns: The Boulderfield Subtype occurs as small patches, often associated with other subtypes of Rich Cove Forest. Higher elevation examples may be surrounded by Northern Hardwood Forest. Examples often grade to oak forests on drier slopes. A few examples may have cliffs or other rock outcrops at their upper end.

Variation: This subtype is not divided by elevation into montane and foothills groups and indeed can extend up to elevations more typical of Northern Hardwood Forest. Division by elevation may prove warranted in the future, but it appears that the extreme environment of boulderfields overrides elevational effects in this subtype. Other variations, such as an odd example in Madison County dominated by *Tsuga canadensis* but otherwise rich, may warrant recognition as variants.

Dynamics: While stand dynamics presumably are similar to other cove forests, canopy gaps last longer because of the difficulty of tree establishment. Chafin and Jones (1989) found windthrow to be more common and canopy gaps more abundant in Boulderfield Forests than in nearby Rich Cove Forests. The ability of *Betula alleghaniensi*s to germinate and establish on top of logs and rocks, with its roots wrapping around these features and continuing downward until they reach soil, allows it to dominate in this unique environment. It is not clear what aspect of the lower elevation makes it possible for other tree species to be more abundant than they are in the High Elevation Birch Boulderfield Forest. The greater dryness of lower elevation might be expected to make establishment of seedings on rocks more difficult. It may be that periglacial processes were less intense at lower elevations or that chemical weathering is more intense, either possibility leading to more soil being associated with the rocks.

Comments: These communities appear to be less distinct from typical Rich Cove Forests than the High Elevation Birch Boulderfield Forest type is from Northern Hardwood Forests; thus they are treated as a subtype rather than as a full type.

Rare species:
Vascular plants: *Aconitum reclinatum, Cardamine clematitis, Geum geniculatum, Meehania cordata*, and others.
Vertebrate animals: *Sorex dispar blitchi* and *Plethodon ventralis.*

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

ACIDIC COVE FOREST (TYPIC SUBTYPE)

Concept: Acidic Cove Forests are low to mid elevation mesophytic mountain and foothill forests dominated by combinations of acid-tolerant trees, primarily *Liriodendron tulipifera, Betula lenta, Tsuga canadensis, Acer rubrum*, *Halesia tetraptera*, or *Betula alleghaniensis,* with acid-tolerant undergrowth lacking the species typical of Rich Cove Forests. The Typic Subtype covers the common examples in most of the Blue Ridge of North Carolina, where neither *Halesia tetraptera* nor *Betula alleghaniensis* is codominant or dominant.

Distinguishing Features: Acidic Cove Forests are distinguished from the closely related Canada Hemlock Forest type by having a mixed canopy in which *Tsuga canadensis* may be present but does not dominate. They are distinguished from Rich Cove Forests by the absence or near absence of plants that require richer or less acidic soils. Trees such as *Aesculus flava, Tilia americana* var. *heterophylla, Acer saccharum*, *Fraxinus americana*, *Magnolia acuminata*, and *Prunus serotina* are present in only minor quantities if at all. Likewise, herbs of rich soils, such as *Actaea racemosa, Caulophyllum thalictroides, Actaea pachypoda*, and *Adiantum pedatum* are absent or nearly so. All species of Acidic Cove Forests also occur in Rich Forests, though not as abundantly. Acidic Cove Forests are distinguished from Northern Hardwood Forests by the presence of low elevation species such as *Liriodendron tulipifera, Betula lenta*, *Rhododendron maximum*, and generally by a less well developed or less diverse herb layer.

Acidic Cove Forests share many canopy, understory, and shrub species with Montane Alluvial Forest and Swamp Forest–Bog Complex. They are distinguished from the former by lacking boggy openings with *Sphagnum* and lacking appreciable numbers of wetland species such as *Osmundastrum cinnamomeum*. They are distinguished from Montane Alluvial Forest by lacking alluvial species such as *Platanus occidentalis* and *Carpinus caroliniana*. The distinction from Montane Alluvial Forest (Small River Subtype) may be subtle, as both may occur on flats along large streams and characteristic alluvial species may be present only as minority components. Acidic Cove Forests usually have some oaks present in the canopy but are distinguished from oak forests by not having these species dominant.

The Typic Subtype is distinguished from the Silverbell Subtype by having *Halesia tetraptera* only in limited numbers, not codominant in the canopy. It is distinguished from the High Elevation Subtype by elevation and by having a canopy with a mix of species that does not include *Betula alleghaniensis* as dominant or codominant.

Synonyms: *Liriodendron tulipifera - Betula lenta - Tsuga canadensis / Rhododendron maximum* Forest (CEGL007543).
Ecological Systems: Southern and Central Appalachian Cove Forest (CES202.373).

Sites: Acidic Cove Forests occur in sheltered, mesic, low to mid elevation sites, primarily in narrow rocky gorges, steep ravines, and low gentle ridges within coves. Local slopes may be concave or convex. Most examples are at 4000 feet or lower, but a few range higher. A few disjunct Piedmont occurrences are below 1000 feet.

Soils: Acidic Cove Forests occur on a wide range of typical mountain soils, most often on Typic Dystrudepts (Ashe, Chestnut, Edneyville,Greenlee) or Typic Hapludults (Cowee, Evard, Tate), sometimes on Lithic Dystrudepts (Cleveland), Typic Humadepts (Cullasaja), or other types. Soils are generally very acidic and low in base saturation and in levels of nutritive cations.

Hydrology: Sites are well-drained but mesic due to topographic sheltering and low slope position.

