

# North Carolina Ecosystem Response to Climate Change: DENR Assessment of Effects and Adaptation Measures

*DRAFT*

## Mountain Cove Forests

### **Ecosystem Group Description:**

Cove forests are some of the most well-known and recognized community types in the mountains, occurring on sheltered, moist, low to moderate elevation sites. They are characterized by a dense forest canopy of moisture-loving trees. The Rich Cove Forest type, occurring in the most fertile sites, has a lush herb layer and relatively few shrubs. The high diversity in all vegetation layers makes this forest of great interest to botanists and ecologists. The Acidic Cove Forest, which occurs in less fertile but otherwise similar sites to those occupied by Rich Cove Forests, is dominated by the more acid tolerant species, and has undergrowth dominated by ericaceous shrubs such as rhododendron, rather than by herbs. Canada hemlock forests have similarly dense shrub layers and relatively few herbs. A related but more geologically restricted community, Basic Mesic Forest (Montane Calcareous Subtype), occurs on the rare outcrops of limestone, marble, or dolomite, and are dominated by trees most favored by high pH soils. These communities are naturally relatively stable, uneven-aged climax forests, with trees up to several centuries old.

### **Ecosystem Level Effects:**

#### **Predicted Impacts of Climate Change:**

Climate Change Factor:	Likelihood:	Effect:	Magnitude:	Comments:
Flooding	Med	Neg	Low	Flash flooding will disturb a limited portion of cove forests near streams.
Wind Damage	Med	Neg	Med	Increased storms may cause more canopy gaps.
Mild Winters	High	Neg	Low	Mild winters may allow some invasion in high elevation coves of species usually associated with lower elevations; these may outcompete the species associated with the high elevation sites.
Increased Temperature	High	Neg	Low	Warmer temperatures may stress some species adapted for high elevation, cooler sites, especially if combined with drought.
Fire	Med	Neg	Low	Drought may increase the potential for wild fire.
Drought	High	Neg	Med	Most of these communities occur in topographically sheltered sites that receive runoff from surrounding areas.

This group of communities covers a wide geographic range in the Mountains and foothills. In the northern escarpment, the Climate Wizard mid value for average annual temperature increase by 2050 is 4.2 degrees (Maurer et al., 2007). The range of models is 2.6 to 6.2 degrees. In the southern escarpment, the average annual temperature increase is 3.8 degrees, with a model range of 2.6 to 6.0 degrees. The range in the models for rainfall is also wide: -14 inches to +16 inches in the northern mountains and -15 inches to +15 inches in the southern mountains. The general expectations of increased rain event intensity and increased drought presumably apply to all of this range. However, their effect in the Mountain Region is particularly

unsure. Rainfall in the mountains is extremely variable, ranging from about 40 inches per year to more than 80 inches. The variation is produced by the interaction of topography with regional weather patterns, and it is unclear how climate change will affect it.

Occurrence of Mountain Cove Forests is controlled by topography more than local climate. Similar communities occur from the highest rainfall areas to the lowest, as do the drier communities. Mountain coves are generally very stable environments. Temperatures are moderated by topographic position in the landscape. Moisture is provided by runoff from surrounding areas, as well as seepage and rainfall.

The effect of a changed climate is likely to vary widely among examples of these communities, depending on topographic sheltering, configuration of rocks, soil depth, and amount of overland runoff. Droughts may cause some areas around the margins to dry out and shift to drier communities, but the interior of most coves should generally remain stable despite the changed climate.

Drought may increase the potential for wild fire. There is potential for significant damage to some cove forests, but probably only a limited portion. Topography as well as moisture levels reduce fire intensity in most coves. Most fires at present do little damage. A few, such as recent wild fires in Linville Gorge, have caused severe damage to some cove forests while having no effect on others. In many places, cove vegetation appears to have expanded into more marginal sites in decades of fire suppression. Fire effects are likely to be particularly extreme in these areas, but loss of cove forests in them may represent a return to more natural conditions.

Increased intensity of rainfall will cause an increase in frequency and scale of flash flooding. This will disturb a limited, but significant, portion of cove forests near streams. Some areas may be scoured out and lost as cove forests.

Some high elevation cove forests now serve as refugia for species for which the current climate in lower areas in NC is not suitable. They are likely to continue to do so, but warming temperature and changed moisture regimes may make some of them less hospitable to some of these species. At the same time, these communities may become refugia for additional species that are currently common, if the regional climate becomes unsuitable for them. They may be crucial for the survival of some species in the state.

