Carolina hemlock (*Tsuga caroliniana*)

Purpose for Selection

Carolina hemlock is a fairly uncommon coniferous tree endemic to the southern Appalachian Mountains. The species was selected as a MIS because of concerns for its population stability due to insect infestations and to help indicate effects of management on species within Carolina hemlock Forest (Bluff) communities. Carolina hemlock Forest communities are distinguished from other forest community types by their dominance of Carolina hemlock on exposed, rocky sites.

Habitat Relationships

Carolina hemlock occurs primarily in open forests on ridge tops, rocky bluffs, or gorge walls, generally in drier and rockier sites than Canadian Hemlock (*Tsuga canadensis*), but the two sometimes grow in close proximity or even intermixed in humid gorges (Weakley 2000). Carolina hemlock is a very narrow southern Appalachian endemic, occurring only in western North Carolina, eastern Tennessee, southwestern and southcentral Virginia, northwestern South Carolina, and northern Georgia (see Figure 1; USDA Plants Database; Weakley 2000). Carolina hemlock is considered globally secure with a conservation rank of G3 (NatureServe 2005).

Figure 1. Distribution of Carolina hemlock in North America (USDA Plants Database 2001).

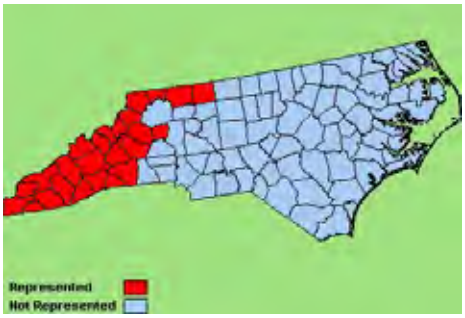

Figure 2. Distribution of Carolina hemlock in North Carolina (USDA Plant Database 2001)

In North Carolina, Carolina hemlock is scattered throughout the southern Blue Ridge Mountains and occasionally in the Piedmont, apparently reaching its eastern limit at Hanging Rock State Park in Stokes County, North Carolina, and ranging east to Halifax County in the Piedmont of Virginia (Weakley 2000). Although this species is known to occur in 25 counties of western North Carolina (Figure 2) it is considered uncommon (state rank S2; BCD 2005) because within this range, habitat for Carolina hemlock is limited (Elias 1980). On the Nantahala and Pisgah National Forests, Carolina hemlock is considered a Sensitive species (USFS 1996).

Carolina hemlock has a stress tolerant strategy, consisting of tolerance to low nutrients and low moisture, tolerance of shade, and slow growth (Humphrey 1989). This species is the dominant species in Carolina hemlock Bluff communities, but individual Carolina hemlock trees also occur in Chestnut Oak or Montane Oak-Hickory Forests (Schafale and Weakley 1990). This species has become a popular Christmas tree, and is now coming into favor as an ornamental tree species (Weakley 2000).

A Carolina hemlock Forest Alliance has been described by ABI (2001) as forests with dense to open canopies dominated by Carolina hemlock; this Alliance follows, in part, the description of Carolina hemlock Bluffs by Schafale and Weakley (1990). Occurrences are typically small, have distinct boundaries, and are generally restricted to rocky bluff habitats. Other associated tree

species include *Quercus prinus, Q. rubra, Pinus rigida,* and *P. pungens.* The shrub stratum is dense and dominated by heath species, including *Rhododendron maximum, Rhododendron catawbiense, Rhododendron carolinianum, Kalmia latifolia, Gaylussacia* spp. and *Vaccinium* spp. The herbaceous stratum is sparse, with typical species including *Gaultheria procumbens, Mitchella repens, Chimaphila maculata, Galax urceolata,* and *Xerophyllum asphodeloides.* Lichens can be abundant. Occurrences of these forests in gorges sometimes have a substantial admixture of Canadian Hemlock.

Suitable Habitat / Population and Trends

We use the following sources of habitat and population data for Carolina hemlock:

- "The Southern Appalachian Vegetation Dataset (SAVD)" (a regional vegetation dataset from the North Carolina Vegetation Survey, Chattooga Ecological Classification, and Winespring Creek Ecological Classification; compiled by Chris Ulrey, 1999.)

- Element occurrence records (BCD 2005).