Vegetation: Acidic Cove Forest (Typic Subtype) is dominated by a varying mix of mesophytic plants tolerant of acidic conditions. Highly constant species in CVS plot data are *Betula lenta, Liriodendron tulipifera, Quercus rubra,* and *Acer rubrum*, and *Quercus montana, Halesia tetraptera, Pinus strobus, Carya glabra, Fagus grandifolia*, and *Quercus alba* also are frequent. *Tsuga canadensis* has high constancy and often is in the canopy but more often has high cover in the understory. Other high constancy or frequent understory species in addition to canopy species are *Magnolia fraseri, Oxydendrum arboreum, Acer pensylvanicum, Nyssa sylvatica, Cornus florida*, and *Ilex opaca*. The shrub layer usually is dense, with *Rhododendron maximum* strongly dominant. In a minority of occurrences, *Rhododendron* is scarce or absent, and the ground cover is a dense shrub layer dominated by *Leucothoe fontanesiana* or shrubs are sparse. Other frequent shrubs include *Kalmia latifolia, Hamamelis virginiana*, and *Euonyumus americana*. *Smilax rotundifolia, Smilax glauca*, and *Parthenocissus quinquefolius* also are frequent and occasionally form tangles. The herb layer is sparse beneath dense shrub cover and consists primarily of scattered individuals of the most acid-tolerant species, such as *Galax urceolata, Goodyera pubescens, Chimaphila maculata*, *Mitchella repens*, and *Viola hastata*. Where shrub cover is less dense, more substantial cover of *Polystichum acrostichoides, Parathelypteris noveboracensis, Athyrium asplenioides*, or *Eurybia divaricata* may be present. Other frequent herbs in CVS plots data are *Arisaema triphyllum* and *Medeola virginica*. Small numbers of plants shared with Rich Cove Forest may be present locally.

Range and Abundance: Ranked G5. The Typic Subtype is widespread throughout the Mountain region and foothills. The equivalent association also occurs in South Carolina, Georgia, Tennessee, Virginia, and in West Virgina.

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Associations and Patterns: Acidic Cove Forest (Typic Subtype) is one of the communities making up the typical landscape mosaic in most low to mid elevation areas. It generally grades into Chestnut Oak Forest, Montane Oak–Hickory Forest, or other Mountain Oak Forests uphill and in drier settings. It may grade to Rich Cove Forest downhill or on more concave slopes. Sometimes Acidic Cove Forest is on spur ridges within larger coves filled with Rich Cove Forest. In other places, it may be on slopes of sharp ravines, with Rich Cove Forest on gentler and more concave slopes uphill of it. If variable geology is present, Acidic Cove Forest may also transition abruptly to Rich Cove Forest on less acidic substrates with similar topography. Acidic Cove Forest may also be associated with Canada Hemlock Forest. Less frequently, it may be associated with Swamp Forest—Bog Complex, Southern Appalachian Bog, Montane Alluvial Forest, or small patches of rock outcrop or seep communities.

Variation: Distinct variation is recognizable in the dominants of the lower strata. Three variants are defined based it. A fourth variant is recognized based on a division described by Ulrey (2002), and a fifth is recognized to parallel units accepted for related communities.

1. Rhododendron Variant has a dense shrub layer dominated by *Rhododendron maximum*. This is the most common and widespread variant.

2. Dog Hobble Variant has a dense shrub layer dominated by *Leucothoe fontanesiana*. It is uncommon but appears to be widespread in the Great Smoky Mountains. This variant often occurs on flatter valley bottoms.

3. Herb Variant has limited shrub cover and usually has a well-developed herb layer, most often dominated by ferns. It usually occurs on flatter valley bottoms. Widely scattered throughout the range of Acidic Cove Forest, it is less common than the Rhododendron Variant.

4. Submesic Variant has more oak present, somewhat less *Rhododendron maximum*, and more of several understory and shrub species such as *Ilex opaca* and *Gaylussacia ursina*. This variant was found distinct in Ulrey's (2002) regionwide analysis of Acidic Cove Forest plot data, at a level comparable to the Silverbell and High Elevation subtypes. It appears to be transitional to drier oak communities, but it is unclear if it occurs as extensive patches or only as a narrow ecotonal zone. It is recognized as a variant rather than a subtype until its ecological significance can be clarified. Its plots were lower in elevation on average. Given the wide elevational range of Acidic Cove Forests, it should be investigated as a possible lower elevation community. .

5. White Pine Variant contains appreciable amounts of *Pinus strobus* in the canopy. This variant is parallel to the White Pine Subtype recognized for Canada Hemlock Forest. Investigation is needed into whether it is distinctive enough to recognize as a subtype.

Dynamics: Most of the dynamics of Acidic Cove Forests likely are similar to those of Rich Cove Forests, including naturally occurring primarily as old-growth multi-aged forests, tree regeneration primarily in small canopy gaps, and limited influence of fire. As with Rich Cove Forests, the widespread and fairly frequent occurrence of fire in oak forests implies an ability of fire to cross the Acidic Cove Forest bands that often dissect them, but the low intensity of fire in these locations limits its ecological effects. However, if more intense fire occurs, it may be a significant natural disturbance. *Rhododendron maximum* is easily top-killed by fire and is slow to sprout. The mesophytic tree species also are not adapted to surviving appreciable fire, though their ability to sprout would limit the likelihood that infrequent more severe fires would change the forest composition.