Wind and ice storm damage may increase. The topographic setting of coves provides some shelter from storm winds.

Increased temperatures may increase the rate at which hemlock wooly adelgid invades natural areas.

### **Predicted Ecosystem Responses:**

Ecosystem Response:	Likelihood:	Effect:	Magnitude:	Comments:
Structural Change	Low	Neg	Low	Increased wind damage will create more gaps and lead to younger overall tree age.
Exotic species invasion	Med	Neg	Med	Increased disturbance and warmer temperatures may facilitate exotic species invasion.
Compositional Change	Low	Neg	Low	Increased wind and fire may increase disturbance-following species at the expense of more stable species.
Acreeage Change	Med	Neg	Low	Drought and flooding may reduce the extent of some cove forests.

Increased drought, especially if coupled with wild fire, is likely to shift the boundary of cove forests, changing

outer, marginal portions to drier communities. This will result in some acreage change, but it is likely to be limited. The more interior portions of most cove forest patches are unlikely to change. Some marginal areas on the edges of cove forests likely represent unnatural expansion in the absence of fire, so that some acreage loss is appropriate. In addition, cove forests will likely spread to some higher elevation areas now occupied by northern hardwood forests. These changes are likely to be gradual, reflected in shifting competitive relationships among plants, but may be more rapid if wind or fire cause severe disturbance.

Increased wind damage will change the structure of forests to some degree, creating more gaps and leading to a younger average age of trees. These effects are likely to be small compared to the effects of logging that has occurred in the past in most examples, but will add to alterations caused by logging. Increased wind damage or fire may also alter the composition of communities, increasing amounts of disturbance-following species at the expense of more stable species. Fire in Acidic Cove Forests dominated by *Rhododendron* may reduce the shrub layer, causing important shifts in the bird communities that depend on shrubs.

Increased disturbance, combined with higher temperatures, also is likely to facilitate more invasion by exotic plants. Most cove forests are not currently prone to significant invasion, but those at the lowest elevations sometimes are. Tree of heaven (*Ailanthus altissima*), princess tree (*Paulownia tomentosa*), Japanese honeysuckle (*Lonicera japonica*), and Japanese stilt grass (*Microstegium vimineum*) are all likely to become problems through much of the range of cove forests. A number of insect pests are also potential threats to cove forests, but it is unclear how climate change will affect them.

## Habitat Level Effects:

### Natural Communities:

Third Approximation Name:	Comments:
Canada Hemlock Forest	The greatest threat to these communities is the hemlock woolly adelgid. All examples may be severely degraded before the climate has changed appreciably.
Basic Mesic Forest (Montane Calcareous Subtype)	This is a very rare community, limited to the few limestone and dolomite outcrops in North Carolina. Its examples have less topographic sheltering than most coves, and could be more subject to the effects of drought and fire. Examples may evolve into a new, equally rare, drier community with time.
Acidic Cove Forest	Acidic Cove Forests are less prone to invasion, but may see some increase. Fire or drought that killed <i>Rhododendron</i> could significantly change the structure of the vegetation and alter the animal community.
Rich Cove Forest	Rich Cove Forests are likely to become very susceptible to invasive plants as warmer temperatures allow invaders of rich soils to thrive at higher elevations.

### LHI Guilds:

Guilds with Significant Concentration in Ecosystem Group:	Comments:
Low Elevation Montane Wet-Mesic Hardwood and Mixed Forests	Includes Montane Floodplain Forests in addition to Cove Forests.
General Montane Wet-Mesic Hardwood and Mixed Forests	Includes Northern Hardwoods in addition to Cove Forests.
Dry-Mesic Montane Basic Hardwood Forests	

Of the guilds that have significant concentration of acreage within this Ecosystem Group, the Low Elevation Montane Wet-Mesic Hardwood and Mixed Forests is virtually entirely contained within this Ecosystem

Group but the rest extend into higher elevations in the mountains or into drier habitats.