Permanent Ecosystems Characterization Field Plots

Across the Southern Appalachians Mountains Carolina hemlock occurs in 143 (6%) of the 2,312 SAVD plots used to develop the 1st approximation of Ecological Zones (Table 1). Carolina hemlock is also primarily associated with Carolina hemlock Bluffs (100% freq.; 38.3% cover). It is also associated with Table Mountain Pine/Pitch Pine forests and woodlands, Chestnut Oak forests, rocky summits, and shrub balds. This species is also present in various Mesic and Dry-Mesic Oak forests, White Pine and White Pine-Oak forests, High Elevation Red Oak forests, Hemlock forests and Cove forests, Alluvial forests and Mafic Glades and Barrens, but in very low frequency and abundance.

Carolina hemlock has been documented in 115 (10 %) of the 1,140 plots in the SAVD plots that occur across the Nantahala and Pisgah National Forests (Table 2). Similar to its distribution across the Southern Appalachian Mountains, Carolina hemlock is associated primarily with Carolina hemlock Bluffs (100% freq.; 30.3% cover). This species is also associated with, but not abundant in, Table Mountain Pine/Pitch Pine forests and woodlands (39% freq.; 4% cover), Chestnut Oak forests (25% freq.; 2.2% cover), rocky summits (23% freq.; 1.5% cover), shrub balds (24% freq.; 12.1% cover), and White Pine - White Pine Oak forests (21% freq.; 1.1% cover). Carolina hemlock individuals may be found in various other mesic to dry-mesic oak forests, and in association with Canada Hemlock but they constitute a very minor component of these communities.

Table 1. Distribution and abundance of Carolina hemlock (*Tsuga caroliniana)* within Ecological subgroups across the Southern Appalachians.

				Tsuga caroliniana Present	
Ecological Zone & Plant Community group	**Ecological subgroup (Ulrey 1999)**	**total plots**	**# of plots**	**freq.**	**Cover**
Spruce-Fir	Yellow Birch-Spruce Forests	21	0	0	0
	Spruce forests	42	0	0	0
	Fir forests	13	0	0	0
	Successional vegetation	15	0	0	0
Northern Hardwood	Beech gaps & slopes	6	0	0	0
	Birch-beech-maple forests	120	0	0	0
	Boulderfields	31	0	0	0
High Elevation Red Oak	High Elevation Red Oak or White Oak Forests	132	2	1.5%	0.38%
Acidic Coves	Acidic cove forests	182	2	1%	0.50%
	Hemlock Forests	103	6	6%	2.0%
Rich Coves	Rich cove forests (transition)	8	0	0	0
	Rich cove forests	239	1	<1%	0.50%
Mesic Oak-Hickory	Red Oak - Montane Oak Hickory	230	11	5%	3.3%
Dry-Mesic Oak-Hickory	Oak - hickory forests	360	0	0	0
Chestnut Oak Heath	Chestnut Oak forest	194	41	21%	2.9%
Shortleaf Pine-Oak Heath	Shortleaf Pine/Shortleaf Pine-Oak Forests	73	0	0	0
Xeric Pine-Oak & Oak Heath	**Table Mt. Pine / Pitch Pine forests & woodlands**	**161**	**38**	**24%**	**3.8%**
White Pine-Oak Heath	White Pine and White Pine - Oak Forests	130	10	8%	1.1%
Other zones not mapped ↓	Forested Seeps (acid)	1	0	0	0
	Sphagnum and Shrub Bogs and Seeps	7	0	0	0
	Shrub balds	43	6	14%	12.1%
	Grassy balds and Meadows	15	0	0	0
	Alluvial forests	48	2	4%	0.90%
	Calcareous dry-mesic forests	9	0	0	0
	Carolina hemlock Forests	**18**	**18**	**100%**	**38.3%**
	Cliffs	2	0	0	0
	Emergent narrow-leaved aquatics	2	0	0	0
	Felsic igneous/metamorphic glades & barrens	3	0	0	0
	Mafic igneous/metamorphic glades & barrens	21	1	5%	0.50%
	Montane talus	1	0	0	0
	Riverbank Shrublands	4	0	0	0
	Rocky summits	16	3	19%	1.5%
	Serpentine woodlands	8	0	0	0
	Shale glades & barrens	16	0	0	0
	Successional fields and meadows	4	0	0	0
	Successional vineland	5	0	0	0
	Unclassified	29	0	0	0

Table 2. Distribution and abundance of Carolina hemlock (*Tsuga caroliniana*) within Ecological Subgroups on the Nantahala/Pisgah National Forests.