Carter, et al. (2000) described successional patterns in the high rainfall southern escarpment area, including in mid elevation mesic sites that appear to be Acidic Cove Forest (Typic Subtype) sites. They described early successional sites dominated by *Liriodendron tulipifera, Robinia pseudo-acacia*, and *Quercus rubra*; mid successional sites dominated by *Quercus alba, Nyssa sylvatica*, and *Robinia pseudo-acacia*, and later successional sites by *Quercus rubra*, *Tsuga canadensis*, and *Betula lenta*. It is not clear how general this pattern is, even in that region, as mature stands with abundant *Liriodendron* and younger stands with abundant *Betula lenta* may be observed.

Comments: The name Acidic Cove Forest apparently was new with the First Approximation. Earlier literature referred simply to cove forests or mixed mesophytic forests and appears to have

meant either both Rich and Acidic Cove Forest or only Rich Cove Forest (e.g. Cooper and Hardin 1970, Dumond 1969). Something recognizable as Acidic Cove Forest is described by Wentworth (1980), who noted the absence of more typical Rich Cove Forest species in the mesophytic forests of the Thompson River gorge, and by Callaway, et al. (1987) in the western Great Smoky Mountains. Whittaker (1956) described only a rich cove forest and a hemlock forest. However, he described the hemlock forests of the Smokies as merging with cove forests below 2500 feet and becoming mixed with hardwoods. Given the abundant of both kinds of communities and the striking difference in appearance, diversity, and composition in all strata, the lack of early recognition is surprising. McLeod (1988) distinguished cove forests with hemlock and oaks from those without, as well as recognizing a hemlock forest. Other literature that used Whittaker (1956) as a primary reference tended to name communities as hemlock forests even when they appear to be more mixed forests more like Acidic Cove Forests. Later studies are much more likely to recognize something analogous to Acidic Cove Forest. Newell (1997) had such communities in all three of her study areas (Linville Gorge, Shining Rock Wilderness, and Joyce Kilmer-Slickrock Wilderness).

Ulrey (2002) focused analysis on the distinction between Acidic Cove Forest and Rich Cove Forest, using plot data from across the North Carolina mountains and adjacent areas. He also analyzed variation within Acidic Cove Forest, and his work is the basis for the three subtypes. He showed significant correlations of vegetation with elevation and soil richness even within the narrow range of conditions represented by Acidic Cove Forests.

The relationship of Acidic Cove Forest to Canada Hemlock Forest may benefit from further investigation, though this may be difficult after the widespread hemlock mortality. In North Carolina, Canada Hemlock Forest and Acidic Cove Forest appear to occupy very similar sites. Whittaker (1956) emphasized the strong effect of *Tsuga canadensis* dominance, which would now be called a keystone role, modifying the environment with its heavy shade and acidic litter. He believed it excluded many species of his (rich) cove forest. However, such effects would present less contrast with typical Acidic Cove Forest, where moderate amounts of *Tsuga canadensis* may be present and where *Rhododendron maximum* similarly produces dense shade and acidic litter even without *Tsuga*. The two communities share most of their species and may differ only in dominance. *Tsuga* appears to dominate larger areas in the Great Smoky Mountains than elsewhere, though it is also abundant on the Highlands Plateau and is present as a minority species in forests throughout the region.

Tsuga is often regarded as a later successional tree in the north, coming to dominate only after years free of disturbance. A similar impression can be gotten in North Carolina from the dense *Tsuga* understory that develops in some hardwood communities. However, in North Carolina mixed Acidic Cove Forests are more abundant than Canada Hemlock Forest even in virgin forest areas. The two community types appear similar enough that it may be as appropriate to treat Canada Hemlock Forest as a subtype of Acidic Cove Forest.

Acer rubrum - Betula (alleghaniensis, lenta) - Magnolia fraseri / (Rhododendron maximum, Kalmia latifolia) Forest (CEGL008558) is an association that appears to represent heavily disturbed versions of all three subtypes of Acidic Cove Forest.

Rare species: Vascular plants – *Calystegia catesbiana ssp. sericata, Cardamine rotundifolia, Carex woodii, Coeloglossum viride var. virescens, Corallorhiza maculata, Geum geniculatum, Hexastylis contracta, Hexastylis rhombiformis, Isotria medeoloides, Liparis loeselii, Listera australis, Lygodium palmatum, Lysimachia fraseri, Meehania cordata, Panax trifolius, Platanthera orbiculata, Shortia galacifolia, Stewartia ovata, Trichomanes petersii, Trientalis borealis.* Nonvascular plants – *Brachymenium andersonii, Brachymenium systylium, Brachythecium rotaeanum, Bryocrumia vivicolor, Bryoxiphium norvegicum, Ditrichum ambiguum, Drepanolejeunea appalachiana, Entodon sullivantii, Lophocolea muricata, Macrocoma sullivantii, Mnium carolinianum, Nardia lescurii, Plagiochila austinii, Plagiochila caduciloba, Plagiochila echinata, Radula sullivantii, Schlotheimia lancifolia.*

References:

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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.

Ulrey, C.J. 2002. The relationship between soil fertility and the forests of the Southern Appalachian region. Ph.D. dissertation, North Carolina State University, Raleigh,

Wentworth, T.R. 1980. Preliminary analysis of vegetation in the Thompson River watershed of North and South Carolina. Veroffentlichungen des Geobotanischen Institutes der Eidg. Techn. Hochshule, Stiftung Rubel, Zurich, 69. Heft.