## Species Level Effects:

### Plants

Species:	Element Rank:	Endemic	Major Disjunct	Extinction/Extirpation Prone	Status: US/NC	Comments:
Hexastylis rhombiformis	G2/S2	Yes			FSC/T	Endemic to a small range in NC and SC.
Carex radfordii	G2/S1	Yes		Yes	FSC/E	Carex radfordii is intrinsically at risk due to its extreme rarity, limited range, and pristine habitat requirements. Its threats include land-use conversion, habitat fragmentation (it has probably lost habitat on private lands), and forest management practices.
Schlotheimia lancifolia	G2/S1				/T	Narrow endemic known only from North Carolina, with disjunct occurrences in the Dominican Republic. Residential development has occurred over much of its range, but the species has persisted, and apparently thrived, in yards, golf courses, and other developed areas.
Trillium simile	G3/S2	Yes			/SR-L	Trillium simile has a narrow range in the vicinity of the Smoky Mountains and the southern edge of the Blue Ridge Mountains, making it especially vulnerable to land-use conversion and habitat fragmentation, such as second home developments. Forest management practices are a low-level threat to this species (Southern Appalachian Species Viability Project 2002).
Coreopsis latifolia	G3/S3	Yes			/W1	Southern Appalachian endemic.
Aconitum reclinatum	G3/S3	Yes			/SR-T	
Silene ovata	G3/S3				FSC/SR-T	
Brachythecium rotaeantum	G3G4/S1		Yes		/SR-D	Disjunct in the mountains of NC and TN. Grows in moist woods.
Collinsonia verticillata	G3G4/S2				/SR-T	
Entodon sullivantii	G3G4/S2				/SR-O	Occurs in moist woods
Panax quinquefolius	G3G4/S3S4				/W5B-SC	Poaching and exploitation (even on protected lands) are major problems for this species in NC.
Rhabdoweisia crenulata	G3G5/S1		Yes		/SR-D	In North America, found on a wet, shaded ledge of about 330 ft. altitude in a seepage area on the south-facing slope of a gorge. Elsewhere, the moss apparently grows in wet rock habitats (Crum and Anderson 1981). In the US, this species is known from NC and HI.
Trillium pusillum var. ozarkanum	G3T3/S1				FSC/E	
Carex woodii	G4/S3				/SR-P	
Adlumia fungosa	G4/S2				/SR-P	
Hydrastis canadensis	G4/S2				/E-SC	

<i>Synandra hispidula</i>	G4/SH				/SR-T	
<i>Trillium discolor</i>	G4/S1				/T	
<i>Verbesina walteri</i>	G4/S1				/SR-T	
<i>Cardamine dissecta</i>	G4?/S2				/SR-P	
<i>Ditrichum ambiguum</i>	G4?/S1				/SR-P	
<i>Viola walteri</i>	G4G5/S1				/SR-T	
<i>Carex careyana</i>	G4G5/S1				/SR-P	
<i>Diarrhena americana</i>	G4G5/S1				/SR-P	
<i>Caulophyllum giganteum</i>	G4G5Q/S1				/SR-P	North Carolina and Tennessee are the southern limit of the species' range.
<i>Sceptridium oneidense</i>	G4Q/S2				/SR-P	
<i>Robinia hispida</i> var. <i>fertilis</i>	G4T1Q/S1				/SR-O	
<i>Trillium flexipes</i>	G5/SH				/SR-P	
<i>Carex pedunculata</i>	G5/S2				/SR-P	
<i>Trientalis borealis</i>	G5/S1				/SR-P	
<i>Jeffersonia diphylla</i>	G5/S1				/SR-P	
<i>Meehania cordata</i>	G5/S2				/SR-P	
<i>Brachymerium systylium</i>	G5/S1				/SR-D	
<i>Botrychium matricariifolium</i>	G5/S1				/SR-P	North Carolina and Tennessee are the southern limit of the species' range.
<i>Celastrus scandens</i>	G5/S2?				/SR-P	
<i>Botrychium lanceolatum</i> var. <i>angustisegmentum</i>	G5TNR/S1				/SR-P	North Carolina is the southern limit of the species' range.
<i>Brachymerium andersonii</i>	GH/SH	Yes		Yes	FSC/SR-L	The area where the single collection of this moss was found is a remnant of the virgin Canada Hemlock Forest. The dominant plant of the forest community in which <i>Brachymerium andersonii</i> was found is <i>Tsuga canadensis</i> , with scattered cove forest trees, <i>Acer saccharum</i> , <i>Aesculus flava</i> , <i>Liriodendron tulipifera</i> , <i>Betula lenta</i> , <i>Magnolia fraseri</i> , and other hardwoods. The canopy is essentially closed, so little light reaches the forest floor. The understory is not dense, consisting principally of a scattering of <i>Rhododendron maximum</i> , <i>Gaylussacia ursina</i> , <i>Kalmia latifolia</i> , and <i>Leucothoe axillaris</i> var. <i>editorum</i> .