				Tsuga caroliniana Present	
Ecological Zone & Plant Community group	**Ecological subgroup (Ulrey 1999)**	**total plots**	**# of plots**	**freq.**	**Cover**
Spruce-Fir	Yellow Birch-Spruce Forests	9	0	0	0
	Spruce forests	19	0	0	0
	Successional vegetation	15	0	0	0
Northern Hardwood	Beech gaps & slopes	4	0	0	0
	Birch-beech-maple forests	63	0	0	0
	Boulderfields	11	0	0	0
High Elevation Red Oak	High Elevation Red Oak or White Oak Forests	76	1	1%	0.25%
Acidic Coves	Acidic cove forests	94	2	2%	0.50%
	Hemlock Forests	64	6	9%	2.0%
Rich Coves	Rich cove forests	149	0	0	0
	Rich cove forests (transition)	8	0	0	0
Mesic Oak-Hickory	Red Oak - Montane Oak Hickory	145	6	4%	2.9%
Dry-Mesic Oak-Hickory	Oak - hickory forests	76	2	3%	0.9%
Chestnut Oak Heath	Chestnut Oak forest	139	35	25%	2.2%
Shortleaf Pine-Oak Heath	Shortleaf Pine/Shortleaf Pine-Oak Forests	1	0	0	0
Xeric Pine-Oak & Oak Heath	**Table Mountain Pine / Pitch Pine forest & woodlands**	**91**	**35**	**39%**	**4.0%**
White Pine-Oak Heath	White Pine and White Pine - Oak Forests	48	10	21%	1.1%
Other zones not mapped	Alluvial forests	14	0	0	0
	Calcareous dry-mesic forests	1	0	0	0
	Carolina hemlock Forests	**9**	**9**	**100%**	**30.3%**
	Emergent narrow-leaved aquatics	1	0	0	0
	Felsic igneous/metamorphic glades & barrens	2	0	0	0
	Forested Seeps (acid)	1	0	0	0
	Grassy balds and Meadows	11	0	0	0
	Mafic igneous/metamorphic glades & barrens	8	0	0	0
	Riverbank Shrublands	2	0	0	0
	Rocky summits	13	3	23%	1.5%
	Serpentine woodlands	8	0	0	0
	Shale glades & barrens	6	0	0	0
	Shrub balds	25	6	24%	12.1%
	Sphagnum and Shrub Bogs and Seeps	3	0	0	0
	Successional fields and meadows	2	0	0	0
	Unclassified	22	0	0	0

Current and past age-class distribution

Stands supporting Carolina hemlock have not been intensively examined and therefore few details are available concerning stand age and successional stage. However, sites that support Carolina hemlock are considered not suited for timber production, i.e. site index for yellow pine is less than 60, and therefore, little timber harvest would have occurred in these areas in the past. No currently timber harvest occurs in Carolina hemlock bluff communities.

Element occurrence records

The Biological and Conservation Datasystem (BCD) is the central information management system that the State of North Carolina's Natural Heritage program uses and updates. The most current (2005) update documents eight examples of Carolina hemlock Bluffs on the Forests - one on the Nantahala NF, and seven on the Pisgah NF (Table 3). Elevations range from 2200 feet in Linville Gorge Wilderness, to 4800 feet in the high elevation in Shining Rock Wilderness near Cold Mountain. These sites are typically small, consisting of scattered groves of trees. It is estimated that less than 100 acres of Carolina hemlock Bluffs probably occur on all Nantahala / Pisgah NF land (Alan S. Weakley, pers. comm.).

Table 3. Element occurrences of Carolina hemlock Bluff communities on the Nantahala and Pisgah National Forests (BCD 2005).

National Forest	District	Site	Elevation (feet)
Nantahala NF	Highlands	Kelsey Tract RHA	4100
Pisgah NF	Grandfather	Beartree Ridge	3200
Pisgah NF	Grandfather	Linville Gorge Wilderness	2200
Pisgah NF	Pisgah	Cold Mountain	4800
Pisgah NF	Appalachian	Rock Knob	3800
Pisgah NF	Grandfather	Walnut Ck-Twin Tunnels	3600
Pisgah NF	Grandfather	Buckeye Knob	3200
Pisgah NF	Appalachian	Spruce Pinnacle	4600

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Suitable Habitat and Trend Summary

- Carolina hemlock occurs in 6% of all SAVD field plots and 10% of those plots sampled on the NP; it is a relatively uncommon species on the Forest.
- There are eight documented occurrences of Carolina hemlock Bluff communities on the Nantahala / Pisgah National Forests.
- Sites that support Carolina hemlock are considered not suited for timber production and therefore little timber harvest would have occurred in these areas in the past and currently there is no timber harvest in Carolina hemlock bluffs.