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ACIDIC COVE FOREST (HIGH ELEVATION SUBTYPE)

Concept: Acidic Cove Forests are low to mid elevation mesophytic mountain and foothill forests dominated by combinations of acid-tolerant trees. The High Elevation Subtype occurs at the higher elevations and has *Betula alleghaniensis* as an important component. This subtype extends up into the elevational range of Northern Hardwood Forest and is somewhat intermediate between them and Acidic Cove Forest.

Distinguishing Features: The High Elevation Subtype is distinguished from other subtypes by the significant presence of *Betula alleghaniensis* in the canopy. Though it occurs at higher elevations on average, it may occur as low as 3000 feet, occasionally lower, and thus substantially overlaps in elevation with the Typic Subtype as well as the Silverbell Subtype. The High Elevation Subtype is distinguished from Northern Hardwood Forest and High Elevation Birch Boulderfield Forest, which also may be dominated by *Betula alleghaniensis*, by having a shrub layer dominated by *Rhododendron maximum* or *Leucothoe fontanesiana*. It also generally contains some trees of lower elevations, such as *Liriodendron tulipifera* and *Magnolia fraseri*. The High Elevation Subtype may be distinguished from the occasional Swamp Forest–Bog Complex that has abundant *Betula alleghaniensis* by lacking opening patches with wetland species.

Synonyms: Synonyms: *Betula alleghaniensis - (Tsuga canadensis) / Rhododendron maximum / (Leucothoe fontanesiana)* Forest (CEGL007861). Montane Type (*Tsuga canadensis - Betula alleghaniensis / Rhododendron maximum - Acer pensylvanicum / Dryopteris intermedia - Huperzia lucidula*) (Ulrey 2002).
Ecological Systems: Southern Appalachian Northern Hardwood Forest (CES202.029).

Sites: The High Elevation Subtype occurs in sheltered, mesic sites such as narrow rocky gorges, steep ravines, and low gentle ridges within coves. Ulrey (2002) reported an elevation range of about 3000-4100 feet, but a few examples have been found much higher, up to around 5000 feet. This elevational range substantially overlaps that of the Silverbell Subtype, overlaps a little of the Typic Subtype's range, and extends well into the range of Northern Hardwood Forest. Lower elevation occurrences may be associated with cold air drainage from higher elevations.

Soils: Examples occur on a wide range of mapped soil series, primarily Typic Dystrudepts, Humic Dystrudepts, and Typic Humadepts. Soils are generally very acidic and low in base saturation and in levels of nutritive cations but are slightly less extreme than in the Typic Subtype.

Hydrology: Sites are well drained but mesic due to topographic sheltering and low slope position. They probably are more moist than the Typic Subtype because of the higher elevation.

Vegetation: The High Elevation Subtype is dominated by *Tsuga canadensis* and *Betula alleghaniensis*, sometimes in combination with *Liriodendron tulipifera*. Other frequent canopy trees include *Betula lenta, Acer rubrum, Quercus rubra*, *Fagus grandifolia*, and occasional *Tilia americana* var. *heterophylla*, *Acer saccharum*, and *Halesia tetraptera*. The understory includes *Acer pensylvanicum* and *Magnolia fraseri*, as well as canopy species. The shrub layer is generally a dense thicket of *Rhododendron maximum*. The herb layer is sparse to moderate. *Dryopteris intermedia* is the most constant and abundant species reported by Ulrey (2002), and *Huperzia*

lucidula, Mitchella repens, and *Arisaema triphyllum* are highly constant. Other frequent species include *Eurybia divaricta, Goodyera pubescens, Medeola virginica, Polystichum acrostichoides, Tiarella cordifolia*, *Trillium undulatum*, and *Viola rotundifolia*.

Range and Abundance: Ranked G3G4Q, but probably more appropriately ranked G3. The classification is no more uncertain than that of many communities, and this community appears to be much less common than the Typic Subtype. The High Elevation Subtype ranges thoughout the higher mountains of North Carolina. The equivalent association also occurs in Tennessee, Virginia, and West Virginia. Though not reported, it could also be found in Georgia.

Associations and Patterns: The High Elevation Subtype occurs as small to large patches. It may grade to other subtypes of Acidic Cove Forest and potentially to Northern Hardwood Forest. It grades to various oak forests on drier slopes.

Variation: Two variants are recognized, but additional clarification is needed.
1. Rhododendron Variant has *Rhododendron maximum* dominant in the shrub layer.
2. Dog Hobble Variant has *Leucothoe fontanesiana* dominant in the shrub layer. Large areas are said to occur around Mount LeConte in the Great Smoky Mountains. It is unclear where, or even if, it occurs in North Carolina.

Dynamics: The dynamics of the High Elevation Subtype are presumably similar to those of Acidic Cove Forests and Mountain Cove Forests in general. As with the Silvervbell Subtype, this subtype has had particularly severe impacts from the hemlock woolly adelgid because of its large component of *Tsuga canadensis*.

Comments: The High Elevation Subtype was defined by Ulrey (2002), who showed that it differs in its combination of soil fertility and elevation from other Acidic Cove Forests as well as being distinct in numerical classification and ordination. An association recognizable as High Elevation Subtype was also described by Newell (1997) in her analysis of vegetation of Joyce Kilmer-Slickrock Wilderness. It was not recognized in her similar analysis of Shining Rock Wilderness, despite similar elevations. It is not found in other local studies, which tend to classify communities more coarsely. The relationship between the High Elevation Subtype and Silverbell Subtype warrants further investigation, as the environmental and elevational differences are relatively subtle. Both share a tendency to contain some species more typical of richer sites.