Rich Cove Forests host a great diversity of trees and herbs, and provide habitat for a large number of rare plant species in NC. Climate change is not expected to be a major threat to these species overall. If drought and wildfire become major problems, ferns and bryophytes may suffer the most harm. Logging and development are much more urgent, widespread threats at this time.

### **Terrestrial Animals**

Species:	Element Rank:	Endemic	Major Disjunct	Extinction/ Extirpation Prone	Status: US/NC/WAP	Comments:
<i>Plethodon amplus</i>	G1G2/S1S2	Yes		Yes	/SR/	Restricted to an extremely small range

						in the southern Blue Ridge Escarpment in North Carolina
<i>Desmognathus folkertsi</i>	G1G2/S1	Yes		Yes	/SR/	Restricted to a tiny global range in the mountain of northern Georgia, South Carolina, and extreme southwestern North Carolina.
<i>Plethodon meridianus</i>	G1G2/S1S2	Yes		Yes	/SR/	Endemic to the South Mountains in North Carolina
<i>Plethodon shermani</i>	G2/S2?				/SR/	
<i>Plethodon cheoah</i>	G2/S2?	Yes		Yes	/SR/	Restricted to the vicinity of Cheoah Bald in North Carolina
<i>Plethodon aureolus</i>	G2G3/S2	Yes		Yes	/SR/P	Restricted to an extremely small range in the Unicoi Mountains on the border of NC and TN
<i>Plethodon chattahoochee</i>	G2G3Q/S2?				/SR/P	
<i>Papaipema astuta</i>	G2G4/SH		Yes		/SR/	Northern species known from a single specimen collected in the Black Mountains.
<i>Eurycea junaluska</i>	G3/S2	Yes		Yes	FSC/T/P	Restricted to an extremely small range located on the border of NC and TN
<i>Plethodon jordani</i>	G3/S3?				/W3/	
<i>Speyeria diana</i>	G3G4/S3S4				FSC/W2/	
<i>Desmognathus aeneus</i>	G3G4/S3				FSC/SR/P	
<i>Abrostola ovalis</i>	G4/SU				/W3/	
<i>Limnothlypis swainsonii</i>	G4/S3B				/W2,W5/P	
<i>Dendroica cerulea</i>	G4/S2B				FSC/SR/P	
<i>Celastrina nigra</i>	G4/S2?				/SR/	
<i>Celastrina neglectamajor</i>	G4/S3S4				/W2/	
<i>Autochton cellus</i>	G4/S2				/SR/	
<i>Lithophane joannis</i>	G4/SU		Yes		/W3/	Ohio Valley species recorded a few times in the NC mountains
<i>Plethodon ventralis</i>	G4/S1				/SC/P	
<i>Papaipema polymniae</i>	G4/SU		Yes		/W3/	Northern species known only from one record in North Carolina from GSMNP
<i>Sorex dispar</i>	G4/S3				/SC/P	
<i>Microtus chrotorrhinus carolinensis</i>	G4T3/S3				FSC/SC/P	
<i>Eurycea guttolineata</i>	G5/S5				//P	
<i>Oporornis formosus</i>	G5/S4B				//P	
<i>Napaeozapus insignis</i>	G5/S4				//P	
<i>Plethodon richmondi</i>	G5/S3				/W2/P	
<i>Eurycea longicauda</i>	G5/S1S2				/SC/P	
<i>Sorex fumeus</i>	G5/S4				//P	
<i>Papilio cresphontes</i>	G5/S2				/SR/	
<i>Pseudacris brachyphona</i>	G5/S1				/SC/P	Known in North Carolina only from an extremely small area in Cherokee County
<i>Scopula ordinata</i>	G5/S2S3				/W3/	

Sorex cinereus	G5/S4	//P
Polygonia faunus smythi	G5T3T4/S2	/SR/
Pyreferra citromba	GNR/S1S2	/W2/
Eupithecia cimucifugata	GNR/S1S2	/W2/

Two salamanders are highly restricted to habitats within this Ecosystem Group: Eurycea junaluska and Plethodon aureolus. Both occupy extremely small global ranges and are likely to be strongly affected by increased drought, fire, or storm-created openings in the canopy. Several other salamanders with extremely limited global ranges also have significant amounts of habitat within this theme and are also likely to be threatened by the same set of climate change factors. The same is true for several species of Lepidoptera associated with mesic habitats and that occur in the Southern Appalachians as major disjuncts from the North.