Effects of Management

Conservation Status

Carolina hemlock is a Regional Forest's sensitive species. Potential effects on sensitive species are determined at the project level, and cumulative effects are analyzed anytime a potential adverse effect in the analysis process or "may impact" determination occurs ((Nantahala / Pisgah Land and Resource Plan, EIS, pg. K-38, 39). The decision to allow the impact to take place must not result in a loss of species viability or create significant trends toward Federal listing. Site-specific analysis conducted by botanists and wildlife biologists also provides information on unique communities within a project area. The Plan (LRMP, Amendment 5, pg. III-23) directs the protection of Carolina hemlock Bluffs when identified as unique in the botanical or wildlife analysis.

Carolina hemlock Bluffs occur almost entirely within management areas not suitable for timber production Management Areas (MA). Most Carolina hemlock bluffs occur in areas designated as a Special Interest Areas or Wilderness (Table 4).

Effects of Insect Pests and Management Actions

Native to Japan, the Hemlock Woolly Adelgid (HWA) is a serious pest in the United States of eastern hemlock and a threat to Carolina hemlock. The range of HWA is expanding rapidly each year. HWA is currently established in eleven eastern states from North Carolina to Massachusetts and tree decline and mortality has increased at an accelerated rate since the late 1980's. If some type of control is not implemented the entire hemlock resource within eastern forests could be lost in just a few decades.

The US Forest Service, NFsNC is implementing a program to suppress infestation of HWA and establish long-term Carolina hemlock conservation areas. A suite of predator beetles, that prey specifically on HWA, are being released in 159 hemlock stands (47 in Carolina hemlock) to limit some current infestations of HWA while helping to establish reproducing populations of these

predators in the wild. Long-term, the hope is these beetles would gain a permanent foothold in the Forests. Up to half of these areas would also have different groups of trees treated with a systemic insecticide to ensure a portion of the hemlock population remains alive until effective biocontrol is established.

Treatments would be repeated after effectiveness declines if evidence of new infestation is present. Treatment would cease when effective biocontrol agents become established or the HWA threat is otherwise diminished, based on annual situation reports from Forest Health Protection.

Nearly all known stands of Carolina hemlock are planned for treatment including stands in two areas not identified as Carolina hemlock bluffs. Both beetle release and chemical control (soil and stem injection with systemic insecticides) will be used in most of the 10 major areas where these stands occur (Table 4).

Table 4. Woolly Adelgid Treatment areas with Carolina hemlock

Site	Elevation (feet)	Treatment	Management Area
Kelsey Tract RHA	4100	Release beetles Chemical	Special Interest Area (13)
Beartree Ridge	3200	Release beetles	4C
Linville Gorge Wilderness	2200	Release beetles Chemical	Wilderness (7)
Cold Mountain	4800	Release beetles	Wilderness (7)
Rock Knob	3800	None	3B
Walnut Ck-Twin Tunnels	3600	Release beetles Chemical	Semi-primitive Non-motorized (5)
Buckeye Knob	3200	Release beetles Chemical	Semi-primitive Non-motorized (5)
Spruce Pinnacle	4600	Release beetles Chemical	Wilderness Study Area (6)
Carolina hemlocks Campground	2800	Release beetles Chemical	Developed Rec. Area (12)
Locust Ridge	4000	Release beetles Chemical	2C

Evaluation

In the Nantahala / Pisgah LRMP Amendment 5, the current strategy for managing Carolina hemlock bluffs appears to be adequate to support suitable habitat conditions for Carolina hemlock. The strategy is predominately one of protection.

The forest-wide trend for Carolina hemlock Bluffs was considered upward prior to the HWA outbreak because: (1) xeric forests where Carolina hemlock occurs are still in a stage of re-growth since 'turn of the century' logging affected most forests in Western North Carolina, and (2) sites that support Carolina hemlock are considered not suited for timber production, i.e. site index for yellow pine is less than 60, and therefore, little timber harvest that would occurred in these areas. Past, current, and future projects including prescribed burning are not likely to affect this forest-wide trend since these activities rarely occur in this biological community. However, because of the rapid advancement of HWA infestation and current damage to the species, **the population trend for Carolina hemlock is considered downward.**

Implementing HWA control treatments, will not be sufficient to reverse the downward habitat trend of Carolina hemlock Bluffs. Stem and soil injection of systemic insecticides, and release of

HWA predator beetles will save numerous trees but many more untreated trees will die. As predator beetles come into equilibrium with HWA populations, Carolina hemlock Bluffs should stabilize in the future but at reduced levels.

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