Acer rubrum - Betula (alleghaniensis, lenta) - Magnolia fraseri / (Rhododendron maximum, Kalmia latifolia) Forest (CEGL008558) is an association that appears to represent heavily disturbed versions of all three subtypes of Acidic Cove Forest.

Rare species:

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.

Ulrey, C.J. 2002. The relationship between soil fertility and the forests of the Southern Appalachian region. Ph.D. dissertation, North Carolina State University, Raleigh.

ACIDIC COVE FOREST (SILVERBELL SUBTYPE)

Concept: Acidic Cove Forests are low to mid elevation mesophytic mountain and foothill forests dominated by combinations of acid-tolerant trees. The Silverbell Subtype covers examples of the southwestern ranges of the Blue Ridge, in which *Halesia tetraptera* is a significant component. It is known from the Tennessee side of the Great Smoky Mountains and from Joyce Kilmer-Slickrock Wilderness but may be found elsewhere in southwestern North Carolina.

Distinguishing Features: Acidic Cove Forests are distinguished by a canopy dominated by *Liriodendron tulipifera, Betula lenta, Acer rubrum*, *Tsuga canadensis*, and other species tolerant of highly acid condition. The Silverbell Subtype is distinguished from the other subtypes by canopy dominance by *Halesia tetraptera* and *Tsuga canadensis*, while generally lacking *Liriodendron tulipifera*. It occurs as somewhat higher elevations than the Typic Subtype but lacks the abundant *Betula alleghaniensis* of the High Elevation Subtype. It has a somewhat more diverse flora than other Acidic Cove Forest subtypes and may be somewhat transitional to Rich Cove Forest. The Silverbell Subtype is similar to Canada Hemlock Forest but has only weak dominance or codominance by *Tsuga canadensis*.

Synonyms: *Tsuga canadensis - Halesia tetraptera - (Fagus grandifolia, Magnolia fraseri) / Rhododendron maximum / Dryopteris intermedia* Forest (CEGL007693).
Ecological Systems: Southern and Central Appalachian Cove Forest (CES202.373).

Sites: The Silverbell Subtype occurs in sheltered, mesic sites such as narrow rocky gorges, steep ravines, and low gentle ridges within coves. The Silverbell Subtype is known from 2700-2800 feet in elevation (Ulrey 2002), higher on average than the Typic Subtype and lower than the High Elevation Subtype but overlapping both.

Soils: Despite its limited range, the Silverbell Subtype occurs on a wide range of soil map units, all Inceptisols, including Typic Dystrudepts (Ditney, Cataska, Soco, Stecoah), Humic Dystrudepts (Jeffrey, Sylva, Whiteoak), Lithic Dystrudepts (Unicoi), Typic Humadepts (Spivey, Santeetlah), and Humic Endoaquepts (Sylco). Soils are generally very acidic and low in base saturation and in levels of nutritive cations, but they are slightly less extreme than in the Typic Subtype.

Hydrology: Sites are well drained but mesic due to topographic sheltering and low slope position.

Vegetation: The Silverbell Subtype typically is dominated by *Tsuga canadensis* and *Halesia tetraptera*. Surprisingly for an Acidic Cove Forests, *Acer saccharum* may also codominates or be abundant. Other frequent canopy species include *Liriodendron tulipifera, Fagus grandifolia*, *Betula lenta*, *Acer rubrum*, and *Quercus rubra*. Understory trees, in addition to the canopy species, frequently include *Acer pensylvanicum* and *Magnolia fraseri*. *Tilia americana* var. *heterophylla* and *Magnolia acuminata* also occur in a surprising number of the plots in small numbers. The shrub layer tends to be less dense than in the other subtypes, but *Rhododendron maximum* is the dominant species. The herb layer is well developed. In Ulrey (2002) constancy tables, *Dryopteris intermedia* has the highest average cover and constancy. Other constant herbs include *Eurybia divaricata, Solidago curtissii, Laportea canadensis, Tiarella cordifolia, Polystichum acrostichoides, Viola rotundifolia, Stellaria pubera, Mitchella repens, Polygonatum biflorum,*

Arisaema triphyllum, Medeola virginica, Viola hastata, Nabalus sp., *Athryrium asplenioides*, *Thelypteris noveboracensis*, and again surprisingly, *Caulophyllum thalictroides* and *Prosartes lanuginosa*.

Range and Abundance: Ranked G2. The Silverbell Subtype appears to be limited to the southwestern part of the Mountain Region and adjacent Tennessee. It is definitively known only in the Great Smoky Mountains and the Joyce Kilmer-Slickrock Wilderness.

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Associations and Patterns: The Silverbell Subtype occurs as large patches where it is present. It can occur in close proximity to both the High Elevation and Typic Subtype. It grades to various oak forests on drier slopes and may potentially grade to Rich Cove Forest on richer soils.

Variation: Variation is not well known. The Silverbell Subtype is narrowly defined.

Dynamics: The dynamics of the Silverbell Subtype are presumably similar to those of Acidic Cove Forests and Mountain Cove Forests in general. This subtype has had particularly severe impacts from the hemlock woolly adelgid, given its large component of *Tsuga canadensis* and occurrence in remote wilderness areas where treatment is difficult.

Comments: The Silverbell Subtype was defined by Ulrey (2002), who showed that it differs in its combination of soil fertility and elevation from other Acidic Cove Forests as well as being distinct in numerical classification and ordination. An association recognizable as this subtype was also described by Newell (1997) in her analysis of vegetation of Joyce Kilmer-Slickrock Wilderness but was not found in Shining Rock Wilderness. It was not recognized in other local studies, which tend to classify communities more coarsely. It appears to be transitional to Rich Cove Forest, with several characteristic species commonly present, while at the same time being transitional to Canada Hemlock Forest. However, this subtype remains little studied beyond its initial recognition. The coexistence of heavy *Tsuga* cover with species of rich soils warrants investigation. The limited range of this association is also curious, given that all the component species range widely in the mountains.

