MOUNTAIN COVE FORESTS

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.

Synonyms:

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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