## Combined Threats and Synergistic Impacts:

### Importance of Climate Change Factors Compared to Other Ecosystem Threats:

Threat:	Rank Order:	Comments:
Invasive Species	1	Hemlock wooly adelgid is the greatest threat to Hemlock Forests; invasive species are less of a threat for other communities.
Logging/Exploitation	1	
Development	1	
Climate Change	2	

Unprotected examples of these forests are most threatened by development and logging. Logging causes more drastic alteration of structure and composition than climate change is expected to. While many examples are protected, many unprotected and threatened examples remain. Development can cause indirect effects as well as outright destruction of these communities, creating edge effect and developing seed sources for invasive species.

Exotic species represent a growing threat. Hemlock wooly adelgid is already causing widespread devastation in Hemlock Forests. Emerald ash borer and several other destructive insects represent large potential threats. Invasive plants are a serious and growing problem in lower elevation examples, particularly in those that are disturbed by logging or that occur near developed areas. Some additional invasive plants, such as garlic mustard (*Alliaria petiolata*) and oriental bittersweet (*Celastrus orbiculatus*) are likely to increase regardless of climate change. Others, mentioned above, are likely to become an increased threat because of warmer temperatures and increased disturbance.

Climate change poses several threats, including loss of area in more marginal sites, alteration by increased wind, flood, and fire disturbance, and increased problems with invasive plants. For some protected examples, this is the most severe threat.

## Recommendations for Action:

### Interventive Measures:

Intervention:	Importance:	Feasibility:	Comments:
Stormwater Controls	Low	High	
Preservation of Riparian Buffers/Floodplains	Low	High	
Conduct Prescribed Burns	Low	High	
Protect/Expand Remaining Examples	Mediu	High	
Protect from Wildfire	Mediu	Medium	
Control Invasive Species	High	Medium	Controlling invasive plant species seems feasible, but controlling Hemlock Woolly Adelgid and other invasive animals is much more problematic. Emerald Ashborer may cause significant problems in the future.

While protection from most direct effects of climate change is not possible, the severe threat from increased invasive plants can be reduced by controlling existing populations of them, addressing seed sources along roads and in developed areas, and responding to new invasions quickly. Limiting controllable disturbances and edge effect will also help.

While many examples of cove forests are protected from development and logging, protecting more examples would help these communities weather climate change. It would reduce the loss of acreage as protected examples shrink, and would allow larger, more robust populations of their species to survive. Landscape connectivity will become more important as individual patches become smaller. Because the effect of increased wind, fire, and drought damage is similar to the effects of logging, reduction in logging in these forests would reduce the alteration caused by them. It is most important to protect examples in the most sheltered sites, and those that serve as landscape connections to other patches.

Several other measures could help protect individual occurrences from climate change-related disturbances. Protection of riparian areas and control of impervious surfaces and stormwater runoff will reduce flood damage to cove forests in altered watersheds, as well as protecting the aquatic systems. In addition, cove forests are the most common kind of riparian vegetation in the Mountain Region. Protecting examples in riparian and flood-prone areas from other forms of disturbance will allow them to play more of a role in protecting streams and slowing floods.

Protection from severe wild fire during drought periods may be necessary to prevent catastrophic disturbance of some cove forests. In more favorable periods, prescribed burning of surrounding landscapes would help reduce the risk of controllable wild fires, as well as benefitting the upland communities. Mild prescribed burning in cove forests themselves is unlikely to be harmful if not done frequently, but is not likely to be beneficial. Prescribed burning in marginal areas where cove forests may have expanded, or where shrinkage is inevitable, would help these areas develop new communities more gradually and reduce the potential for catastrophic changes.

## **Ecosystem Group Summary:**

Climate change will likely cause some impacts to Mountain Cove Forests, however, invasive species, logging, and development currently present more severe threats to these communities. Threats associated with climate change that can be expected include alteration by increased wind, flooding, and fire disturbance as well as increased problems with invasive species. Controlling invasive species would increase resilience in these habitats, although combating Hemlock Woolly Adelgid is problematic. Other important adaptation strategies include protecting remaining high quality examples to allow for landscape connectivity and protecting them from catastrophic wildfire.

## **References:**

Louis R. Iverson , Anantha M. Prasad, Stephen N. Matthews, Matthew Peters 2008. Estimating potential habitat for 134 eastern US tree species under six climate scenarios. *Forest Ecology and Management* 254 (2008) 390–406.

Maurer, E.P, L.Brekke, T.Pruitt, and P.B. Duffy. 2007. Fine-resolution climate projections enhance regional climate change impact studies. *Eos Trans. AGU*, 88(47), 504.

---