Rare species:

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.

Ulrey, C.J. 2002. The relationship between soil fertility and the forests of the Southern Appalachian region. Ph.D. dissertation, North Carolina State University, Raleigh.

CANADA HEMLOCK FOREST (TYPIC SUBTYPE)

Concept: Canada Hemlock Forests are mesophytic mountain and foothill forests dominated by *Tsuga canadensis*, with acid-tolerant undergrowth and low species richness. These communities occur in coves, gorges, or on sheltered slopes and share many species with Acidic Cove Forests. The Typic Subtype lacks appreciable *Pinus strobus* in the canopy.

Distinguishing Features: Canada Hemlock Forest (Typic Subtype) is distinguished by having *Tsuga canadensis* constituting more than 60 percent of the canopy, at least before recent mortality, in a mesic but not wet environment. The long term future of *Tsuga canadensis* in the region is uncertain, and Canada Hemlock Forests may lose their distinctive character if a solution to the hemlock woolly adelgid is not found, but the identify of this community is retained for the present and may be based on the evidence of recently dead trees.

Acidic Cove Forests, especially the Silverbell Subtype, usually have abundant *Tsuga canadensis* in the canopy and often have a *Tsuga* understory but have a predominance of hardwoods. *Tsuga canadensis* may also be abundant in Swamp Forest–Bog Complex, but that community has wetland conditions and wetland plants at least in a series of boggy patches dispersed through the forest. *Pinus rigida, Nyssa sylvatica*, and a variety of wetland herbs occur in Swamp Forest–Bog Complex but rarely in Canada Hemlock Forest. Montane Alluvial Forest, especially the Small River Subtype, may have abundant *Tsuga canadensis* but also contains species indicative of periodic flooding and alluvial deposition, such as *Platanus occidentalis*, and tends to have higher species richness. Rich Cove Forest, Acidic Cove Forest, and Northern Hardwood Forest sometimes have small groves where *Tsuga canadensis* is locally dominant but have hardwoods dominant in the stand as a whole. Carolina Hemlock Forest (Mesic Subtype) may occur in similar environments and look similar but is dominated by *Tsuga caroliniana*.

The Typic Subtype is distinguished from the White Pine subtype by lacking appreciable natural occurrence of *Pinus strobus*. This may be difficult to distinguish, as planting or logging of pines may have affected their presence without being obvious.

Synonyms: *Tsuga canadensis / Rhododendron maximum - (Clethra acuminata, Leucothoe fontanesiana)* Forest (CEGL007136).
Ecological Systems: Southern and Central Appalachian Cove Forest (CES202.373).

Sites: Canada Hemlock Forests occur in sheltered, mesic, low- to mid-elevation sites, primarily in narrow rocky gorges, steep ravines, and low gentle ridges within coves. Local slopes may be concave or convex. In a few places, such as the area around Highlands and parts of the Great Smoky Mountains, Canada Hemlock Forests occupy or occupied larger expanses of the landscape. A few examples occur as disjunct patches on north-facing river bluffs in the western Piedmont, as well as in more typical mountainous terrain in the foothills. Elevations range from below 1000 feet to 5000 feet or somewhat higher.

Soils: Canada Hemlock Forests occur on the same wide range of Typic Dystrudepts, Typic Hapludults, Lithic Dystrudepts, Typic Humadepts, or other types as Acidic Cove Forests do. Soils are extremely acidic because the hemlock litter adds organic acids.

Hydrology: Sites are well drained but mesic due to topographic sheltering and low slope position.

Vegetation: Canada Hemlock Forests generally had a dense canopy before the widespread recent mortality, with *Tsuga canadensis* dominant. *Betula lenta* and *Liriodendron tulipifera* have high constancy in CVS plots, and *Acer rubrum, Quercus rubra*, and *Halesia tetraptera* are frequent. *Betula alleghaniensis, Quercus alba*, and other species occur occasionally. The understory often is dominated by *Tsuga canadensis* as well, but *Magnolia fraseri, Nyssa sylvatica, Oxydendrum arboreum*, and *Acer pensylvanicum* are highly constant or frequent, along with the other species in the canopy. *Ilex opaca* or *Amelanchier laevis* and *Sassafras albidum* sometimes are abundant. The shrub layer may be dense or open. *Rhododendron maximum* is universally present and often forms dense thickets comparable to those in many Acidic Cove Forests. *Kalmia latifolia* also is high constant and may have fairly high cover. Occasionally *Leucothoe fontanesiana* may form a dense thicket. Other shrubs, generally not dense, include *Clethra acuminata*, *Hamamelis virginiana*, and less frequently, *Symplocos tinctoria, Ilex montana*, and *Pyrularia pubera*. *Smilax rotundifolia* is highly constant and *Smilax glauca* frequent. The herb layer is usually sparse though *Galax urceolata* may occasionally have high cover. Other frequent herb layer species include *Mitchella repens, Goodyera pubescens, Chimaphila maculata,* and *Medeola virginica*. Other characteristic species include *Monotropa uniflora, Arisaema triphyllum, Polystichum acrostichoides*, and *Viola rotundifolia*. Overall diversity is low, with an average of only 25 species per 1/10 hectare. A large majority of the constant and frequent species are woody.

Range and Abundance: Ranked G3G4. Occurrences are scattered throughout the Mountain region, more heavily concentrated south of the Asheville basin. Sparser occurrences are present in the foothills and a few disjunct examples occur on river bluffs in the upper Piedmont as far east as Stokes County. The equivalent association is attributed to South Carolina, Georgia, Tennessee, and Kentucky.

Associations and Patterns: Canada Hemlock Forest occurs in large or small patches. It often grades to Acidic Cove Forest in mesic areas. It grades to various oak forests on drier slopes and may occasionally grade to Northern Hardwood Forest or Red Spruce–Fraser Fir Forest. The boundary of occurrences sometimes is a typical gradual transition but sometimes is abrupt.

Variation: Whittaker (1956) and others have described two different kinds of hemlock forest. One has a dense heath shrub layer, and the other has more open and herb-dominated undergrowth. These may be worthy of recognition as variants if they are a result of different environments.

Dynamics: In most ways the natural dynamics of Canada Hemlock Forests have been similar to other cove forests. *Tsuga canadensis* is considered very intolerant of fire, but this community, like other mesic forests, could potentially allow low intensity fire to spread through it without being greatly affected. This may be less likely in Canada Hemlock Forest, given the likelihood of even higher humidities than in the other cove forests, with the dense evergreen canopy and understory.

The spread of the hemlock woolly adelgid (*Adelges tsugae*) through North Carolina from 1995-2005 has severely disrupted almost all Canada Hemlock Forests and leaves the future of these communities and their dominant species in doubt. This introduced insect kills both adult and

juvenile trees. Except where protected by systemic insecticides or occasionally successful biological controls, the hemlock trees in most examples are dead or dying. Living infested or uninfested trees may still be observed in some places, but it is unclear if these represent natural resistance or merely not yet complete spread of the aldegid. All examples of Canada Hemlock Forest therefore are now in a heavily disturbed state, with only a sparse canopy of other tree species. It remains to be seen if natural resistance may develop or if an effective lasting control measure may be found. In the absence of a resurgence of hemlock, it is likely that mesophytic hardwoods will come to be dominant, and that Canada Hemlock Forests will become indistinguishable from Acidic Cove Forests.

The natural relationship of Canada Hemlock Forests to Acidic Cove Forests is unclear. Hemlock is often regarded as a late successional or climax tree, coming to dominate in forests that are long undisturbed. Oosting and Billings (1939) suggest that the marked acidity of the soil caused by the hemlocks may exclude other species. Whittaker (1956) emphasized the competitiveness of the species, noting that hemlock forests often corresponded to a gap in their otherwise continuous distributions of other tree species on environmental gradients. He suggested that, once established, hemlock excludes other species through its dense shade and acidified soil.

Hemlock is extremely shade-tolerant, and the understory of saplings that often is present suggests it could capture all canopy gaps that form above it. The presence of such a hemlock understory in many Acidic Cove Forests might suggest that they too are succeeding to Canada Hemlock Forest. Yet, even before widespread mortality, hemlock did not seem to be rapidly taking over mixed forests. Hemlock widely coexists with other tree species, including ones such as *Liriodendron* that are not considered tolerant of shade. Whittaker's study area on the Tennessee side of the Great Smoky Mountains apparently had much Canada Hemlock Forest, but in North Carolina hemlock more often occurs in mixed stands of Acidic Cove Forests than as a strong dominant. As in other cove forests, the fall of one or a few large old-growth trees may open a gap large enough to allow shade-intolerant species to reproduce. Both Canada Hemlock Forests and Acidic Cove Forests with varying amounts of hemlock exist as old-growth forests that were never logged.

In the more widespread second growth forests, land use history may further confuse interpretation. Hemlock was not a desirable wood, and the species often was left when other trees were cut. Some sites may be seen to have old hemlocks embedded in younger hardwood forests, suggesting that hemlock was mixed with more desired species at the time of selective logging. Given the abundance of hemlock saplings and seedlings, logging might be expected to increase rather than decrease the species. However, slash fires may have eliminated hemlock from some second growth forests and may even have destroyed some unlogged forests. At a later time, hemlock bark was desired for tanneries, and so hemlock was selectively removed at some locations.

The varying abundance of Canada Hemlock Forests may offer clues to its ecological drivers, but it is not yet clear how to interpret these clues. Hemlock is abundant at higher elevations in parts of the Smokies, more so than elsewhere. The Highlands plateau is an area of high rainfall and relatively gentle slopes at moderate elevation, but other areas of high rainfall do not have extensive Canada Hemlock Forest.

It is possible that rare penetration of fire could determine the difference between Canada Hemlock Forest and Acidic Cove Forest, with the former developing only in sites that are more sheltered from fire, or in longer fire-free intervals. This would warrant investigation.

Comments: Canada Hemlock Forests appear to have been recognized in many local studies, e.g., Oosting and Bordeau (1955), Valentine (1983), Feil (1988), and McLeod (1988). They were found in Whittaker's (1956) study in the Smokies and in Newell's (1997) analysis of Linville Gorge and Joyce Kilmer but not Shining Rock. Because of the lack of the concept of Acidic Cove Forest in earlier years, it can be hard in qualitative site descriptions to tell if what was identified would be classified as Canada Hemlock Forest here.

Rare species:
Vascular plants -- *Hexastylis contracta, Hexastylis rhombiformis, Meehania cordata.*

References:

Feil, E.G. 1988. Floristics and vegetation of Chimney Rock Park, Rutherford County, North Carolina. M.S. Thesis, University of North Carolina, Charlotte.

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Valentine, D.W. 1983. Forest vegetation distribution in relation to soils and other environmental characteristics in the Black Mountains of North Carolina. M.S. Thesis, Duke University.

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

CANADA HEMLOCK FOREST (WHITE PINE SUBTYPE)

Concept: Canada Hemlock Forests are mesophytic mountain and foothill forests dominated by *Tsuga canadensis*, with acid-tolerant undergrowth and low species richness. The White Pine Subtype has *Pinus strobus* as a significant component, sometimes codominant.

Distinguishing Features: Canada Hemlock Forest (White Pine Subtype) is distinguished from all other communities by having *Pinus strobus* as a significant component in a forest, at least until recently, dominated or codominated by *Tsuga canadensis*. Associated canopy species and undergrowth are generally the same as in Canada Hemlock Forest (Typic Subtype) but are somewhat different from in White Pine Forest. This subtype should be applied only for mixtures that are apparently of natural origin. Forests in which white pine was planted, where it is not believed to previously have been a component, should be regarded as altered examples of the Typic Subtype.

Synonyms: *Pinus strobus - Tsuga canadensis / Rhododendron maximum - (Leucothoe fontanesiana)* Forest (CEGL007102).
Ecological Systems: Southern and Central Appalachian Cove Forest (CES202.373).

Sites: The White Pine Subtype occurs in sites similar to those of the Typic Subtype and of Acidic Cove Forest: sheltered, mesic, low- to mid-elevation sites, primarily in narrow rocky gorges, steep ravines, and low gentle ridges within coves.

Soils: Soils of the White Pine Subtype are similar to those of the Typic Subtype.

Hydrology: Sites are well drained but mesic due to topographic sheltering and low slope position.

Vegetation: The White Pine Subtype is dominated by a combination of *Tsuga canadensis* and *Pinus strobus*. *Tsuga* is always at least codominant, and *Pinus* may be codominant or present in smaller but appreciable amounts. Other highly constant canopy species include *Acer rubrum, Betula lenta, Liriodendron tulipifera*, *Quercus alba*, *Quercus montana, Quercus rubra, Halesia tetraptera*, and *Carya glabra*. The understory may be dominated by the canopy species, and usually contains *Oxydendrum arboreum, Ilex opaca, Nyssa sylvatica,* and *Magnolia fraseri*. Also frequent are *Cornus florida* and *Sassafras albidum*. *Rhododendron maximum* is generally present and usually forms a dense thicket. *Kalmia latifolia* also is highly constant and may have high cover. Other highly constant or frequent shrubs include *Hamamelis virginiana, Leucothoe fontanesiana,* and *Gaylussacia ursina*; less frequent ones include *Symplocos tinctoria, Calycanthus floridus, Pyrularia pubera,* and *Clethra acuminata*. *Smilax rotundifolia* is usually present and may be abundant. The herb layer is generally sparse, but *Galax urceolata* may occasionally have high cover. Other frequent herb layer species include *Chimaphila maculata, Mitchella repens, Goodyera pubescens, Polystichum acrostichoides,* and *Medeola virginiana*. Less frequent species include *Parathelypteris noveboracensis, Hexastylis shuttleworthii*, *Viola hastata, Eurybia divaricata*, and *Arisaema triphyllum*. As in the Typic Subtype, species richness is low, averaging 27 species per 1/10 hectare. Woody species substantially outnumber herbaceous.

Range and Abundance: Ranked G4. The abundance of this community is uncertain. Very few sites are recorded, but many may be overlooked since earlier site descriptions may not emphasize the pine. Recorded occurrences are concentrated in the southern mountains, especially in the high rainfall area and south-facing Blue Ridge escarpment. Many plots are attributed to this subtype, possibly suggesting it is more abundant than occurrence records indicate. However, most plots are from a few locations, with more than a third from Ellicott Rock Wilderness alone. It is not entirely clear that all plots are good examples of this community. The equivalent association is attributed to South Carolina, Georgia, Tennessee, Kentucky, and possibly Virginia.

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Associations and Patterns: The White Pine Subtype appears to occur primarily as large patches. It may grade to the Typic Subtype or to Acidic Cove Forest. It grades to various oak forests on drier slopes.

Variation: Little is known about natural variation in this subtype.

Dynamics: The dynamics of the White Pine Subtype are generally similar to those in the Typic Subtype. However, the coexistence of two conifer species believed to have rather different life histories warrants further study. Understanding their interaction will be particularly complex given the effects of logging and other land use on populations of white pine.

Where appreciable white pine is present, the death of the hemlock may lead this subtype to be developed into White Pine Forest rather than Acidic Cove Forest.

Comments: This subtype is one of the least well supported communities in the Fourth Approximation, and it is accepted only provisionally. Though an equivalent association is recognized in the NVC, it is not clear that this particular mixture of canopy trees is ecologically more distinct and important than other combinations. It is also less sure than for most associations that it occurs naturally. However, with the widespread mortality of hemlock, this subtype retains a more evergreen structure than the Typic Subtype, a characteristic that may prove important for animal populations and perhaps for ecological dynamics.

It also is ambiguous whether this community should be treated as a subtype of Canada Hemlock Forest or of White Pine Forest. The NVC description emphasizes the pine, and in fact suggests hemlock is not necessarily even present, which would make it indistinguishable from White Pine Forest. A somewhat different circumscription is taken here, emphasizing the hemlock component and treating white pine as an indicator that may be present in smaller amounts.

Rare species:

References: