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Suppression of Hemlock Woolly Adelgid Infestations

Pisgah National Forest: Haywood, Madison, Avery, Burke, Caldwell, McDowell, Buncombe, Henderson, Mitchell, Transylvania, and Yancey Counties, North Carolina

Nantahala National Forest: Graham, Swain, Jackson, Macon, Cherokee, and Clay Counties, North Carolina

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Table of Contents

Abstract 1

Chapter 1 – Purpose and Need 3
1.1 Proposed Action 3
1.2 Need for the Proposed Action 5
1.3 Project Objectives 7
1.4 Decision to be Made 8
1.5 Scoping 8
1.6 Significant Issues Related to the Proposed Action 8
1.7 Other Issues 8

Chapter 2 – Alternatives Including the Proposed Action..... 11
2.1 Alternative Considered in Detail 11
Alternative A 11
Alternative B 11
Alternative C 13
2.2 Alternatives Considered But Not Evaluated in Detail 14

Chapter 3 – Affected Environment and Environmental Consequences 17
3.1 Botanical Resources.....18
3.2 Terrestrial Wildlife Resources 25
3.3 Aquatic Resources 36
3.4 Management Indicator Species Population Trend Information 42
3.5 Threatened, Endangered, Sensitive and Forest Concern Species.....58
3.6 Scenery and Recreation 104
3.7 Wilderness.....107
3.8 Heritage Resources 113
3.9 Road Management 114
3.10 Soil Resources.....114
3.11 Human Health and Safety 115
3.12 List of Preparers and Agencies/Persons Consulted 116

Appendix A – Hemlock Areas Selected for Treatment 119
Appendix B – Hemlock Conservation Design.....133
Appendix C – Hemlock Frequency Information 153
Appendix D – Biological Evaluation 155
Appendix E – Wilderness Considerations 169
Appendix F – Economic Assumptions 175
References 179

ABSTRACT:

The National Forests in North Carolina are proposing to treat selected hemlocks in Nantahala and Pisgah National Forests (hereafter referred to as "the Forests"), including designated wilderness, to suppress infestations of the non-native insect pest Hemlock Woolly Adelgid (HWA). The treatments would focus on the release of biocontrol agents such as predatory beetles on up to 159 hemlocks areas across the Forests. The purpose would be 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, continue to eat large quantities of HWA and thereby effect an overall reduction in hemlock death from HWA. 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. This project would begin in 2005.

Project objectives are to: (1) Reduce hemlock mortality from HWA by establishing reproducing populations of predator beetles that feed on HWA; (2) Maintain reproducing populations of Eastern Hemlock and Carolina Hemlock throughout the historical geographic and elevational range across the Forests, and; (3) Ensure survival of certain ecologically and culturally important groups of hemlocks.

Use of insecticides as a control measure for HWA would be a significant issue related to the proposed action.

A total of five alternatives were considered; three alternatives are analyzed in detail. These three are a No Action alternative (Alternative A), the Proposed Action (Alternative B), and one alternative developed to address potential impacts from using insecticide (Alternative C). Two alternatives were considered but eliminated from detailed study. These were an alternative that utilized spraying trees with insecticidal soaps and oils, and an alternative that did not include treatments in wilderness.

The activities in the three alternatives considered in detail are summarized in Table A-1.

Table A-1. Activity Summary for Each Alternative Considered in Detail

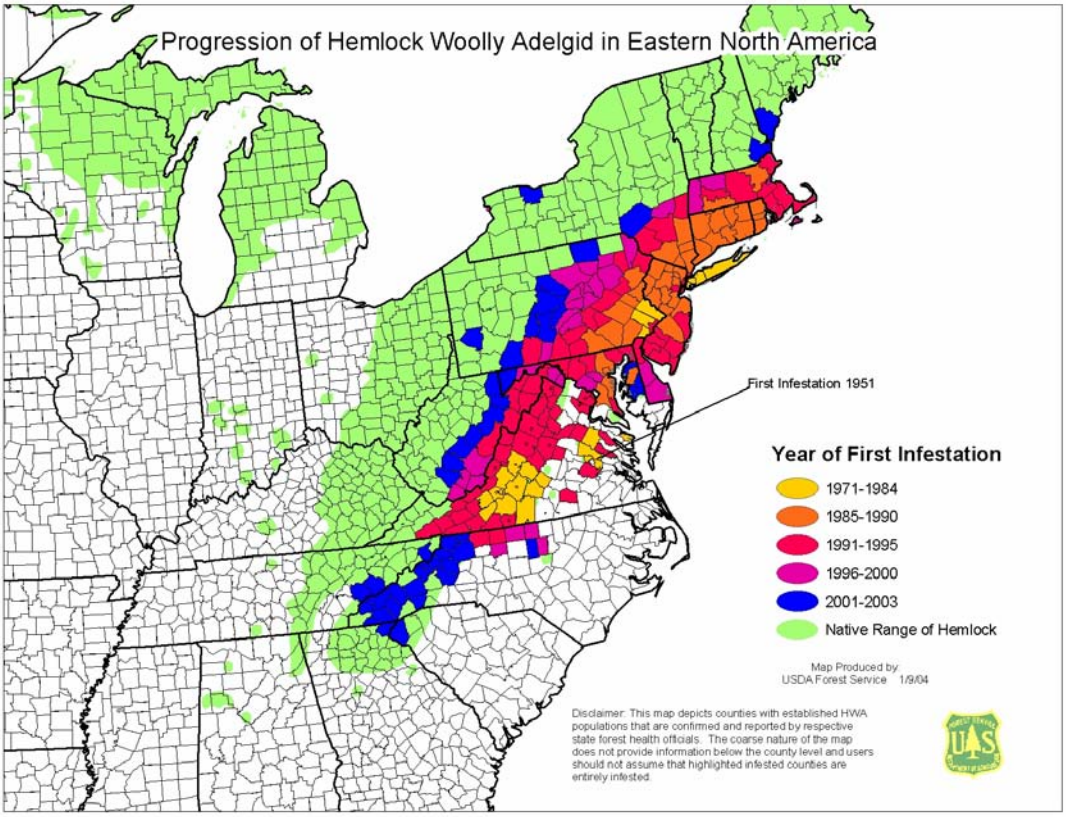
Activities	Alt. A	Alt. B	Alt. C
Release of predator beetles in as many as 159 areas	NO	YES	YES
Treatment of groups of trees with a systemic insecticide in as many as 79 areas	NO	YES	NO

Each alternative is evaluated in regard to how well it meets the purpose and need for the proposed action, and according to environmental impacts for each relevant resource area. Table A-2 compares how each alternative addresses the project objectives and the significant issue.

Table A-2. Comparison of How Alternative Address Project Objectives and Significant Issue

Objective	Measure	Alternative A	Alternative B	Alternative C
Promotes reduced hemlock mortality by establishing predators	**Beetle Release**	**NO**	**YES**	**YES**
Successfully maintains reproducing hemlock populations	**Likelihood of success where 1 = highest and 3 = lowest**	**3**	**1**	**2**
Successfully maintains survival of important trees	**Likelihood of success where 1 = highest and 3 = lowest**	**3**	**1**	**2**
Significant Issue	**Measure**	**Alternative A**	**Alternative B**	**Alternative C**
Use of Chemical Treatment	Approximate Annual Amount Used	NONE	Approx. 60 lbs. of Merit to treat approx. 2400 trees (approximately 0.0075% of all hemlocks on the Forests ≥ 1" diameter)	NONE

Figure 1-1.



1. PURPOSE AND NEED FOR ACTION

1.1 Proposed Action

The National Forests in North Carolina are proposing to treat selected hemlocks in Nantahala and Pisgah National Forests (hereafter referred to as "the Forests"), including designated wilderness, to suppress infestations of the non-native insect pest Hemlock Woolly Adelgid (HWA). The treatments would focus on the release of biocontrol agents such as predatory beetles on up to 159 hemlock areas across the Forests. Several hundred to several thousand beetles would be released per area, depending on established protocols for each beetle species. "Areas" are approximately 125 acres in size.

The purpose would be to limit some current infestations of HWA while helping to establish reproducing populations of these predators in the wild. Long-term, the hope is that these beetles would gain a permanent foothold in the Forests, continue to eat large quantities of HWA and thereby help bring about an overall reduction in hemlock death from HWA.

Up to half of these areas would also have different groups of trees treated with a systemic insecticide to ensure an adequate gene pool remains alive until effective biocontrol is established. This project would begin in 2005.

Approximately 112 eastern hemlock (*Tsuga canadensis*) and 47 Carolina hemlock (*Tsuga caroliniana*) areas would be prioritized annually for biocontrol based on

criteria such as degree of HWA infestation and the health of the trees. These 159 areas are dispersed across the Forests to meet the requirements of a hemlock conservation design outlined in Appendix B. This design calls for a distribution of hemlocks across physiographic zones and elevation ranges.

The biocontrol agents would be predatory beetles that have had their biology and environmental safety thoroughly evaluated, and that meet USDA risk assessment criteria for release (Hennessey, R. 1995, Salom, S. 1998, Zilahi-Balogh, G.M.G. 2001, Montgomery et al. 1997, Lu and Montgomery 2001, Butin et al. 2002) . Currently, these beetles are the non-native predators *Sasajiscymnus tsugae* , *Scymnus sinuanodulus* and *Scymnus ningshanensis,* and *Laricobius nigrinus* which is presumed native to the Pacific Northwest. See Figures 1-2, 1-3, 1-4, and 1-5. Hopefully, establishing a suite of predator beetles would keep the HWA population checked and reduce hemlock mortality.

The number of beetles released at an area would vary by species but would range from several hundred to several thousand. Release areas were selected from a list of outstanding hemlock areas including Natural Heritage sites, Special Interest Areas identified in the Nantahala/Pisgah land management plan, and additional hemlock areas identified from other sources as having important ecological and/or cultural values. Many of these important hemlock areas occur in designated Wildernesses. Other known hemlock areas were added as needed to fill gaps in the hemlock conservation design. Specific hemlocks within the areas would be evaluated as suitable for release based on evaluation criteria developed from observations of previous successful releases.

Insecticide would be used as a stop gap measure to keep specific groups of trees alive in half the hemlock conservation areas. The predator beetles are expected to take years to establish widespread reproducing populations, and adelgid populations are already at a level where there is no assurance that currently infested trees can survive. Treating some trees with a systemic insecticide would kill the adelgids feeding on those trees, allowing them to recover from the attack (Webb et al. 2003). This would ensure that a broad gene pool of hemlocks remain alive in their native environment until biocontrol takes effect. For these groups of trees the treatment would be the systemic insecticide imidacloprid injected into the soil at the base of the tree (“soil injection”) or injected directly into the trunk of the tree (“stem injection”). Figure 1-6 depicts imidicloprid being injected into the soil at the base of an infested hemlock. The insecticide, once successfully taken up by the tree, is generally effective for at least two years for soil injection and at least one year for stem injection. 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 (USDA Forest Service).

1.2 Need for the Proposed Action

1.2.1 Hemlock Woolly Adelgids could kill almost all Eastern Hemlocks and Carolina Hemlocks across Pisgah and Nantahala National Forests over the next 10 to 20 years.

HWA is a non-native species that poses an imminent threat to hemlock communities, which are an important component of the native forest ecosystems.

The National Forest Management Act gives the USDA Forest Service statutory responsibility to maintain the diversity of tree species. In 2002, Forest Inventory and Analysis (FIA) data indicated that Western North Carolina (WNC) contained over 95 million hemlocks one inch or greater in diameter, of which approximately 32 million, or about one third, were on National Forest System (NFS) lands. FIA data show that hemlocks make up a larger share of the trees on Pisgah and Nantahala National Forests than on the surrounding privately owned forests. Also, a disproportionate share of the larger hemlocks (40% of those at least 20 inches in diameter) are on NFS lands (see Appendix C).

Eastern hemlock is the second most common conifer after white pine, and the seventh most common of the approximately 130 tree species in these forests (Brown, 2002). Approximately 6% of all the trees in the Forests are hemlocks. Carolina hemlocks make up a tiny proportion (less than 1%) of all hemlocks in North Carolina.

While hemlock is an important component of many forests in the eastern United States, some of the most notable examples of old growth hemlock occur on National Forest System lands in North Carolina, notably in some of our Wilderness areas. Loss of a sizable amount of the hemlock component would change the nature of these forests.

The HWA is a non-native species first collected from hemlock in the eastern United States on April 25, 1951, in Richmond, Virginia. It was collected in Pennsylvania in 1969 and in Maryland in 1973 and has established itself as a serious pest on hemlocks in the eastern United States (Stoetzel 2002). See Figure 1-1. Thirteen years of monitoring HWA in New Jersey indicate tree mortality occurred within 5 to 6 years after a stand became heavily infested, with more than 90% mortality in about 10 to 12 years (Mayer et al. 2002).

In 2001, HWA infestations were detected in a few areas of the Forests. They may have been present but undetected for several years before this. By 2004, mortality was occurring in some stands and the insect was widespread. Based on observations of the high rate of mortality in states such as Virginia and New Jersey, quick action is needed to reduce widespread hemlock deaths.

Releasing non-native predator beetles can potentially reduce the threat.

Studies of HWA-consuming predator beetles native to the Eastern United States have not shown any capacity to eat enough HWA to effectively reduce hemlock mortality. In part, this may be due to life-cycles non-synchronous with the HWA life-cycle (HWA Newsletter No. 3, Sept. 1998). In contrast, predatory beetles from other areas

have demonstrated a potential to reduce HWA populations significantly. These beetles were collected from China and Japan where HWA originated, and from the Pacific Northwest where western hemlock has survived HWA infestation. These species demonstrate a life-cycle more synchronous with and more dependent upon HWA.

Studies have shown the beetles are able to reduce HWA populations on release trees and adjacent trees, reproduce in the wild, overwinter, and disperse to new areas. Some infested hemlocks, especially those on productive sites, show recovery when HWA numbers decline (Cheah and McClure 2002).

Chemical treatments can ensure survival of specific trees

Separate trials demonstrated that soil injection of the insecticide imidacloprid was 99.9% and >98% effective in eliminating HWA from specific trees (Steward and Horner 1994, Stewart el al. 1998). Webb et al. (2003) found that hemlocks recovered dramatically with new growth once HWA were reduced following imidacloprid treatment. While large scale or long-term use of this chemical would be impractical, short-term use would allow more trees to survive longer. Delaying mortality for several years could allow enough time for some biocontrols to take effect. Then these trees would be in good condition to contribute to regeneration and restoration of the hemlock community.

Stem injection of imidacloprid is currently regarded as less effective in controlling HWA and not as long lasting as soil injection. Stem injection can also damage the tree itself. It would be a tool for trees in situations where soil injection is inappropriate such as proximity to water or highly permeable soils. It is possible that new technology would make stem injection more feasible in the next few years.

1.2.2 Widespread hemlock death would degrade aquatic habitats.

Hemlock is common in riparian areas and plays an important role in maintaining cool stream water temperatures, preventing erosion on steep banks, and providing shelter to wildlife by moderating temperatures in cold winter months and during hot summer days. Brook trout are found more commonly in streams associated with hemlock ecosystems because of the shaded cooling effect of the hemlock canopy. Studies from Delaware Water Gap National Recreation Area found brook trout three times more likely to occur in hemlock bordered streams than in hardwood bordered streams. The average number of aquatic macroinvertebrate taxa found in hemlock bordered streams was 37% greater than that found in hardwood bordered streams (Evans, 2002). The implication is that widespread hemlock loss could result in a loss of species diversity and changes in species distribution.

1.2.3 Widespread hemlock death would reduce habitat for Neotropical migratory birds.

Hemlock forests increase bird diversity at a landscape scale (Ross 2002). While bird species richness is typically lower in hemlock forests than hardwood forests, several species common in hemlock forests are rare in hardwood forests. Birds common in hemlock forests and that use hemlock for breeding habitat include the blackburnian

warbler (*Dendroica fusca*), and the black-throated green warbler (*Dendroica virens).* Populations of these species might decline as hemlock forests decline (Ross 2002).

1.2.4 Widespread hemlock death would result in a loss of scenic and other aesthetic values, and would degrade some recreation experiences.

Hemlocks are an exceptional component of the mountain forest scenery in Western North Carolina. In addition to providing a year-round scenic backdrop for many viewpoints and a more scenic overall driving experience, they may enhance the scenery by blocking less pleasing areas, providing site and sound buffers between recreationists and distractions such as roads or other developments, and providing welcome shade for outdoor activities. Widespread hemlock loss would result in undesirable changes to many recreation experiences. The presence of dead hemlocks would also increase the danger of fallen snags and roads and trails blocked by fallen trees, thus making some recreational activities more hazardous.

1.2.5 Widespread hemlock death would change the wilderness character in congressionally designated wilderness areas.

Wilderness is a unique and valuable resource. In addition to offering primitive recreation opportunities, it is valuable for its scientific and educational uses, as a benchmark for ecological studies, and for the preservation of historical and natural features (FSM 2320.1). While it is important to manage for both naturalness and wildness, large scale ecological changes caused by unnatural influences such as exotic pests present difficult choices for the management of Wilderness.

Hemlock is an important component of several Wildernesses in the Forests. Loss of this component would constitute an unnatural loss of Wilderness resources by an exotic pest. Hemlock is an important component of wilderness ecology and character by being a distinct visual asset and by providing an old growth component. While treatments would constitute a trammeling of “wildness” due to human activity, they would in contrast act to help preserve the “naturalness” of the native vegetation. Treatments would make possible the protection of the biological benchmark value of Wilderness.

1.3 Project Objectives

1. To reduce hemlock mortality from HWA by establishing reproducing populations of predator beetles that feed on HWA. Each alternative would be evaluated as to whether or not it promotes the establishment of predator beetle populations.

2. To maintain reproducing populations of Eastern Hemlock and Carolina Hemlock throughout the historical geographic and elevational range across the Forests. These would be sources of genetic diversity and potential sources of natural regeneration for future hemlock restoration, should that become necessary. To evaluate how well each alternative meets this objective, alternatives would be relatively ranked, most-to-least, according to the assurrance each provides that a wide range of reproducing populations of hemlock can be maintained.

3. To ensure survival of certain ecologically and culturally important groups of hemlock. There are specific named hemlock groves that are highly valued for the character they perpetuate. Hemlocks such as the big trees in Joyce Kilmer Memorial Forest (within the Joyce Kilmer-Slickrock Wilderness) are one example. To evaluate how well each alternative meets this objective, alternatives would be relatively ranked, most-to-least, according to the assurrance each provides that these trees survive HWA.

1.4 Decision To Be Made

The decision to be made by the Regional Forester is:

Should the USDA Forest Service pursue the goal of maintaining hemlock across Nantahala and Pisgah National Forests by attempting to establish reproducing populations of natural enemies of HWA, and through the use of insecticides in specific locations. The Regional Forester has the authority to decide whether or not to include for treatment those important hemlock areas inside Wildernesses, and to determine the minimum tool needed for treatment in Wilderness.

1.5 Scoping

In June 2004 after initial internal scoping with a Forest Service interdisciplinary team, a scoping letter was distributed to over 300 individuals and organizations on the Nantahala-Pisgah mailing list. The letter was also posted on the Forests' website. Approximately 25 responses were received. Most responses expressed overwhelming support for the project, including both beetle release and use of insecticide. However some responses, while supporting beetle release, were not supportive of using insecticide, particularly the method of injecting imidacloprid into the soil at the base of the tree. Respondents from the North Carolina Division of Environment and Natural Resources recommended a cautious approach for both beetle release and insecticide use. The USDI Fish and Wildlife Service recommended monitoring to ensure the beetles do not impact species other than HWA. Several other commenters suggested monitoring would be appropriate. Other points of view included one individual who recommended more widespread use of insecticide until biocontrol was proven effective; and one individual who recommended employing field rearing of predator beetles using volunteer groups. More than one commenter asked that the scope of the project be expanded to include all public lands in the Southern Appalachians, or to include collecting hemlock seed for a seed bank.

1.6 Significant Issue related to the Proposed Action

Use of insecticide as a control measure for HWA. Commenters cite concerns specific to the use of imidacloprid, especially when injected into soil around the base of the tree. Respondents are concerned about the potential for impacts to invertebrates other than HWA, and the potential for leaching into water.

To respond to this issue, an alternative was developed that does not include insecticide.

1.7 Other Issues

1. Expanding the proposal to include all Southern Appalachian public lands. This idea has merit and was discussed by managers prior to establishing this ID Team. Managers felt that the broad coordination required for such an effort would be time consuming and as a result the project might not be ready for implementing by the beginning of 2005. However, informal discussion and exchanges of information with adjacent public land managers indicate they may be able to use this proposed action and environmental assessment to speed development of something similar for the public lands under their jurisdiction.

2. Expanding the proposal to include collecting seed for a seed bank. Seed collection is already happening separately from HWA control efforts, and therefore it is unnecessary to include it in this proposed action.

3. Expanding the proposal to include field-based rearing operated primarily by volunteers. While this technique may be available in the future it is not well enough developed for use now. There is precedence for the use of field insectaries for propagation of biological control agents, though seldom in a forest environment. Kok and Salom (2002) report development of a field insectary for propagation of the HWA predator *Laricobius nigrinus* in a seed orchard in Virginia. They also report some problems associated with the use of field insectaries. If practical techniques are devised they could become part of a future proposed action.

4. Monitoring the released beetles for any indications of a shift in choice of prey. The USDA studied these beetles for years before approving them for release, and "host range" is one of the attributes evaluated. In the case of these beetles, they are all extremely adelgid specific in their nutritional requirements and require adelgid eggs to grow to maturity. They will occasionally consume adelgids other than HWA in laboratory tests, and *S. tsugae* is known to consume balsam woolly adelgids (another non-native invasive forest health threat). They have not shown any ability to survive by eating adelgids that are considered an important food source for any species at risk.

5. Effects of the project on Wilderness. This issue is addressed by an Alternative Not Considered in Detail (see Chapter 2), and in the analysis in Chapter 3.

6. Effects of the project on Threatened, Endangered, and Sensitive species. This issue would be addressed through the analysis in Chapter 3.

7. Effects of the project on Management Indicator Species. This issue would be addressed in the analysis in Chapter 3.

Figure 1-2. *Sasajiscymnus tsugae* attacking HWA

Figure 1-3. *Scymnus sinuanodulus* on hemlock

.

Figure 1-4. *Laricobius nigrinus* adult attacking HWA

Figure 1-5. *Laricobius nigrinus* larva attacking HWA

Figure 1-6. Imidacloprid injected into soil at base of infested hemlock

2. ALTERNATIVES INCLUDING THE PROPOSED ACTION

This chapter presents a detailed description of the alternatives. These alternatives were developed by the interdisciplinary team in response to the purpose and need and the significant issue identified for this project. Mitigation measures for activities in each alternative, if any, are also described in this chapter. Table 2-1 summarizes the management activities for each alternative. All amounts are approximate.

Table 2-1. Activity Summary for Each Alternative Considered in Detail

Activities	Alt. A	Alt. B	Alt. C
Release of predator beetles in as many as 159 areas	NO	YES	YES
Treatment of groups of trees with a systemic insecticide in as many as 79 areas	NO	YES	NO

See Appendix A for a table listing specific areas and maps showing the approximate locations of treatment areas.

2.1 Alternatives Considered in Detail

2.1.1 Alternative A – No Action

This alternative proposes no forest-wide activities to meet the objectives outlined in Chapter 1: (1) To reduce hemlock mortality from HWA by establishing reproducing populations of predator beetles that feed on HWA; (2) To maintain reproducing populations of Eastern Hemlock and Carolina Hemlock throughout the historical geographic and elevational range across the Forests, and; (3) To ensure survival of certain ecologically and culturally important groups of hemlock.

2.1.2 Alternative B – Proposed Action

1. **Releases of Predator Beetles That Eat HWA to Establish Long-Term Population Control**

Hemlocks in approximately 112 eastern hemlock and 47 Carolina hemlock areas would be potential areas for releases of the predator beetles *Sasajiscymnus tsugae, Laricobius nigrinus, Scymnus sinuanodulus* and *Scymnus ningshanensis.* Each year these areas would be prioritized for releases with consideration for geographic distribution and to ensure releases in both eastern hemlock and Carolina hemlock stands. The number of releases each year would depend on the available supply of beetles. The desire would be to release beetles at all areas that have trees sufficiently infested (showing evidence of adelgids at most leaflet intersections).

See Appendix A for a table listing specific areas and maps showing the approximate locations of treatment areas.

The 159 potential release areas were selected to meet the requirements of a hemlock conservation network designed to capture community diversity within the distribution of known hemlock stands. This design is described in Appendix B. Areas that would form the conservation network were selected from a list of outstanding hemlock areas

including Natural Heritage sites, Special Interest Areas identified in the Nantahala/Pisgah land management plan, and additional hemlock areas identified through internal and external scoping as having important ecological and/or cultural values. In a few instances hemlock stands not recognized as ecologically or culturally important were added to the network to fill a gap in the design.

The number of beetles released at an area would vary by species according to established release protocols developed by Forest Health Protection and university researchers who study the insects. Current protocols call for several hundred to several thousand beetles to be released per area.

Specific hemlocks within the areas would be evaluated as suitable for releasing beetles. These would be trees that are infested with HWA to the degree that evidence of adelgids can be seen at most leaflet nodes. The trees themselves, as well as nearby trees, should still be healthy enough to be putting on new growth. The objective is to find a spot with enough HWA so the beetles can successfully feed and reproduce, and where other similarly infested hemlocks are nearby so it is possible for the beetles to disperse.

A representative sample of release areas would be monitored at six months and one year to determine if the beetles are still present, if they have successfully overwintered, and if and how far they have dispersed. The condition of the release trees would also be noted.

This alternative proposes the following number of beetle release areas in Wilderness (W) and Wilderness Study Areas (WSA): Linville Gorge W – 11; Joyce Kilmer-Slickrock W – 5; Shining Rock W – 3; Ellicott Rock W – 3; Craggy Mountains WSA – 4; Lost Cove WSA – 1; Harper Creek WSA – 2. See Appendix A for locations.

2. Chemical Treatment for Maintaining Genetic Reserves

Specific groups of trees would be selected for chemical treatment at up to half of the potential release areas. The areas slected to receive chemical treatment are specified in Table A in Appendix A. Treatment areas were selected to meet the requirements of the hemlock conservation network for hemlock genetic diversity (refer to Appendix B). An average of 60 trees per area would be treated to reach the desired number of eastern and Carolina hemlock trees for genetic diversity within the hemlock conservation network, with some allowance for mortality due to natural events (fires, windstorms, etc.). This would ensure that genetically diverse hemlocks remain alive until biocontrol takes effect. For these groups of trees the treatment would be the systemic insecticide imidicloprid injected into the soil at the base of the tree ("soil injection"), except for trees unsuitable for soil injection due to their proximity to water or highly permeable (sandy or gravelly) soils. For these, imidacloprid would be injected directly into the trunk of the tree ("stem injection"). Treatment would be repeated once effectivenss declines and if evidence of new infestation is present. Soil injection is generally effective for at least two years and stem infejection for as least one year.

Treatment would cease when effective biocontrol agents become establsihed or the HWA threat is otherwise diminished, based on annual situation reports from Forest

Health Protection (USDA Forest Service).

Clearance process prior to application of soil injected imidacloprid. (1) Soil would be sampled to determine the presence of sandy or gravelly (highly permeable) soils. The presence of highly permeable soils would disqualify the site for soil injection. (2) The area would be scouted for the presence of any surface water or waterbodies (springs, creeks, ponds, bogs, etc.). Any tree with a direct vegetative connection to surface water would be eliminated from soil injection treatment.

This alternative proposes the following number of imidacloprid treatment areas in Wilderness (W) and Wilderness Study Areas (WSA): Linville Gorge W – 4; Joyce Kilmer-Slickrock W – 2; Shining Rock W – 1; Ellicott Rock W – 2; Craggy Mountains WSA – 1; Lost Cove WSA – 0; Harper Creek WSA – 0. See Appendix A for locations.

2.1.3 Alternative C – No Chemical Treatments

1. **Alternative C would include activity #1 from Alternative B: Releases of predator beetles that eat HWA to establish long-term population control.**

Hemlocks in approximately 112 eastern hemlock 47 Carolina hemlock areas would be potential areas for releases of the predator beetles *Sasajiscymnus tsugae, Laricobius nigrinus, Scymnus sinuanodulus* and *Scymnus ningshanensis.* Each year these areas would be prioritized for releases with consideration for geographic distribution and to ensure releases in both eastern hemlock and Carolina hemlock stands. The number of releases each year would depend on the available supply of beetles. The desire would be to release beetles at all areas that are sufficiently infested.

The 159 potential release areas were selected to meet the requirements of a hemlock conservation network designed to capture community diversity within the distribution of known hemlock stands. This design is described in Appendix B. Areas that would form the conservation network were selected from a list of outstanding hemlock areas including Natural Heritage sites, Special Interest Areas identified in the Nantahala/Pisgah land management plan, and additional hemlock areas identified through internal and external scoping as having important ecological and/or cultural values. In a few instances hemlock stands not recognized as ecologically or culturally important were added to the network to fill a gap in the design. Appendix A contains a table identifying the potential release areas and maps pinpointing the location of the areas.

The number of beetles released at an area would vary by species according to established release protocols developed by Forest Health Protection and university researchers involved with evaluating these insects. Current protocols call for several hundred to several thousand beetles to be released per area.

Specific hemlocks within the areas would be evaluated as suitable for releasing beetles. These would be trees that are infested with HWA to the degree that evidence of adelgids can be seen at most leaflet nodes. The trees themselves, as well as nearby trees, should still be healthy enough to be putting on new growth. The objective is to find a spot with enough HWA so the beetles can successfully feed and reproduce, and

where other similarly infested hemlocks are nearby so it is possible for the beetles to disperse.

A representative sample of release areas would be monitored at six months and one year to determine if the beetles are still present, if they have successfully overwintered, and if and how far they have dispersed. The condition of the release trees would also be noted.

This alternative proposes the following number of beetle release areas in Wilderness (W) and Wilderness Study Areas (WSA): Linville Gorge W – 11; Joyce Kilmer-Slickrock W – 5; Shining Rock W – 3; Ellicott Rock W – 3; Craggy Mountains WSA – 4; Lost Cove WSA – 1; Harper Creek WSA – 2. See Appendix A for locations.

2. NO Chemical Treatment for Maintaining Genetic Reserves

2.2 Alternatives Considered But Not Evaluated In Detail

2.2.1 Treatment by Spraying Insecticidal Soaps and Horticultural Oils

Insecticidal soaps and horticultural oils can be sprayed on hemlocks when the objective is immediate knock down of an insect pest. If complete coverage is achieved, these agents act by smothering all invertebrates on the tree at the time of treatment. There is no residual effect, so HWA could reinfest the tree immediately. With this method there is an increased risk of applicator contamination and increased concern with drift, since the product is sprayed. This treatment method is appropriate for smaller, more accessible trees that could be treated frequently. It would not be appropriate for treating large or inaccessible trees. It would not meet the project objective of keeping HWA suppressed for months or years, as would be necessary to ensure tree survival.

2.2.2 Exclusion of Treatments in Wildernesses

Wilderness is a unique and valuable resource. In addition to offering primitive recreation opportunities, it is valuable for its scientific and educational uses, as a benchmark for ecological studies, and for the preservation of historical and natural features (FSM 2320.1).

Wilderness is defined in Section 2 (c) of the Wilderness Act of 1964: “A wilderness, in contrast with those areas where man and his works dominate the landscape, is hereby recognized as an area where the community of life are untrammeled by man, where man himself is a visitor who does not remain.” However the Act also allows for “[s]uch measures as may be necessary in the control of fire, insects and diseases, subject to such conditions that the Secretary deems desirable.” As follow-on to this, Section 2324.12 of the Forest Service Manual (FSM) states: “Do not control insect or plant disease outbreaks unless it is necessary to prevent unacceptable damage to resources on adjacent lands or an unnatural loss to the wilderness resource due to exotic pests.”

The highest concentrations of ecologically important hemlock areas occur in the Joyce Kilmer-Citico Creek and Linville Gorge Wildernesses. A concentration of areas also occurs in the Shining Rock Wilderness. Not only are these hemlock areas ecologically important, they are an integral part of the wilderness experience and an important element in the wilderness character itself. Excluding wildernesses from treatment could eliminate an important portion of the genetic and community diversity of hemlock across the Forests. As mentioned earlier, observations in the Northeast indicate we could expect losses of hemlock in the 90% range or greater if no treatments occur. Excluding wildernesses from treatment would also not allow the purpose and need to be met.

Refer to Chapter 3 Section 3.7 for more discussion of wilderness concepts and the effects to Wilderness Areas and Wilderness Study Areas.

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3. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

Chapter 3 describes the environmental components of the area that would be affected by the alternatives under consideration. It provides the analytic basis for comparison of the alternatives, and describes direct, indirect, and cumulative impacts of the alternatives. Chapter 3 is organized around each potentially affected resource.

Summary of Direct Effects on Biological Resources from Project Activities

Release of Predatory Beetles: No direct effects to plants are likely from releasing predator beetles because these insects feed almost exclusively on HWA and not on plants. HWA is the only insect that would be directly affected by beetle release since the beetles would be released on hemlock trees and the beetles do not eat anything but adelgids. The scientific literature does not indicate a potential for released beetles to eat any other adelgid (or anything else) inhabiting hemlocks (Hennessey, R. 1995, Salom, S. 1998, Zilahi-Balogh, G.M.G. 2001, Montgomery et al. 1997, Lu and Montgomery 2001, Butin et al. 2002). It is likely that insect-eating species inhabiting hemlock could eat some of the predator beetles, but this would not affect these insectivores. It is conceivable that some beetles released on trees near streams could fall into the streams and become food for aquatic organisms, but the frequency would be so small as to have no discernable effect as a food source.

Soil Injection of the Insecticide Imidacloprid: There would be no direct effects on any plant because imidacloprid is not toxic to plants. Imidacloprid is highly toxic to invertebrates that directly contact it, such as invertebrates in the soil below the duff layer at the time of application and potentially for some months afterward. Effects would be very localized, because imidacloprid is not highly mobile in most soils, and a clearance process would ensure that it is not injected in soils where it could potentially move off site such as highly permeable soils or wet soils. Effects would be temporary since the chemical breaks down and does not accumulate in the environment. Since imidacloprid is injected approximately 8-10 inches deep in the soil, it would not affect invertebrates or other organisms in the duff or leaf litter. A month or two after injection, when the insecticide has been taken up by the tree, all the invertebrates feeding on the tree would likely be killed, but not other invertebrates on the tree. The clearance process would reduce any likelihood of direct effects to aquatic resources since it would prevent treatment of trees in contact with water or in soils where leaching would be likely.

Tree injection of the Insecticide Imidacloprid: There is a potential for direct effects to hemlock from repeated stem injections of systemic insecticides. Although localized tissue damage may result in decreased tree vigor, it is unlikely that treated trees will die (Rhea 2004). While the chemical itself is not toxic to plants, injection sites often show damage to the cambium layer of the tree. While tree injection is somewhat less effective in eliminating HWA from infested trees, many of the invertebrates feeding on the tree would likely be killed, but not other invertebrates on the tree. There would be no direct effects on aquatic resources since no imidacloprid would contact water and the possibility of leaching through soil is eliminated.

Additional discussions of effects are in the sections that follow.

3.1 Botanical Resources

The release of predator beetles and use of systemic insecticide to control the hemlock woolly adelgid (HWA) is proposed in two very different and distinct forested environments on the Nantahala and Pisgah National Forests. These are: (1) 112 forest stands dominated by or having a major component of eastern hemlock (*Tsuga canadensis)* on stream terraces, in cool and moist coves, or on sheltered mountain slopes, and (2) 47 forest and woodland stands where Carolina hemlock (*Tsuga caroliniana)* is a major canopy component on hot and dry mountain ridges and exposed upper slopes. A comprehensive description of the eastern hemlock and Carolina hemlock plant communities is available in the project file.

Eastern hemlock is a widespread species occurring in five Canadian provinces and in the United States from New England to the Lake States, Mid-Atlantic States, and Southern Appalachians. On the Nantahala and Pisgah National Forests it occurs primarily at mid-elevation forests in plant communities classified as Acidic Cove Forest or Eastern Hemlock Forest (Schafale and Weakley 1990).

Carolina hemlock is not a widespread species and is limited in its range to southwestern and southcentral Virginia, western North Carolina, northwestern South Carolina and Georgia, and eastern Tennessee (Natureserve 2004, Weakley 2002). Carolina hemlock, although not a common species, is more widespread in North Carolina than elsewhere within its rangewide distribution and populations were stable before HWA infestation. The species can occur on a variety of landscapes but persists as a canopy dominant only along xeric to dry ridges and upper slopes, or in rare situations, on rocky well-drained river banks, e.g. the Carolina Hemlocks campground. It is the characteristic species in plant communities classified as Carolina Hemlock Bluffs (Schafale and Weakley 1990). Tables 3-1 and 3-2 summarize the extent of hemlock dominated stands across the Forests and across the southern Appalachian region, and the age class distribution of hemlock dominated stands across the Forests.

Table 3-1. Area of forests in the Southern Appalachian and North Carolina mountains dominated by eastern and Carolina hemlock or where these species are a major stand component
(CISC is the Continuous Inventory of Stand Conditions database maintained on the Forests)

	CISC Hemlock [1/]	Acidic Coves [2/]	CISC xeric pine [3/]	Pine-Oak Heath [/2]	Hemlock	Hemlock - White Pine	Total
Pisgah	5,270	151,500	12,700	128,630			
Nantahala	8,500	50,500	11,300	66,270			
National Forest total	13,770	202,000	22,800	194,900			
Western NC		1,331,000		759,000			
NC Mountains [4/]				Private	11,200	21,100	32,300
				USFS	2,400	9,500	12,900
				Total	13,600	30,700	44,300
Southern Apps. [5/]					40,100	185,300	225,400

[1/] CISC Hemlock = Forest types 5 (Hemlock), 4 (White Pine-Hemlock), and 8 (Hemlock-Hardwood)
[2/] from Simon, and McNab 2004
[3/] CISC xeric pine = Forest types 38 (Pitch Pine), 15 (Pitch Pine-Oak), 39 (Table Mountain Pine) and 20 (Table Mountain Pine-Hardwoods)
[4/] FIA 2002 Includes 21 Mountain counties in N.C.
[5/] FIA 1999 Includes Southern Appalachian States (Alabama, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia)

Table 3-2. Age class distribution in Eastern and Carolina hemlock Stands on the Nantahala and Pisgah National Forests

	Eastern hemlock				Carolina hemlock			
	All CISC [1/]		HWA control stands		All CISC [2/]		HWA control stands[/]	
Age Class (years)	acres	percent	acres	percent	acres	percent	acres	percent
0-10	0	0.0%	0	0.0%	326	1.5%	0	0.0%
11-20	16	0.1%	0	0.0%	34	0.2%	45	0.7%
21-30	0	0.0%	0	0.0%	0	0.0%	80	1.3%
31-40	0	0.0%	0	0.0%	608	2.8%	53	0.9%
41-50	450	3.4%	169	2.0%	68	0.3%	0	0.0%
51-60	340	2.5%	23	0.3%	268	1.2%	0	0.0%
61-70	1160	8.7%	592	6.9%	1603	7.4%	386	6.3%
71-80	2243	16.7%	991	11.6%	5475	25.2%	3423	55.6%
81-90	2525	18.9%	1733	20.2%	6521	30.0%	1169	19.0%
91-100	1043	7.8%	781	9.1%	2664	12.3%	460	7.5%
100+	5616	41.9%	4289	50.0%	4175	19.2%	544	8.8%

[1/] CISC Hemlock = Forest types 5 (Hemlock), 4 (White Pine-Hemlock), and 8 (Hemlock-Hardwood)
[2/] CISC xeric pine = Forest types 38 (Pitch Pine), 15 (Pitch Pine-Oak), 39 (Table Mountain Pine) and 20 (Table Mountain Pine-Hardwoods)

Species Composition – eastern hemlock stands: Approximately 10% of all plant species documented on the Nantahala and Pisgah National Forests (Danley and Kauffman 2000) occur within eastern hemlock stands proposed for HWA treatment. These 245 species include 46 trees, 31 shrubs, 160 herbs, sedges, and grasses, and 8 vines. Species diversity is even greater in Acidic Coves, an ecological zone where eastern hemlock is often a major stand component.

Species Composition – Carolina hemlock stands: Overall, there is less species diversity in Carolina hemlock stands. There were only 56 different species in sample plots versus 245 found in eastern hemlock stands. The 56 species included 20 trees, 20 shrubs, 14 herbs, sedges, and grasses, and 2 vines .

3.1.1 Summary of Environmental Consequences

It is not feasible to protect individually all of the hemlock trees across the Nantahala and Pisgah National Forests and therefore some damage and loss of individuals and stands will occur regardless of the proposed HWA control measures. However, there are important differences among the alternatives in the degree of damage and probability of persistence of eastern and Carolina hemlock. This is also true for some other species associated with hemlock communities.

In general, without control measures, the HWA infestation will increase and spread across the Nantahala and Pisgah National Forests and potentially result in the loss of both eastern and Carolina hemlock (Table 3-3). HWA infestation could be controlled by the release of predator beetles on well-distributed areas that reflect the range of environments where hemlock occurs on the Forests. Loss of hemlock would likely continue for years until beetles become established and in equilibrium with HWA populations. During this period, unless sufficient hemlocks can be maintained to represent the genetic variability of the species, populations would be less adaptable and their long-term persistence on the Forests would be less likely. Chemical

treatment of individual trees in genetic conservation areas (Appendix B - Hemlock Conservation Design) proposed in Alternative B could provide a stopgap measure that would have a high probability of successfully retaining genetic diversity of hemlock on the Forests. The persistence of other species on the Forests that are associated with hemlock is also related to the time it will take for biological controls to become established; the longer the time period, the greater the probability for loss of individuals. Although groves of hemlock in genetic conservation areas will not provide sufficient habitat to support all associated species, some protection may be provided.

3.1.2 Botanical Community Evaluation

The following assumptions were made in evaluating community and landscape-level effects of the different alternatives:

1. The application of systemic insecticides will effectively protect treated hemlock individuals (Silcox 2002) for up to two years. Continued treatment will be required until biological controls are effective.
2. Each biological control area is approximately 125 acres in size.
3. Only limited control of HWA will occur in public or private lands adjacent to the Nantahala and Pisgah National Forests within the next 5 years (exception – Great Smoky Mountains National Park).

Table 3-3. A comparison of the generalized effects to hemlock from implementing HWA control alternatives.

Alternative	Hemlock genetic diversity and persistence on the Forests	Persistence of other species on the Forests that are associated with hemlock communities
A – NO ACTION	Increasing damage and death of hemlock from HWA across the Forests. Eventual loss of genetic diversity resulting from habitats insufficient to support stable populations of the species; ultimately the loss of hemlock from a majority of the Forests over the next two decades.	Across the Forests, a reduction in population size and loss of plant species associated with the moist and shaded conditions found in eastern hemlock stands, especially non-vascular species.
B – Predator beetle release at 112 eastern hemlock and 47 Carolina hemlock areas; chemical treatment on a subset of these areas.	Reduced damage and death of hemlock from HWA across the Forests. Persistence of well-distributed hemlock groves that provide genetic diversity. Habitat of sufficient quality, abundance, and distribution to allow species to stabilize but in a pattern altered from current conditions.	Away from treatment areas, a reduction in population size of plant species associated with the moist and shaded conditions found in eastern hemlock stands, especially non-vascular species.
C – Predator beetle release at 112 eastern hemlock and 47 Carolina hemlock areas; no chemical treatments.	Reduced damage and death of hemlock from HWA on well-distributed habitats across the Forests. Persistence of some hemlock groves that provide genetic diversity but reduced from current levels. Habitat is the minimum quality, abundance, and distribution to allow species to stabilize but in a pattern highly altered from current conditions.	A reduction in population size of plant species associated with the moist and shaded conditions found in eastern hemlock stands, especially non-vascular species.

Direct Effects

The direct effects to hemlock from HWA are discussed in Table 3-3 for the three alternatives.

In general, the direct effects to hemlock or other plant species from control treatments are negligible (other than reducing HWA damage):

- (Alternative B) There is a potential for direct effects to hemlock from repeated stem injections of systemic insecticides. Although localized tissue damage may result in decreased tree vigor, it is unlikely that treated trees will die (Rhea 2004). There are no negative effects likely from soil injection since imidacloprid is not toxic to plants.
- (Alternatives B & C) No direct effects to plants are likely from releasing predator beetles because these insects feed exclusively on adelgids and not on plants.

Indirect Effects

The loss of hemlock on the Nantahala and Pisgah National Forests will have an indirect effect on associated plant species. Some species will benefit from the reduced competition for light, moisture, and nutrients while other species that thrive in deep shade may be harmed. There are no plant species that depend entirely upon hemlock for substrate, e.g. non-vascular plants and there are no plant species that depend entirely on hemlock for shade. Associated tree species such as white pine and many shrubs such as rhododendron are likely to increase in cover in the gaps left by the death of hemlock. Still, some reduced vigor and mortality of shade-dependent forbs and non-vascular plants, especially rare species, is likely where hemlock mortality is high.

Shifts in species composition are likely but deforestation is highly unlikely, especially in Acidic Coves where hundreds of tree, shrub and forb species currently exist. Propagules of these species also exist in the soil and can provide potential rapid stand replacement when the canopy is opened up after hemlock mortality. For example, yellow birch seeds, evergreen woodfern (*Dryopteris intermedia*) spores, red-berried elder *(Sambucus pubens)* seeds and hay-scented fern *(Dennstaedtia punctilobula*) spores germinated in abundance from the propagule banks in eastern hemlock stands in New York (Yorks et. al. 1999) in controlled greenhouse situations.

Approximately 1/3 of all hemlock-dominated stands (CISC forest type = hemlock, white pine-hemlock, and hemlock-hardwood) are within ¼ mile of the proposed beetle release areas. Even if an action alternative (B or C) is implemented, it is assumed that hemlock outside of these areas will eventually succumb to HWA. Therefore, indirect effects are expected to differ markedly between areas treated and those outside of treatment areas where shifts in species composition are expected to be the greatest. Differences in indirect effects, however, will be most pronounced in stands that are totally dominated by hemlock than in those where hemlock is just a major component regardless of the alternative selected.

Alternative A: Indirect effects include a major increase in rhododendron on both eastern hemlock and Carolina hemlock areas, an increase in white pine on moist sites and yellow pines on xeric sites especially where hemlock was a dominant species. Tolerant tree species are more likely to increase in stands where hemlock is not

dominant but a major component. Some non-vascular species and shade demanding forbs will decrease in population size and may be locally extirpated.

Alternatives B & C: Within 1/3 (5,100 acres) of stands dominated by eastern hemlock indirect effects would include mostly minor shifts in species composition. Tolerant species will increase in small gaps created by scattered dead and dying hemlock. On approximately 2/3s (9,000 acres) of stands dominated by eastern hemlock indirect effects would include a major increase in rhododendron and white pine especially where hemlock was a dominant species. Tolerant tree species are more likely to increase in stands where hemlock is not dominant but a major component. Some rare non-vascular species and common shade demanding forbs will decrease in population size and viability may be reduced in isolated populations.

Cumulative Effects

Past and present timber harvest and prescribed burning activities on the Nantahala and Pisgah National Forests have affected individual eastern and Carolina hemlocks and have affected sites that could support eastern hemlock such as Acidic Coves. Many of these activities will continue in the future but the resulting effects are individually minor when compared with the major impacts expected from the HWA. They are therefore unlikely to add or combine measurably with the impact resulting from an expanding HWA population over time. Alternatives B and C would result in lessening cumulative losses to hemlocks from HWA infestation and all other actions.

Timber Management

Timber management activities on the Nantahala and Pisgah National Forests since implementation of the Land and Resource Management Plan (LRMP), Amendment 5 was on a downward trend between 1994 and 2000 (MIS report 2001). Timber harvest and timber stands improvements ranged from 3,300 to 5,000 acres / year and averaged around 4,400 acres / year. Since 2000, these activities have stabilized around this average. Carolina hemlock is not a commercial species and sites that support this species are considered not suited for timber production. Current, and future timber management activities are therefore not expected to impact Carolina hemlock. Eastern hemlock, on the other hand, can reach merchantable size and status and occurs on sites where some timber harvest activities have and will continue to occur. However, it is estimated that this species, the dominant component in less than 2% of the Forests (Table 1), accounted for less than 1% of the timber volume removed from the Forests during the past 20 years (Blanton 2004). Any harvest of this species in the future will be outside of the proposed HWA treatment areas and will likely include some limited salvage of dead hemlocks. An additional indication that timber harvest activities will not significantly impact hemlock or incrementally add to the HWA effect is the elimination of stand conversions in Acidic Coves that could potentially support eastern hemlock (MIS Report 2001).

Prescribed Fire

Prescribed fire is used on the Nantahala and Pisgah National Forests to reduce hazardous fuels and restore open conditions for rare plant species and plant communities. Within burn areas, individual eastern and Carolina hemlock have been

affected by these activities. The Nantahala and Pisgah Land and Resource Management Plan calls for approximately 1,000 acres per year to be burned on the Forests for hazardous fuel reduction. Given the national concern for hazardous fuel reduction adjacent to private land, these treatments could potentially increase to over 10,000 acres per year by 2010 (Maguire 2004). Prescribed fire has also been used since 1990 on approximately 5 acres of the Pisgah National Forest to restore open conditions and maintain viable populations of mountain golden heather (*Hudsonia montana*), a federally threatened species. In addition, prescribed fire has been used since 1994 on approximately 100 acres of the Nantahala National Forest to restore habitat conditions for rare plants associated with serpentine barrens including tufted hairgrass (*Deschampsia caespitosa ssp. Glauca*) and prairie dropseed (*Sporobolus heterolepsis)*. These activities will continue in the future. Neither hazardous fuel reduction or habitat restoration burn treatments have greatly impacted hemlock on the Forests because of the activities' very limited extent. They are also not expected to greatly impact hemlock in the future for the following reasons: (1) prescribed burning is not targeted to sites that support either eastern hemlock or Carolina hemlock, (2) although fire can and historically has burned readily through the xeric sites that support Carolina hemlock, fire is not able to spread in the moist conditions found in Acidic Coves that support eastern hemlock, and (3) prescribed fire treatments will continue to be used on only a small portion of the Forests and will be located away from the proposed HWA treatment areas.

HWA Treatments on Adjacent Land

Control of HWA on the Nantahala and Pisgah National Forests will continue to be affected by the condition of hemlock forests and HWA infestations on adjacent private and public lands. Limited beetle releases and chemical treatments have occurred in the previous three years on both public and private lands adjacent to the Forests and some are likely to occur in the future. The Great Smoky Mountains National Park, Blue Ridge Parkway, and Highlands, NC area in particular have implemented treatments, though outside the context of an overall conservation design scheme. These actions would hopefully add to the effectiveness of this proposed action in maintaining hemlock community and genetic diversity across the landscape.

It has taken about 10 to 12 years from the initial heavy HWA infestations to see mortality of more than 90% in some of the hemlock stands in New Jersey (Mayer et al 2002). During this period of time, other factors may contribute to the death of the hemlock trees, such as the secondary pest *Fiorinia externa* and the hemlock borer, *Melanophila fulvoguttata* both of which cause additional stress. The longer that a stand has been heavily infested or the more times that a stand has been heavily infested, the greater the tree mortality. Tree mortality occurs 5 to 6 years after a stand has been heavily infested and surviving trees may begin to recover if HWA populations decline but are not likely to survive a second heavy infestation (Mayer et al 2002). Secondary infestations originating from adjacent lands are likely if control measures are not implemented in those areas in the near future. There is some indication that hemlock stands with HWA infestations located at lower elevations tend to cause more crown health decline and subsequent mortality than those found at higher elevations (Bair 2002) and therefore there is hope that colder temperatures at higher elevation may limit HWA spread. However this hope may dissipate because it

is expected that the HWA will develop sufficient cold-hardiness over time to expand its distribution (McClure 1996) both northward and into higher elevations.

Cumulative Effects Summary: With Alternative A, the small amount of hemlock affected by past, present, and reasonably foreseeable future treatments would still likely result in the loss of almost all of the hemlock across the Forests.

Overall cumulative effects of Alternative B is there will still be losses to hemlock, but enough stands would survive to maintain hemlock across the Forests as a genetic reserve to retain much of the range of hemlock diversity across the Forests.

Overall cumulative effects of Alternative C would result in retention of hemlock over time but at levels less than Alternative B and without assurance of retaining the range of hemlock diversity across the Forests.

The cumulative effects to botanical resources, by alternative, are summarized in Table 3-4.

Table 3-4. Cumulative effects to Botanical Resources

Alternative	Hemlock genetic diversity and persistence on the Forests and the Southern Appalachians	Persistence of other species on the Forests that are associated with hemlock communities
A – NO ACTION	Loss of hemlock dominated stands from approximately 14,000 acres on the Forests and 225,000 acres in the Southern Appalachians. Loss of stands where hemlock is a minor to major component on 200,000 acres of the Forests and over 1,000,000 acres across the Southern Appalachians	Reduction in population size and loss of plant species associated with the moist and shaded conditions found in eastern hemlock stands, especially non-vascular species. Local extirpations are likely.
B – Predator beetle release at 112 eastern hemlock and 47 Carolina hemlock areas; chemical treatment on a subset of these areas.	Persistence of well-distributed hemlock groves on approximately 1,000 acres that provide genetic diversity. Habitat of sufficient quality, abundance, and distribution to allow species to stabilize on the Forests but in a pattern altered from current conditions. Throughout the Southern Appalachians, additional beetle releases and chemical treatments would help support stable populations of the species in a somewhat altered pattern.	Away from treatment areas, a reduction in population size of plant species associated with the moist and shaded conditions found in eastern hemlock stands, especially non-vascular species.
C – Predator beetle release at 112 eastern hemlock and 47 Carolina hemlock areas; no chemical treatments.	Persistence of some hemlock groves that provide genetic diversity but reduced from current levels. Habitat is the minimum quality, abundance, and distribution to allow species to stabilize but in a pattern highly altered from current conditions. Throughout the Southern Appalachians outside the Forests, additional beetle releases and chemical treatments would help species to stabilize but in a highly altered pattern.	A reduction in population size of plant species associated with the moist and shaded conditions found in eastern hemlock stands, especially non-vascular species.

3.2 Terrestrial Wildlife Resources

Environmental consequences to terrestrial wildlife resources are evaluated based on impacts to the following management indicator species: golden-crowned kinglet, Blue Ridge two-lined salamander, raccoon, mink, black bear, bats, gray squirrel, white-breasted nuthatch, yellow-bellied sapsucker, ruffed grouse, pileated woodpecker, and Jordan's salamander. See section 3.4 for more information regarding the selection of these species for analysis, and MIS population trend information.

3.2.1 Existing Condition

Eastern hemlock forests create distinctive microclimates and provide important habitat for a wide variety of wildlife. Many species of birds, small mammals, amphibians, and insects inhabit hemlock forests. In the the Northeast, 96 bird and 47 mammal species are associated with hemlock forests (Yamasaki et al. 2000). Use of hemlock by various wildlife include habitat considerations such as the distribution of hemlock trees and the variety of structural habitat features, dense patches of regeneration, hard-mast inclusions, cavity trees, coarse wood debris, wetland seeps and inclusions, and suitable cover opportunities (Yamasaki et al. 2000)

During the non-breeding season and throughout the winter, eastern hemlock provide an important seed source for pine siskin, goldfinch, red crossbill and evening grosbeak (DeGraaf and Rudis 1986, Howe and Mossman 1995). Birds such as blackburnian warblers and black-throated green warblers occur almost exclusively in hemlock forests in the Delaware Water Gap National Recreation Area (Evans et al. 1996). Ruffed grouse, yellow-bellied sapsucker, great horned owl, and a number of overwintering forest birds use hemlock for a variety of reasons. Ruffed grouse habitat management guidelines often address the importance of hemlock stands, inclusions, and single trees as high quality fall and winter roosting locations (Edminster 1947, Jordan and Sharp 1967). Affinity for hemlock tree boles by foraging and cavity dwelling primary excavators like the yellow-bellied sapsucker and pileated woodpecker have been recognized by Rushmore (1969). Hemlock tends to be long-lived, develops a number of potential cavity sites and perhaps a higher level of cavity-dwelling and foraging use by an array of woodpeckers and smaller mammals.

Many small mammals, such as deer mouse, southern red-baked vole, masked shrew, short-tailed shrew, white-footed mounse, and woodland jumping mouse use hemlock forests. Annual small mammal abundance and species richness can fluctuate dramatically due to variables such as food availability (e.g., prior year's mast crop) and winter severity (e.g., frozen ground with no snow cover). Important structural habitat features to smaller mammal communities include a range of overstory canopy closures. The resulting effects on the midcanopy and shrub layers, and perhaps the patterns of coarse woody debris, contribute to the subsequent accessibility of prey by both avian and mammalian predators such as northern gowhawk, barred and great horned owls, and typical forest carnivores like raccoon, red fox, and bobcat (DeGraaf et al. 1992, Powell et al. 1997a,b). Species like gray squirrel, eastern chipmunk, and

northern flying squirrel also use hemlock stands and inclusions, especially when hard mast-producing trees such as beech (*Fagus grandifolia*) and oak (*Quercus* spp.) are present in the overstory even though hemlock is not their preferred habitat (DeGraaf et al. 1992). Throughout the winter, eastern hemlock provide an important seed source for red squirrels. Cavity trees, both live and dead, provide summer roosting opportunities for forest bats; the hoary bat is known to roost in coniferous foliage (DeGraaf and Rudis 1986).

Hemlock is a well-documented habitat element in winter deer range management throughout the northeastern United States and eastern Canada (Mattfeld 1984, Huot et al. 1984, Blouch 1984, Reay et al. 1990). Black bear are known to forage in wetland seeps, swales, and riparian drainages in the spring for ephemeral herbaceous forage (e.g., skunk cabbage, various sedges, grasses, and tubers) present in these habitat conditions (Elowe 1984). Female black bear use coniferous riparian areas in Maine when hard mast crops and marginal (Schooley 1990). Vander Haegen and DeGraaf (1996) found black bear travelling coniferous tributary buffer zones between forested watersheds. Coarse woody debris is a source of grubs and ants especially in the spring, and large hollow trees and logs, and slash piles can be wintering den sites (DeGraaf and Rudis 1986).

3.2.2 Direct and Indirect Effects

Alternative A - No Action

Golden-crowned Kinglet

In the Southeast, kinglet is common in spruce-fir forests during the breeding season and uncommon in hemlocks and white pines (Hamel 1992). In western North Carolina, the kinglet nests in several mountain counties, including Buncombe and Haywood (LeGrand and Hall 1999). Its southern most range is near Highlands, NC (FEIS Vol. I, p.III-46; North Carolina Natural Heritage Program database), where it nests in Carolina hemlocks (*Tsuga carolinensis*) growing along the Blue Ridge Escarpment. The kinglet breeds in high elevation (>3,500 feet) mature, cool montane coniferous forests, mainly spruce-fir and less frequently in hemlocks, white pines and mixed forests of hardwoods and spruce-fir or hemlock (Hamel 1992). Kinglet uses other forest communities at high elevation in addition to spruce-fir. High elevation cove forests (acidic and rich coves) are considered moderate quality, as kinglets will nest in Eastern and Carolina Hemlocks (*Tsuga canadensis and T. carolinensis*). White pine forests (including white pine-oak heath) are also considered moderate quality, as Kinglets occasionally nest in white pines (*Pinus strobus*).

The balsam woolly adelgid has caused a decline in the kinglet's spruce-fir habitat, its primary habitat, so kinglets will more readily use habitat of moderate quality (i.e., high elevation cove, hemlock, and white pine forests). If no action is taken to control infestations of the hemlock woolly adelgid, hemlocks will die across the forest, thus reducing the amount of potential nesting habitat.

Blue Ridge Two-lined Salamander

The Blue Ridge two-lined salamander is common to uncommon throughout its range, and it is found at all altitudes within its range. In North Carolina, two-lined

salamanders are found throughout the state, but the Blue Ridge two-lined salamander is most numerous in the mountains. Adults dwell beneath rocks and logs along the margins of small, rocky streams or seeps, but also occur in forest floor habitats far from running water. During the breeding season adults can be found beneath submerged rocks and debris in streams.

The Blue Ridge two-lined salamander is often found far from any water, usually on the forest floor in mixed mesophytic deciduous forests (cove, upland, and northern hardwood communities) and spruce/fir forests. Because adult Blue Ridge two-lined salamanders breathe by cutaneous respiration they are sensitive to environmental disturbances that modify temperature, humidity, soil moisture or chemical composition of the soil or water, and their skin must be kept moist to facilitate gas exchange. Hemlock along streams and in the general forest provides moist conditions for Blue Ridge two-lined salamander.

When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any salamander species, including the Blue Ridge two-lined salamander, that moves on the forest floor (through the leaf litter).

Raccoon

Raccoon populations are strongly related to riparian and wetlands habitat as well and elevated tree cavities and therefore represents alluvial forest and the riparian community utilizing moderate size dens. The raccoon is primarily a tree-denning animal. They use a variety of shelters during the winter season, and tree dens are significant to their survival. Hollow trees are the most common winter den sites but abandoned fox or groundhog burrows as well as rock crevices, caves, abandoned buildings, and brush piles are also utilized for dens (Kaufmann 1982). Sleeping sites and dens are anywhere within the home range; however, all dens are located near water.

Raccoons are found almost everywhere that water is available. They are most abundant in hardwood swamps, mangroves, flood plain forests, and fresh and salt-water marshes. They are also common in mesic hardwoods stands, in cultivated and abandoned farmlands, and in suburban residential areas. They are relatively scarce in dry upland woodlands, especially where pines are mixed with hardwoods, and few are found in southern pine forests (Kaufmann 1982). The majority of their diet consists of plant food, with the primary winter food of acorns, but invertebrates continue to be important (Whitaker and Hamilton 1998).

Although raccoons are riparian-zone dependent, they are not dependent on hemlock. The raccoon's highest suitable habitat is 80+ year old stands with an oak component, usually within half a mile of water. Since raccoons require tree dens near water, the death of hemlock trees, especially those near streams, may actually increase habitat for the raccoon by creating snags that could serve as potential tree dens.

Mink

The mink is a predatory, semi-aquatic mammal that is generally associated with stream and river banks, lake shores, freshwater and saltwater marshes, and marine shore habitats (Gerell 1970). Mink exhibits considerable variation in its diet,

according to season, prey availability, and habitat type (Burgess 1978). Habitat quality influences the distribution, density, and reliability of prey, which in turn, affect mink population density and distribution.

Mink dens are an important component of the size of their home range and suitability of habitat. Dens utilized by mink are generally within 50 meters of water and vary from log debris dams to old muskrat dens as long as they are above the high water flow levels (Allen 1986). Fallen branches, brush and other debris may be utilized as dens where thick brush or high percentages of canopy cover are found. Because of the mink's use of upland cover types for denning and foraging, optimum habitat must also support suitable cover adjacent to water bodies.

Although mink is a riparian-associated species, it is not dependent on hemlock. Because mink populations tend to be limited by the availability of denning sites (e.g., dens of other species such as the bank dens of beavers or muskrats) or food sources, the death of hemlock will not affect mink.

Black Bear

Black bear requires large areas free from disturbances of motorized vehicles and intensive timber harvesting, and sufficient hard mast production to sustain reproduction and cub survival (USFS 1994b, pg. III-47). It also prefers large, elevated tree cavities for dens (trees > 36 inches diameter at breast height, or dbh), and early successional habitat or areas of sufficient fruit production under tree canopies for spring and summer foraging. The species also uses areas with large, down, woody materials and root mats.

Black bears in the southern Appalachians exhibit pronounced seasonal shifts in diet, between grasses, forbs, and soft mast in the summer, and hard mast in the fall. Brody (1984) noted a preference by bears for areas with high diversity (diversity across local areas) of stand ages, which would provide a variety of foods within a local area. The value of tree dens to black bear reproduction is not well known, however Pelton et al. (1980) and Johnson and Pelton (1981) documented a preference by female bears for dens in above ground tree cavities in the Great Smoky Mountains National Park. Tree dens provide bears with increased protection from extreme weather and harassment by humans and dogs, and so increase the quality of bear habitat. Elevated tree dens provide better protection for young cubs during hibernation, indirectly contributing to reproductive success.

The death of hemlock can affect black bear both negatively and positively. Bears often use forested riparain corridors as travel ways. Hemlock in riparian areas provide cover along these travel corridors. Death of hemlock would initially open up riparian areas, and cover would be lacking until other trees species grow up to replace the hemlock in the canopy. However, with the opening up of stream-side areas, a flush of growth (both herbaceous and soft mast) would occur, thus providing food for black bears. Hemlock snags, especially larger ones (>36" dbh) could provide denning opportunities for black bears. An increase in coarse woody debris could increase the amount of protein food source (e.g., grubs and ants), especially in the spring.

Bats

With the exception of cave obligate species (gray bats and Virginia big-eared bats) and species dependent upon rocky habitats (eastern small-footed bat), most of the other species of bats known to occur in western North Carolina will utilize snags for summer roost sites. Optimal roost sites occur beneath the bark of dead trees with adequate spaces to allow for air circulation and for bats to change their position on the trunk (Garner and Gardner 1992). Larger diameter snags are more often selected over smaller snags apparently because they have more potential surface area under the loose bark. In addition, their greater mass may be important in moderating ambient temperatures when used as maternity colonies.

Summer habitat selection by bats is thought to be driven by roosting and foraging requirements (Fenton 1970) and may be the product of interactions between the two (Kunz and Martin 1982). Summer roosts must provide appropriate thermal environments (Hamilton and Barclay 1994) and protection from predators (Fenton et al. 1994). Mature forests with dense evergreen mid and understories most likely do not represent quality summer foraging habitat, due to too much “clutter” for echolocating prey.

Certain tree species, either due to live bark exfoliating characteristics, or tendency to exfoliate bark upon mortality, are of higher value as snags. For Indiana bats, shellbark hickory, shagbark hickory, white ash, chestnut oak, red oak, white oak, sugar maple, birch, sycamore, and yellow birch provide higher quality snags than other hardwoods or conifers. Species such as hickories, white oak, and older-aged sugar maple typically provide loose sloughing bark as live trees. Hardwoods provide better snag habitat than conifers; however, conifer snags are used by bats for roosting.

Bats use certain forest types more readily for summer foraging and/or roosting than other forest types. Stands dominated by conifers are generally considered to represent poor summer habitat for many species of bats that are found in western North Carolina. Bats will readily use standing live trees for summer roosting sites if they meet the criteria for roosting, such as broken tops, cavities, holes left from previous limbs, loose sloughing bark, and open roosting within the canopy.

Riparian areas are also used by many species of bats for foraging. The importance of riparian areas to bats, especially *Myotis* species, as foraging habitat has been documented in several studies (Furlonger et al. 1987, Lunde and Harstad 1986, Thomas 1988, Thomas and West 1991).

Although hemlock is generally considered to represent poor summer habitat for many species of bats that are found in western North Carolina, the death of hemlock could increase potential summer roosting habitat. Many bats will use conifer snags for summer roosting habitat, and hemlock snags could provide good roosting habitat, especially since hemlock snags persist on the landscape for an extended period of time.

Gray Squirrel

Eastern gray squirrels are most common in woodlands >100 acres with a diverse woody understory (Koprowski 1994). Densities are highest in habitats composed of tree species that produce winter-storable foods such as oak, hickory and walnut (Nixon

and Hansen 1987). Nixon et al. (1975) reported that the preseason density of squirrels was found to be significantly correlated with the size of the total seed crop the previous year.

Gray squirrels almost always use tree cavities for rearing their winter litters. At least one den per 2 acres was recommended as necessary to provide winter denning for gray squirrels (Sanderson 1975). Two to five den trees per acre are optimum (U.S. Forest Service 1971). Even-aged hardwood stands less than 30-40 years of age do not produce sufficient mast or cavities to support gray squirrel populations (U.S. Forest Service 1971).

Although gray squirrels are not dependent on hemlock, the death of scattered hemlock that occur in mature hardwood stands may increase habitat for the squirrel by creating snags that could provide potential cavity nests.

White-breasted Nuthatch

White-breasted nuthatch is a permanent resident in woodlands, except in fraser fir and red spruce-fraser fir communities. It uses open deciduous forests, decaying woodlands, forest edges, and park-like habitats. It is strongly associated with mature hardwoods. Nuthatch is a cavity nester, nesting in knot holes or cavities excavated by woodpeckers. Cavities are also used for roosting. It nests in cavities excavated in living or dead trees 12 inches or greater dbh. It uses elm and maple and prefers old woodpecker holes. Its breeding range includes all of North Carolina, though it is uncommon to fairly common in the mountains (<5,000 feet) and in parts of the Piedmont and rare along the Coastal Plain (Hamel 1992). One study showed that white-breasted nuthatch presence was directly correlated with area of the forest, tree species richness, and canopy height (Robbins et al. 1989). It was negatively correlated with dominance of conifers and density of trees >3cm dbh.

Although the nuthatch is not dependent on hemlock, the death of scattered hemlock that occur in mature hardwood stands may increase habitat for the nuthatch by creating snags that could provide potential cavity nests.

Ruffed Grouse

The ruffed grouse ranges from Alaska across southern Canada and the northern United States to Maine, and south along the Appalachian Mountains to north Georgia. Grouse populations are highest in southern Canada and the Lake States where quaking and bigtooth aspen are found. The low population density of ruffed grouse in the southern Appalachians is thought to be a reflection of the generally low quality of the forested habitat. The nutritional quality of the diet is poor, particularly during late winter. During this period, southern Appalachian grouse rely primarily upon evergreen plants such as mountain laurel, Christmas fern, and greenbrier, which have low energy and protein levels. Also, protective cover is often separated by large expanses of forest with little or no shrubby understory. High quality habitat for rearing broods is very scarce. Young grouse chicks require lush herbaceous vegetation that supports abundant insects adjacent to secure protective cover. Riparian zones can be managed to provide succulent herbaceous vegetation by removing a significant portion of the overstory.

The death of hemlock can affect ruffed grouse both negatively and positively. Grouse will use hemlock as roosting cover in riparian areas. Death of hemlock would initially open up riparian areas, and this roosting cover would be lacking until other tree species grow up to replace the hemlock in the canopy. However, with the opening up of stream-side areas, a flush of growth (both herbaceous and soft mast) would occur, thus providing food for ruffed grouse. An increase in coarse woody debris could increase the amount of drumming logs utilized by male grouse during the breeding season.

Yellow-bellied Sapsucker

In North Carolina, yellow-bellied sapsucker is restricted as a breeder to elevations above 3,500 feet. It is associated with mature hardwood forests containing patches of dead trees and early successional to sapling stage stands produced by frequent large scale disturbances, such as tree cutting, fire, windthrow, or disease. Sapsuckers are associated with disturbed sites due to their preference for young trees for drilling sap wells during the nesting season (Hunter et al. 1999).

Although yellow-bellied sapsuckers are not dependent on hemlock, the death of hemlock would increase the amount of potential woodpecker habitat by creating snags that would be used for foraging and cavity nesting.

Pileated Woodpecker

The pileated woodpecker is primarily associated with dense, mature deciduous forests having standing dead trees (i.e., snags). Suitable pileated woodpecker habitat is limited by either the density or maturity of forests or by the abundance of snags (Schroeder 1983). The pileated woodpecker requires dead wood for both foraging and nesting. Pileated woodpeckers forage for ants on stumps, fallen logs, and snags (Schroeder 1983). Nest trees may be dead or live with dead limbs, but typically are dead trees in old, deciduous or mixed deciduous-coniferous forests. Species of nest trees include oak, maple, hickory, hemlock and pine.

In addition to stand age and density of trees, several other habitat measurements are indicative of suitable pileated woodpecker habitat. At the microhabitat level, suitable nesting habitat consists of stands having high basal area, density of stems and canopy cover (Bull and Jackson 1996). It also occurs in younger forests having scattered standing dead trees and in mixed deciduous-coniferous forests. The pileated woodpecker is rarely associated with stands of pole timber (small trees). Important habitat components include large snags, large trees, diseased trees, dense forest stands and high snag densities. In the Southeast, the woodpecker is associated with mesic and bottomland sites, perhaps due to the higher productivity and faster tree growth at these sites (Hamel 1992).

Although pileated woodpeckers are not dependent on hemlock, the death of hemlock could increase the amount of potential woodpecker habitat by creating snags that would be used for foraging and cavity nesting.

Jordan's Salamander
Jordan's salamander is abundant to common in the mountains and upper Piedmont of the Southern Appalachians. It requires mesic, shaded woodlands with abundant leaf litter, decaying logs, and similar structures to serve as shelter, at elevations ranging from 698 to 6,400 feet. Jordan's salamander also inhabits shaded rock outcrops covered with lichens and mosses. Adults retreat to underground quarters with the onset of freezing weather in the autumn and remain underground even during bouts of warm weather. Jordan's salamanders are active from April to November, and are usually seen well away from water, under rotting logs, flat stones, or at night at the entrance of small burrow holes.

The death of hemlock can affect Jordan's salamander both negatively and positively. Although Jordan's salamander is not dependent on hemlock, when hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any salamander species, including Jordan's salamander, that moves on the forest floor (through the leaf litter). On the other hand, the death of hemlock will cause an increase of the amount of downed woody debris. This salamander uses various cover objects (e.g., rocks, logs, downed wood, etc.) as shelter, and they retreat to underground borrows during the heat of the day and forage at night. Therefore, the death of hemlock will have little effect on the Jordan's salamander because of its nocturnal nature and its very limited use of hemlock forests.

<u>Alternatives B and C</u>

Golden-crowned Kinglet
Treating infested hemlock trees will help save some of the hemlocks across the Nantahala and Pisgah National Forests. Biocontrol will have no negative effect on the kinglet since the released beetles only eat adelgids. Release of predatory beetles on infested hemlocks will help curtail the spread of the adelgid. The use of imidacloprid will have no negative effect on the kinglet since the bird would have no contact with the chemical. Imidacloprid is either injected directly into the bole of the tree, or it is injected approximately 8-10 inches deep into the soil within a six foot radius of the bole of the tree. By saving hemlocks, kinglets will have another habitat (although of moderate quality) in which to nest.

Blue Ridge Two-lined Salamander
When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any salamander species, including the Blue Ridge two-lined salamander, that moves on the forest floor (through the leaf litter). By treating the hemlock with biocontrol or chemicals, shade will be maintained in the forest, thus making it more suitable for this salamander species that requires moist conditions. Since imidacloprid is either injected directly into the bole of the tree, or it is injected approximately 8-10 inches deep into the soil (below the leaf litter), use of this chemical will have no negative effect on the Blue Ridge two-lined salamander. This is because the chemical, once injected, does not move upward in the soil toward the leaf litter zone (Bayer 2004).

Raccoon

Although raccoons are riparian-zone dependent, they are not dependent on hemlock. The raccoon's highest suitable habitat is 80+ year old stands with an oak component, usually within half a mile of water. Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect raccoon as there would be no contact with either the biocontrol agent or the insecticide. Since raccoons require tree dens near water, the death of hemlock trees, especially those near streams, may actually increase habitat for the raccoon by creating snags that could serve as potential tree dens. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created as untreated hemlock die, thus creating potential den trees for raccoon.

Mink

Although mink is a riparian-associated species, it is not dependent on hemlock. Because mink populations tend to be limited by the availability of denning sites (e.g., dens of other species such as the bank dens of beavers or muskrats) or food sources, the death of hemlock probably would not affect mink. Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect mink as there would be no contact with either the biocontrol agent or the insecticide.

Black Bear

The death of hemlock can affect black bear both negatively and positively. Bears often use forested riparain corridors as travel ways. Hemlock in riparian areas provide cover along these travel corridors. Death of hemlock would initially open up riparian areas, and cover would be lacking until other trees species grow up to replace the hemlock in the canopy. However, with the opening up of stream-side areas, a flush of growth (both herbaceous and soft mast) would occur, thus providing food for black bears. Hemlock snags, especially larger ones (>36" dbh) could provide denning opportunities for black bears. An increase in coarse woody debris could increase the amount of protein food source (e.g., grubs and ants), especially in the spring.

Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect black bear as there would be no contact with either the biocontrol agent or the insecticide. Maintenance of hemlock along streams will help provide cover along riparian travel corridors. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags and coarse woody debris will still be created as untreated hemlock die, thus creating potential den trees and foraging habitat for black bears.

Bats

Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect bats as there would be no contact with either the biocontrol agent or the insecticide. Although hemlock is generally considered to represent poor summer habitat for many species of bats, the death of hemlock could increase potential summer roosting habitat. Many bats will use conifer snags for summer roosting habitat, and hemlock snags could provide good roosting habitat, especially since hemlock snags persist on the landscape for an extended period of time. However, it is reasonable to believe that all infested hemlocks across the Nantahala

and Pisgah National Forests will not be treated, thus some snags will still be created that are potential roost trees for a variety of bats.

Gray Squirrel

Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect gray squirrels as there would be no contact with either the biocontrol agent or the insecticide. Although gray squirrels are not dependent on hemlock, the death of scattered hemlock that occur in mature hardwood stands may increase habitat for the squirrel by creating snags that could provide potential cavity nests. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created that provide potential cavity nests for the squirrel.

White-breasted Nuthatch

Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect white-breasted nuthatch as there would be no contact with either the biocontrol agent or the insecticide. Although nuthatches are not dependent on hemlock, the death of scattered hemlock that occur in mature hardwood stands may increase habitat for the nuthatch by creating snags that could provide potential cavity nests. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created that provide potential cavity nests for the nuthatch.

Ruffed Grouse

Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect ruffed grouse as there would be no contact with either the biocontrol agent or the insecticide. Maintenance of hemlock will help provide roosting cover. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some coarse woody debris will still be created as untreated hemlock die, thus creating potential drumming logs for male grouse. Also, with the flush of growth that will occur with the death of hemlock, an increase in food (both herbaceous and soft mast) may increase for ruffed grouse.

Yellow-bellied Sapsucker

Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect yellow-bellied sapsuckers as there would be no contact with either the biocontrol agent or the insecticide. Although sapsuckers are not dependent on hemlock, the death of hemlock could increase the amount of potential woodpecker habitat by creating snags that would be used for foraging and cavity nesting. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created that are potential nest and foraging trees for woodpeckers.

Pileated Woodpecker

Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the pileated woodpecker as there would be no contact with either the biocontrol agent or the insecticide. Although pileated woodpeckers are not dependent on hemlock, the death of hemlock could increase the amount of potential

woodpecker habitat by creating snags that would be used for foraging and cavity nesting. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created that are potential nest and foraging trees for woodpeckers.

Jordan's Salamander

When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any salamander species, including Jordan's salamander, that moves on the forest floor (through the leaf litter). By treating the hemlock with biocontrol or chemicals, shade will be maintained in the forest, thus making it more suitable for this salamander species that requires moist conditions. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some downed woody debris will still be created that provide potential cover for Jordan's salamander. Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect Jordan salamander as there would be no contact with either the biocontrol agent or the insecticide

Refer to Section 3-4 for population trend information.

3.2.3 Cumulative Effects

Past and present timber harvest and prescribed burning activities on the Nantahala and Pisgah National Forests have affected eastern and Carolina hemlocks and have affected sites that could support eastern hemlock such as acidic coves. Many of these activities will continue in the future but the resulting individually minor effects are insignificant when compared with the major impacts expected from infestation of the HWA. Therefore, these activities are unlikely to add or combine measurably with the impact resulting from an expanding HWA population over time. This project would result in lessening cumulative impacts to hemlock from HWA infestation and all other actions.

When hemlock dies, numerous changes will occur across the landscape. Where trees die along streams, cover is eliminated initially from riparian travel corridors (especially for black bears). Once the canopy is opened up, sunlight reaches the forest floor, thus drying out the leaf litter and making those moist areas unsuitable for salamanders (until cover returns and the leaf litter is shaded again). A flush of herbaceous and soft mast species growth will occur, creating forage for black bears and ruffed grouse. The increase in the creation of snags will increase potential habitat for several species, especially those that use snags for denning, roosting or foraging. Increased snags will benefit raccoons, black bears, bats, and pileated woodpeckers, and increased downed woody debris will benefit Jordan's salamanders and ruffed grouse. However, death of hemlock forests could be detrimental for the golden-crowned kinglet, which occasionally uses hemlock. As a result of the death of high elevation spruce-fir forests (kinglet's primary habitat) from the Balsam woolly adelgid, kinglet habitat has declined, thus causing kinglets to use habitat of moderate quality (e.g., hemlock).

Treating infested hemlock trees will help save some of the hemlocks across the Nantahala and Pisgah National Forests. Release of predatory beetles on infested hemlocks will help curtail the spread of the adelgid. The use of chemicals will have no negative effect on any of the MIS. Imidacloprid is either injected directly into the bole of the tree, or it is injected approximately 8-10 inches deep into the soil within a six foot radius of the bole of the tree. By saving hemlocks, kinglets will have another habitat (although of moderate quality) in which to nest, and Blue Ridge two-lined salamanders and Jordan's salamanders will continue to have moist habitats. However, it is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created that will potential roost trees for a variety of bats, den trees for raccoons and black bears, and nesting and foraging habitat for pileated woodpeckers, and downed woody debris for Jordan's salamanders and ruffed grouse.

3.3 Aquatic Resources

Environmental consequences to aquatic resources are evaluated based on impacts to the following management indicator species habitats: brook, brown, and rainbow trout, blacknose dace, sculpin, and smallmouth bass. See section 3.4 for more information regarding the selection of these species for analysis, and population trend information.

3.3.1 Existing Condition

Approximately 5,060 miles of streams and rivers flowing through the Nantahala and Pisgah National Forests have been defined as coldwater habitats (National Forests in North Carolina 2001). These streams represent all major stream types (Rosgen 1996) and exhibit a broad range of environmental conditions (i.e. from "pristine" to rated as impacted by the NCDWQ). Coldwater streams are approximately 89% of the total stream and river mileage across the Forests (Table 3.1-1). Aquatic ecoclassification efforts on the National Forests in North Carolina have indicated that approximately 58% of all stream mileage is not inhabited by any fish species, largely due to low stream order and high gradient (Bryan and Hill 2000, unpublished). If these assumptions are applied across the Forests, approximately 2,100 miles of occupied coldwater habitat are occupied by coldwater MIS across the National Forests in North Carolina (Table 3.3-1). Over six hundred miles of fish-occupied coldwater streams are associated with hemlock communities.

Approximately 400 miles of streams and rivers flowing through the Nantahala and Pisgah National Forests have been defined as coolwater habitats (National Forests in North Carolina 2002). These streams represent all major stream types (Rosgen 1996) and exhibit a broad range of environmental conditions (i.e. from "pristine" to rated as impacted by the NCDWQ). Coolwater streams are approximately 7% of the total stream and river mileage across the Forests. Approximately 168 miles of coolwater streams are occupied by the MIS smallmouth bass. An estimated seven miles of fish-occupied coolwater streams are associated with hemlock communities.

None of the estimated 210 miles of warmwater streams on the Forests are associated with hemlock communities.

Table 3.3-1 Aquatic resources across the Nantahala and Pisgah National Forests. The biological communities were selected from Table MIS-1 of the Management Indicator Species Habitat and Population Trends: Nantahala and Pisgah National Forests (2001).

Biological Community	**Forest wide Estimate (miles)**	**Occupied Habitat (miles, estimated)**
coldwater streams	5,060	2,125
coolwater streams	400	168
warmwater streams	210	88

Woody debris constitutes the major organic input to low order streams, where it is apparent that wood has a significant role in energy flow, nutrient dynamics, and stream morphology, and in shaping the biotic community (Swanson et al. 1976, Keller and Swanson 1979, Anderson and Sedell 1979). Across the Forests, aquatic habitats and populations associated with low order, coldwater streams are what is at risk from the decline or loss of hemlock species. While this influence is less observable in larger streams, the influence of large woody debris (LWD) along the margins of larger coolwater systems is still important.

3.3.2 Direct and Indirect Effects

Potential direct and indirect effects are discussed together in this analysis because it is not only difficult to separate these effects in writing, but it is also very difficult for the reader to synthesize how effects on habitat affect species (and vice versa) if the discussions are separated. Therefore, in this analysis, direct effects are defined as the results of the action on the quality and quantity of aquatic habitat. Indirect effects are the result of the action's effects on habitat on aquatic species themselves due to habitat changes.

Alternative A - No action

Left untreated, stands containing hemlock have the potential to lose all or part of the hemlock from damage from the hemlock wooly adelgid. When this hemlock is associated with riparian habitats, the potential to affect several parameters important to stream and riparian health and function exists. First, LWD transport to stream channels will increase as infested trees die. And second, the loss of all or part of the shading on a stream will affect primary productivity and water temperature. These direct effects to the stream channel and habitats will result in indirect effects in aquatic community composition and health within the stream, and cumulative effects on landscape-level community structure and species viability.

As hemlocks are affected and LWD enters streams, aquatic invertebrate populations will respond with increases in species which utilize wood, including borers, gougers, and scrapers, and several groups which utilize wood surfaces (e.g. Chironomidae, Heptageneidae, Baetidae, Nemouridae, Peltoperidae, Perlodidae, Limnephilidae, Rhycophilidae) (Dudley and Anderson 1982). As LWD decomposes and is utilized by aquatic invertebrates, its usefulness diminishes, which results in the gradual return to pre-LWD community structure. In systems dependent on cooler water temperatures (such as trout streams), species may occur in lower densities where shade has been measurably affected until riparian conditions (particularly streamside shading) return

to pre-infestation levels. In this analysis, it is the aquatic insect community and trout populations that stand to be measurably affected. While smallmouth bass populations could be affected, it is unlikely that such effects would be measurable and attributable to the loss of hemlock since coolwater streams associated with hemlock considered in the analysis are higher order streams (many would define the systems as small rivers rather than streams) where production is driven by autochthonous (defined as indigenous or native to a place or thing) rather than allochthonous (defined as introduced, foreign in origin) energy inputs (Stein 1980).

As with many groups of organisms, fish community dynamics have been proven to be cyclic and adaptable to surrounding conditions. For example, habitat suitability for a particular species may be improved with the input and retention of LWD, which is reflected in increased population levels of that species. But as the microhabitat (e.g. surface of the log) deteriorates and becomes less suitable, population levels respond accordingly. This process can take anywhere from several weeks (if environmental conditions cause rapid breakdown of woody material) to many years, and is thought to occur more rapidly with hemlock and other soft wood species than with hardwood species (Webster 1977).

In this situation, it is expected that relatively large amounts of LWD will enter adjacent stream systems as the HWA damage results in tree mortality within riparian areas. Aquatic invertebrate communities will respond accordingly, becoming dominated by species utilizing wood at some point in its life history (see above). This immediate burst of LWD input will be followed by a period of relatively little LWD transport to streams as riparian forests move through early stages of succession. And, if succession rates lag behind the retention and decomposition rates of the LWD in the streams, it could be even longer before natural LWD transport rates return (Bryant 1983).

Hall and Baker (1975) summarize many of the beneficial and adverse effects of organic debris on fish habitat. Most of the adverse effects concern water quality, particularly intragravel dissolved oxygen, and stream channel instability. Concerns about water quality involve increased biological oxygen demand (BOD) from large deposits of decomposing fine particulate organic matter, which can potentially affect fish spawning success. In most cases, this fine organic matter is flushed downstream before problems with BOD reach problem levels.

Although debris has been cited as a problem for instream fish movement (Merrell 1951, Holman and Evans1964), this may have been overstated, as there is a plethora of literature documenting the benefits of LWD to habitat diversity and fish production, particularly addressing spawning and nursery areas and juvenile and adult instream cover (Narver 1971, Sheridan 1969, Hall and Baker 1975, Boussu 1954, Bryant 1981, et al.). Studies also clearly demonstrate that increased habitat diversity results in more diverse, stable fish communities (Fraser and Cerri 1982, Bisson and Sedell 1984). Results of these and other studies clearly document the importance of LWD for fish habitat.

Habitat for brook, brown, and rainbow trout, blacknose dace, sculpin, and smallmouth bass would likely be improved as LWD enters the system through tree mortality. The influx of LWD would be likely to allow for increases in aquatic invertebrates that fish

eat, and would likely result in measurable improvements in fish population levels--especially for species whose habitat requirements are structurally-oriented (e.g. trout, bass). Such improvements would continue until LWD is decomposed or flushed downstream by high flows (Lisle 1986). This temporary improvement in fish population levels may be negated in systems dependent on cooler water temperatures if there is not understory shade and the death of hemlock measurably lessens the amount of stream shading. In these cases, the species may occur in lower densities until riparian conditions (particularly streamside shading) return to pre-infestation levels.

In summary, increased LWD transport immediately following hemlock decline will benefit aquatic systems; however over time declines in LWD transport will result in loss of microhabitat diversity until the new riparian vegetation approaches decadence. If the period of decreased LWD input exceeds the life history of brook trout, for example, measurable declines in local populations could be seen through lost reproductive and foraging success. It is important to look past the short-term benefits if increased LWD and improved instream habitat to long-term effects on trout, dace, and sculpin populations from structural habitat losses. In North Carolina, brook trout (as well as other coldwater species) often exist at densities lower than those witnessed in their northern cousins, making the loss of successive year classes a tremendous risk to population viability. Brook trout is a short-lived species, and if habitat recovery exceeds their life history (often as short as 3 years), populations will suffer. Locally, individual populations could be lost if densities drop below viable levels for successive years, resulting in the loss of range and distribution of the species. In areas where brook trout is the only trout species present, the habitat would remain unoccupied. In areas where this occurs and brown or rainbow trout are present, the range and distribution of brook trout would decline. At the landscape level (i.e. across the Nantahala and Pisgah National Forests), measurable effects on the aquatic community and habitat are not likely to be seen, except locally within stands containing hemlock having no riparian understory. In this situation, potential effects would consist of shifts in aquatic invertebrate and fish communities as described above. In this worst-case scenario, approximately 500 miles of habitat and associated aquatic populations could be affected (measured as a long lasting change from original condition), which is approximately 26% of the occupied coldwater habitat across the Forests. At the local level, these losses could be dramatic, and measurable effects on the gene pool for Southern strain brook trout could be seen. Similar effects would be seen with other coldwater and coolwater MIS. At the landscape level, long-term survival of the habitats and species (particularly brook trout) would continue, although with fewer populations and a potentially smaller range.

Alternative B – Beetle Releases and Imidacloprid Treatment

Predator Beetles

The use of predator beetles will have no measurable direct or indirect effects on any of the MIS considered or their habitat. Some beetles could fall into the streams and be eaten by the fish, but it would have no measurable effect on species survival. Until the beetles become established in riparian hemlock stands, it is assumed that the effects above (reference No Action) could occur, although at a slower rate, until hemlock components of riparian vegetation are maintained. It is likely that treatment

of riparian hemlock stands with predator beetles would stop effects of hemlock loss on aquatic resources and the short-term benefits of increased LWD and long-term losses would not be seen if the beetles are successful at controlling the HWA.

Imidacloprid

Imidacloprid is moderately toxic to fish and highly toxic to aquatic invertebrates. It has a long half-life (>31 days) at pH 5, 7, and 9, which represents most of the soil and water conditions across the Forests. Additionally, the chemical is moderately mobile in some soils. Pesticide label restrictions prohibit the use of the chemical where surface water is present. It further states that use of the chemical where the water table is shallow may contaminate groundwater.

The Forests have developed a clearance process to aid in the determination of whether it is safe to use imidacloprid to treat individual trees. This process was developed to minimize or eliminate the potential for contact between imidacloprid and aquatic resources. By following the clearance process and label restrictions there will be no effect on aquatic resources from the use of imidacloprid. Mixing and transporting procedures for the chemical are designed to avoid any possibility of imidacloprid accidentally entering a stream. In the unlikely event an accident does occur during application that results in imidacloprid entering a stream, local populations of brook trout or smallmouth bass (as well as other fish species occurring in the affected stream) would likely be affected. The local aquatic invertebrate community could be lost entirely. The chemical would then be rapidly diluted to a level of no observable effect. It is important to note that the loss of one population of brook trout or smallmouth bass or one local aquatic invertebrate community will not affect overall species' trends across the Forests. This is because the local stream reach that could be affected by an accidental spill would be quickly recolonized by fish populations upstream or downstream following rapid dilution.

Alternative C – Beetle Releases

Predator Beetles

The use of predator beetles will have no measurable direct or indirect effects on any of the MIS considered or their habitat. Some beetles could fall into the streams and be eaten by the fish, but it would have no measurable effect on species survival. Until the beetles become established in riparian hemlock stands, it is assumed that the effects above (reference No Action) could occur, although at a slower rate, until hemlock components of riparian vegetation are maintained. It is likely that treatment of riparian hemlock stands with predator beetles would stop effects of hemlock loss on aquatic resources and the short-term benefits of increased LWD and long-term losses would not be seen if the beetles are successful at controlling the HWA.

3.3.3 Cumulative Effects

Alternative A - No action

It has been asked, "How will the loss of hemlock be any different than the loss of chestnut years ago?" During the chestnut blight, riparian vegetation was altered

forever in the Southern Appalachians, and no doubt brook trout populations were affected. Without reliable, quantitative, historical data, it is impossible to say just how much they were affected, but the documented loss in range of the species across the Southern Appalachians since this time is undeniable. While the loss of chestnut was only one of many factors resulting in the decline of brook trout in the Southeast (others include the introduction of brown and rainbow trout, heavy logging and other land uses, acidic atmospheric deposition, and urbanization of the rural landscape), it undeniably played a role in the loss and set the stage for what we are currently managing today. State, Federal, and local governments, as well as many private organizations, are currently making the conservation, preservation and restoration of the native brook trout a priority in their management.

Potential local and landscape level effects are discussed above. Assuming that other states in the southern Appalachian mountains are also experiencing the hemlock woolly adelgid, cumulative effects to southern strain brook trout need to be considered at the regional level. North Carolina, because it supports the most miles of occupied habitat for brook trout in the Southeast, serves as the heart of the distribution of the species. Generally speaking, losses (as a result of the HWA) at the periphery of the species' range (e.g. Virginia, South Carolina, Tennessee) would occur first, only increasing the value of those populations in North Carolina, particularly as restoration efforts increase. However, as mentioned above, long-term survival of the habitats and species (particularly brook trout) would continue, although with fewer populations and a potentially smaller range.

Extensive studies of the effects of atmospheric deposition on high elevation streams across the National Forests in North Carolina have indicated that at the present, Forest streams are not being impacted by acid deposition. Air quality models show that, as a result of improved air quality legislation and industry standards, the threat of streams being affected by acid deposition in the mountains of North Carolina actually lessens over time. Any potential effects of this project will not contribute to potential effects of acid deposition (or lack thereof) on cold- and coolwater streams or MIS population trends.

Alternative B – Beetles Releases and Imidacloprid Treatments

Vegetation management activities seldom occur near streams, though recreational activities are often occur near water. Past, present, and reasonably foreseeable future activities include the occasional construction of stream crossings for roads or trails, water based recreational activities and streamside camping. If sediment enters the stream from these sources it can result in localized and temporary reductions in the quality of the habitat for aquatic invertebrates and fish. In areas with many streamside hemlocks, the addition of LWD from dead hemlocks (from HWA infestation) could initially help offset effects from sedimentation by providing additional instream habitat in the short term. However, once that influx of LWD decomposed, a more lengthy loss of new LWD inputs would occur while riparian forests move through early stages of succession. Alternative B would allow for a moderating affect to LWD inputs, without as much swing up and down, since fewer hemlocks would die over the next few years, allowing for a more even flow of LWD into streams over time.

Imidacloprid

Since use of a clearance process and other safety precautions would minimize or eliminate the potential for contact between imidacloprid and aquatic resources, the use of imidacloprid would not add cumulatively to effects on aquatic habitats or populations from all other sources.

Predator Beetles

Since releasing predator beetles will have no measurable direct or indirect effects on aquatic resources, this action would not add cumulatively to effects on aquatic habitats or populations from all other sources.

Alternative C – Beetle Releases

Alternative C would moderate the influx of LWD similarly to Alternative B, but to a lesser extent.

Predator Beetles

Since releasing predator beetles will have no measurable direct or indirect effects on aquatic resources, this action would not add cumulatively to effects on aquatic habitats or populations from all other sources.

3.4 Management Indicator Species (MIS) Population Trend Information

A summary of the assessment of habitat changes in biological communities and special habitats and the effect of these changes on terrestrial and aquatic species used as MIS is documented in this section. This summary is based on more detailed analyses found in the Aquatic, Terrestrial Wildlife, and Botanical reports available in the project file and repeated in part in sections 3.1, 3.2, and 3.3. These assessments provide a checkpoint of project level activities, the anticipated change in habitat used by MIS, and the likely contribution to forest-wide population trends. The MIS Report for the Nantahala and Pisgah National Forests (2001) is also incorporated by reference.

3.4.1 MIS considered for this project

The forest-wide list of MIS was considered as it relates to this project analysis area. The project analysis area includes forests dominated by eastern or Carolina hemlock, forests where these species are important components, and aquatic habitats associated with these forests. Only those MIS that occur or have habitat within the project analysis area and may be affected by any of the alternatives were carried through the in-depth analysis. All MIS were considered and this documentation shows which MIS were or were not chosen to represent the effects of management actions along with the rationale for these selections.

Consistent with the Forest Plan and the associated FEIS, the effects analysis focuses on changes to MIS habitat. These project-level effects are then put into context with the forest-wide trends for populations and habitats.

To process and document the information efficiently, a series of tables are used as follows:

1) **Tables MIS-1** and **MIS-2:** These tables display the biological communities, special habitats, associated MIS, and reasons species were, or were not, selected to reflect management activities in the project area. The source of these tables is the Final Supplement to the Final Environmental Impact Statement (FSFEIS), Vol. I, Tables III-8 and III-9.

2) **Tables MIS-3** and **MIS-4:** These tables compare the effects (expressed as changes in habitat) by alternative to the forest-wide estimates of habitats for each biological community and special habitat selected in the project-level analysis. Following these tables is a discussion of how the project's effects to habitats affect forest-wide trends and the cumulative effects for these selected habitats.

3) **Table MIS-5:** This table displays by MIS the forest-wide population trend along with the associated biological community or special habitat selected in the project-level analysis. The information in this table is included in the MIS Report for the Nantahala and Pisgah National Forests and is incorporated by reference. This table is used in conjunction with the information presented in Tables 3 and 4 to explain how the project's effects to habitats affect forest-wide population trends for the species considered. Following these tables is a discussion of the cumulative effects for the selected species.

Table MIS-1. Biological communities, associated MIS (per the Final Supplement to the Final Environmental Impact Statement Volume I, Table III-8), and why species were chosen to reflect management activities or eliminated from further in-depth analysis.

Biological Community	**MIS**	**Analyzed Further/ Evaluation Criteria***
Fraser fir forests	Fraser fir, golden-crowned kinglet, Carolina northern flying squirrel	No[/1]
Red Spruce/fraser fir forests	Golden crowned kinglet, Carolina northern flying squirrel, solitary vireo	No[/1]
Grassy and heath balds	Mountain oat-grass, Catawba rhododendron	No[/1]
Northern hardwood forests	Carolina northern flying squirrel, twisted stalk, solitary (blue-headed) vireo	No[/1]
Carolina hemlock bluff forests	Golden-crowned kinglet, Carolina hemlock	Yes
Cove forests	Ginseng, black cherry, buckeye, basswood, solitary (blue-headed) vireo	No[/1]
Oak and oak/hickory forests	Red oak, white oak, hickories	No[/1]
White pine forests	White pine (natural community only)	No[/1]
Yellow pine mid-successional communities	Pine warbler (low elevational shortleaf/Virginia pine)	No[/1]
Xeric yellow pine forests	Pine warbler (pine/oak/heath low elevation habitats) pitch pine, table mountain pine, turkey beard, mid-successional)	No[/1]
Reservoirs	Index of biotic integrity, largemouth bass, bluegill	No[/1]
Forested seep wetlands	Golden saxifrage, umbrella leaf, mountain lettuce	No[/1]
Bogs	*Sphagnum spp.*	No[/1]
Mountain ponds and ephemeral pools	Spotted salamander (vernal pools)	No[/2]
Barrens and glades	Prairie dropseed, slender wheatgrass	No[/1]
Shaded rock outcrops and cliffs	Green salamander (granitic gneiss rock outcrops with crevices and mesic conditions), Jordan's salamander, alumroots, saxifrages	No[/2]
Open rock outcrops and cliffs	Raven, peregrine falcon, Biltmore sedge, wretched sedge, mountain oat-grass	No[/2]
Caves	Bats (all cave-using species)	No[/2]
Alluvial forests	Two-lined salamander (mid-late successional stages), raccoon (all forest types), mink	Yes
Coldwater streams	Brook, brown, and rainbow trout; sculpin, blacknose dace	Yes
Coolwater streams	Smallmouth bass, white sucker, moxostoma spp., index of biotic integrity	Yes
Warmwater streams	Index of biotic integrity, smallmouth bass, freshwater mussels, spotfin chub	No[/1]

[/1] Biological Community and its represented species do not occur within the project area; therefore, this biological community will not be affected by any of the alternatives. Given no effects to the community, the alternatives in this project will not cause changes to forest-wide habitat trends or changes in population trends of species associated with this community. For cove forests, these MIS represent rich coves, not the acidic coves where hemlocks are found

[/2] Biological Community is imbedded in only a small portion of the analysis area and will be excluded by project management activities. This biological community will not be affected by any of the alternative. Given no effects to the community, the alternatives in this project will not cause changes to forest-wide trends or changes in population trends of species associated with this community.

Table MIS-2. Special Habitats, associated MIS (per Final Supplement to the Final Environmental Impact Statement Volume I, Table III-9), and why were species chosen or eliminated from further analysis.

Special Habitat	**MIS**	**Analyzed Further/ Evaluation Criteria***
Old Forest Communities (100+ years old)	Black bear (dens, low levels of disturbance), bats (roosting and foraging habitats in mature forests), pileated woodpecker (cavities, foraging habitat), lung lichens	Yes
Early successional (0-10 years old)	White-tailed deer (all communities and elevations), eastern wild turkey (all communities), ruffed grouse (early and mid-successional all communities) rabbits, rufous-sided (eastern) towhee, bobcat, field sparrow (brushy, riparian thickets)	No[/1]
Early successional (11-20)	Rufous-sided (eastern) towhee, ruffed grouse (early and mid-successional all communities)	No[/1]
Soft mast producing species	Wild grape (*vitus spp.)*, cedar waxwing (all communities soft mast)	No[/1]
Hard mast-producing species (>40 yrs)	Black bear, wild turkey, gray squirrel, white-tailed deer	No[/1]
Cove forests	Ginseng, black cherry, buckeye, basswood, solitary (blue-headed) vireo	No[/1]
Mixed pine/hardwood forest types (successional stage and hard mast)	Black bear, eastern wild turkey, gray squirrel, white-tailed deer	No[/1]
Contiguous areas with low disturbance (< 1 mile open travelway/4 square miles	Black bear (all communities)	No[/1]
Contiguous areas with moderate disturbance levels (<1 mile open travelway/2 square miles)	Eastern wild turkey (all communities)	No[/1]
Large contiguous forest areas	Ovenbird (in breeding range, moderately productive sites), northern parula warbler (in breeding range, requires cover and riparian habitats) veery, solitary (blue-headed) vireo	No[/1]
Permanent grass/forb openings	Eastern wild turkey, eastern meadowlark, rabbit	No[/1]
Den trees (>36” dbh)	Black bear (large dens)	No[/1]
Snags and dens (>22” dbh)	Pileated woodpecker, raccoon (moderate sized dens)	Yes
Small snags and dens	Gray squirrel, white-breasted nuthatch, yellow-bellied sapsucker (breeding populations)	Yes
Downed woody debris – all sizes (foraging and cover habitats)	Black bear (all communities), pileated woodpecker, ruffed grouse (down logs for drumming), Jordan’s salamanders	Yes

[/1]Special habitat and its represented species do not occur within the project area; therefore, this special habitat will not be affected by any of the alternatives. Given no effects to the habitat, the alternatives in this project will not cause changes to forest-wide trends or changes in population trends of species associated with this habitat.

Table MIS-3. Biological communities, forest-wide estimates, and expected changes resulting from the alternatives.

Biological Community	**Forest wide Estimate**	**Estimated Changes**		
		Alternative A	**Alternative B**	**Alternative C**
Carolina hemlock bluff forests	6 occurrences	HWA infestation will continue to expand throughout the range of Carolina hemlock resulting in widespread reduction in individual trees and stands of trees. Carolina Hemlock Bluff forests will be poorly distributed across the Forests, there will be little likelihood of recolonization of these sites, and habitat will be insufficient to support stable populations of the species.	The spread of HWA will be slowed and the degree of infestation and damage to hemlock will lessen. Although not all hemlocks will survive, the species will remain well-distributed across the Forests on xeric pine sites and bluff forests The diversity of other species in Carolina Hemlock bluff forests will be maintained.	The spread of HWA will be slowed and the degree of infestation will lessen. However, damage to hemlocks will continue until predator beetles are in equilibrium with HWA populations. This time-lag could result in the loss of hemlock in some Carolina Hemlock Bluffs, reducing the diversity of species in this community and its distribution across the Forests.
Alluvial forests	21,000 ac Alluvial Forest 55,000 ac other floodprone areas	Species composition will shift to more hardwood and white pine in alluvial forests on about 10% of all alluvial forests.	Shifts in species composition will be negligible. The eastern hemlock component will persist but with somewhat reduced vigor.	Shifts in species composition to more hardwood and white pine dominance in some locations. Eastern hemlock will persist but with reduced vigor.
Coldwater Streams	5,060 miles (2,125 miles occupied by aquatic MIS)	14% (725 miles) of all coldwater streams and 29% (616 miles) of those supporting aquatic MIS could be affected. Large woody debris (LWD) in these areas would increase substantially in the short-term while shading from hemlock crowns will decrease. Following a period of relatively little LWD transport to streams and increased shading from streamside shrubs and expanding live tree crowns, more natural LWD transport rates and shading will stabilize in the long-term (>60 years).	Same as Alternative A for about 400 miles of coldwater streams supporting aquatic MIS. (see cumulative effects analysis of biological communities for analysis reasoning)	Same as Alternative A for about 500 miles of coldwater streams supporting aquatic MIS. (see cumulative effects analysis of biological communities for analysis reasoning)
Coolwater Streams	400 miles (168 miles occupied by aquatic MIS)	Same as above for 4% of all coolwater streams.	Same as Alternative A	Same as Alternative A

Table MIS-4 Special Habitats, forest-wide estimates, and expected changes resulting from the alternatives.

Special Habitat	**Forest wide Estimate**	**Estimated Changes**		
		Alternative A	**Alternative B**	**Alternative C**
Old Forest Communities (100+ years old)	171,000 ac	Loss of 5,900 acres of old forests characterized by hemlock plant communities; loss of individual older hemlock throughout the oldgrowth management area	Loss of 4,400 acres of old forests characterized by hemlock plant communities: reduction in old hemlock trees in the old growth management areas	Loss of 4,400 acres of old forests characterized by hemlock plant communities: reduction in old hemlock trees in the old growth management areas
Snags and dens (> 22” dbh)	Ave. at 80 yr. Cove= 4/ac Upland=3/ac Pine-2/ac	A very large increase (10x) in snags on 13,770 acres where eastern hemlock is currently the dominant species and a moderate but measurable increase (2-3x) on an additional 200,000 acres in Acidic Cove habitats	A small increase in snags (an additional 1-2 snag per acre) on over 200,000 acres	An increase in snags (an additional 2-3 snag per acre) on over 200,000 acres
Small snags and dens	Ave. at 80 yr. Cove= 4/ac Upland=3/ac Pine-2/ac	A very large increase (10x) in snags on 13,770 acres where eastern hemlock is currently the dominant species and a moderate but measurable increase (2-3x) on an additional 200,000 acres in Acidic Cove habitats	A small increase in snags (an additional 1-2 snag per acre) on over 200,000 acres	An increase in snags (an additional 2-3 snags per acre) on over 200,000 acres.
Down Woody Material	*High Accumulation* Small wood: 18,000 ac. Large wood: 386,000 *Low Accumulation* approx: 600,000	A very large increase (10 times) in downed wood on about 14,000 acres where eastern hemlock is currently the dominant species and a moderate but measurable increase (2-3 times) on an additional 200,000 acres in Acidic Cove habitats	A small increase (an additional 1 - 2 stems per acre) in downed wood on over 200,000 acres	An increase (an additional 2-3 stems per acre) in downed wood on over 200,000 acres.

3.4.2 Forest-wide trends and cumulative effects of project-level activities for Biological Communities and Special Habitats

The release of beetles in Alternatives B & C will have no direct effects on these communities and habitats. Effects will be indirect in terms of long-term changes to species composition (i.e. loss of hemlock). There will be no direct effect from chemical treatments in Alternative B because the treatment will only affect invertebrates in the soil at injection sites and feeding on treated hemlocks, and not the communities or habitats as a whole. Indirect effects will be long-term due to changes in species composition.

Carolina hemlock bluff forests: The forest-wide trend for Carolina Hemlock Bluffs was considered upward prior to the HWA outbreak because: (1) xeric forests 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 have favored other, more valuable commercial species has 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, (Alternatives B & C) 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.

Unless HWA treatments occur on public and private lands adjacent to the Nantahala and Pisgah National Forests, in the near future, renewed infestations from off-Forest will continue. The cumulative effects of reduced Hemlock Bluff Forests on the Forests and the loss of Carolina hemlock on adjacent lands will reduce the potential for gene flow between isolated Carolina Hemlock Bluff Forests. This will increase the potential for loss of these forests both within and outside the Nantahala and Pisgah National Forests.

Alluvial Forests: Alluvial Forests currently are static, i.e. they are not expanding or being reduced in extent. Forest composition is also fairly static because few vegetation management activities have occurred in the

past, are currently ongoing, or are foreseeable in the future because these forests are considered riparian areas and only activities that enhance riparian benefits are permitted by the Nantahala and Pisgah National Forest LRMP. The HWA, left uncontrolled, could eliminate eastern hemlock in alluvial forests and shift composition in these areas to other shade tolerant or intermediate tolerant species.

Implementing HWA treatments (Alternatives B & C) will reduce the rate of infestation and the resulting damage and death to hemlocks. Overall, current species composition and structure will remain static in alluvial forests but species composition shifts will be evident in some stands.

The elm-ash-cottonwood forest-type group declined in the mountain counties of North Carolina between 1990 and 2002 (Brown 2002). Although hemlock is not a major associate of this alluvial forest group that includes willow, sycamore, beech, and maple, it does occur in alluvial forests in more confined stream channels. The decline of alluvial forests on private lands and the reduction of hemlock throughout its range in North Carolina is not likely to cumulatively impact the extent of alluvial forests on the Nantahala and Pisgah National Forest because: (1) they are not included in any foreseeable land exchanges, and (2) riparian standards in the LRMP require that management activities will maintain riparian benefits in these forests. However, species composition shifts in alluvial forests will occur throughout the Southern Appalachians and on the Nantahala and Pisgah National Forests.

Old Forest Communities: These communities increased 2.5 times from 1980 to 2000 and continue to increase because of the large number of acres currently in older age classes across the Nantahala and Pisgah National Forests, especially within old growth management areas. Most of the increase in older forests occurred in Acidic Coves that support or could support eastern hemlock (MIS Report 2001) and in areas not suited for timber production.

Few if any vegetation management activities have impacted old hemlock communities in the recent past, currently, or in the reasonably foreseeable future. Implementing HWA treatments (Alternatives B&C) will reduce the foreseeable future loss from HWA of old hemlock individuals and old hemlock stands. Natural mortality will continue and mortality of old trees will increase as HWA infestations occur away from the proposed HWA control areas. However, loss of old forest hemlock communities will be offset by gains in old forest communities represented by other forest types (MIS report 2001), especially in areas not suited for timber production and old growth management areas, therefore forest-wide upward trends will continue.

Snags and dens > 22" and small Snags and Dens < 22" in diameter: The current, average level of snag production is relatively stable across the Nantahala and Pisgah National Forests. Past, present, and reasonably foreseeable timber management and prescribed fire activities typically reduce snags in the treated areas, but the amount of acres treated is too small to affect the forestwide trend. Recent (< 5 years) pine beetle infestations have increased snags forest-wide especially in xeric pine and xeric pine-hardwood stands. Although many of these snags are no longer standing, current and ongoing damage from the HWA has also contributed to the rate of snag production on these xeric sites and on more mesic Acidic Coves and therefore to a forest-wide increase in the amount of snags < 22" in diameter and snags and dens > 22" in diameter.

The proposed HWA treatments will slow the current accelerated snag production across the Forests, however, stands away from treatment areas will continue to experience higher than normal rates of hemlock mortality and thus greater snag production. Even with some HWA controls implemented on adjacent private and public lands, small snags are expected to increase throughout the Southern Appalachians.

Down Woody Material: Down woody material will increase as hemlock mortality and snag production increases in HWA infested areas. The amount of down woody material has increased due to recent rain and wind events as well as insects and diseases attacking forest trees. Past, present, and reasonably foreseeable activities such as prescribed burning are expected to reduce down woody material in treated areas, but that is a very small portion of the landscape. The proposed HWA treatments will slow the current accelerated snag and downed wood production across the Forests, however, stands away from treatment areas will continue to experience higher than normal rates of hemlock mortality and thus greater snag production and eventually greater downed wood. Even with some HWA controls implemented on adjacent private and public lands, downed wood is expected to increase throughout the Southern Appalachians.

Coldwater Streams: In the past there have been occasional management activities to add LWD to streams. Recent wind and rain events have added large amounts of LWD to some stream reaches while flushing it from others. It is reasonably foreseeable that some stream restoration activities would occur in the future to correct damage from these recent storms. The proposed HWA treatments will slow the current accelerated LWD production across the Forests, however, stands away from treatment areas will continue to experience higher than normal rates of hemlock mortality and thus greater snag production and eventually greater LWD.

Approximately 14% of all coldwater streams are associated with hemlock forests and 29% (616 miles) of the 2,125 miles of coldwater streams that

are occupied by at least one aquatic MIS on the Nantahala and Pisgah National Forests. About 132 miles of these coldwater stream habitats are associated with hemlock forests that support brook trout. Over 80% (105 miles) of these areas are proposed for HWA control treatments; predator beetles will be released in all of these areas and additional chemical treatments will occur in ½ of the areas in Alternative B. Because immediate or total control of HWA is not feasible, some hemlock mortality will occur and result in decreased shading and increased LWD even in HWA control treatment areas. It is likely the effects to other coldwater streams that support aquatic MIS are similar to those that support brook trout. Therefore, with no HWA control treatments implemented (Alternative A) all of the 616 miles of coldwater streams that are occupied by at least one aquatic MIS associated with hemlock forests will experience increased LWD transport rates and decreased shading from loss of hemlock. Similar effects will occur on about 400-500 miles of coldwater streams with Alternatives B and C, with fewer acres impacted in Alternative B than in Alternative C.

Coolwater Streams: In the past there have been occasional management activities to add LWD to streams. Recent wind and rain events have added large amounts of LWD to some stream reaches while flushing it from others. It is reasonably foreseeable that some stream restoration activities would occur in the future to correct damage from these recent storms. Due to the small amount of coolwater streams associated with hemlock, no alternative would add or subtract measurably from input from these other sources.

Approximately 4% of the 168 miles of coolwater streams on the Nantahala and Pisgah National Forests are associated with hemlock forests. A temporary reduction in stream shading and an increase in LWD due to hemlock mortality resulting from HWA infestations are expected adjacent to these streams. This is not, however, likely to result in a measurable change in forest-wide characteristics of coolwater streams due to the small amount of stream miles affected.

Table MIS-5. Management Indicator Species, estimated population trend, and biological community and special habitat indicated by the species

Species	**Estimated Population Trend**	**Biological Community or Special Habitat**					
		1	**2**	**3**	**4**	**5**	**6**
Carolina Hemlock	Decreasing	Carolina Hemlock Bluffs					
Lung lichen	Increasing	Old Forest Communities					
Golden Crowned Kinglet	Decreasing	Fraser Fir Forests	Red Spruce/Fraser Fir Forests	Carolina Hemlock bluff forests			
Blue Ridge two-lined salamander	Static	Alluvial Forests					
Raccoon	Increasing	Alluvial Forests	Snags and dens (>22 dbh)				
Mink	Static	Alluvial Forests					
Black Bear	Increasing	Old Forest Communities	Hard mast-producing species	Mixed Pine/hardwood forest types	Contiguous areas with low disturbance	Den trees (>36 dbh)	Downed woody debris- all sizes
Bats	Varies by species	Caves	Old Forest Communities				
Gray Squirrel	Static	Hard mast-producing species	Mixed pine/hardwood forest types	Small snags and dens			
White-breasted Nuthatch	Increasing	Small snags and dens					
Ruffed Grouse	Static	Early successional (0-10)	Early successional (11-20)	Downed woody debris			
Yellow-bellied Sapsucker	Decreasing	Small snags and dens					
Pileated Woodpecker	Increase	Old Forest Communities	Snags and dens (>22 dbh)	Downed woody debris – all sizes			
Jordan's salamander	Static	Down woody debris – all sizes					
Brook trout	Static	Coldwater streams					
Brown trout	Static	Coldwater streams					
Rainbow trout	Static	Coldwater streams					
Blacknose dace	Static	Coldwater streams					
Sculpin	Static	Coldwater streams					
Smallmouth Bass	Static	Coolwater streams					

3.4.3 Effects of Alternatives B and C on forest-wide trends for aquatic and terrestrial MIS on the Nantahala and Pisgah National Forests

Refer to sections 3.1, 3.2, 3.3 for a general discussion of effects.

Carolina hemlock: Refer to the discussion regarding Carolina hemlock bluff forests in section 3.4.2. Implementation of HWA control treatments (Alternatives B & C) will not be enough to reverse the downward population trend in Carolina hemlock.

Lung Lichens: The population trend for lung lichens is upward because the species' primary old forests habitats are increasing across the Nantahala and Pisgah National Forests. Loss of old forest hemlock communities due to HWA infestations will be offset by the gains in old forest communities represented by other forest types therefore forest-wide upward trends will continue. Similarly, species associated with old forests such as lung lichens, will remain on an upward trend.

Sawtimber-size stands decreased 193,000 acres in the mountain counties of North Carolina between 1990 and 2002 (Brown 2002). Although there are no species considered hemlock oldgrowth obligates, the decline of these stands, many of which reflect old forest communities, the decline in old forest hemlock stands on the Nantahala and Pisgah National Forest, and the loss of old hemlocks on private and public lands from HWA could result in an incremental impact. This impact could negatively affect other species in the Southern Appalachians on private and other public lands adjacent to the Nantahala and Pisgah National Forests that are dependent upon old forest conditions being maintained on the National Forests.

Golden-crowned kinglet: The estimated population trend of the golden-crowned kinglet is downward due to the decline in its primary habitat (fraser fir forests and red spruce-fraser fir forests) across the Forests. Hemlocks, although a habitat of moderate quality, are used by kinglets for nesting, especially at the southern end of their range. Even with implementation of this proposed project, not all infested hemlock will be treated. As hemlocks die from infestation of the hemlock woolly adelgid, habitat will continue to decline for the golden-crowned kinglet, thus continuing the downward population trend for this species. The cumulative impact resulting from the decline of all primary habitat types that support the species could lead to a loss of some local populations even with implementation of HWA control treatments.

Blue Ridge two-lined salamander: The estimated population trend of the Blue Ridge two-lined salamander is static. As hemlocks die, the character of alluvial forests, the primary habitat for the species, will change where hemlock is the dominant overstory species. Initially,

populations of Blue Ridge two-lined salamander may appear to decline after hemlocks die off. However, they are able to take refuge in surrounding moist areas until the hemlock or other conifer dominated overstory trees can recover and once again provide shade (i.e., moisture) to the forest leaf litter. Implementation of this proposed project would help retain hemlock, which will maintain the moist condition for these salamanders along streams and in the general forest.

Raccoon: The estimated population trend of the raccoon is upward. Although the composition of alluvial forests, the primary habitat for the species, may change to some degree, this will not impact habitat suitability for the species. In fact, habitat conditions for raccoon are likely to improve because there will be an increase in snags and potential dens as hemlocks die. Raccoons prefer to den close to water sources, so hemlock snags would provide suitable den trees for raccoons. Even with implementation of this proposed project, not all infested hemlock will be treated. As hemlocks die from infestation of the hemlock woolly adelgid, potential den habitat will continue to increase, thus continuing the upward population trend for this species.

Mink: The estimated population trend of mink is static. Although mink is an alluvial forest-associated species, it is not dependent on hemlock. Because mink populations tend to be limited by the availability of denning sites (e.g., dens of other species such as the bank dens of beavers or muskrats) or food sources, the death of hemlock probably would not affect mink. Also, biocontrol or chemical treatment of hemlock infested with HWA will not negatively affect mink since mink is not dependent on the hemlock resource. Thus, implementation of this proposed project will not change the population trend for this species.

Black bear: The estimated population trend of black bear is upward. This trend is related to the increasing amounts of suitable habitats on the Nantahala and Pisgah National Forests that provide food, cover, and denning areas for the species. These include the following biological communities or species habitats: old forest communities, contiguous areas with low distrubance, and mixed pine-hardwod forests, hard mast-producing species, den trees (> 36” dbh) and downed woody debris.

Although the death of hemlock along streams may reduce cover on travel corridors, there will be an increase in forage and denning opportunities for black bear. Maintenance of hemlock along streams with implementation of this proposed project will help provide cover along riparian travel corridors. It is also reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags and coarse woody debris will still be created as untreated hemlock

die, thus creating potential den trees and foraging habitat for black bears. Thus, population trends for black bear will continue to increase.

Bats: The estimated population trend for bats varies with the species of bat. Although hemlock is generally considered to represent poor summer habitat for many species of bats, the death of hemlock could increase potential summer roosting habitat. Even with implementation of this project, hemlock snag production will accelerate and therefore increase potential roost trees for a variety of bats. However, roosting trees across the Forests are not a limiting factor, so this increase in potential roosting habitat will not change the population trend for any particular bat species.

Gray squirrel: The estimated population trend of the gray squirrel is static across the Nantahala and Pisgah National Forests. Although the character of the forest may change, there will be an increase in snags that may provide potential cavity nests as hemlocks die. Gray squirrel is very closely tied to mature hardwood (i.e., hard mast) forests. With implementation of this proposed project, not all infested hemlock will be treated. Since hard mast, not the amount of cavity nests, limits squirrel populations, implementation of the proposed project will maintain the static population trend for this species.

White-breasted nuthatch: The estimated population trend of the white-breasted nuthatch is upward across the Nantahala and Pisgah National Forests. Although nuthatches are not dependent on hemlock, the death of scattered hemlock that occur in mature hardwood stands may increase habitat for the nuthatch by creating snags that could provide potential cavity nests. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created that provide potential cavity nests for the nuthatch. This potential increase in nesting habitat will help to maintain the increasing population trend for this species.

Ruffed grouse: The estimated population trend of ruffed grouse is static across the Nantahala and Pisgah National Forests. Although the death of hemlock along streams may reduce roosting cover, there will be an increase in forage and drumming log opportunities for grouse. Maintenance of hemlock with implementation of this proposed project will help provide roosting cover. It is also reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus coarse woody debris will still be created as untreated hemlock die, creating potential drumming logs for male grouse and foraging habitat for grouse in general. Ruffed grouse are also dependent upon early successional habitat 0-10 and 10-20 years in age. This habitat remains relatively stable due to stable timber harvest levels across the Forests, and HWA control treatments will have no effect on this special

habitat. Although HWA infestations will result in some improvement in downed woody debris habitat, this improvement will be limited to hemlock associated forests. The population trend for ruffed grouse is therefore expected to remain static because hemlock associated stands occur on only 2 to 10% of the Forests and because a primary habitat need, early successional habitat, is static across the Forests.

Yellow-bellied sapsucker: The estimated population trend for yellow-bellied sapsucker is downward across the Nantahala and Pisgah National Forests. Although these woodpeckers are associated with small snags and dens which are expected to increase will all alternatives, other habitat needs such as high elevation open forests with dense saplings are still at reduced levels. The death of hemlock could increase the amount of potential woodpecker habitat by creating snags that would be used for foraging and cavity nesting. However, these habitat improvements will be limited to hemlock associated forests. The population trend for sapsuckers is therefore expected to remain downward because hemlock associated stands occur on only 2 to 10% of the Forests and because other primary habitat needs are not improving.

Pileated woodpecker: The estimated population trend for pileated woodpecker is upward across the Nantahala and Pisgah National Forests. These woodpeckers are associated with older forest communities, snags and dens, and down woody debris. Although pileated woodpeckers are not dependent on hemlock, the death of hemlock could increase the amount of potential woodpecker habitat by creating snags that would be used for foraging and cavity nesting. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created that are potential nest and foraging trees for woodpeckers. Therefore, pileated woodpecker populations will continue to increase.

Jordan's salamander: The estimated population trend for Jordan's salamander is currently static across the Nantahala and Pisgah National Forests. As hemlocks die, the character of stands where hemlocks occur will change as sunlight hits the forest floor, drying out leaf litter. Initially, populations of Jordan's salamander may appear to decline after hemlocks die off. However, they are able to take refuge in surrounding moist areas, under cover objects, and in underground burrows until the area recovers vegetatively and once again provides shade (i.e., moisture) to the forest leaf litter. Also, Jordan's salamander is nocturnal, so this behavior helps them cope with existing in "drier" forested settings. Also, with the death of hemlocks, woody debris will increase, thus increasing cover objects which these salamanders can use as shelter. Implementation of this proposed project will help retain hemlock to maintain the moist condition

for these salamanders in the general forest, and the death of untreated hemlock will increase woody debris, thus maintaining a static population trend.

Brook trout: The population trend for brook trout is static. Few vegetation management activities have occurred in the past, are currently ongoing, or are foreseeable in the future in riparian forests associated with brook trout habitat. Approximately 26% of the occupied brook trout habitat across the Forests could be affected by a temporary reduction in stream shading and an increase in LWD due to hemlock mortality resulting from HWA infestations adjacent to streams. At the local level, losses of brook trout could be dramatic, forest-wide population trends could be affected, and measurable effects on the gene pool for Southern strain brook trout could be seen. However, long-term habitat suitability and species viability would not be affected.

Approximately 80% of all hemlock stands adjacent to brook trout streams are proposed for HWA control treatments. Because total and immediate control of HWA is not feasible, even in HWA control treatment areas, some hemlock mortality will occur and result in decreased shading and increased LWD. This is not expected, however, to significantly affect brook trout forest-wide populations for the following reasons: (1) the loss of shading could be offset by the gains in habitat capability from increased LWD, (2) 75% of occupied brook trout habitat on the Nantahala and Pisgah National Forests is not associated with hemlock and therefore not affected by the HWA, and (3) future activities adjacent to brook trout streams are expected to maintain the current population trend because the only activities that are permitted by the Nantahala and Pisgah National Forest LRMP are those that would enhance riparian benefits. Therefore, although local losses will occur, brook trout populations are expected to remain static across the Forests if HWA control treatments are implemented.

Brown trout, Rainbow trout, Blacknose dace, and Sculpin: The population trend for these species is static. Few vegetation management activities have occurred in the past, are currently ongoing, or are foreseeable in the future in riparian forests associated with stream habitat supporting these species. Approximately 25%, 36%, 29%, and 29% of the occupied brown trout, rainbow trout, blacknose dace, and sculpin habitat across the Forests, respectively, could be affected by a temporary reduction in stream shading and an increase in LWD due to hemlock mortality resulting from HWA infestations adjacent to streams. At the local level, losses could be dramatic, measurable effects on individual brown trout, rainbow trout, blacknose dace, and sculpin populations could be seen, and forest-wide population trends could be affected. However, long-term habitat suitability and species viability would not be affected.

Although some hemlock mortality will occur even in HWA control areas and this will result in decreased shading and increased LWD to streams supporting brown trout, rainbow trout, blacknose dace, and sculpin it is not expected to greatly impact these species forest-wide populations for the following reasons: (1) the loss of shading could be offset by the gains in habitat capability from increased LWD, (2) 75%, 65%, 71%, and 71% of occupied brown trout, rainbow trout, blacknose dace, and sculpin habitat on the Nantahala and Pisgah National Forests, respectively, is not associated with hemlock and therefore not affected by the HWA, and (3) future activities adjacent to streams supporting these species are expected to maintain the current population trend because the only activities that are permitted by the Nantahala and Pisgah National Forest LRMP are those that would enhance riparian benefits. Therefore, although local losses will occur, brown trout, rainbow trout, blacknose dace, and sculpin populations are expected to remain static across the Forests if HWA control treatments are implemented.

Smallmouth bass: The population trend for smallmouth bass is static. Few vegetation management activities have occurred in the past, are currently ongoing, or are foreseeable in the future in riparian forests associated with brook trout habitat. Only 4% of the occupied smallmouth bass habitat across the Forests could be affected by a temporary reduction in stream shading and an increase in LWD due to hemlock mortality resulting from HWA infestations adjacent to streams. Losses of smallmouth bass due to these impacts may not even be measurable at the local level because these habitats are interspersed with other suitable smallmouth bass habitats where hemlock is not an associated species and therefore riparian vegetation is not affected by HWA. Forest-wide population trends in smallmouth bass populations will not be affected and long-term habitat suitability and species viability would not be affected. Therefore, smallmouth bass population trends are expected to remain static across the Forests regardless of which HWA alternative is implemented.

3.5Threatened, Endangered, Sensitive, and Forest Concern Species

3.5.1 Botanical Species Evaluation

The USDA Forest Service considered approximately 351 potential hemlock treatment areas prior to developing the proposed action. The proposed action selected 112 eastern hemlock areas and 47 Carolina hemlock areas that are distributed in a manner that fulfills the requirements of the Hemlock Conservation Design. The species discussions that follow consider all 351 potential treatment areas.

Species Considered and Species Evaluated

Four hundred twenty-five rare plant species are either known to occur, or may occur on the Nantahala or Pisgah National Forests. These include fourteen federally listed plant species: seven endangered species and seven threatened species. One hundred forty eight are regionally-listed sensitive plant species. Sixty-nine of the sensitive plant species are non-vascular, either a hornwort, liverwort, moss, or lichen. The remaining 263 are forest concern plant species, 72 of these which are non-vascular. Regional sensitive species are believed to have viability concerns throughout the southern region and generally exhibit a global rank of G3 or T3 or lower, or a national rank of N3 or lower. Forest concern plant species are less globally restricted species but typically grow at the periphery of their range in North Carolina or disjunct from their main range. This list of 425 plant species includes species that are known from the mountains of North Carolina only from some historical records (> 20 yr since last observed), and records from both private and public lands.

Eastern Hemlock

The list of 425 rare plants was queried for those species documented within habitats with significant eastern hemlock components. Of the 425 tracked species, 373 species were excluded from further analysis because proper habitat does not occur within the proposed activity area. Excluded habitat included high elevation grassy openings, southern Appalachian bogs, rock outcrop communities, Rich Cove Forest, Northern Hardwood Forest, oak dominated forest communities, and xeric pine dominated forest communities. Queried habitats for eastern hemlock associated rare plant species included Canadian Hemlock Forest, Acidic Cove Forest, and Spray Cliff Communities. One federally-listed, 34 sensitive and 22 forest concern plants, (57 rare plant species in total) have been documented within these habitats (Table 3.5-1)**.** Three rare vascular plant species, *Carex woodii*, *Robinia hispida var. fertilis*, and *Lysimachia fraseri* were excluded from this eastern hemlock habitat list of plant species since they are only occasionally located within Acidic Cove Forest and are not known to occur within this habitat where hemlock is an important component (G. Kauffman, personal observation). Species such as *Taxiphyllum alternans*, which are associated with high base rock surrounding Spray Cliff communities, were also excluded since eastern hemlock is not associated with soils influenced by high base rock. These three species prefer either partially open or open habitat not found in hemlock influenced Acidic Cove Forest (Weakley 2004, Isley 1990).

None of the 57 eastern hemlock forest associated rare species are known to be obligate associates of hemlock forest communities although

Brachymenium andersonii is only known within North Carolina from the Kelsey tract, a tract dominated by both eastern and Carolina hemlock near Highlands. However it has not been relocated since 1951. Various searches during the past 15 years have not successfully located the species. Only one species, *Schlotheimia lancifolia*, is known to occur on eastern hemlock bark although it does not exclusively occur on the bark (Anderson 1996). This species has also been located on Acer rubrum and Quercus rubra (P. Davison, personal communication). *Buckleya distichyphylla, a* rare southern Appalachian endemic shrub, parasitizes eastern and Carolina hemlock, however neither hemlock species is an obligate host (Natureserve 2004, Weakley 2004).

Table 3.5-1. Federally-listed, sensitive and forest concern rare plants known to occur or suspected within Eastern Hemlock dominated forest communities.

Species	**Pops[a]**	**Form**	**Designation[b]**	**Documented[c]**	**Substrate[d]**
Gymnoderma lineare	32	Lichen	Endangered	Yes	Stream Boulder
Acrobolbus ciliatus	05	Liverwort	Sensitive	No	Rock
Aneura sharpii	03	Liverwort	Sensitive	Yes	Rock
Anzia americana	01	Lichen	Sensitive	No	Bark
Bartramidula wilsonii	04	Moss	Sensitive	No	Rock
Bryocrumia vivicolor	01	Moss	Sensitive	Yes	Rock
Buckleya distichophylla	10	Vascular plant	Sensitive	Yes	Forest Floor
Ditrichum ambiguum	01	Moss	Sensitive	No	Forest Floor
Drepanolejeunea appalachiana	12	Liverwort	Sensitive	Yes	Bark
Fissidens appalachensis	1	Moss	Sensitive	No	Stream Boulder
Grammitis nimbata	01	Vascular plant	Sensitive	No	Rock
Hexastylis contracta	00	Vascular plant	Sensitive	No	Forest Floor
Hexastylis rhombiformis	03	Vascular plant	Sensitive	No	Forest Floor
Hydrothyria venosa	75	Lichen	Sensitive	Yes	Stream Boulder
Hymenophyllum tayloriae	05	Vascular plant	Sensitive	Yes	Forest Floor
Lejeunea blomquistii	02	Liverwort	Sensitive	Yes	Rock
Lophocolea appalachiana	03	Liverwort	Sensitive	No	Rock
Marsupella emarginata var. latiloba	00	Liverwort	Sensitive	No	Rock
Megaceros aenigmaticus	35	Hornwort	Sensitive	Yes	Stream Boulder
Pellia appalachiana	00	Liverwort	Sensitive	No	Rock
Plagiochila caduciloba	12	Liverwort	Sensitive	Yes	Rock
Plagiochila echinata	03	Liverwort	Sensitive	Yes	Rock
Plagiochila sullivantii var. spinigera	02	Liverwort	Sensitive	Yes	Rock
Plagiochila sullivantii var. sullvantii	07	Liverwort	Sensitive	Yes	Rock
Plagiochila virginica var. caroliniana	03	Liverwort	Sensitive	Yes	Rock
Plagiomnium carolinianum	02	Moss	Sensitive	Yes	Rock
Platyhypnidium pringlei	00	Moss	Sensitive	No	Rock
Porella appalachiana	00	Liverwort	Sensitive	No	Rock
Radula sullivantii	04	Liverwort	Sensitive	No	Rock

Species	Pops[a]	Form	Designation[b]	Documented[c]	Substrate[d]
Radula voluta	00	Liverwort	Sensitive	No	Rock
Schlotheimia lancifolia	02	Moss	Sensitive	No	Bark, Rock
Shortia galacifolia var. brevistylia	04	Vascular plant	Sensitive	No	Forest Floor
Shortia galacifolia var. galacifolia	02	Vascular plant	Sensitive	Yes	Forest Floor
Sphagnum flavicomans	01	Moss	Sensitive	No	Rock
Waldsteinia lobata	00	Vascular plant	Sensitive	No	Forest Floor
Brachymenium andersonii	01	Moss	Forest concern	Yes	Forest Floor
Brachymenium systylium	01	Moss	Forest concern	No	Forest Floor
Brachythecium populeum	00	Moss	Forest concern	No	Rock
Brachythecium rotaeanum	02	Moss	Forest concern	Yes	Bark, Rock
Bryoxiphium norvegicum	05	Moss	Forest concern	No	Rock
Bryum riparium	01	Moss	Forest concern	No	Rock
Cirriphyllum piliferum	02	Moss	Forest concern	Yes	Rock
Dichodontium pellucidum	06	Moss	Forest concern	Yes	Rock
Entodon sullivantii	07	Moss	Forest concern	Yes	Rock
Ephebe lanata	1	Lichen	Forest concern	No	Stream Boulder
Ephebe solida	00	Lichen	Forest concern	No	Stream Boulder
Homalia trichomanoides	03	Moss	Forest concern	Yes	Rock
Huperzia porophila	09	Vascular plant	Forest concern	Yes	Forest Floor
Mylia tayorii	2	Liverwort	Forest concern	No	Rock
Rhabdoweisia creulata	02	Moss	Forest concern	No	Rock
Spartina pectinata	01	Vascular plant	Forest concern	No	Forest Floor
Sphagnum squarrosum	02	Moss	Forest concern	No	Rock
Trichomanes boschianum	04	Vascular plant	Forest concern	No	Forest Floor
Warnstorfia fluitans	01	Moss	Forest concern	Yes	Stream Boulder
Phegopteris connectilis	07	Vascular plant	Forest concern	No	Forest Floor
Stewartia ovata	03	Vascular plant	Forest concern	No	Forest Floor
Trichomanes petersii	05	Vascular plant	Forest concern	Yes	Forest Floor

a --- Number of Populations documented on the Nantahala and Pisgah National Forests
b --- National Forests in North Carolina rare plant designation
c --- 1 or more populations documented within 1320 feet (1/4 mile) of the proposed treatment release area
d --- substrate preference for rare pant species

Carolina Hemlock

The list of 425 rare plants was queried for those species documented within habitats with significant eastern hemlock components. Of the 425 tracked species, all but three were excluded from further analysis because proper habitat does not occur within the proposed activity area. The queried habitat for Carolina Hemlock associated rare species included Carolina Hemlock Forest (Bluff or Typic type), Carolina Hemlock-Pine Forest, and Carolina Hemlock Forest (mesic type) (Natureserve 2004). All three of these communities are much more limited in abundance and

range across western North Carolina in comparison to Canadian Hemlock Forest or Acidic Cove Forest.

Table 3.5-2. Federally listed, sensitive and forest concern plant species known or suspected to occur in the Potential Carolina Hemlock Treatment Areas.

SPECIES	Pops	Grank	Srank	FORM	Designation	Documented*
Tsuga caroliniana	60+	G3	S3	Vascular plant	Sensitive	Yes
Buckleya distichophylla	10	G2	S2	Vascular plant	Sensitive	No
Brachymenium andersonii	01	GH	SH	Moss	Forest concern	Yes

* occurrence within 1320 feet (1/4 mile) of the beetle release area.

Two sensitive and one forest concern plant have been documented within these habitats (Table 3.5-2)**.** Both *Brachymenium andersonii* and *Buckleya distichophylla* have been located within eastern hemlock associated forests also. Rare species such as *Liatris helleri* and *Hudsonia montana*, can occur on rock outcrops with scattered *Tsuga caroliniana* trees nearby. However, these species are not associated with stands proposed for hemlock wholly adelgid (HWA) treatment, i.e. Carolina hemlock dominated communities or communities where the species is a major component associates.

Site-Specific Information based on Previous Surveys

Eastern Hemlock

All the rare species that occur within eastern hemlock dominated areas with known populations within the potential activity area are documented in the project file. The potential activity area is defined as a maximum ¼ mile zone around HWA treatment sites, the dispersal distance for HWA predator beetles. Given the dissected topography included within any single ¼ mile zone surrounding a release site, non-hemlock dominated forest communities can also be present. As such, those rare plant species not known to be associated with eastern hemlock dominated habitats were excluded from the final species evaluated list. One federally-listed lichen, 14 sensitive species and 8 forest concern species are known to occur within ¼ mile of the release areas. This list of 24 documented species includes 1 hornwort, 7 liverworts, 9 mosses, 2 lichens and 5 vascular plants. The list of known occurrences indicates the dominance of non-vascular rare plant species associated with hemlock forests.

Four potential treated sites have rare liverwort populations documented within ¼ mile of the beetle release area. The liverwort populations include 3 occurrences of *Drepanolejeunea appalachiana* occurrences, 2 occurrences of *Lejuenea bloomquistii*, and 1 occurrence each of *Aneura sharpii, Plagochila caduciloba, Plagiochila echinata, Plagiochila*

sullivantii var. spingerii, Plagiochila sullivantii var. sullivantii, and Plagiochila virginica var caroliniana.

Rare moss species are documented within ¼ mile of the beetle release area in three potential treated sites. The mosses include 1 population each of *Entodon sullivantii, Brachymenium andersonii, Brachytecium rotaeanum, Bryocrumia vivicolor, Cirriphyllum piliferum, Warnstorfia fluitans, Plagiomnium carolinianum, Homalia trichomanoides,* and *Dichontium pellucidum*.

There are 19 potential treated sites that have rare lichens documented within ¼ mile of the beetle release area. Two populations of *Gymnoderma lineare* and 16 populations of *Hydrothyria venosa* are present within these 19 treatment areas.

Megaceros aenigmaticus is a narrow southern Appalachian endemic hornwort occurring in nine counties in North Carolina and Tennessee. In North Carolina it is locally abundant in Graham County, North Carolina becoming less abundant further east to Jackson County. The species is present in 31 of the potential treatment areas, 23 which are proposed in Graham County. Twenty-five separate *Megaceros aenigmaticus* populations are present within these 31 sites.

Five rare vascular plant species occur within potential treated hemlock areas. One population of each of the following five species occur within the treatment sites, *Hymenophyllum taylorei, Trichomanes petersii, Huperzia porpophila, Shortia galacifolia* var. *galacifolia,* and *Buckleya distichiphylla*.

Fifty-six of the 284 potential treatment sites have documented occurrences of eastern hemlock associated rare plant species within ¼ mile of the treatment sites (Figure 3.5-1). All but 3 of these sites occur within the Nantahala National Forest. The vast majority of the rare species associated sites are concentrated in two geographic areas, Joyce Kilmer Wilderness and lower Whitewater River watersheds (Figures 3.5-2 & 3.5-3). Joyce Kilmer has a higher density of rare plant associated treatment sites primarily because it is the geographic center of *Megaceros aenigmaticus*, where it is locally abundant. There is much greater diversity of rare plant species occurring in treatment sites in the Whitewater River Gorge. For instance, one site in the Whitewater River Gorge has 8 rare liverwort species, 7 rare mosses, and 3 rare vascular plant species. This site may also have the only recorded occurrence of *Ephebe lanata*, a rare lichen, although the exact location is uncertain at this time.

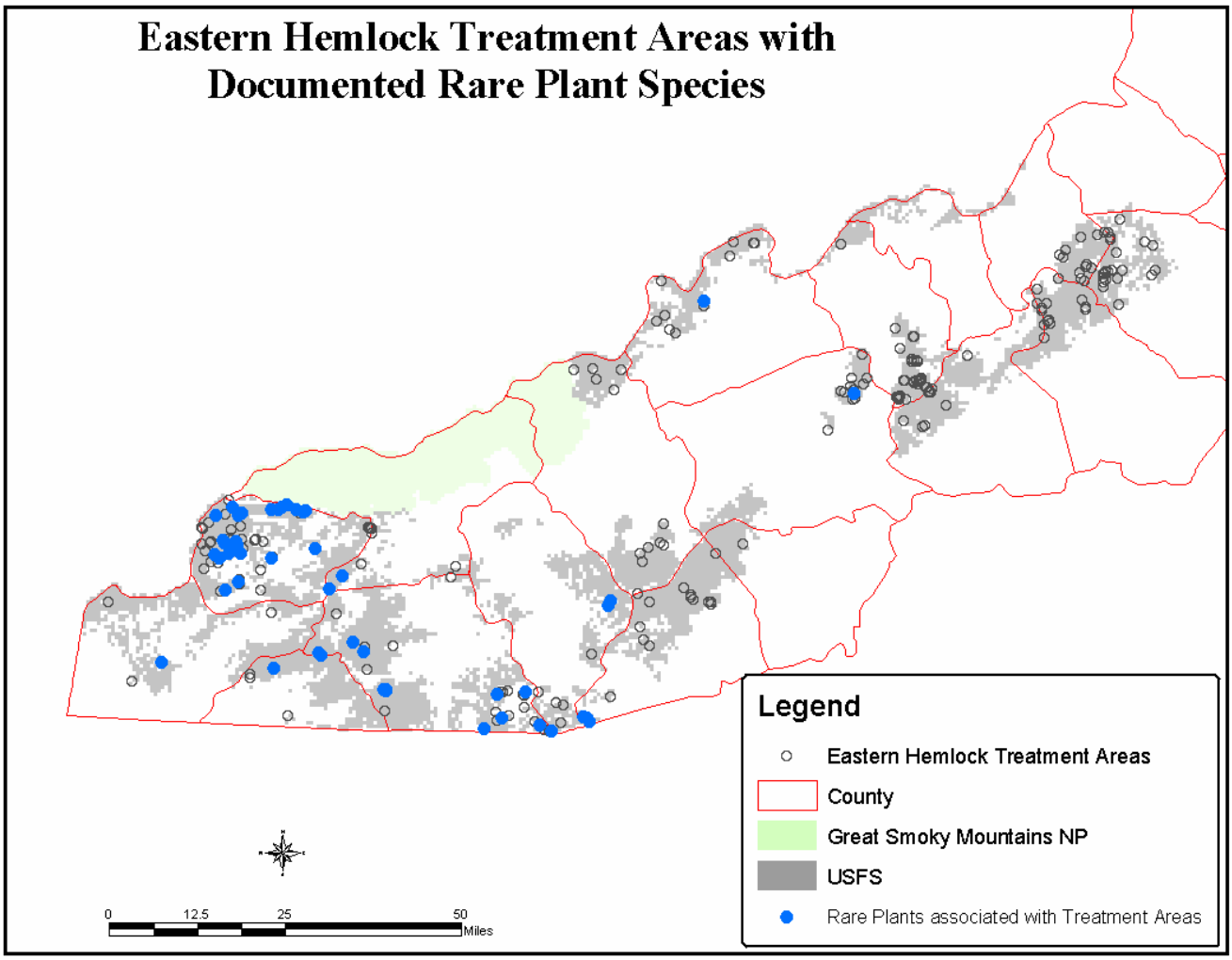

Figure 3.5-1. Distribution of potential eastern Hemlock Treated Areas with or without any associated rare plant species.

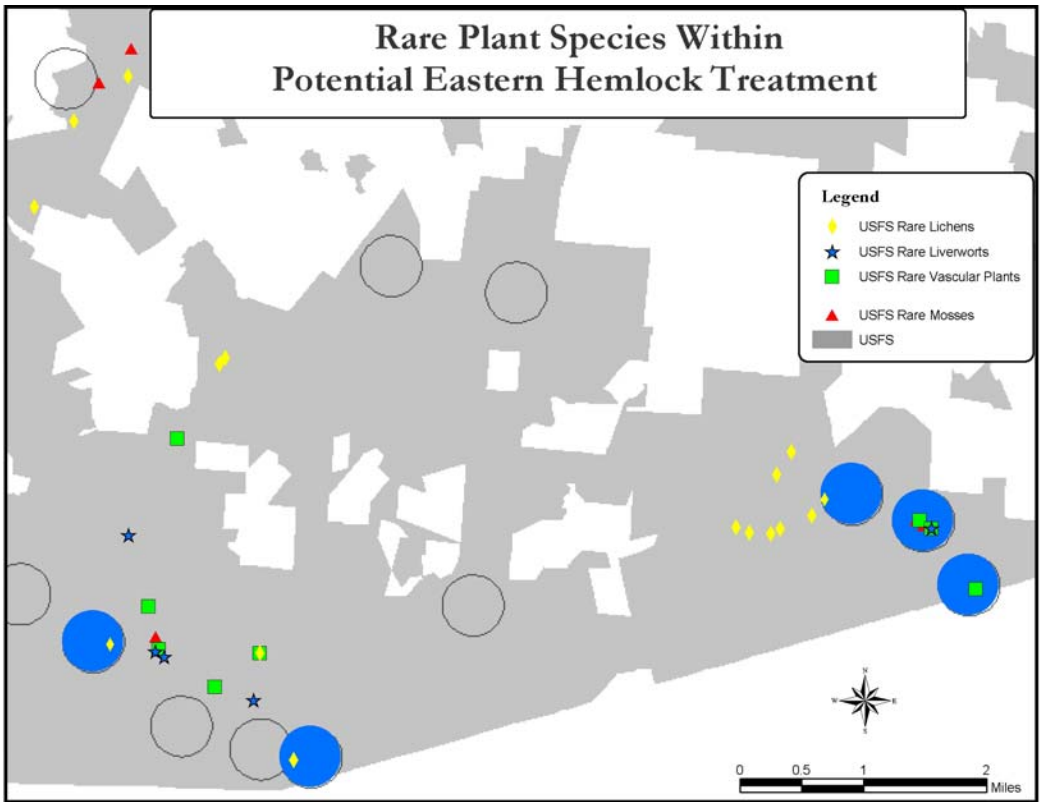

Figure 3.5- 2 . Distribution of eastern hemlock associated rare plant species across the Chattooga and Whitewater River drainages. Shaded circles denote treatment areas with documented rare species, unshaded circles have no known documented rare plant occurrences.

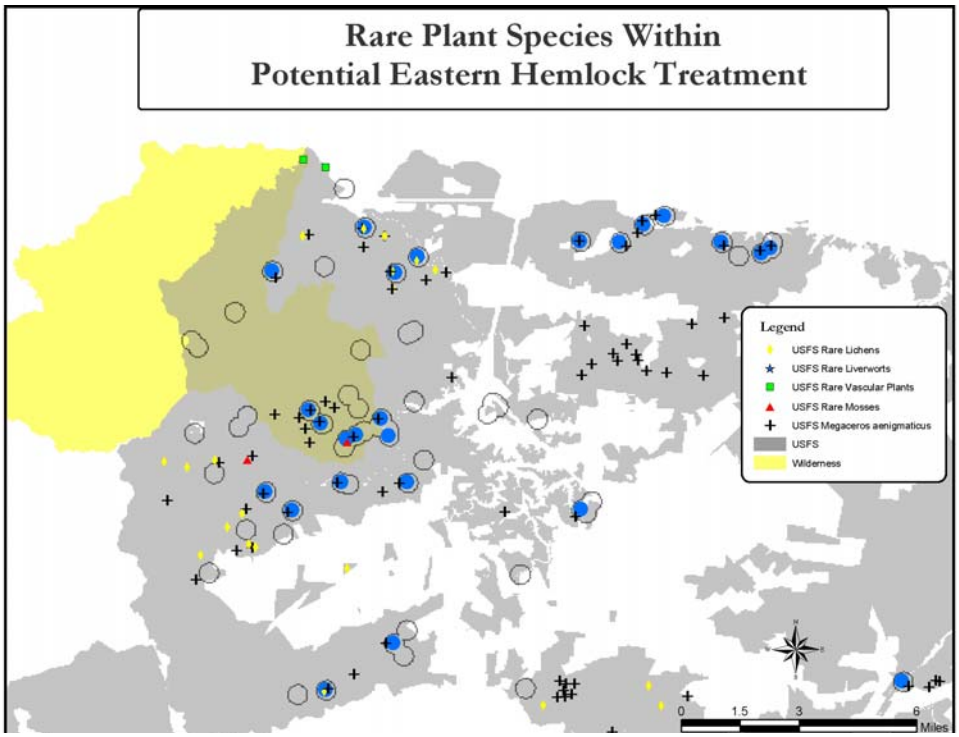

Figure 3.5-3 . Distribution of eastern hemlock associated rare plant species across Graham County, NC. Shaded circles denote treatment areas with documented rare species, unshaded circles have no known documented rare plant occurrences.

Carolina Hemlock Forest

Table 3.5-2 lists the Carolina hemlock associated rare species with documented populations within the potential activity area. Similar to the ¼ mile zone around eastern hemlock treatment areas, the zone around Carolina hemlock treatment areas also includes other communities such as high elevation rocky summits and southern Appalachian Bogs that are not associated with hemlock Those rare plant species not known to be associated with Carolina hemlock dominated habitats were excluded from the final species evaluated list. This includes *Carex biltmoreana, Oenothera perennis, Helonias bullata, Spiraea virginiana, Dalibarda repens, Lilium grayi, Liatris helleri, Hudsonia montana* and *Brachyelytrum septentrionale*. One sensitive tree, *Tsuga caroliniana* and one forest concern moss, *Brachymenium andersonii*, are known to occur within ¼ mile of the release areas. *Brachymenium andersonii* is only known within North Carolina from the Kelsey tract near Highlands. However it has not been relocated since 1951. Various searches during the past 15 years have not successfully located the species. *Tsuga caroliniana*, the host species for hemlock wooly adelgid, is present within all the 67 potential treatment areas. The Pink Beds in the Pisgah Ranger District contains Carolina hemlock mixed in with the Acidic Cove Forest. One of the Carolina hemlock areas is proposed as a treatment site. One eastern hemlock rare species, *Entodon sullivantii*, is present within the adjacent eastern hemlock forest within this proposed treatment area.

New Surveys or Inventories Conducted

There have been no site-specific surveys for the potentially affected rare plant species within the 67 Carolina hemlock potential treatment sites or within the 284 eastern hemlock treatment sites. A few treatment sites were previously surveyed during analysis for other projects during the last 10 years, however the vast majority have never had an extensive bryophyte or vascular plant survey.

Effects of alternatives by species

Eastern Hemlock

All 57 of the rare plant species associated with eastern hemlock-dominated forests prefer humid conditions. They can be more readily separated for an effects analysis by the substrate they occupy, varying from either the forest floor to hardwood bark. Table 3.5-1 details the substrate preference for each of these 57 species. The botanical analysis will determine effects to these groups of species based on their preference for 4 separate substrates.

Sixteen rare species associated with eastern hemlocks are typically rooted in humus or soil on the forest floor or soil adjacent to Spray Cliffs (Table 3.5-3). This diverse group includes 3 mosses, 5 ferns or fern like plants, 2 deciduous herbaceous plants, 4 evergreen herbaceous plants, 1 shrub, and 1 small tree. Except for *Buckleya distichophylla*, *Huperzia porophila*, or *Phegopteris connectilis*, the species are very limited or are not presently known within the Nantahala and Pisgah National Forest. The limited species are almost exclusively restricted to the Blue Ridge Escarpment. Typically these species are found in shaded, moist or wet situations in deep, relatively narrow gorges. As previously mentioned *Brachymenium andersonii* is only known from the Kelsey tract on the Highlands Plateau.

Table 3.5-3. Eastern hemlock associated species primarily occurring on the forest floor.

Species	**Populations**	**Form**	**Designation**	**Documented**	**Substrate**
Brachymenium andersonii	01	Moss	Forest concern	Yes	Forest Floor
Brachymenium systylium	01	Moss	Forest concern	No	Forest Floor
Ditrichum ambiguum	01	Moss	Sensitive	No	Forest Floor
Buckleya distichophylla	10	Vascular plant	Sensitive	Yes	Forest Floor
Hexastylis contracta	00	Vascular plant	Sensitive	No	Forest Floor
Hexastylis rhombiformis	03	Vascular plant	Sensitive	No	Forest Floor
Huperzia porophila	09	Vascular plant	Forest concern	Yes	Forest Floor
Hymenophyllum tayloriae	05	Vascular plant	Sensitive	Yes	Forest Floor
Phegopteris connectilis	07	Vascular plant	Forest concern	No	Forest Floor
Shortia galacifolia var. brevistylia	04	Vascular plant	Sensitive	No	Forest Floor
Shortia galacifolia var. galacifolia	02	Vascular plant	Sensitive	Yes	Forest Floor
Spartina pectinata	01	Vascular plant	Forest concern	No	Forest Floor
Stewartia ovata	03	Vascular plant	Forest concern	No	Forest Floor
Trichomanes boschianum	04	Vascular plant	Forest concern	No	Forest Floor
Trichomanes petersii	04	Vascular plant	Forest concern	Yes	Forest Floor
Waldsteinia lobata	00	Vascular plant	Sensitive	No	Forest Floor

The 16 species listed above, while all associated with Acidic Cove Forest, occur in quite diverse microhabitats. Five species either occur behind the waterfall of a Spray Cliff or within a recessed grotto (NC BCD 2004). These species include *Trichomanes boschianum, Spartinia pectinata, Phegopteris hexagonoptera, Hymenophyllum tayloriae, and Huperzia*

porophila. These 5 species should not be heavily impacted as a result of decrease in relative humidity and increase in light from nearby hemlocks dying.

The two *Hexastylis* species, the two *Shortia* species, are closely associated with either *Rhododendron maximum* and or *Rhododendron minus*. As such the indirect effects from a dieback of *Tsuga canadensis* in the overstory will be buffered. Recent surveys within *Hexastylis rhombiformis* and the *Shortia galacifolia* var. *brevistylia* occurrences indicate Tsuaga canadensis is scattered within the canopy (Kauffman, personal observation, NC BCD 2004). In addition, *Pinus strobus* is typically common and will buffer any abrupt indirect changes.

Stewartia ovata and *Buckleya distichophylla* are the only 2 rare woody species associated with eastern hemlock forests. However both are also associated with either drier habitats such as bluffs and appear to bloom more profusely with more light (Weakley 2004, NC BCD 2004, G. Kauffman, personal observation).

Trichomanes petersii, like *T. boschianum* is typically found in humid gorges, however unlike the later species it occurs on relatively dry rock faces not directly affected by seepage or dry rock (Weakley 2004, TNC of Tennessee 1999). As a result this *Trichomanes* has a greater potential for negative impacts from hemlock dieback.

The remaining 4 individual species could also experience a dramatic decrease in their surrounding relative humidity if any eastern hemlock trees died and opened a gap. *Schlotheimia lanicifolia* would eventually die if it occurred on a dead eastern hemlock tree. Effects on individual species from changes in light levels are less certain. *Drepanolejeunea appalachiana* has been located within more open woodland at the Standing Indian Campground. It has been difficult to locate populations of *Schlotheimia lanicifolia* since it has been located as high as 34 feet above the butt of the tree trunk (Crum and Anderson 1981, Anderson 1996, Paul Davison, personal communication). This would suggest the species prefers higher light levels present in the upper reaches of the canopy. These 2 species may not be dramatically affected by higher light levels if adjacent hemlock trees die provided the humidity levels remain high. All of these species are believed to prefer low light levels and could be adversely affected by a change in light levels.

Table 3.5-4. Eastern hemlock associated species occurring on boulders within streams.

Species	Populations	Form	Forest Designation	Documented	Substrate
Megaceros aenigmaticus	35	Hornwort	Sensitive	Yes	Stream Boulder
Ephebe lanata	01	Lichen	Forest concern	Yes	Stream Boulder
Ephebe solida	00	Lichen	Forest concern	No	Stream Boulder
Gymnoderma lineare	32	Lichen	Endangered	Yes	Stream Boulder
Hydrothyria venosa	75	Lichen	Sensitive	Yes	Stream Boulder
Fissidens appalachensis	01	Moss	Sensitive	No	Stream Boulder
Warnstorfia fluitans	01	Moss	Forest concern	Yes	Stream Boulder

Seven rare species associated with eastern hemlock occur on bedrock or boulders within streams, creeks or rivers (Table 3.5-4). The majority of these species primarily occur directly adjacent to the stream edge. Only occasionally during storm events are these species completely inundated. In contrast *Megaceros aenigmaticus* and *Fissidens appalachiensis* are typically immersed. This group of organisms includes 4 lichens: two *Ephebe* species that are currently not documented on the Forest, and *Hydrothyria venosa* and *Megaceros aenigmaticus* that have a relatively well-known distribution in western North Carolina and can be locally abundant on the Nantahala National Forest. *Gymnoderma lineare*, a federally endangered species, typically occurs throughout its range and across the Forest in high elevation shaded rock outcrops. The discussion for this analysis only includes those occurrences where it occurs on boulders within streams or cascading spray cliffs surrounded by eastern hemlock dominated forest communities. As such this would include between 15-20% of the occurrences known for this species in North Carolina. However, *Gymnoderma lineare* occurs within only one of the proposed HWA control treatment zones in Alternative B.

Of all of the 57 rare species analyzed in eastern hemlock treatment zones, these seven species will be less affected by hemlock mortality, and the resulting reduction in relatively humidity, because of their proximity to water. It is less certain how these species will be affected by a change in light level due to hemlock canopy loss. Existing light levels surrounding known populations can be highly variable ranging from densely shaded with 2-3 meter tall overhanging *Rhododendron maximum* to completely open surrounding larger rivers or creeks such as occurs on the Pigeon River, the Whitewater River, the Chattooga River, and upper Greenland Creek (NC BCD 2004, G. Kauffman, personal observation). Of the seven rare plants, the least well known both in terms of range and habitat characteristics, are the two *Ephebe* species. Most information indicates that these species occur on moist rock near waterfalls or within flowing streams. Light conditions in these situations varies from shaded to open (Hale 1979, Flenniken 1999, Brodo, Sharnoff & Sharnoff 2001). Because of the variable site conditions and since the species have been known to persist within more open conditions, it is believed this group of

organisms will not be negatively impacted by the loss of surrounding *Tsuga canadensis* trees or the amount of change will be imperceptible.

Table 3.5-5. Eastern hemlock associated species primarily occurring on tree bark.

Species	Populations	Form	Designation	Documented	Substrate
Anzia americana	01	Lichen	Sensitive	No	Bark
Drepanolejeunea appalachiana	12	Liverwort	Sensitive	Yes	Bark
Brachythecium rotaeanum	02	Moss	Forest concern	Yes	Bark, Rock
Schlotheimia lancifolia	02	Moss	Sensitive	No	Bark, Rock

Four of the 57 rare species occur on and prefer bark (Table 3.5-5). *Schlotheimia lancifolia* is known to occur on eastern hemlock bark although the moss is not dependent on hemlock as a substrate (Anderson 1996). In fact the type locality of *Schlotheimia lancifolia* is hemlock hardwood forest (Crum and Anderson 1981). None of the other three bark preferring species are known to adhere to eastern hemlock bark. Except for *Drepanolejuenea appalachiana*, all of the bark-preferring rare species are quite limited within the Nantahala and Pisgah National Forest as well as within North Carolina. All 4 are primarily restricted to the Blue Ridge escarpment apparently preferring narrow vertical gorges where high rainfall and high humidity is maximized (NC Natural Heritage Program BCD 2004).

Individuals of these four species could experience a dramatic decrease in their surrounding relative humidity if any eastern hemlock trees died and opened a gap. *Schlotheimia lanicifolia* would eventually die if it occurred on a dead eastern hemlock tree. Effects on individual species from changes in light levels are less certain. *Drepanolejeunea appalachiana* has been located within more open woodland at the Standing Indian Campground. It has been difficult to locate populations of *Schlotheimia lanicifolia* since it has been located as high as 34 feet above the butt of the tree trunk (Crum and Anderson 1981, Anderson 1996, Paul Davison, personal communication). This would suggest the species may persist at higher light levels present in the upper reaches of the canopy. These 2 species may not be dramatically affected by higher light levels if adjacent hemlock trees die provided the humidity levels remain high. The remaining 2 species, *Anzia americana* and *Brachytecium roteanum* are thought to prefer low light levels and could be adversely affected by a change in light levels. *Brachythecium rotaeanum* is known from Whitewater River Falls but occurs on dry ledges within the gorge and not necessarily associated with the Spray Cliff community there (NC BCD 2004).

Table 3.5-6. Eastern hemlock associated species primarily occurring on rock.

Species	Populations	Form	Designation	Documented	Substrate
Acrobolbus ciliatus	05	Liverwort	Sensitive	No	Rock
Aneura sharpii	03	Liverwort	Sensitive	Yes	Rock
Lejeunea blomquistii	02	Liverwort	Sensitive	No	Rock
Lophocolea appalachiana	03	Liverwort	Sensitive	No	Rock
Marsupella emarginata var. latiloba	00	Liverwort	Sensitive	No	Rock
Mylia tayorii	01	Liverwort	Forest concern	No	Rock
Pellia appalachiana	00	Liverwort	Sensitive	No	Rock
Plagiochila caduciloba	12	Liverwort	Sensitive	Yes	Rock
Plagiochila echinata	03	Liverwort	Sensitive	Yes	Rock
Plagiochila sullivantii var. spinigera	02	Liverwort	Sensitive	Yes	Rock
Plagiochila sullivantii var. sullvantii	07	Liverwort	Sensitive	Yes	Rock
Plagiochila virginica var. caroliniana	03	Liverwort	Sensitive	Yes	Rock
Porella appalachiana	00	Liverwort	Sensitive	No	Rock
Radula sullivantii	04	Liverwort	Sensitive	No	Rock
Radula voluta	00	Liverwort	Sensitive	No	Rock
Bartramidula wilsonii	04	Moss	Sensitive	No	Rock
Brachythecium populeum	00	Moss	Forest concern	No	Rock
Bryocrumia vivicolor	01	Moss	Sensitive	Yes	Rock
Bryoxiphium norvegicum	05	Moss	Forest concern	No	Rock
Bryum riparium	01	Moss	Forest concern	No	Rock
Cirriphyllum piliferum	02	Moss	Forest concern	Yes	Rock
Dichodontium pellucidum	06	Moss	Forest concern	Yes	Rock
Entodon sullivantii	07	Moss	Forest concern	Yes	Rock
Homalia trichomanoides	03	Moss	Forest concern	Yes	Rock
Plagiomnium carolinianum	02	Moss	Sensitive	Yes	Rock
Platyhypnidium pringlei	00	Moss	Sensitive	No	Rock
Rhabdoweisia creulata	02	Moss	Forest concern	No	Rock
Sphagnum flavicomans	01	Moss	Sensitive	No	Rock
Sphagnum squarrosum	02	Moss	Forest concern	No	Rock
Grammitis nimbata	01	Vascular plant	Sensitive	No	Rock

Almost all of the rare species preferring rock substrates occur within Spray Cliff communities (Table 3.5-6). If not present in a Spray Cliff, the species (when occurring in hemlock dominated forests) are associated with a specific habitat, fast-flowing streams and cascades (The Nature Conservancy of Tennessee 1999, Hicks 1992, Hicks 1996, Anderson 1996). Three exceptions to Spray Cliff habitats are *Lejuenea bloomquistii*, *Brachythecium rotaeanum* and *Plagiochila sullivantii var sullivantii*. *Lejuenea bloomquistii* was documented in the mid 90's on rocks near creeks in humid gorges from South Carolina to Kentucky (Hicks 1996).

According to Hicks (1996) *Plagiochila sullivantii var sullivantii* is a species most commonly found "in crevices or in shady boulders where the humidity is high but where water does not flow" (Hicks 1996). Hicks notes this species is not as restricted to the escarpment gorge as are the majority of the other rock substrate species listed in table 4. A few species, *Acrobolus ciliatus*, *Marsupella emarginata* var. *latiloba*, *Mylia taylorii*, and *Plagiochila sullivantii* var *sullivantii*, occur within Spray Cliff communities and high elevation Spruce-Fir Forests (Hicks 1992, NC Natural Heritage BCD).

Bryocrumnia vivicolor is considered historical in the state and has not been located on the Nantahala National Forest since 1949 when it was first located at Upper Whitewater Falls (Anderson 1996). Except for three species, *Plagiochila caduciloba, Plagiochila sullivantii* var *sullivantii*, and Entodon sullivantii, most of the rock preferring species are limited across the Forest and occur in 5 populations or less.

Individuals of these 30 species could experience a dramatic decrease in their surrounding relative humidity if any eastern hemlock trees died and opened a gap. However this negative effect would be less dramatic or not result in any perceptible change for those species associated with the spray zone from a waterfall. The exception would be for *Plagiochila sullivantii var sullivantii*.

Effects on individual species from changes in light levels can be variable for individual species and populations depending on where individuals are rooted. For the majority of the species associated with Spray Cliffs the overhanging rock can already provide dense shade. The greatest negative impact based on increased light levels would be to *Plagiochila sullivantii var sullivantii*.

By treating eastern hemlocks in 4 areas, it would be possible to significantly reduce the threat of losing 1 sensitive species, *Bryocrumia vivicolor*, and 3 forest concern species, *Brachymenium andersonii, Rhabdoweisia crenulata*, and *Brachymenium systylium* on the Nantahala and Pisgah National Forest. All four are mosses. The areas are:

1. Upper Whitewater Falls in Transylvania & Jackson County
2. Kelsey Tract in Highlands Plateau
3. East Slope of Dry Falls in Macon County
4. Devils Elbow north of Panthertown Valley in Jackson County

If these 4 areas are treated with insecticides and predatory beetles it should be possible to maintain the populations of the 4 rare species mentioned above although it can not be discounted that some individuals within each population may be negatively impacted.

Upper Whitewater Falls and the Kelsey tract have been identified as potential treatment areas. The two other rare moss occupied treatment sites are shown in figures 4 and 5.

Alternative A (No-Action):

This alternative proposes no action to eradicate the current spread of hemlock woolly adelgid. Since this alternative proposes to take no action there will be no direct effects to TES plant species.

Indirect effects of this no-action alternative could result from dead hemlock trees crushing individual rare plants when they die and fall. The greatest likelihood of this impact would be to those species rooted in the forest floor and specifically those species not associated with Spray Cliff soils. Species with the greatest risk include: *Ditrichum ambigum, Buckleya distichophylla, Hexastylis rhombiformis, H. contracta, Shortia galacifolia var galicifolia, S. galacifolia var brevistyla, Stewartia ovata,* and *Waldsteinia lobata*.

Many of the 57 eastern hemlock associated rare plant species are thought to require shading by what typically is a dense canopy. While all the species do not specifically require shading by eastern hemlocks, any death by individual hemlocks could indirectly affect site conditions for associated individual rare plant species. These indirect affects include decreased relative humidity and increased light intensity. As a group, it is anticipated the effect will be less severe to the species occurring in more open conditions associated with stream boulders because of their greater adaptation to higher light intensity and because the adjacent water will buffer any relative humidity changes following hemlock mortality. It is unlikely that the 8 species associated with stream boulders will be measurable affected by hemlock loss.

Stand conditions and hemlock density are variable in the proposed treatment zones. However, it is assumed that changes in relative humidity and light intensity level following any hemlock mortality could reduce the suitability of these habitats to support the other 49 rare plant species associated with moist and shaded conditions. Impacts would be much less severe for those individuals either shaded by a rock or buffered by water within Spray Cliff communities, but some individuals may be impacted if they occur on the fringes of the community and away from these microhabitats.

An analysis of the habitat for the other 49 eastern hemlock associated species currently known on the Nantahala and Pisgah National Forests was completed to identify those species with the greatest risk of extirpation from the Forests if no action was taken to control the HWA. Rare species

with five or fewer known populations across the Nantahala and Pisgah National Forests are most at risk because any losses would result in further limiting gene flow and could result in habitat insufficient to support stable forest-wide populations. Eight species were identified with only 1 occurrence on the Forest (Table 3.5-7) and three of species occur under a dense hemlock canopy. These three species may be affected regardless of HWA control treatments because of their rarity, their close association with hemlock, and the fact that not all hemlock trees can be totally protected from HWA damage within these areas.

Table 3.5-7. Alternative A (No-Action) determination of effect to rare species with 1 population known on the Forest.

SPECIES	FORM	Documented	Substrate	Effects	Community
Anzia americana	Lichen	No	Bark	May Impact individuals	Sparse Hemlock
Brachymenium andersonii	Moss	Yes	Forest Floor	**May Affect**	Hemlock community
Brachymenium systylium	Moss	Yes	Forest Floor	**May Affect**	Hemlock-hardwood community
Ditrichum ambiguum	Moss	No	Forest Floor	May Impact individuals	Sparse Hemlock
Spartina pectinata	Vascular plant	No	Forest Floor	May Impact individuals	Spray Cliff associated
Bryocrumia vivicolor	Moss	Yes	Rock	**May Affect**	Hemlock-hardwood community
Bryum riparium	Moss	No	Rock	May Impact individuals	Spray Cliff associated
Grammitis nimbata	Vascular plant	No	Rock	May Impact individuals	Spray Cliff associated

There are 23 eastern hemlock associated rare species with 2 to 5 populations documented on the Nantahala and Pisgah National Forests (Table 3.5-8). One species, *Rhabdoweisia crrenulata*, was identified at risk of extirpation from the Nantahala and Pisgah National Forests with implementation of alternative A. All of the remaining 22 in table 6 species are anticipated to have impacts to individuals within populations as eastern hemlocks die and fall opening up the forest canopy.

Table 3.5-8. Alternative A (No-Action) determination of effect to rare species with more than one population.

Species	Form	Documented	Substrate	No-Action	Reasoning
Two Populations					
Mylia tayorii	Liverwort	Forest concern	Rock	May Impact individuals	Sparse Hemlock
Sphagnum flavicomans	Moss	Sensitive	Rock	May Impact individuals	Spray Cliff Associated
Brachythecium rotaeanum	Moss	Forest concern	Bark, Rock	May Impact individuals	Spray Cliff Associated
Schlotheimia lancifolia	Moss	Sensitive	Bark, Rock	May Impact individuals	1 pop without hemlock
Lejeunea blomquistii	Liverwort	Sensitive	Rock	May Impact individuals	Spray Cliff Associated
Plagiochila sullivantii var. spinigera	Liverwort	Sensitive	Rock	May Impact individuals	Spray Cliff Associated
Cirriphyllum piliferum	Moss	Forest concern	Rock	May Impact individuals	Sparse Hemlock
Plagiomnium carolinianum	Moss	Sensitive	Rock	May Impact individuals	Sparse Hemlock
Rhabdoweisia crrenulata	Moss	Forest concern	Rock	**May Affect**	Hemlock-hardwood community

Species	Form	Documented	Substrate	No-Action	Reasoning
Sphagnum squarrosum	Moss	Forest concern	Rock	May Impact individuals	Spray Cliff Associated
Shortia galacifolia var. galacifolia	Vascular plant	Sensitive	Forest Floor	May Impact individuals	Dense Rhododendron
Three Populations					
Hexastylis rhombiformis	Vascular plant	Sensitive	Forest Floor	May Impact individuals	Dense Rhododendron
Stewartia ovata	Vascular plant	Forest concern	Forest Floor	May Impact individuals	Tolerates More Open Sites
Aneura sharpii	Liverwort	Sensitive	Rock	May Impact individuals	Spray Cliff Associated
Lophocolea appalachiana	Liverwort	Sensitive	Rock	May Impact individuals	Spray Cliff Associated
Plagiochila echinata	Liverwort	Sensitive	Rock	May Impact individuals	Spray Cliff Associated
Plagiochila virginica var. caroliniana	Liverwort	Sensitive	Rock	May Impact individuals	Spray Cliff Associated
Homalia trichomanoides	Moss	Forest concern	Rock	May Impact individuals	Spray Cliff Associated
Four Populations					
Shortia galacifolia var. brevistylia	Vascular plant	Sensitive	Forest Floor	May Impact individuals	Dense Rhododendron
Trichomanes boschianum	Vascular plant	Forest concern	Forest Floor	May Impact individuals	Spray Cliff Grottos
Radula sullivantii	Liverwort	Sensitive	Rock	May Impact individuals	Spray Cliff Associated
Bartramidula wilsonii	Moss	Sensitive	Rock	May Impact individuals	Spray Cliff Associated
Five Populations					
Acrobolbus ciliatus	Liverwort	Sensitive	Rock	May Impact individuals	Spray Cliff Associated
Bryoxiphium norvegicum	Moss	Forest concern	Rock	May Impact individuals	Spray Cliff Associated
Hymenophyllum tayloriae	Vascular plant	Sensitive	Forest Floor	May Impact individuals	Spray Cliff Associated

Eight of the remaining 16 rare species have not been documented on the Nantahala and Pisgah National Forest. All of these species occur in dense *Rhododendron* thickets or associated with Spray Cliff communities in other portions of North Carolina. The dense every shrub cover would ameliorate any adverse indirect effects to these rare plant species from dying eastern hemlock trees. The remaining 8 species have documented occurrences on the Nantahala and Pisgah National Forests and are associated with Spray Cliff communities or a variety of other habitats including those where hemlock is not a dominant species or an important stand component. For example, *Drepanolejuenea appalachiana*, while typically associated with Acidic Cove forests has also been documented within Oak-hickory forests. These species can occur in a variety of other habitats besides hemlock stands and therefore should be least affected by the HWA and by no action (Alternative A).

Alternative B:

As adelgid populations rapidly expand across western NC it is anticipated there will need to be some chemical stop gap measures taken to maintain hemlock trees before beetle populations can get to appropriate densities

for effective biological control within individual release areas. The insecticide proposed in Alternative B is imidacloprid, either as a soil or stem injection. These measures would be implemented only to a select number of trees or small stands/groups until the biological control agents have had time to establish, flourish and become effective. These measures would be implemented on up to 55 of the eastern hemlock and 24 of the Carolina hemlock potential treatment areas. Predator beetles will also be released near these sites and at an additional 80 sites.

This proposal also includes treating sites that contain rare plants having the greatest risk of extirpation from the Forests with no HWA control. The sites include: Upper Whitewater Falls in Transylvania & Jackson County, the Kelsey Tract on the Highlands Plateau, the East Slope of Dry Falls in Macon County, and Devils Elbow north of Panthertown Valley in Jackson County. The species include: *Bryocrumia vivicolor*, *Brachymenium andersonii, Rhabdoweisia crenulata,* and *Brachymenium systylium.*.

Direct effects are those effects occurring during project implementation. For Alternative B the direct effects include the application of the insecticide imidacloprid, and the release of predatory beetles. There will be no direct effect to any TES plant species from predator beetles because these beetles do not feed on plants. There will be no direct effect to any TES plant species from insecticides because the chemical is not an herbicide. There will be no direct effect to any TES plant species from application of the insecticide because none of these species occur in the application zone, i.e. below the ground in the drip zone, or on the bark at the base of the tree.

The indirect effects of Alternative B from dying hemlocks will be the same as the no-action alternative. Even within proposed treatment areas undoubtedly some of the hemlocks will die prior to effective suppression by predatory beetles. In addition hemlocks potentially will die in the untreated areas which may impact rare plant individuals. As a result there will be negative impacts to individuals within all rare plant populations that do not exclusively attach to rock substrates in moving water. The indirect effects should not be as dramatic within the treated areas as anticipated with the no action alternative. For instance the numbers of trees dying within a treated area should be significantly reduced thereby diminishing the likelihood of large gaps resulting from adjacent hemlock trees dying.

Alternative C:

This alternative differs from Alternative B only by exclusion of insecticide. It proposes only to release predatory beetles within the

treatment areas. There will be no direct effect to any TES plant species from predator beetles because these beetles do not feed on plants.

The indirect effects of this alternative are no different than Alternative A or B. They only differ in the degree of potential impact. The potential for eastern hemlocks dying and indirectly impacting rare plant species is less than Alternative A but greater than Alternative B. Since there will be potential negative impacts to individuals within rare plant populations that are not associated with stream boulders, the determination of effect will be the same for individual species as within Alternative B except for *Brachymenium andersonii, Rhabdoweisia crenulata, Bryocrumia vivicolor,* and *Brachymenium systylium.* It is uncertain if the predator beetles would deter the HWA enough to greatly reduce the death of hemlock trees within the four critical rare plant treatment areas. If so it should allow the four rare species to persist within these areas. However, given the uncertainty and knowing the current spread of the HWA, the persistence of these 4 rare species on the Forests is unlikely unless at least a portion of the hemlock overstory can be retained. Therefore, this alternative will indirectly impact individuals of one sensitive species - *Bryocrumia vivicolor,* and 3 forest concern species, *Brachymenium andersonii, Rhabdoweisia crenulata,* and *Brachymenium systylium.* These impacts could result in habitat conditions insufficient to support stable populations of these species across the Forests and could eventually result in the extirpation of these species on the Nantahala and Pisgah National Forests. These impacts, however, will not lead to a trend in federal listing or a loss of range-wide viability.

Cumulative Effects

Many of the 57 rare eastern hemlock associated plant species may be negatively impacted on private lands over the next 10 to 20 years as HWA populations increase and hemlocks die. On the Nantahala and Pisgah National Forests, most of these species occur within humid gorges where few vegetation management projects occur. For these rare plant species, the HWA represents the greatest potential impact to the surrounding environment for the foreseeable future. A few of the more widespread rare species such as *Megaceros aenigmaticus, Hydrothyria venosa, Buckleya distichyophylla,* and *Gymnoderma lineare* have been more recently impacted from other forest management activities

During the past 11 years, 16 projects may have impacted portions of *Hydrothyria venosa* populations on the Nantahala National Forest. Of these sixteen projects, eight were implemented in Macon County, three were implemented in Jackson County, two were implemented in Graham County, and 1 project each was implemented within Clay and Cherokee Counties. These projects included ten timber sales with associated

roading, three road improvements including widening, constructing one new horse trail and developing a commercial rock quarry. None of these activities were expected to eliminate *Hydrothyria venosa* from the respective analysis area (G. Kauffman, personal communication). Seven of these timber sales and the four road improvement and trail projects occur within areas of the Nantahala National Forest where *Hydrothyria venosa* is abundant. The Nantahala and Pisgah National Forests contain over 55 other *Hydrothyria venosa* populations that are undisturbed and without anticipated impacts for the foreseeable future.

During that same time period, there have been six timber sales with associated roading, both on the Wayah Ranger District and the Cheoah Ranger District that have impacted portions of *Megaceros aenigmaticus* populations. A horse trail and two road improvement projects have impacted three other populations. One population no longer occurs within federal lands due to a recent land exchange. Four of the timber sales and the three other road and trail projects occur within the Nantahala National Forests where *Megaceros aenigmaticus* is abundant. None of these projects are anticipated to result in the loss of this species from the immediate areas provided proper installation of erosion control measures was implemented. Twenty-five other populations occur on federal land across the range of this species within North Carolina with no known or anticipated impact from any upcoming project.

A recreational use closure was implemented across portions of Roan High Bluff at Roan Mountain in 1998. Recent monitoring indicates the closure improved site conditions for *Gymnoderma lineare* (D. Danley, personal observation). A wildfire within Madison County near the Tennessee border affected a small *Buckleya distichophylla* population.
The population was relocated and found to be as persistent as prior to the fire (D. Danley, personal observation).

There will be no cumulative affect or loss of viability across the Forest for *Megaceros aenigmaticus, Hydrothyria venosa, Buckleya distichyophylla,* and *Gymnoderma lineare* with implementation of the HWA control measures. There are no other projects across the Nantahala and Pisgah National Forests that have affected any of the other 53 species.

It is not feasible to protect individually all of the hemlock trees across the Nantahala and Pisgah National Forests and therefore some damage and loss of individuals and stands will occur regardless of the proposed HWA control measures. If no HWA control treatments occur on private land or other public lands, rare plant species associated with hemlock could be further affected. The combined effect of these impacts could result in range-wide viability concerns for several species. Mortality of eastern hemlock due to the HWA could indirectly impact individuals of one sensitive species - *Bryocrumia vivicolor*, and 3 forest concern species,

Brachymenium andersonii, *Rhabdoweisia crenulata*, and *Brachymenium systylium* but will not lead to a trend in federal listing. Although the proposed control treatments will reduce the indirect effects of hemlock mortality on the Nantahala and Pisgah National Forest, the lack of HWA control on private and other public land could result in habitat conditions insufficient to support stable populations of these species outside of the Nantahala and Pisgah National Forest.

Consultation History

One federally listed plant species, *Gymnoderma lineare*, occurs within the ¼ mile treatment zone of one proposed treatment area near the Chattooga River. Only beetle release is proposed in this area. It has been determined that even without HWA control treatment, there would be a negligible effect to *Gymnoderma lineare* and no direct or indirect effect of the action. The USDI Fish and Wildlife Service, Asheville Office concurred with this determination in an informal consultation in August 2004.

There has been no project on the National Forests in North Carolina that has negatively affected *Gymnoderma lineare*. Informal consultation with the North Carolina Ecological Services office of the Fish & Wildlife Service regarding *Gymnoderma lineare* and other federally-listed species over the closure of Roan High Bluff in Mitchell County was undertaken in 1998. The Service concurred with the Appalachian Ranger District that the proposed action was likely to reduce recreational impacts thereby improving suitable habitat for *Gymnoderma lineare* and the other federally listed species present on Roan High Bluff.

Determination Of Effect

Federally-Listed
All three alternatives will have no effect on any Federally listed or proposed plant species. Consultation with the U. S. Fish and Wildlife Service is not required.

Sensitive
Both the no-action alternative and Alternative C may affect one sensitive moss, *Bryocrumia vivicolor*, causing the loss of viability for the species across the Nantahala and Pisgah National Forests. Both of these alternatives may impact individuals of 31 separate sensitive plant species but are not likely to cause a loss of viability or a trend to federal listing for any of these species (Table 3.5-9). Seven of these species are not currently known on the Nantahala and Pisgah National Forest but if present would still be able to persist if either Alternative A or C were implemented.

Alternative B may impact individuals of 32 sensitive plant species, including *Bryocrumia vivicolor* but is not likely to cause a loss of viability or a trend to federal listing for any of these species.

Forest Concern

Both the no-action alternative and Alternative C may affect three forest concern mosses, *Brachymenium andersonii, Rhabdoweisia crenulata,* and *Brachymenium systylium*, causing the loss of viability for the three species across the Nantahala and Pisgah National Forests. Both of these alternatives may impact individuals of 16 forest concern plant species but are not likely to cause a loss of viability or a trend to federal listing for any of these species. One of these 16 species is not currently known on the NPNF but if present would still be able to persist if either alternative A or C were implemented.

Alternative B may impact individuals of 19 forest concern plant species, including *Brachymenium andersonii, Rhabdoweisia crenulata,* and *Brachymenium systylium* , but is not likely to cause a loss of viability or a trend to federal listing for any of these species.

Table 3.5-9. Determination of effect of each alternative on the evaluated threatened and endangered species and sensitive species.

SPECIES	Pops	Form	Designation	No-Action	Alternative B	Alternative C
Federally-Listed Plants						
Gymnoderma lineare	32	Lichen	Endangered	No Effect	No Effect	No Effect
Sensitive Plants						
Bryocrumia vivicolor	01	Moss	Sensitive	May Affect	may impact individuals	May Affect
Hexastylis contracta	00	Vascular plant	Sensitive	may impact individuals	may impact individuals	may impact individuals
Waldsteinia lobata	00	Vascular plant	Sensitive	may impact individuals	may impact individuals	may impact individuals
Marsupella emarginata var. latiloba	00	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Pellia appalachiana	00	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Porella appalachiana	00	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Radula voluta	00	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Platyhypnidium pringlei	00	Moss	Sensitive	may impact individuals	may impact individuals	may impact individuals
Anzia americana	01	Lichen	Sensitive	may impact individuals	may impact individuals	may impact individuals
Ditrichum ambiguum	01	Moss	Sensitive	may impact individuals	may impact individuals	may impact individuals
Sphagnum flavicomans	2	Moss	Sensitive	may impact individuals	may impact individuals	may impact individuals
Grammitis nimbata	01	Vascular plant	Sensitive	may impact individuals	may impact individuals	may impact individuals
Schlotheimia lancifolia	02	Moss	Sensitive	may impact individuals	may impact individuals	may impact individuals
Lejeunea blomquistii	2	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Plagiochila sullivantii var. spinigera	02	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Plagiomnium carolinianum	02	Moss	Sensitive	may impact individuals	may impact individuals	may impact individuals
Hexastylis rhombiformis	03	Vascular plant	Sensitive	may impact individuals	may impact individuals	may impact individuals
Aneura sharpii	03	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Lophocolea appalachiana	03	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals

SPECIES	Pops	Form	Designation	No-Action	Alternative B	Alternative C
Plagiochila echinata	03	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Plagiochila virginica var. caroliniana	03	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Shortia galacifolia var. brevistylia	02	Vascular plant	Sensitive	may impact individuals	may impact individuals	may impact individuals
Shortia galacifolia var. galacifolia	04	Vascular plant	Sensitive	may impact individuals	may impact individuals	may impact individuals
Radula sullivantii	04	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Bartramidula wilsonii	04	Moss	Sensitive	may impact individuals	may impact individuals	may impact individuals
Hymenophyllum tayloriae	05	Vascular plant	Sensitive	may impact individuals	may impact individuals	may impact individuals
Acrobolbus ciliatus	05	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Plagiochila sullivantii var. sullvantii	07	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Buckleya distichophylla	10	Vascular plant	Sensitive	may impact individuals	may impact individuals	may impact individuals
Plagiochila caduciloba	12	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Drepanolejeunea appalachiana	12	Liverwort	Sensitive	may impact individuals	may impact individuals	may impact individuals
Tsuga caroliniana	60	Vascular Plant	Sensitive	may impact individuals	may impact individuals	may impact individuals
Megaceros aenigmaticus	35	Hornwort	Sensitive	No Effect	No Effect	No Effect
Hydrothyria venosa	75	Lichen	Sensitive	No Effect	No Effect	No Effect
Fissidens appalachensis	01	Moss	Sensitive	No Effect	No Effect	No Effect
Forest Concern Plants						
Brachymenium andersonii	01	Moss	Forest concern	May Affect	may impact individuals	May Affect
Brachymenium systylium	01	Moss	Forest concern	May Affect	may impact individuals	May Affect
Rhabdoweisia crenulata	02	Moss	Forest concern	May Affect	may impact individuals	May Affect
Brachythecium populeum	00	Moss	Forest concern	may impact individuals	may impact individuals	may impact individuals
Spartina pectinata	01	Vascular plant	Forest concern	may impact individuals	may impact individuals	may impact individuals
Mylia tayorii	2	Liverwort	Forest concern	may impact individuals	may impact individuals	may impact individuals
Bryum riparium	01	Moss	Forest concern	may impact individuals	may impact individuals	may impact individuals
Brachythecium rotaeanum	02	Moss	Forest concern	may impact individuals	may impact individuals	may impact individuals
Cirriphyllum piliferum	02	Moss	Forest concern	may impact individuals	may impact individuals	may impact individuals
Sphagnum squarrosum	02	Moss	Forest concern	may impact individuals	may impact individuals	may impact individuals
Homalia trichomanoides	03	Moss	Forest concern	may impact individuals	may impact individuals	may impact individuals
Trichomanes boschianum	04	Vascular plant	Forest concern	may impact individuals	may impact individuals	may impact individuals
Bryoxiphium norvegicum	05	Moss	Forest concern	may impact individuals	may impact individuals	may impact individuals
Dichodontium pellucidum	06	Moss	Forest concern	may impact individuals	may impact individuals	may impact individuals
Entodon sullivantii	07	Moss	Forest concern	may impact individuals	may impact individuals	may impact individuals
Huperzia porophila	09	Vascular plant	Forest concern	may impact individuals	may impact individuals	may impact individuals
Stewartia ovata	03	Vascular plant	Forest concern	may impact individuals	may impact individuals	may impact individuals
Trichomanes petersii	05	Vascular plant	Forest concern	may impact individuals	may impact individuals	may impact individuals
Phegopteris connectilis	07	Vascular plant	Forest concern	may impact individuals	may impact individuals	may impact individuals
Warnstorfia fluitans	01	Moss	Forest concern	No Effect	No Effect	No Effect
Ephebe solida	00	Lichen	Forest concern	No Effect	No Effect	No Effect
Ephebe lanata	01	Lichen	Forest concern	No Effect	No Effect	No Effect

3.5.2 Aquatic Species Evaluation

Species Evaluated and Rationale

One hundred seven rare aquatic species have been listed by the NCWRC, USFWS, or NCNHP as occurring or potentially occurring on the Nantahala and Pisgah National Forests (reference Aquatic Report in the project file). Of the 107 aquatic species included on the original list for analysis, 44 were dropped as a result of a likelihood of occurrence evaluation based on preferred habitat elements and known species occurrences. Aquatic Report Appendix B (available from project file) summarizes this process. Table 3.5-10 lists rare aquatic species considered in this analysis. Those species dropped from analysis were largely fish and freshwater mussels, where knowledge of the species, their habitats, and occurrence across the Forests are well documented. Species considered in this analysis include many aquatic insects, crayfish, and other invertebrates for which accurate, comprehensive habitat and distribution data do not yet exist (although many of these species and groups of species are currently under study). For this analysis, if suitable habitat is present, species in Table 3.5-10 are considered present. Since data on individual species is difficult (and expensive) to collect and analyze and because each of the species listed below contributes to the stability and diversity if the aquatic invertebrate community as a whole, species listed in Table 3.5-10 will be addressed as the *aquatic insect community*. Also, when data on aquatic invertebrates is collected, it is most often presented in the community perspective, with individual species considered as components of the community. For example, the EPT index used by most resource agencies in North Carolina to assess aquatic community health relies on this community approach, while also maintaining lists of individual species contributing to the index.

Table 3.5-10 Rare aquatic species considered in the analysis of potential effects of the presence and treatment of the hemlock wooly adelgid across the Nantahala and Pisgah National Forests.

Group	Designation	Scientific Name	Common Name
Mussel	Endangered	*Alasmidonta raveneliana*	Appalachian elktoe
Crayfish	Sensitive	*Cambarus chaugaensis*	Oconee stream crayfish
Crayfish	Sensitive	*Cambarus georgiae*	Little Tennessee R crayfish
Crayfish	Sensitive	*Cambarus parrishi*	Hiwassee headwaters crayfish
Crayfish	Sensitive	*Cambarus reburrus*	French Broad crayfish
Crustacean	Sensitive	*Caecidotea carolinensis*	Bennett's Mill cave water slater
Crustacean	Sensitive	*Stygobromus carolinensis*	Yancey sideswimmer
Dragonfly	Sensitive	*Gomphus diminutus*	diminuitive clubtail
Dragonfly	Sensitive	*Ophiogomphus edmundo*	Edmund's snaketail
Dragonfly	Sensitive	*Ophiogomphus howei*	pygmy snaketail
Mussel	Sensitive	*Alasmidonta varicose*	brook floater
Amphibian	Forest Concern	*Cryptobranchus alleganiensis*	hellbender

Group	Designation	Scientific Name	Common Name
Caddisfly	Forest Concern	*Ceraclea mentiea*	a caddisfly
Caddisfly	Forest Concern	*Ceraclea slossonae*	a caddisfly
Caddisfly	Forest Concern	*Matrioptila jeanae*	a caddisfly
Caddisfly	Forest Concern	*Micrasema burksi*	a caddisfly
Caddisfly	Forest Concern	*Micrasema sprulesi*	a caddisfly
Caddisfly	Forest Concern	*Palaeagapetus celsus*	a caddisfly
Caddisfly	Forest Concern	*Rhyacophila amicus*	a caddisfly
Caddisfly	Forest Concern	*Rhyacophila melita*	a caddisfly
Caddisfly	Forest Concern	*Rhyacophila vibox*	a caddisfly
Crustacean	Forest Concern	*Ascetocythere cosmeta*	Grayson crayfish ostracod
Crustacean	Forest Concern	*Cymocythere clavata*	Oconee crayfish ostracod
Crustacean	Forest Concern	*Dactylocythere isabelae*	Catawba crayfish ostracod
Crustacean	Forest Concern	*Dactylocythere prinsi*	Whitewater crayfish ostracod
Crustacean	Forest Concern	*Skistodiaptomus carolinensis*	Carolina skistodiaptomus
Crustacean	Forest Concern	*Waltoncythere acuta*	Transylvania crayfish ostracod
Damselfly	Forest Concern	*Lestes congener*	spotted spreadwing
Dragonfly	Forest Concern	*Aeshna tuberculifera*	black-tipped darner
Dragonfly	Forest Concern	*Aeshna verticalis*	green-striped darner
Dragonfly	Forest Concern	*Cordulia shurtleffii*	American emerald
Dragonfly	Forest Concern	*Gomphus adelphus*	moustached clubtail
Dragonfly	Forest Concern	*Gomphus consanguis*	Cherokee clubtail
Dragonfly	Forest Concern	*Gomphus descriptus*	harpoon clubtail
Dragonfly	Forest Concern	*Gomphus lineatifrons*	splendid clubtail
Dragonfly	Forest Concern	*Gomphus viridifrons*	green-faced clubtail
Dragonfly	Forest Concern	*Neurocordulia yamaskanensis*	stygian shadowdragon
Dragonfly	Forest Concern	*Ophiogomphus asperses*	brook snaketail
Dragonfly	Forest Concern	*Ophiogomphus mainensis*	Maine snaketail
Dragonfly	Forest Concern	*Ophiogomphus rupinsulensis*	rusty snaketail
Dragonfly	Forest Concern	*Somotochlora elongate*	ski-tailed emerald
Dragonfly	Forest Concern	*Stylurus scudderi*	zebra clubtail
Dragonfly	Forest Concern	*Sympetrum obtrusum*	white-faced meadowhawk
Mayfly	Forest Concern	*Acerpenna macdunnoughi*	a mayfly
Mayfly	Forest Concern	*Baetis punctiventris*	a mayfly
Mayfly	Forest Concern	*Baetopus sp. 1*	a mayfly
Mayfly	Forest Concern	*Barbaetis benfieldi*	Benfield's bearded small minnow mayfly
Mayfly	Forest Concern	*Barbaetis cestus*	a mayfly
Mayfly	Forest Concern	*Barbaetis gloveri*	a mayfly
Mayfly	Forest Concern	*Drunella longicornis*	a mayfly
Mayfly	Forest Concern	*Ephemerella berneri*	a mayfly
Mayfly	Forest Concern	*Habrophlediodes spp*	a mayfly
Mayfly	Forest Concern	*Heterocleon petersi*	a mayfly
Mayfly	Forest Concern	*Homoeneuria cahabensis*	Cahaba sand-filtering mayfly
Mayfly	Forest Concern	*Leptohyphes robacki*	a mayfly
Mayfly	Forest Concern	*Macdunnoa brunnea*	a mayfly
Mayfly	Forest Concern	*Serratella spiculosa*	spicilose serratellan mayfly
Snail	Forest Concern	*Elimia (Goniobasis) interrupta*	knotty elimnia
Snail	Forest Concern	*Leptoxis virgata*	smooth mudalia

Group	Designation	Scientific Name	Common Name
Stonefly	Forest Concern	*Attaneuria ruralis*	a stonefly
Stonefly	Forest Concern	*Bolotoperla rossi*	a stonefly
Stonefly	Forest Concern	*Isoperla frisoni*	a stonefly
Stonefly	Forest Concern	*Megaleuctra williamsae*	Williams' rare winter stonefly
Stonefly	Forest Concern	*Zapada chila*	a stonefly

Existing Condition

Amount and Quality of Habitat

Refer to section 3.3 for a description of aquatic habitats. This section incorporates information from the Aquatic Resource Analysis - Treatment of the Hemlock Wooly Adelgid on the Nantahala and Pisgah National Forests (available from the project file).

All perennial stream miles on the Forests have the potential to be occupied by aquatic invertebrates. Hellbenders are known to occur or may occur in lower elevation, lower gradient coldwater systems with medium to large substrate and abundant instream cover. In general, hellbenders occupy at the upper end of the transition zone between cold- and coolwater systems across the Forests.

Direct and Indirect Effects on Rare Aquatic Species by Alternative

Effects are summarized in Table 3.5-11.

Alternative A – No Action

Refer to section 3.3.2 for a general discussion of effects to aquatic resources

As hemlocks are affected and LWD enters streams, aquatic invertebrate populations will respond with increases in species which utilize wood, including borers, gougers, and scrapers, and several groups which utilize wood surfaces (e.g. Chironomidae, Heptageneidae, Baetidae, Nemouridae, Peltoperidae, Perlodidae, Limnephilidae, Rhycophilidae) (Dudley and Anderson 1982). As LWD decomposes and is utilized by aquatic invertebrates, its usefulness diminishes, which results in the gradual return to pre-LWD community structure. In systems dependent on cooler water temperatures (such as trout streams), species may occur in lower densities where shade has been measurably affected until riparian conditions (particularly streamside shading) return to pre-infestation levels.

As with many groups of organisms, aquatic invertebrate community dynamics have been proven to be cyclic and adaptable to surrounding conditions. For example, habitat suitability for a particular species may be

improved with the input and retention of LWD, which is reflected in increased population levels of that species. But as the microhabitat (e.g. surface of the log) deteriorates and becomes less suitable, population levels respond accordingly. This process can take anywhere from several weeks (if environmental conditions cause rapid breakdown of woody material) to many years, and is thought to occur more rapidly with hemlock and other soft wood species than with hardwood species (Webster 1977).

In this situation, it is expected that relatively large amounts of LWD will enter adjacent stream systems as the HWA damage results in tree mortality within riparian areas. Aquatic invertebrate communities will respond accordingly, becoming dominated by species utilizing wood at some point in its life history. This immediate burst of LWD input will be followed by a period of relatively little LWD transport to streams as riparian forests move through early stages of succession. And, if succession rates lag behind the retention and decomposition rates of the LWD in the streams, it could be even longer before natural LWD transport rates return (Bryant 1983).

In summary, increased LWD transport immediately following hemlock decline will benefit aquatic systems; however over time declines in LWD transport will result in loss of microhabitat diversity until the new riparian vegetation approaches decadence. If the period of decreased LWD input exceeds the life history of a rare aquatic invertebrate, measurable changes in overall community structure and diversity could be seen. It is important to look past the short-term benefits if increased LWD and improved instream habitat to long-term effects on aquatic invertebrate community structure from structural habitat losses. Hemlock loss across the Nantahala and Pisgah National Forests could result in community-level shifts in the aquatic insect community, as described above. However, it is unlikely that rare aquatic species will be affected if the correlation between the probability of occurrence of rare aquatic species and forest composition (hemlock vs. hardwood) witnessed in the Delaware Water Gap study holds true in North Carolina. This assessment, incorporated by reference, found rare species more likely to be found in hardwood-associated streams. It is unlikely that hellbenders will be affected by any alternative since their mobility allows them to escape adverse conditions and since it is unlikely that their habitats will be measurably affected.

<u>Alternative B – Beetle Releases and Imidacloprid Treatments</u>

Imidacloprid

Refer to section 3.3 and 3.3.2 for discussion of the effects of using imidacloprid on aquatic resources, which is applicable to rare aquatic

invertebrates. For hellbenders, they would not be affected since they would not come into contact with imidacloprid.

Predator Beetles

Refer to section 3.3 and 3.3.2 for discussion of the effects of releasing predator beetles, which is applicable to rare aquatic invertebrates. For hellbenders, they would not be affected since they are not likely to encounter the beetles.

Alternative C – Beetle Releases

Predator Beetles

Refer to section 3.3 and 3.3.2 for discussion of the effects of releasing predator beetles, which is applicable to rare aquatic invertebrates. For hellbenders, they would not be affected since they are not likely to encounter the beetles.

Cumulative Effects on Rare Aquatic Species by Alternative

Vegetation management activities seldom occur near streams, though recreational activities are often occur near water. Past, present, and reasonably foreseeable future activities include the occasional construction of stream crossings for roads or trails, water based recreational activities and streamside camping. If sediment enters the stream from these sources it can result in localized and temporary reductions in the quality of the habitat for aquatic invertebrates and fish. In areas with many streamside hemlocks, the addition of LWD from dead hemlocks (from HWA infestation) could initially help offset habitat loss from sedimentation by providing additional instream habitat in the short term. However, once that influx of LWD decomposed, a more lengthy loss of new LWD inputs would occur while riparian forests move through early stages of succession. Alternatives B and C would allow for a moderating affect to LWD inputs, without as much swing up and down over time. None of the alternatives considered in this EA would add to the cumulative effects of other actions on hellbenders, since their mobility allows them to escape adverse conditions and since it is unlikely that their habitats will be measurable affected.

Table 3.5-11 Effects of alternatives by rare aquatic species.

Status	Scientific Name	Common Name	No Treatment	Imidacloprid	Predator Beetles
E	*Alasmidonta raveneliana*	Appalachian elktoe	Not likely to adversely affect	Not likely to adversely affect	Not likely to adversely affect
S	*Cambarus chaugaensis*	Oconee stream crayfish	May impact*	Not likely to impact	Not likely to impact
S	*Cambarus georgiae*	Little Tennessee R crayfish	May impact*	Not likely to impact	Not likely to impact

Status	Scientific Name	Common Name	No Treatment	Imidacloprid	Predator Beetles
S	*Cambarus parrishi*	Hiwassee headwaters crayfish	May impact*	Not likely to impact	Not likely to impact
S	*Cambarus reburrus*	French Broad crayfish	May impact*	Not likely to impact	Not likely to impact
S	*Caecidotea carolinensis*	Bennett's Mill cave water slater	May impact*	Not likely to impact	Not likely to impact
S	*Stygobromus carolinensis*	Yancey sideswimmer	May impact*	Not likely to impact	Not likely to impact
S	*Gomphus diminutus*	diminuitive clubtail	May impact*	Not likely to impact	Not likely to impact
S	*Ophiogomphus edmundo*	Edmund's snaketail	May impact*	Not likely to impact	Not likely to impact
S	*Ophiogomphus howei*	pygmy snaketail	May impact*	Not likely to impact	Not likely to impact
S	*Alasmidonta varicosa*	brook floater	Not likely to impact	Not likely to impact	Not likely to impact
FC	*Cryptobranchus alleganiensis*	hellbender	Not likely to impact	Not likely to impact	Not likely to impact
FC	*Ceraclea mentiea*	a caddisfly	May impact*	Not likely to impact	Not likely to impact
FC	*Ceraclea slossonae*	a caddisfly	May impact*	Not likely to impact	Not likely to impact
FC	*Matrioptila jeanae*	a caddisfly	May impact*	Not likely to impact	Not likely to impact
FC	*Micrasema burksi*	a caddisfly	May impact*	Not likely to impact	Not likely to impact
FC	*Micrasema sprulesi*	a caddisfly	May impact*	Not likely to impact	Not likely to impact
FC	*Palaeagapetus celsus*	a caddisfly	May impact*	Not likely to impact	Not likely to impact
FC	*Rhyacophila amicus*	a caddisfly	May impact*	Not likely to impact	Not likely to impact
FC	*Rhyacophila melita*	a caddisfly	May impact*	Not likely to impact	Not likely to impact
FC	*Rhyacophila vibox*	a caddisfly	May impact*	Not likely to impact	Not likely to impact
FC	*Ascetocythere cosmeta*	Grayson crayfish ostracod	May impact*	Not likely to impact	Not likely to impact
FC	*Cymocythere clavata*	Oconee crayfish ostracod	May impact*	Not likely to impact	Not likely to impact
FC	*Dactylocythere isabelae*	Catawba crayfish ostracod	May impact*	Not likely to impact	Not likely to impact
FC	*Dactylocythere prinsi*	Whitewater crayfish ostracod	May impact*	Not likely to impact	Not likely to impact
FC	*Skistodiaptomus carolinensis*	Carolina skistodiaptomus	May impact*	Not likely to impact	Not likely to impact
FC	*Waltoncythere acuta*	Transylvania crayfish ostracod	May impact*	Not likely to impact	Not likely to impact
FC	*Lestes congener*	spotted spreadwing	May impact*	Not likely to impact	Not likely to impact
FC	*Aeshna tuberculifera*	black-tipped darner	May impact*	Not likely to impact	Not likely to impact
FC	*Aeshna verticalis*	green-striped darner	May impact*	Not likely to impact	Not likely to impact
FC	*Cordulia shurtleffii*	American emerald	May impact*	Not likely to impact	Not likely to impact
FC	*Gomphus adelphus*	moustached clubtail	May impact*	Not likely to impact	Not likely to impact
FC	*Gomphus consanguis*	Cherokee clubtail	May impact*	Not likely to impact	Not likely to impact
FC	*Gomphus descriptus*	harpoon clubtail	May impact*	Not likely to impact	Not likely to impact
FC	*Gomphus lineatifrons*	splendid clubtail	May impact*	Not likely to impact	Not likely to impact
FC	*Gomphus viridifrons*	green-faced clubtail	May impact*	Not likely to impact	Not likely to impact
FC	*Neurocordulia yamaskanensis*	stygian shadowdragon	May impact*	Not likely to impact	Not likely to impact
FC	*Ophiogomphus aspersus*	brook snaketail	May impact*	Not likely to impact	Not likely to impact
FC	*Ophiogomphus mainensis*	Maine snaketail	May impact*	Not likely to impact	Not likely to impact
FC	*Ophiogomphus rupinsulensis*	rusty snaketail	May impact*	Not likely to impact	Not likely to impact
FC	*Somotochlora elongata*	ski-tailed emerald	May impact*	Not likely to impact	Not likely to impact
FC	*Stylurus scudderi*	zebra clubtail	May impact*	Not likely to impact	Not likely to impact
FC	*Sympetrum obtrusum*	white-faced meadowhawk	May impact*	Not likely to impact	Not likely to impact
FC	*Acerpenna macdunnoughi*	a mayfly	May impact*	Not likely to impact	Not likely to impact

Status	Scientific Name	Common Name	No Treatment	Imidacloprid	Predator Beetles
FC	*Baetis punctiventris*	a mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Baetopus sp. 1*	a mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Barbaetis benfieldi*	Benfield's bearded small minnow mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Barbaetis cestus*	a mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Barbaetis gloveri*	a mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Drunella longicornis*	a mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Ephemerella berneri*	a mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Habrophlediodes spp*	a mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Heterocleon petersi*	a mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Homoeneuria cahabensis*	Cahaba sand-filtering mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Leptohyphes robacki*	a mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Macdunnoa brunnea*	a mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Serratella spiculosa*	spicilose serratellan mayfly	May impact*	Not likely to impact	Not likely to impact
FC	*Elimia (Goniobasis) interrupta*	knotty elimnia	May impact*	Not likely to impact	Not likely to impact
FC	*Leptoxis virgata*	smooth mudalia	May impact*	Not likely to impact	Not likely to impact
FC	*Attaneuria ruralis*	a stonefly	May impact*	Not likely to impact	Not likely to impact
FC	*Bolotoperla rossi*	a stonefly	May impact*	Not likely to impact	Not likely to impact
FC	*Isoperla frisoni*	a stonefly	May impact*	Not likely to impact	Not likely to impact
FC	*Megaleuctra williamsae*	Williams' rare winter stonefly	May impact*	Not likely to impact	Not likely to impact
FC	*Zapada chila*	a stonefly	May impact*	Not likely to impact	Not likely to impact

*May impact individuals. Will not affect viability across the forest.

3.5.3 Terrestrial Wildlife

Species Evaluated and Rationale

Thirteen federally threatened or endangered, 50 Region 8 Regional Forester's Sensitive, and 83 Forest Concern (locally rare) wildlife species were originally considered from the National Forests in North Carolina rare species list (available from the project file). All but three federally threatened or endangered, four Sensitive and 12 forest concern species were dropped since these were listed by the North Carolina Wildlife Resources Commission (NCWRC), North Carolina Natural Heritage Program (NCNHP), and the US Fish and Wildlife Service (USFWS) as occurring near (within 1320 feet) of treatment areas on the Nantahala and Pisgah National Forests in western North Carolina (Table 3.5-12). The 1320 foot radius from treatment centers was chosen since it is believed that predator beetles of the HWA will disperse up to 0.25 mi from the release site (Rusty Rhea, USDA Forest Service Entomologist, Pers. Comm.).

Table 3.5-12. Endangered, threatened, sensitive and forest concern species evaluated for the Suppression of Hemlock Wooly Adelgid Infestations Project (known to occur within 1320 feet of treatment areas on the Nantahala and Pisgah National Forests).

Species	Type	Brief Habitat Description	Occurrence/Evaluation Criteria*
Federally Threatened and Endangered Species			
Carolina Northern Flying Squirrel	Mammal	High elevation forests, mainly spruce-fir	About 1000'/2,3
Bog Turtle	Reptile	Bogs, wet pastures, wet thickets	About 700'/2,3
Noonday Globe	Terrestrial Gastropod	Nantahala Gorge (endemic to this site)	About 1300'/2,3
August 7, 2001 Regional Forester's Forest Sensitive Species			
Peregrine Falcon	Bird	Cliffs (for nesting)	≤1300'/1,3
Tellico Salamander	Amphibian	Forests in the Unicoi Mountains	About 500'/2,3
Junaluska Salamander	Amphibian	Forests near seeps and streams in the southwestern mountains	≤1000'/2,3
Bidentate Dome	Terrestrial Gastropod	Forests near seeps and streams in the southwestern mountains	About 300'/2,3
March 19, 2002 Forest Concern Species			
Allegheny Woodrat	Mammal	Rocky places and abandoned buildings in deciduous or mixed forests in the northern mountains and adjacent Piedmont	≤ 1100'/2,3
Hermit Thrush	Bird	Spruce-fir forests (for nesting) [breeding season only	About 1200'/2,3
Yellow-bellied Sapsucker	Bird	Mature, open hardwoods with scattered dead trees [breeding season only]	≤750'/2,3
Cerulean Warbler	Bird	Mature hardwood forests; steep slopes and coves in mountains [breeding season only]	≤1250'/2,3
Blue-winged Warbler	Bird	Low elevation brushy fields and thickets	About 1200'/2,3
Magnolia Warbler	Bird	Spruce-fir forests, especially in immature stands [breeding season only]	About 100'/1,3
Green Salamander	Amphibian	Damp, shaded crevices of cliffs or rock outcrops in deciduous forests (southern forests)	≤1100'/1,3
Diana Fritillary	Insect	Rich woods and adjacent edges and openings; host plants -- violets	≤1200'/2,3
Tawny Crescent	Insect	Rocky ridges, woodland openings, at higher elevations; host plants-Asters, mainly *Aster undulatus*	About 900'/1,3
Dusky Azure	Insect	Rich, moist deciduous forests; host plant-goat's beard (*Aruncus dioicus*)	About 1100'/1,3
Golden-banded Skipper	Insect	Moist woods near streams; host plant-hog peanut (*Amphicarpa bracteata*)	About 900'/3
Spiral Coil	Terrestrial Gastropod	Leaf litter on wooded hillsides	About 800'/3

* 1 = Recent survey data within project area (<5 year old)
2 = Historical survey data within project area (>5 years old)
3 = Vicinity records (NCWRC, NCNHP, USFWS)

The remaining species not considered for further analysis (those not included in the above table were dropped on the basis that (1) the species does not occur on the Nantahala or Pisgah Natioal Forests; therefore, the species will not be affected by any of the alternatives, (2) the species does not occur within the 1320 feet of sites being treated (based on element occurrence records kept by the North Carolina Natural Heritage Program); therefore the species will not be affected by the any of the action alternatives, or (3) the species' habitat is not tied to hemlock or moist sites where hemlock occur; therefore the species will not be affected by any of the alternatives. Given no effects to these species, the alternatives in this project will not cause changes to current population levels of those species not chosen for further analysis.

Existing Condition

Please refer to discussion in Section 3.2.1.

Effects of Alternatives by Species

Federally Threatened and Endangered Species

Direct and Indirect Effects:

Alternative A - No Action

Carolina northern flying squirrel
In North Carolina, the Carolina northern flying squirrel occurs at elevations above 4000 feet. The squirrel is found in spruce-fir and northern hardwood forests where beech occurs. Its optimal conditions include cool, moist, mature forest with abundant standing and down snags. These squirrels occupy tree cavities, leaf nests, underground burrows, but they prefer cavities in mature trees as den sites. They may occasionally use small outside twig nests sometimes used for den sites, and squirrels will readily use nest boxes.

Although Carolina northern flying squirrel prefers cool, moist, mature forests, it is not dependent on hemlock. The death of hemlock that occurs within the squirrel's habitat could increase the amount of snags that will be suitable for cavity nesting.

Bog turtle
The bog turtle inhabits sphagnum bogs, swamps, and marshy meadows that have clear, slow-moving streams with soft muddy bottoms (Ernst and Barbour 1972). It occurs from sea level to elevations above 1400 meters. This small turtle is shy and frequently burrows, making it difficult to find even in known localities. The bog turtle requires soft, muddy substrate in which to burrow and grassy, marshy areas with adequate cover. The species is therefore excluded from closed-canopied streams. The turtle depends on a mosaic of microhabitats for foraging, nesting, basking, hibernation, and shelter.

Although the turtle occurs in wetlands where hemlock may occur, it does not depend on hemlock. Where hemlock shade wetlands, the death of hemlock may open up the wetlands and make them more suitable for the turtle by allowing herbaceous vegetation (e.g., grasses) to grow.

Noonday globe
This snail is endemic to the Nantahala Gorge in Swain County. This snail requires moist leaf litter on wooded hillsides in which to move about and to reproduce. When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any terrestrial snail, including the noonday globe that moves through the leaf litter.

<u>Alternatives B and C</u>

Carolina northern flying squirrel
Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the Carolina northern flying squirrel. Although squirrels are not dependent on hemlock, the death of hemlock could increase the amount of potential squirrel habitat by creating snags that would be used for cavity nesting. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created that are potential nest trees for squirrels.

Bog turtle
Although the bog turtle is a wetland-dependent species, it is not dependent on hemlock. The optimal habitat is a wetland covered with herbaceous vegetation (e.g., grasses). Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the bog turtle. Imidacloprid will only be used in soils that are not wet nor excessively well-drained. Furthermore, it is injected approximately 8 - 10 inches below the surface and therefore should not affect surface litter, vegetation, or species. The clearance process and application procedures would mean there is very little chance that the chemical will reach water.

Since bog turtles require open wetlands, the death of hemlock trees, especially those near streams, may actually increase habitat for the turtle opening up the canopy and creating a flush of herbaceous cover. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some hemlocks will die and open up the canopy around wetlands.

Noonday globe
When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any snail species, including the noonday globe that moves through the leaf litter. By treating the hemlock with biocontrol or chemicals, shade will be maintained in the forest, thus making it more suitable for this snail species that requires moist conditions. Since imidacloprid is either injected directly into the bole of the tree, or it is injected approximately 8 - 10 inches deep into the soil (below the leaf litter), use of this chemical will have no negative effect on the noonday globe.

Region 8 Forester's Sensitive Species

Direct and Indirect Effects:

Alternative A - No Action

Peregrine falcon
Peregrine falcons tend to nest in high, steep, exposed rock faces or cliffs which are frequently in remote, inaccessible locations and are often a fair distance from each other. These birds nest on ledges on these cliffs, and they forage in extensive open areas and in or near forests. In Western North Carolina, Boynton (1994) looked at 32 potential peregrine falcon sites, of which about 12 of them occur on the Nantahala and Pisgah National Forests. Essentially, any high, exposed cliff with ledges would represent suitable habitat for Peregrine falcons to nest.

Although hemlock may grow near rock faces or cliffs, the peregrine falcon is not dependent on hemlock. Because falcon populations tend to be limited by the availability of nest sites or food sources, the death of hemlock will not affect the peregrine falcon.

Tellico salamander
This salamander occurs on the lower mountain slopes and adjacent lowlands in forested habitats with abundant leaf litter and rotting logs on the forest floor. Like many other woodland species, it prefers hardwood over coniferous forests. It requires shaded woodlands, usually hardwoods but occasionally pine areas in the vicinity of bottomlands, with fallen logs, leaf litter, and an organic soil layer. They forage at night on the surface or

within their burrows, capturing arthropods and worms. Some canopy closure is necessary to prevent excessive drying of the forest floor.

Although this salamander prefers hardwood to conifer forests, it requires shaded woodlands. When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any salamander species, including the Tellico salamander, that moves on the forest floor (through the leaf litter).

Junaluska salamander
This salamander is found at low elevations under logs and rocks along the Cheoah River and its tributaries in Graham County, North Carolina. It ventures some distance across land during rainy nights. It requires clean, clear streams with abundant rocks and logs, and its diet consists of small arthropods. Siltation or pollution of streams as well as destruction of adjacent forests and their leaf litter would be detrimental to this species. The habitat requirements of this species appear to be generally similar to the Blue Ridge two-lined salamander.

When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any salamander species, including the Junaluska salamander, that moves on the forest floor (through the leaf litter).

Bidentate dome
This snail occurs in the northern mountains, and is found in Alleghany, Avery, Madison, and Watauga counties. This snail requires moist leaf litter on wooded hillsides in which to move about and to reproduce. When hemlock die, the amount of sunlight to the ground increases, thus drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any terrestrial snail, including the bidentate dome that moves through the leaf litter.

<u>Alternatives B and C</u>

Peregrine falcon
Although hemlock may grow near rock faces or cliffs, the peregrine falcon is not dependent on hemlock. Because falcon populations tend to be limited by the availability of nest sites or food sources, the death of hemlock will not affect the peregrine falcon. Also, biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect peregrine falcon since the falcon is not dependent on the hemlock resource.

Tellico salamander
When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any salamander species, including the Tellico salamander, that moves on the forest floor (through the leaf litter). By treating the hemlock with biocontrol or chemicals, shade will be maintained in the forest, thus making it more suitable for this salamander species that requires moist conditions. Since imidacloprid is either injected directly into the bole of the tree, or it is injected approximately 8 - 10 inches deep into the soil (below the leaf litter), use of this chemical will have no negative effect on the Tellico salamander, since it lives in the leaf litter and the chemical would not move up into the leaf litter.

Junaluska salamander
When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any salamander species, including the Junaluska salamander, that moves on the forest floor (through the leaf litter). By treating the hemlock with biocontrol or chemicals, shade will be maintained in the forest, thus making it more suitable for this salamander species that requires moist conditions. Since imidichloprid is either injected directly into the bole of the tree, or it is injected approximately 8 - 10 inches deep into the soil (below the leaf litter), use of this chemical will have no negative effect on the Junaluska salamander since it lives in the leaf litter and the chemical would not move up into the leaf litter.

Bidentate dome
When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any snail species, including the bidentate dome that moves through the leaf litter. By treating the hemlock with biocontrol or chemicals, shade will be maintained in the forest, thus making it more suitable for this snail species that requires moist conditions. Since imidacloprid is either injected directly into the bole of the tree, or it is injected approximately 8 - 10 inches deep into the soil (below the leaf litter), use of this chemical will have no negative effect on the bidentate dome since it lives in the leaf litter and the chemical would not move up into the leaf litter.

National Forests in North Carolina Forest Concern Species

Direct and Indirect Effects:

Alternative A - No Action

Allegheny woodrat
The Allegheny woodrat is, throughout its range, associated with extensive rocky areas such as outcrops, cliffs, talus slopes with boulders and crevices, and caves in forested areas. It occasionally uses abandoned buildings but generally avoids humans. It generally occurs at higher elevations and is rarely found in lowlands or open areas. These areas are often associated with a variety of forests, including cove hardwoods, hemlock-birch, oak-pine, and various combinations of oaks, maples, hickories, beech and yellow poplar.

Although the woodrat is not a hemlock dependent species, the death of hemlock around rock outcrops could make the rocky habitat inhospitable for the woodrat. Woodrats prefer the cover of the forest, and opening the canopy would expose the boulders they inhabit, making the habitat less suitable.

Hermit thrush
This thrush inhabits open humid coniferous and mixed forest and forest edges and less frequently in deciduous forest and thickets. In North Carolina, hermit thrush is often found at higher elevations in spruce and /or fir forests, especially in moist spots, with a light to moderate understory. Hermit thrush are typically ground nesters, usually on the ground under conifers with low branches or hidden by low plants, or in low conifers or other trees or bushes within seven feet of the ground.

Hemlock does provide suitable nesting habitat for hermit thrush, and it may be an important component of the thrush's habitat where spruce/fir trees are sparse. Death of hemlock will reduce the amount of suitable nesting habitat for the thrush in North Carolina.

Appalachian yellow-bellied sapsucker
In North Carolina, yellow-bellied sapsucker is restricted as a breeder to elevations above 3,500 feet. It is associated with mature hardwood forests containing patches of dead trees and early successional to sapling stage stands produced by frequent large scale disturbances, such as tree cutting, fire, windthrow, or disease. Sapsuckers are associated with disturbed sites due to their preference for young trees for drilling sap wells during the nesting season (Hunter et al. 1999).

Although yellow-bellied sapsuckers are not dependent on hemlock, the death of hemlock would increase the amount of potential woodpecker habitat by creating snags that would be used for foraging and cavity nesting.

Cerulean warbler
In North Carolina, cerulean warblers are found in mature cove hardwood forests on relatively steep slopes with little understory. The size of the trees is of primary importance and their species identity secondary. Landscape situation and context has a strong bearing on whether otherwise suitable breeding habitat will actually contain warblers (Hamel 1992). This warbler typically nests high in the tree, well out on a large branch, often near a forest opening.

Since this species does not depend on hemlock, the death of hemlock will have no negative effect on cerulean warbler. However, scattered dying hemlock may cause canopy gaps in cove hardwood forests that may make the habitat more suitable for nesting.

Blue-winged warbler
Blue-winged warbler favors overgrown fields or thickets, on fairly level ground. It often occurs in moist situations, such as streamside shrubbery, but are not birds of dense thickets. It nests close to or on the ground, in bushes, weeds, or grasses, or under bushes, or between exposed roots of stumps (Terres 1996).

Since this species does not depend on hemlock, the death of hemlock will have no negative effect on blue-winged warbler. However, the death of hemlock will cause a flush of growth that may create suitable habitat for blue-winged warbler.

Magnolia warbler
This bird inhabits spruce or fir forests, both mature stands and fairly young ones, and it is also found around the edges of bogs where spruce or fir occur. Hemlock forests are probably used sparingly, and it avoids pure hardwood forests. In British Columbia, it breeds in mature, mixed forests and openings in mixed or coniferous woods where a dense conifer shrub layer has developed (Campbell et al. 2001). This bird nests on branches among twigs and foliage of conifers, or by the trunk, usually 13 feet or less above ground.

Although this bird does not depend on hemlock, it will nest in hemlock trees. Death of hemlock will reduce the amount of nesting habitat available for the magnolia warbler.

Green salamander
The green salamander lives in damp, but not wet, crevices in shaded rock outcrops and ledges, situated where the atmosphere is humid, and well protected from the sun and direct rain. It is sometimes found under the bark and in cracks of trees in cove hardwoods (Gordon 1967). This

species is also found in upland pine areas, particularly Virginia pine and white pine-hemlock with mountain laurel occupying the understory.

Although this salamander is not a hemlock dependent species, the death of hemlock around rock outcrops could make the rocky habitat unsuitable for the green salamander. Green salamanders inhabit shaded rock outcrops, and death of hemlock trees that shade rock outcrops will dry the microclimate of the crevices, thus making the rocks unsuitable for green salamanders.

Diana fritillary
The breeding habitats of the Diana fritillary are generally mesic forests such as cove forests and sometimes bottomland areas that can be swampy. Adults also use adjacent fields, pastures, shrublands and grassland for nectar but do not breed there unless possibly in edges near woods. Adults visit flowers of many species and also scat and moist soil. Larvae of this entire genus feed on foliage of genus *Viola*, probably any species available in the breeding habitats. This butterfly is not dependent on hemlock; therefore, the death of hemlock will have no effect on Diana fritillary.

Tawny crescent
In North Carolina, the tawny crescent occurs in openings, glades, open woods, and roadsides in often heavily forest regions, but its habitats are probably better characterized as woodland-hardwood than as forest. Its host plant is *Aster undulates*. This species is not dependent on hemlock, so the death of hemlock will not negatively affect this butterfly. The death of hemlock may actually create openings in wooded areas making the habitat more suitable for the tawny crescent.

Dusky azure
The dusky azure inhabits moist deciduous forests, especially shaded northern slopes, where its host, *Aruncus dioicus*, occurs. This species is not dependent on hemlock, so the death of hemlock will not negatively affect this butterfly.

Golden-banded skipper
The golden-banded skipper occurs in rich open bottomlands near creeks and streams or in openings along creeks and dirt roads in moist woods where *Amphicarpa bracteata*, its host plant, occurs. This species is not dependent on hemlock, so the death of hemlock will not negatively affect this butterfly.

Spiral coil
This snail is endemic to the Nantahala Gorge in Graham, Macon, and Swain counties. This snail requires moist leaf litter on wooded hillsides in which to move about and to reproduce. When hemlock die, the amount of

sunlight to the ground increases, thus drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any terrestrial snail, including the spiral coil that moves through the leaf litter.

Alternatives B and C

Allegheny woodrat
Although the woodrat is not a hemlock dependent species, the death of hemlock around rock outcrops could make the rocky habitat inhospitable for the woodrat. Woodrats prefer the cover of the forest, and opening the canopy would expose the boulders they inhabit, making the habitat less suitable. By treating the hemlock with biocontrol or chemicals, shade will be maintained in the forest, thus making it more suitable for this woodrat that requires cover around its nest sites.

Hermit thrush
Hemlock does provide suitable nesting habitat for hermit thrush, and it may be an important component of the thrush's habitat where spruce/fir trees are sparse. Death of hemlock will reduce the amount of suitable nesting habitat for the thrush in North Carolina. Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will help to preserve some of the hemlock diversity in the forest, thus helping maintain suitable nesting habitat for the hermit thrush.

Appalachian yellow-bellied sapsucker
Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the yellow-bellied sapsucker. Although sapsuckers are not dependent on hemlock, the death of hemlock could increase the amount of potential woodpecker habitat by creating snags that would be used for foraging and cavity nesting. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created that are potential nest and foraging trees for woodpeckers.

Cerulean warbler
Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the cerulean warbler. Because this species does not depend on hemlock, the death of hemlock will have no negative effect on cerulean warbler. However, scattered dying hemlock may cause canopy gaps in cove hardwood forests that may make the habitat more suitable for nesting. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some canopy gaps in cove hardwood forests that may make the habitat more suitable for nesting will be created as hemlock die.

Blue-winged warbler
Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the blue-winged warbler. Although this species does not depend on hemlock, the death of hemlock will cause a flush of growth that may create suitable habitat for blue-winged warbler. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus when hemlock die, the resulting growth may create more suitable habitat for the blue-winged warbler.

Magnolia warbler
Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the magnolia warbler. Although this bird does not depend on hemlock, it will nest in hemlock trees. Treating hemlocks will help maintain nesting habitat across the forests for the magnolia warbler.

Green salamander
Although the green salamander is not a hemlock dependent species, the death of hemlock around rock outcrops could make the rocky habitat inhospitable for the salamander. Green salamanders live in shaded rock outcrops with moist crevices, and opening the canopy would expose the rock outcrops they inhabit, making the habitat less suitable. By treating the hemlock with biocontrol or chemicals, shade will be maintained in the forest, thus making it more suitable for this salamander that requires shade around its habitat.

Diana fritillary
Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the Diana fritillary since this butterfly is not dependent on hemlock.

Tawny crescent
Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the tawny crescent. Although this species does not depend on hemlock, the death of hemlock will actually create openings in wooded areas making the habitat more suitable for the tawny crescent. It is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus when hemlock die, the resulting growth may create more suitable habitat for the tawny crescent.

Dusky azure
Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the dusky azure since this butterfly is not dependent on hemlock.

Golden-banded skipper
Biocontrol or chemical treatment of hemlock infested with hemlock woolly adelgid will not negatively affect the golden-banded skipper since this butterfly is not dependent on hemlock.

Spiral coil
When hemlock die, the amount of sunlight to the ground increases, drying out any leaf litter on the forest floor. This drying of the site will make the areas less hospitable for any snail species, including the bidentate dome that moves through the leaf litter. By treating the hemlock with biocontrol or chemicals, shade will be maintained in the forest, thus making it more suitable for this snail species that requires moist conditions. Since imidichloprid is either injected directly into the bole of the tree, or it is injected approximately 8 - 10 inches deep into the soil (below the leaf litter), use of this chemical will have no negative effect on the spiral coil.

Cumulative Affects for Threatened, Endangered, Sensitive and Forest Concern Species

Past and present timber harvest and prescribed burning activities on the Nantahala and Pisgah National Forests have affected eastern and Carolina hemlocks and have affected sites that could support eastern hemlock such as acidic coves. Many of these activities will continue in the future but the resulting individually minor effects are insignificant when compared with the major impacts expected from infestation of the HWA. Therefore, these activities are unlikely to add or combine measurably with the impact resulting from an expanding HWA population over time. This project would result in lessening cumulative impacts to hemlock from HWA infestation and all other actions.

When hemlock die, numerous changes will occur across the landscape. Where trees die along streams, the canopy will open up, thus creating potential habitat for bog turtles, cerulean warblers, blue-winged warblers, and tawny crescent. A flush of herbaceous and soft mast species growth will occur, creating nesting habitat for the blue-winged warbler and cover for the bog turtle. Also, the canopy gaps created by the death of hemlocks may increase suitability for nesting habitat for the cerulean warbler. The snags of dead hemlock will increase potential cavity nesting habitat for the Carolina northern flying squirrel and Appalachian yellow-bellied sapsucker. However, death of hemlock forests could be detrimental for the hermit thrush and the magnolia warbler, which occasionally use hemlock for nesting. Once the canopy is opened up, sunlight reaches the forest floor, thus drying out the leaf litter and making those moist areas unsuitable for Tellico and Junaluska salamanders and the noonday globe, bidentate dome, and spiral coil (until cover returns and the leaf litter is

shaded again). The death of hemlock will have no effect on the peregrine falcon, Diana fritillary, dusky azure, and golden-banded skipper since they do not use hemlock habitat.

Treating infested hemlock trees will help save some of the hemlocks across the Nantahala and Pisgah National Forests. Release of predatory beetles on infested hemlocks will help curtail the spread of the adelgid. The use of chemicals will have no negative effect on any of the threatened, endangered, sensitive or forest concern species. Imidichloprid is either injected directly into the bole of the tree, or it is injected approximately 8 - 10 inches deep into the soil within a six foot radius of the bole of the tree. By saving hemlocks, hermit thrush, magnolia warbler, Allegheny woodrat, green salamander, noonday globe, bidentate dome, spiral coil, Tellico salamander and Junaluska salamander will continue to have suitable habitat in which to live. However, it is reasonable to believe that all infested hemlocks across the Nantahala and Pisgah National Forests will not be treated, thus some snags will still be created that will potential roost trees for the Carolina northern flying squirrel and yellow-bellied sapsucker.

Determination of Effect

Implementation of the proposed project will have no negative effect on any federally threatened or endangered wildlife species, for the reasons stated above, nor is it likely to result in a trend towards federal listing of sensitive species since there will be no impact to sensitive species or the species may benefit from the proposed action. This project will have no impact or even beneficial impact on forest concern species if project implementation is in compliance with the Endangered Species Act and Forest Service Manual 2670. Consultation with the U.S. Fish and Wildlife Service not required. Table 3.5-13 summarizes the effects of Alternatives A, B, and C on the Threatened, Endangered, Sensitive and Forest Concern species considered in the analysis of this project.

Table 3.5-13. Effects to Threatened, Endangered, Sensitive and Forest Concern Terrestrial Wildlife Species by Alternative

COMMON NAME	Status	Alt. A	Alt. B	Alt. C
Carolina Northern Flying Squirrel	E	Not likely to adversely effect	Not likely to adversely effect	Not likely to adversely effect
Bog Turtle	T	Not likely to adversely effect	Not likely to adversely effect	Not likely to adversely effect
Noonday Globe	T	Adverse effects	Not likely to adversely effect	Not likely to adversely effect
Peregrine Falcon	S	No impact	No impact	No impact
Tellico Salamander	S	May impact individuals but not	Beneficial impact	Beneficial impact

COMMON NAME	Status	Alt. A	Alt. B	Alt. C
		likely to cause a trend to federal listing or a loss of viability		
Junaluska Salamander	S	May impact individuals but not likely to cause a trend to federal listing or a loss of viability	Beneficial impact	Beneficial impact
Bidentate Dome	S	May impact individuals but not likely to cause a trend to federal listing or a loss of viability	Beneficial impact	Beneficial impact
Allegheny Woodrat	FC	May impact individuals	Beneficial impact	Beneficial impact
Hermit Thrush	FC	May impact individuals	Beneficial impact	Beneficial impact
Appalachian Yellow-bellied Sapsucker	FC	Beneficial impacts	No impact	No impact
Cerulean Warbler	FC	Beneficial impacts	No impact	No impact
Blue-winged Warbler	FC	Beneficial impacts	No impact	No impact
Magnolia Warbler	FC	May impact individuals	Beneficial impact	Beneficial impact
Green Salamander	FC	May impact individuals	Beneficial impact	Beneficial impact
Diana Fritillary	FC	No impact	No impact	No impact
Tawny Crescent	FC	No impact	No impact	No impact
Dusky Azure	FC	No impact	No impact	No impact
Golden-banded Skipper	FC	No impact	No impact	No impact
Sprial Coil	FC	May impact individiuals	Beneficial impact	Beneficial impact

If Alternative A (the No Action alternative) is chosen, then it is not likely to adversely effect The Carolina northern flying squirrel or bog turtle. The creation of snags will increase potential cavity nests for the flying squirrel, and the death of hemlock around wet areas will open up the canopy, thus potentially making wetlands more suitable for bog turtle. Alternative A will also have beneficial impacts for the yellow-bellied sapsucker (by creating snags for foraging and nesting), cerulean warbler (by creating canopy gaps necessary for nesting), and blue-winged warbler (causing a flush of undergrowth which may be used for nesting). However, Alternative A may have some adverse effects to the noonday globe and may impact individuals but not likely to cause a trend to federal listing or a loss of viability for the Tellico salamander, Junaluska salamander, and bidentate dome by drying out their habitat.

Treating hemlock that are infested with hemlock woolly adelgid by biocontrol or herbicides (Alternatives B or C), is not likely to adversely affect the flying squirrel, bog turtle or noonday globe. Maintaining hemlock will not affect the flying squirrel or the bog turtle (which are not dependent on hemlock), but it will benefit the noonday globe (by maintaining moisture at the sites). Treating hemlock will also be beneficial for the Tellico salamander, Junaluska salamander, bidentate dome, Allegheny woodrat, green salamander, and spiral coil by maintaining shade over these areas, thus maintaining the moist conditions or cover that these species need. Also, maintaining hemlock will be of benefit to the hermit thrush and magnolia warbler, which both nest in hemlocks. Implementation of Alternatives B or C will have no impact on the yellow-bellied sapsucker, cerulean warbler, blue-winged warbler, Diana fritillary, tawny crescent, dusky azure, and golden-banded skipper since these species do not depend on hemlock for survival.

Mitigation Measures

No mitigation measures are required.

3.6 Scenery and Recreation Resources

3.6.1 Scenery

The Nantahala-Pisgah Forest Plan utilizes the Visual Management System (VMS) as an integral component of Forest-wide and Management Area direction.

The VMS is used to establish Visual Quality Objectives (VQO's) for each Management Area. Visual Quality Objectives are determined by three primary components: Variety Class (A, B, or C), Distance Zones (Foreground, Middleground, or Background) and Sensitivity Level (1, 2, or 3). The VQO's of Preservation, Retention, and Partial Retention have the highest standards for the protection of visual quality and tend to be located in areas with the highest visual sensitivity and/or in Variety Class A landscapes.

Variety Classes are rated from Class A to Class C based on criteria established for Southern Appalachian landscapes, with Variety Class A being the most visually distinctive. Variety Class A landscapes consist of various combinations of distinctive topographic, water, or vegetative features such as steep slopes, rock outcrops, streams, rivers, large trees, or unusual native vegetation.

Hemlocks tend to be a significant vegetative component in many Variety Class A (distinctive) landscapes such as scenic stream and river corridors and major rock outcrops. Also, because of the long life and large size of many hemlocks they can be a distinctive feature anywhere they occur in abundance.

One-hundred-fifty-nine hemlock conservation areas were selected on the Pisgah and Nantahala National Forests. The conservation reserve areas tend to be in visually important locations as indicated by the fact that 131 of the 159 areas (82%) are in locations with the highest VQO's of Preservation, Retention, and Partial Retention. See the table below.

Visual Quality Objective	**Conservation Areas**	**Alternative A** Treatments		**Alternative B** Treatments		**Alternative C** Treatments	
		Chemical	Biological Control	Chemical	Biological Control	Chemical	Biological Control
Preservation	24	0	0	9	23	0	23
Retention or Partial Retention	107	0	0	48	108	0	108

Modification	28	0	0	20	28	0	28

Direct and Indirect Effects

None of the alternatives would have any direct effects except in Alternatives B and C Forest Service personnel would occasionally be seen administering treatments. The following discussion describes indirect effects from loss of hemlock over time.

Alternative A. Many distinctive (Class A) landscapes would be degraded visually by the loss of hemlocks. This would be very evident to visitors at many campgrounds, along rivers, and on trails. Because of the distinctive visual character of hemlocks and the relatively large size and age of many specimens, the loss of hemlocks would be most evident in foreground views. In more distant views, many dead patches would appear in the landscape in drainages and near rock outcrops.

Alternative B. There is a good chance of protection of some hemlock populations in key places, including some distinctive (Class A) and sensitive landscapes, since most of the treatments (82%) are located in areas with the highest VQO's of Preservation, Retention, and Partial Retention. However, many areas will remain untreated and will result in effects similar to those in Alternative A. Hemlock populations may be able to recover much quicker if some key stands remain in place. There would be more flexibility for future recovery as knowledge of HWA and treatments improve.

Alternative C. The effects are similar to Alternative B although the retention of some key hemlock sites will not be as assured as in Alternative B because of the lack of chemical treatment.

Cumulative Effects

All cumulative effects are tied to the indirect effects on scenery over time except the present of Forest Service personnel occasionally administering treatments and monitoring conditions over time in Alternatives B and C.

Alternative A. It is likely that hemlock mortality will approach or reach 100% over time. Most Class A landscapes near streams, rivers, and rock outcrops will permanently lose part of their distinctive character. It is also likely that non-native invasive species will occupy some of the void left by the extirpation of the hemlock and further diminish visual distinctiveness of the Class A landscapes.

Alternative B. Some Class A landscapes near streams, rivers, and rock out will retain enough hemlock component to not lose their distinctive character. Recovery of the remainder of the forest will likely be faster than without treatment.

Alternative C. The cumulative effects would be similar to Alternative B except that retention of hemlocks in some key areas would not be as assured.

3.6.2 Recreation

Hemlocks contribute to the mountain recreation setting in several ways. In addition to their visual distinctiveness, hemlocks contribute to producing a cool, desirable microclimate. Their presence in riparian areas shades streams and helps produce a healthy trout fishery. Many of the 159 selected hemlock conservation reserve areas are in or near developed recreation areas.

Direct and Indirect Effects

There are no direct effects from the Alternatives. Neither beetle releases nor imidacloprid injection would directly affect recreation settings since the beetles are inconspicuous and the imidacloprid would be underground or in the treated tree. The following discussion describes indirect effects over time.

Alternative A. This Alternative may result in the most change in setting and microclimate. There will be many downed trees along trails, rivers, and other places on the Forest where people may visit.

Alternative B. This alternative provides the most potential to protect settings at key places where visitors may be present. There will be many downed trees along trails and other areas but less than if there are no treatments.

Alternative C. The effects will be similar to Alternative B but there is less assurance of protecting settings at key places because the lack of chemical treatments.

Cumulative Effects

The following cumulative effects relate to the indirect effects of the Alternatives over time.

Alternative A. The recreation setting will be changed for the foreseeable future where hemlock and hemlock related plant communities now exist.

The cooling effect of hemlocks will be lost in streams and drainages although the space hemlocks occupied may be taken over by non-native invasive vegetation and other native species.

Alternative B. Much of the recreation setting on the Forests will be changed with the loss of up to 80% of the hemlock and hemlock related plant communities. However, the surviving areas of hemlock may be able to enhance future recovery in the areas of the Forests where hemlock populations have been lost.

Alternative C. The effects would be similar to Alternative B except that there would be less assurance of survival of hemlocks in some locations.

3.7 Wilderness Resources

Wilderness is a unique and valuable resource. In addition to offering primitive recreation opportunities, it is valuable for its scientific and educational uses, as a benchmark for ecological studies, and for the preservation of historical and natural features (FSM 2320.1).

Wilderness is defined in Section 2 (c) of the Wilderness Act of 1964: "A wilderness, in contrast with those areas where man and his works dominate the landscape, is hereby recognized as an area where the community of life are untrammeled by man, where man himself is a visitor who does not remain.

An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements and habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historic value."

The National Wilderness Preservation System now includes over 105 million acres in 44 states. Individual Wildernesses range in size from some that are millions of acres in Alaska and the Western United States to others that are much smaller in the eastern United States. Wildernesses also vary greatly in the amount of human influences surrounding them and affecting them.

3.7.1 Wilderness and Wilderness Study Areas in Western North Carolina

In Western North Carolina, 66,388 acres have been Congressionally designated as Wilderness. These Wildernesses include Linville Gorge, Shining Rock, and Middle Prong on the Pisgah National Forest and Joyce Kilmer-Slickrock, Southern Nantahala, and Ellicott Rock on the Nantahala National Forest.

In addition, 23,649 acres have been established as Wilderness Study Areas including Lost Cove, Harper Creek, and Craggy Mountain on the Pisgah National Forest and Snowbird on the Nantahala National Forest. These areas are managed to protect their wilderness attributes until Congress determines whether or not to include them in the National Wilderness Preservation System.

3.7.2 Exotic Pests in Wilderness

The dilemma of how Wilderness can be "protected and managed so as preserve its natural conditions" while at the same time remaining "untrammeled by man" is recognized as a key topic in the Forest Service's *Wilderness Agenda: Thinking like A Mountain.* Exotic pests, both plants and other organisms, have the potential to drastically alter the natural processes in Wilderness. The question of whether or not to take management action to counteract an exotic pest or other unnatural influence is a difficult one. *In Naturalness and Wildness: The Dilemma and Irony of Managing Wilderness* (Landres, et. al. 2000) this is described as an emerging dilemma between managing for these two values which are both central to the concept of Wilderness. While it is important to manage for both naturalness and wildness, large-scale ecological changes caused by unnatural influences such as exotic pests present difficult choices for the management of Wilderness. A decision either to act or not to act will have consequences for the natural or wild conditions of wilderness.

3.7.3 HWA Infestations in Wilderness

Hemlocks and hemlock related plant communities are a large component of most of the Wildernesses in Western North Carolina. Infestations of HWA have been confirmed in all the Wildernesses and Wilderness Study Areas in Western North Carolina. The effects and projected progression of infestation are projected to eventually reach up to 100% mortality of both species. The hemlock populations and associated plant communities are a distinct visual attribute contributing to Wilderness character. The "naturalness" and value of Wilderness as a biological benchmark is threatened if the great majority or all the hemlock population and associated plant communities are extirpated. However, chemical

treatments or biological control of the HWA result in diminishing the "wildness" of the Wildernesses with the direct intervention of technology to mitigate a large-scale outbreak of an exotic pest. Chemical treatments inside wilderness should be carefully considered because of their potential effects on the total biological complex. Because HWA is an exotic pest introduced to North America by humans, its infestation of wilderness is a type of "trammeling" of the wilderness resource. However, attempts to control HWA infestations in wilderness need to meet the intent of the "minimum tool" concept as addressed in Appendix E. The following section and Appendices A and B address how and why areas are selected for potential treatment since it is impractical to treat all hemlocks.

3.7.4 Hemlock Conservation Areas

Using concepts of metapopulation and Minimum Viable Population (MVP), hemlock conservation areas have been identified on National Forest lands in Western North Carolina as the best places in which to maintain genetic reserves of both hemlock species and their associated plant communities. Out of 159 conservation areas identified, 29 of these areas occur in Wilderness or Wilderness Study Areas. See Appendices A and B for specific locations of treatment areas and discussion of the conservation area design.

The hemlock conservation areas in wilderness are important for several reasons. The conservation areas in wilderness are high quality hemlock populations with a wide distribution of confirmed tree ages ranging up to 500 years old and potentially 800 years old or greater. The conservation areas in Linville Gorge Wilderness are key to the genetic distribution of Carolina Hemlock. Joyce Kilmer-Slickrock Wilderness is important for its high quality Eastern Hemlock and is one of only two known areas with a high concentration of non-vascular species diversity related to hemlock plant communities. Likewise, Ellicott Rock and Shining Rock Wildernesses are important for genetic distribution in the overall design of the hemlock conservation areas. Consideration was given to the location of potential treatment areas in relation to wilderness trails and some key locations of larger specimens. The distribution of potential treatment areas in wilderness is displayed on page 130.

3.7.5 Distribution of hemlocks and hemlock-related plant communities in Wilderness and Wilderness Study Areas

Eastern Hemlock (*Tsuga canadensis*) is present in all Wildernesses in Western North Carolina including Joyce Kilmer, Linville, Shining Rock, Middle Prong, Ellicott Rock, and Southern Nantahala. Carolina Hemlock (*Tsuga carolina*) is rarer but is present in all of these Wildernesses except

for Joyce Kilmer (it has been found in the same county but its has not been confirmed in Joyce Kilmer).

Both of these species are long-lived, reaching ages of 800 years or more in some cases. Both species are especially important components of wilderness character because of their distinct visual appearance. Hemlocks are thought of by many visitors as "icons" of the wilderness because of the size and old growth character of many hemlock specimens and stands of trees.

Eastern hemlock is found primarily in acidic coves and related slope areas and is a dominant feature in a distinct plant community. This plant community is important ecologically in supplying shade for riparian areas as well as contributing significantly to wilderness character as a distinct visual attribute.

Carolina Hemlock is located primarily on xeric slopes and is much rarer but also serves as a distinct visual attribute to wilderness character.

Within Linville Gorge, Joyce Kilmer, Shining Rock, and Ellicott Rock Wildernesses detailed plant surveys have been conducted in recent years (Newell and Peet, 1995,1996,1997 and Patterson 1994). Eastern Hemlock is generally found as a component of acidic cove and slope forests and riparian areas. It is associated with a variety of plant communities that contain species such as black and yellow oak, birch, fraser magnolia, yellow poplar, rhododendron, and others. These Eastern Hemlock community associations comprise approximately 20% of Joyce Kilmer, 25% of Shining Rock, 20% of Linville Gorge, and 20% of Ellicott Rock. Carolina Hemlock is less abundant and is found primarily on xeric slopes and rock ledges. The Carolina Hemlock community associations comprise approximately 3% of Shining Rock, 10% of Linville Gorge, and 1% of Ellicott Rock. The quantity of both Eastern and Carolina Hemlock is estimated to be less in Southern Nantahala and Middle Prong Wildernesses than in Shining Rock Wilderness.

Craggy Mountain, Lost Cove, and Harper Creek Wilderness Study Areas have significant populations of hemlock although detailed inventories have not been conducted.

Table 3.7-2 displays the nuimber and type of treatments proposed in the alternatives by wilderness area and wilderness study area.

Wilderness or Wilderness Study Area	**Alternative A** Treatments		**Alternative B** Treatments		**Alternative C** Treatments	
	Chemical	Biological Control	Chemical	Biological Control	Chemical	Biological Control
Linville Gorge Wilderness	0	0	4	11	0	11
Joyce Kilmer/Slickrock Wilderness	0	0	2	5	0	5
Shining Rock Wilderness	0	0	1	3	0	3
Ellicott Rock Wilderness	0	0	2	3	0	3
Craggy Mountain Wilderness Study Area	0	0	1	4	0	4
Lost Cove Wilderness Study Area	0	0	0	1	0	1
Harper Creek Wilderness Study Area	0	0	0	2	0	2

3.7.6 Effects of Alternatives

Direct and Indirect Effects

The presence of Forest Service personnel administering treatments or conducting monitoring would be a direct effect on “wildness” in Alternatives B and C but would be subtle. Also, the direct biological effects of chemical treatments and biological control measures in Alternatives B and C are described under “biological effects” at the beginning of Chapter 3. Other effects on the Wilderness resource are primarily indirect.

Alternative A. Hemlock mortality will likely approach or reach 100% over time. The value of Wildernesses as a biological benchmark of conditions least altered by total human influence will be reduced. Wilderness character will be altered to a high degree because of visual changes. The overall “naturalness” of the Wildernesses will be negatively affected to the highest degree in this Alternative by the disruption of

natural processes caused by the HWA. All the older groups of hemlocks that now exist (some approaching or surpassing 500 years old) would likely be lost.

The current level of "wildness" of the Wilderness resource would remain unaltered because of the lack of direct human intervention to mitigate the effects of HWA.

Alternative B. The overall chances of faster recovery of hemlock populations and hemlock associated plant communities in Wildernesses are best in this Alternative. This provides the highest proposed level of protection to the "naturalness" of the Wilderness resource. Hemlock mortality would still likely approach 70-80% because much of the hemlock population would remain untreated. Some of the more easily accessible key groups of older hemlocks could be chemically treated to give them the best chance of long-term survival. Also, the majority of conservation reserve areas in wilderness are in the vicinity of trails. The treatment of these areas will likely result in less downed hemlock near trails.

However, the process of chemical treatment brings an inherent reduction in the "wildness" of the Wilderness resource because the treatment process would involve repeated human interventions even though it is intended to reduce the degradation of the biological and visual aspects of Wilderness character. The introduction of the non-native beetles is also a human intervention with the intent of reducing biological degradation. The biological control to check the spread of the non-native HWA involves a compromise of choosing the non-native beetles to combat the non-native adelgid. The treatments would be virtually invisible except for technical experts occasionally administering treatments or monitoring vegetation. The overall effect on "wildness" would generally be subtle, especially if the beetles prove to be highly effective and all chemical treatments can eventually be curtailed.

Alternative C. The direct and indirect effects are similar to Alternative B in relation to the introduction of the beetles. Retention of key remnant stands and older hemlocks would not be as assured, but the repeated human intervention with chemical treatments and its inherent reduction in the "wildness" of the Wilderness resource would not be a factor. The human intervention would be slightly more subtle because only the beetles would be introduced as a treatment.

Cumulative Effects

Ongoing human influences within wilderness that tend to reduce its "wildness" include recreational activities such as trail use impacts, trail

maintenance, bridge repair, campsite impacts, and the sights and sounds of humans. Outside influences on wilderness that tend to reduce its "wildness" and "naturalness" include visual, noise, water, and air pollution as well as exotic plants or organisms. These influences would continue regardless of which alternative (A, B, or C) is implemented.

Alternative A. Based on observations in the Northeast, we could expect losses of over 90% to occur within the next ten years, and perhaps 100% over a longer time, although the exact timeframe cannot be accurately predicted. As the hemlock dies, it is likely that non-native invasive species will replace them in some locations. This is likely to occur with aggressive species such as *Pawlonia* in areas where dead hemlocks tip over leaving disturbed ground. Over time this will further degrade the "naturalness" of the Wilderness resource and create problems in removing these additional non-native invasive species.

Alternative B. There will be similar effects in some parts of the Wildernesses because most of the hemlock population won't receive treatment unless more cost-effective methods are found or the beetles spread to keep the adelgid in check faster than anticipated. However, because of more of the populations of hemlock being in place, the recovery of the hemlock population will likely be much faster than if it were completely extirpated from the Wildernesses. There will be some reduction in the "wildness" of wilderness because of the continuing chemical treatments and the monitoring of beetle releases. However, the effects to wildness from these actions would be of very short duration and unnoticeable once the activity is complete. There is a chance chemical treatments would be curtailed if beetle releases are highly successful.

Alternative C. There will be similar effects to those in Alternative B. The lack of chemical treatment may result in a smaller hemlock population being present in the future and may slow long-term recovery of the hemlock populations and result in more areas impacted by non-native invasive species. The lack of chemical treatment will make the overall human influence slightly more subtle over time.

3.8 Heritage Resources

This proposed project has no potential for effect, adverse or beneficial, to a heritage resource, and therefore is and Exempt Undertaking, no further Section 106 compliance documentation is required.

Precise locations of proposed treatment areas would be shared with the Eastern Band of Cherokee Indians to ensure avoidance of undesired overlap with Traditional Cultural Properties or traditional gathering sites.

3.9 Road Management

No road construction, road reconstruction, changes to current road management, or road obliteration is proposed as a part of this project. No roads analysis is needed.

3.10 Soils

Direct and Indirect Effects

Alternative A has no potential for effect, adverse or beneficial, to soils. No activity is proposed that would increase or decrease soil productivity through soil erosion or soil compaction.

Alternative B proposes no activity that would increase or decrease soil productivity through soil erosion or soil compaction. This alternative does includes the use of the systemic insecticide imidacloprid, injected into the soil at the base of as many as 4800 hemlock trees (average 60 trees times 79 potential treatment areas, with ½ half of the sites treated each year). The portion of the chemical that is not taken up by the tree could spread downward in the soil a few feet from the injection sites and bind with soil particles and would not be expected to reach ground water (Burkingstock et al. 1997). Its biodegradation rate in soil has been characterized as moderately slow, with about 50% of the applied residue dissipating in a range of 48 – 190 days (Felsot 2001). Soil-inhabiting invertebrates that come into contact with the chemical while it is still active in the soil would likely be impacted, but the properties of the soil itself would not change. Invertebrates would be expected to recolonize the soil near the base of the tree when the chemical was no longer active. The loss of invertebrates in the soil at the bases of the treated hemlocks would be localized and temporary.

Alternative C has no potential for effect, adverse or beneficial, to soils. No activity is proposed that would increase or decrease soil productivity through soil erosion or soil compaction. This alternative does not include the use of the systemic insecticide imidacloprid injected into the soil.

Cumulative Effects

Since none of alternatives considered would impact soil productivity through erosion or compaction, this project would not contribute to any cumulative impacts.

In regard to the soil injection of imidacloprid in Alternative B, some additional use is anticipated on both public and private lands as infestation of HWA progresses. This additional use is expected to be very limited,

due to cost and logistics of treatment. On these other lands, loss of invertebrates in the soil at the bases of the treated hemlocks would be localized and temporary, as with Alternative B. There would be no additive or overlapping of impacts.

3.11 Human Health and Safety

Direct and Indirect Effects

Alternative A

Dead hemlocks would be a threat to human safety in the years to come as HWA kills trees in recreation areas and along trails. Hemlocks are very susceptible to wind storms and are frequently broken off and uprooted. The threat exists that broken or uprooted hemlocks could fall on humans using the Forests.

Alternative B

The threat from dead hemlocks would be reduced from that in Alternative A due to treatments proposed that will keep some hemlocks alive in areas used by recreationists.

Tree-climbing would be needed to implement the release of predatory beetles to combat HWA. To accomplish this activity, professional arborists would be contracted to do this work. They would be experienced professional tree climbers who are licensed and insured and who must follow the specifications of the contract, including any safety-related provisions.

Soil injection and stem injection of imidacloprid would be performed with a combination of USDA Forest Service employees and private contractors. All would be certified pesticide applicators and would be required to follow precautionary procedures proscribed by the manufacturer. The potential safety issues include: accidental spills of the product and accidental contamination of skin or clothing of the applicators. A spill response plan would be developed as part of implementation of this project.

The potential for the imidacloprid used in this project to impact human health under any circumstances is extremely minimal as its toxicity to mammals in general including humans is very low. No imidacloprid is expected to reach ground water since no soil injection will occur in close proximity to water or in highly permeable soils. Also, the method of application deposits the agent within a small area approximately 10 inches beneath the surface of the soil. Imidacloprid is known to bind with the

soil so that whatever is not taken up by the roots of the tree is not expected to move away from the application site.

The U.S. Environmental Protection Agency Office of Pesticide Programs has evaluated imidacloprid and determined it to be non-cancer causing (USEPA, Science and Information Branch).

Alternative C

The threat from dead hemlocks would be reduced from that in Alternative A but not reduced as much as in Alternative B. Without using insecticide to treat specific groups of trees in areas used by recreationists, there is less assurance these hemlocks will remain alive. Beetle releases may reduce mortality in the long-term.

The health and safety impacts regarding beetle release would be the same as for Alternative B.

Imidacloprid would not be used in this alternative, so there would be no health and safety impacts in this regard with Alternative C.

Cumulative Effects

Alternative A

Impacts of widespread hemlock mortality and the threat from these trees being broken off or uprooted and falling on humans using the forests would add to the level of risk that always exists in the Forests for a tree to potentially fall on a person. This rarely occurs on the Forests.

Alternative B

Hemlock mortality would be reduced with this alternative, therefore there would be less cumulative effects to tree-fall potential across the Forests than with Alternative A.

Tree climbers were employed to release beetles for research purposes in 2004. Impacts of this project would not extend beyond the activities required for implementation.

Soil injection of imidacloprid occurred at some developed recreation sites and administrative sites in 2004 following separate NEPA compliance processes. Most of these sites are incorporated into and analyzed as a part of this proposed action therefore there would be no additive cumulative effects.

Alternative C

Hemlock mortality would be reduced with this alternative, though not reduced as much as with Alternative B. Therefore there would be less cumulative effects to tree-fall potential than with Alternative A.

Tree climbers were employed to release beetles for research purposes in 2004. Impacts of this project would not extend beyond the activities required for implementation.

3.12 List of Preparers and Agencies/Persons Consulted

Preparers:

Ruth Berner	ID Team Leader
Steve Simon	Ecologist
John Blanton	Silviculturist
Steve Hendricks	Landscape Architect
Sheryl Bryan	Fisheries Biologist
MaeLee Hafer	Wildlife Biologist
Gary Kauffman	Botanist

Agencies/Persons Consulted:

Rusty Rhea	Entomologist
Monica Schwalbach	Deputy Forest Supervisor
R E Vann	District Ranger
Terry Seyden	Public Affairs Officer
Linda Randolph	Silviculturist
Mark Robison	Forester
Dave Danley	Botanist

Southern Region Wilderness Advisory Group – USDA Forest Service
USDI Fish and Wildlife Service
North Carolina Department of Environment and Natural Resources

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APPENDIX A – HEMLOCK AREAS SELECTED FOR TREATMENT

Appendix A contains the list of areas selected for treatment in this environmental assessment, along with maps indicating the approximate locations of the areas. Areas were selected from 351 potential treatment areas, including the 39 areas that were part of a research study of predatory beetle release that began in the spring of 2004 (see **Hemlock Woolly Adelgid Biological Control Decision Memo** ***at*** **http://www.cs.unca.edu/nfsnc/nepa/nepa.htm**), . The initial list of potential treatment areas were stands considered ecologically important, culturally important, or that otherwise filled a hole in the conservation design (see Appendix B). These categories are defined as:

Ecologically Important Hemlock Stands: Stands were identified as ecologically important from either the NC Natural Heritage database or the Southern Appalachian Vegetation Database. Hemlock communities are rated for the quality of the occurrence, which takes into account factors such as population or community size, high cover abundance, representation of all age classes within a population, and other biological indicators. Proximity to native brook trout waters was one specific biological indicator. A second determining factor is the condition of rare species occurrence and to what degree it has been damaged or altered. A third determining factor is the viability of the occurrence for the long term.

Culturally Important Hemlock Stands: those areas that are: 1) known to have a long history of traditional human uses, including but not limited to social gathering, recreation, nature-based learning, and spiritual experiences, and; 2) where hemlocks are an essential component of the sense of place. These areas were identified by local input from the various ranger districts.

Other Hemlock Stands: When an insufficient number of ecologically or culturally important stands were identified for a particular strata of the hemlock conservation design, stands were added based on information from the Continuous Inventory of Stand Conditions database or from the personal knowledge of USDA Forest Service botanists and silviculturists.

The selected treatment areas are listed in Table A. The headings for the columns in Table A are explained below.

#: The area number that corresponds to the numbers on the maps.

AREA NAME: The name of the area. Most names are associated with closeby landmarks or physical features of the landscape.

DISTRICT:

2	Cheoah Ranger District	8	Appalachian Ranger District
5	Grandfather Ranger District	9	Tusquitee Ranger District
6	Highlands Ranger District	11	Wayah Ranger District
7	Pisgah Ranger District		

STRATA: Definitions from Hemlock Conservation Design (Appendix B)

1 - low elevation, southern blueridge escarpment
2 - low elevation, blueridge mountains
3 - low elevation, metasedimentary mountains
4 - mid elevation, southern blueridge escarpment
5 - mid elevation, blueridge mountains
6 - mid elevation, metasedimentary mountains
7- high elevation, southern blueridge escarpment
8 - high elevation, blueridge mountains
9 - high elevation, metasedimentary mountains

low elevation = < 2500'
mid elevation = 2500-4500'
high elevation = > 4500'

metasedimentary = sedimentary rocks (sandstones, etc) that have undergone some transformation due to heat and pressure like metamorphic rock

ALT. B CHEM: In Alternative B, all 159 areas would receive beetle releases and half the areas would additionally have some trees treated with imidacloprid insecticide. Those areas selected to have some trees treated with imidacloprid are shown as "YES" in this column. Areas that would not have trees treated with imidacloprid are shown as "NO." In Alternative C all areas are selected to have trees receive only beetle releases.

Table A. List of Treatment Areas

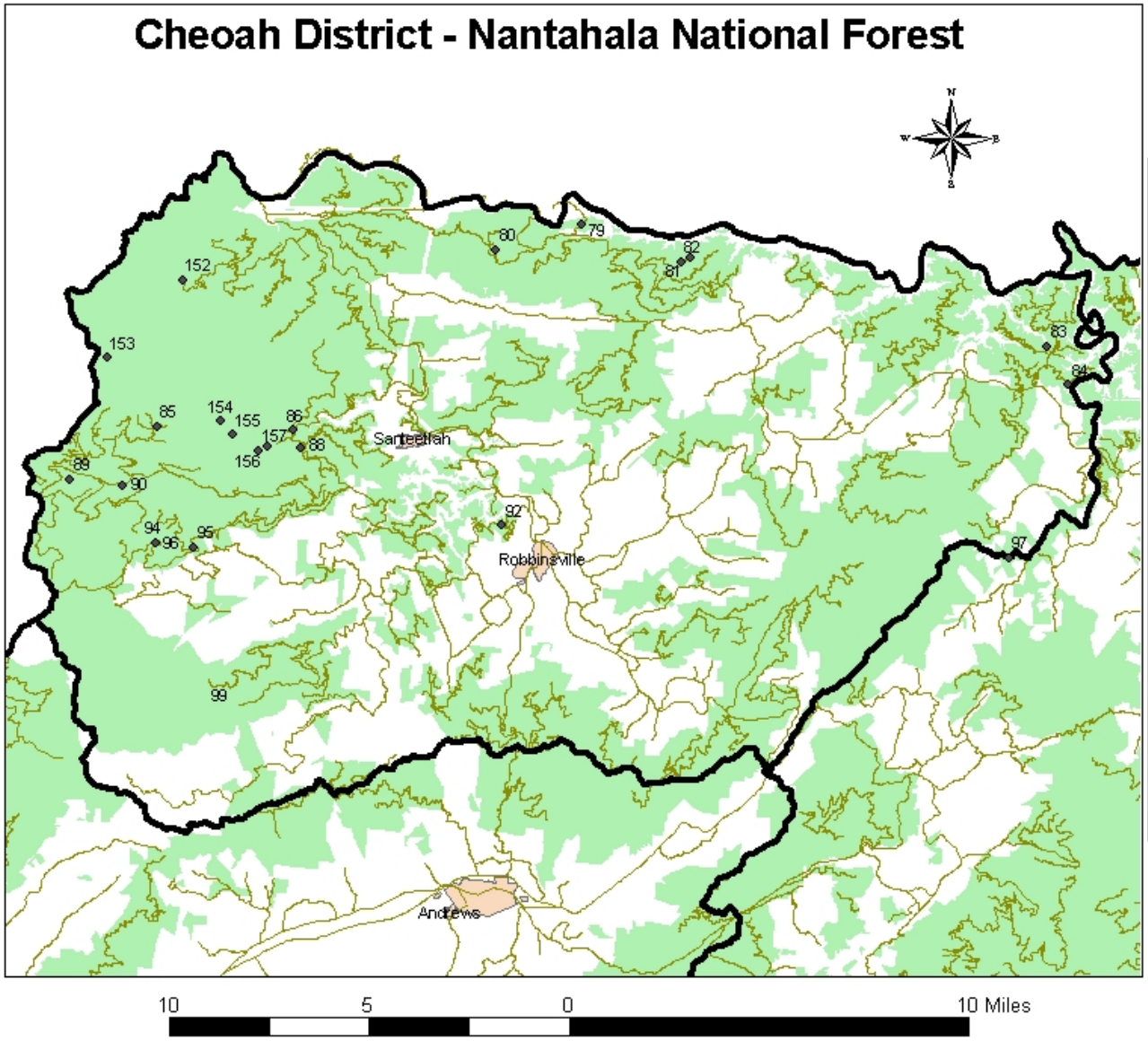
#	AREA NAME	SPECIES	DISTRICT	STRATA	ALT. B CHEM
1	Nolichucky	CAROLINA	8	2	YES
2	Pack Hill Ridge	EASTERN	5	1	NO
3	Nolichucky	CAROLINA	8	2	NO
4	Nolichucky	CAROLINA	8	2	YES
5	Devils Creek	CAROLINA	8	5	YES
6	Flat Top Mtn.	CAROLINA	8	5	YES
7	Flattop Mtn.	CAROLINA	8	5	NO
8	Devils Creek Gap	CAROLINA	8	5	NO
9	Gragg Prong	EASTERN	5	4	YES
10	Gragg Prong	EASTERN	5	4	YES
11	Woodruff Branch	EASTERN	5	1	YES
12	Woodruff Branch	EASTERN	5	1	NO
13	Upper Nolichucky	CAROLINA	8	2	NO
14	Barnett Branch	CAROLINA	8	5	NO
15	Whiteoak Creek	CAROLINA	8	2	YES
16	Woodruff Branch	EASTERN	5	1	NO
17	Hickey Fork	EASTERN	8	6	YES
18	Upper Mulberry	EASTERN	5	1	YES
19	Rock Branch-Big Creek	EASTERN	8	3	NO
20	Rush Branch	EASTERN	5	1	NO
21	Potts Hollow	EASTERN	5	1	NO
22	Lost Cove	EASTERN	5	4	NO
23	Hickey Fork	EASTERN	8	3	YES
24	Long Ridge	EASTERN	5	1	NO
25	Larken Estes Mill	EASTERN	5	1	NO
26	Brown Branch	EASTERN	5	1	NO
27	Estes Mill Creek Br.	EASTERN	5	1	YES
28	Wilsons Creek	EASTERN	5	1	NO
29	Brown Branch	EASTERN	5	1	NO
30	Elijah Estes Mill Creek	EASTERN	5	1	NO
31	Elijah Estes Mill Creek	EASTERN	5	1	NO
32	Devils Creek	EASTERN	8	3	NO
33	Wilson Ridge	EASTERN	5	1	NO
34	Laurel Creek	EASTERN	8	3	YES
35	Steel's Creek	CAROLINA	5	4	NO
36	Carrol Mill Creek	EASTERN	5	1	YES
37	Upper Creek	EASTERN	5	1	NO
38	Little Btm. Branch	EASTERN	8	3	NO
39	Puncheon Camp Br.	EASTERN	8	3	YES
40	Locust Ridge	CAROLINA	8	5	NO
41	Locust Ridge	CAROLINA	8	5	YES
42	Locust Creek	CAROLINA	8	5	YES
43	Hamrick	CAROLINA	8	5	NO

#	AREA NAME	SPECIES	DISTRICT	STRATA	ALT. B CHEM
44	North Fork Ivy	EASTERN	8	5	NO
45	Armstrong Creek	EASTERN	5	1	NO
46	Carolina Hemlocks	CAROLINA	8	5	YES
47	Carolina Hemlocks	CAROLINA	8	5	YES
48	Carolina Hemlocks	CAROLINA	8	5	NO
49	Toe River	CAROLINA	8	5	NO
50	Crabtree Ck.	CAROLINA	8	5	NO
51	Black Mountains	EASTERN	8	5	NO
52	Rock Creek	CAROLINA	8	5	YES
53	Pigeon, Big Bend	EASTERN	8	3	YES
54	Rock Creek	CAROLINA	8	5	YES
55	Fall Branch	EASTERN	8	6	NO
56	Open Ridge	CAROLINA	8	5	NO
57	Roaring Fork	CAROLINA	8	5	YES
58	Roaring Fork	CAROLINA	8	5	NO
59	Walker Falls	EASTERN	8	8	YES
60	Beartree Ridge	CAROLINA	5	4	YES
61	Little Mtn. Creek	CAROLINA	8	5	NO
62	South Toe	EASTERN	8	5	NO
63	Big Ridge	CAROLINA	8	5	NO
64	Big Ridge	CAROLINA	8	5	NO
65	Roaring Fork	CAROLINA	8	5	YES
66	Big Laurel Mtn.	CAROLINA	8	5	YES
67	Big Laurel Mtn.	CAROLINA	8	5	YES
68	Upper Toe River	CAROLINA	8	5	YES
69	Carter Creek	EASTERN	8	5	NO
70	Upper Curtis Crk.	EASTERN	5	4	NO
71	Craggy Mountains	EASTERN	8	5	NO
72	Craggy Mountains	CAROLINA	8	8	YES
73	Rt. Prong S. Toe	EASTERN	8	8	NO
74	Craggy Mountains	EASTERN	8	8	NO
75	Mackey Mtn.	EASTERN	5	4	NO
76	Buckeye Knob-Curtis Creek	CAROLINA	5	4	YES
77	Pritchard Crk.	EASTERN	5	1	NO
78	Deep Branch	EASTERN	5	1	YES
79	Llewyllen Cove	EASTERN	2	3	YES
80	Brooks Cove-Rhymers Ferry	EASTERN	2	3	NO
81	Cable Cove	EASTERN	2	3	YES
82	Cable Cove	EASTERN	2	3	NO
83	Tsali	EASTERN	2	3	YES
84	Tsali Boat Ramp	EASTERN	2	3	NO
85	Wolf Laurel Basin	EASTERN	2	6	NO
86	Horse Cove	EASTERN	2	3	YES
87	North Mills River	EASTERN	7	1	YES

#	AREA NAME	SPECIES	DISTRICT	STRATA	ALT. B CHEM
88	Rattler Ford Group Camp	EASTERN	2	3	NO
89	JohnsBranch	EASTERN	2	6	YES
90	Santeetlah Creek Bluff	EASTERN	2	6	NO
91	Bradley Creek	EASTERN	7	4	YES
92	Cheoah Admin Complex	EASTERN	2	3	YES
93	Pinkbeds	CAROLINA	7	4	NO
94	Spirit Ridge	EASTERN	2	9	YES
95	Wright Cove	EASTERN	2	6	YES
96	Wright Creek	EASTERN	2	6	NO
97	Nantahala River Gorge	EASTERN	11	3	YES
98	Cradle of Forestry	CAROLINA	7	4	YES
99	Snowbird Creek	EASTERN	2	6	YES
100	Looking Glass	CAROLINA	7	4	NO
101	Courthouse Creek	EASTERN	7	4	YES
102	Davidson River	EASTERN	7	1	NO
103	Coon Tree Pcinic Area	EASTERN	7	1	YES
104	Balsam Lake	EASTERN	6	5	NO
105	Pisgah Admin Complex	EASTERN	7	1	YES
106	Davidson River Campground	EASTERN	7	1	YES
107	Pretty Pine Branch	EASTERN	9	3	NO
108	Bratton Creek	EASTERN	9	3	NO
109	Cathey's Creek	EASTERN	7	4	NO
110	Winesprings Horsecamp	EASTERN	11	5	YES
111	Arrowood Glade	EASTERN	6	2	YES
112	Devils Elbow	EASTERN	6	5	YES
113	Clear Creek	EASTERN	9	6	YES
114	Fires Creek	EASTERN	9	3	YES
115	Brush Creek	EASTERN	6	5	NO
116	Cherokee Lake	EASTERN	9	3	NO
117	Kimsey Creek	EASTERN	11	5	YES
118	Cliffside	EASTERN	6	5	YES
119	Skitty Branch Cove	EASTERN	6	5	NO
120	Kelsey Tract	CAROLINA	6	5	YES
121	Kelsey Tract	CAROLINA	6	5	YES
122	McCall Cabin/Homesites	EASTERN	6	5	YES
123	Horsepasture River	EASTERN	6	1	NO
124	Dry Falls	EASTERN	6	5	YES
125	Little Whitewater Crk	EASTERN	6	4	YES
126	Horse Cove	EASTERN	6	4	NO
127	Jackrabbit	EASTERN	9	2	NO
128	Whitewater River	EASTERN	6	4	YES
129	Blue Valley/Glen Falls	EASTERN	6	4	YES
130	Whitewater River	EASTERN	6	1	YES
131	East Fork-Blue Valley	EASTERN	6	1	YES

#	AREA NAME	SPECIES	DISTRICT	STRATA	ALT. B CHEM
132	Whitewater Falls	EASTERN	6	1	YES
133	Bulll Pen Trailheads	EASTERN	6	4	YES
134	Overflow	EASTERN	6	4	YES
135	Linville Falls	EASTERN	5	4	NO
136	Linville Gorge Wilderness	CAROLINA	5	4	NO
137	Linville Gorge Wilderness	CAROLINA	5	4	YES
138	Linville Gorge Wilderness	CAROLINA	5	4	NO
139	Linville Gorge Wilderness	CAROLINA	0	4	NO
140	Linville Gorge Wilderness	CAROLINA	5	4	NO
141	Linville Gorge Wilderness	EASTERN	5	4	NO
142	Linville Gorge Wilderness	EASTERN	5	4	NO
143	Linville Gorge Wilderness	CAROLINA	5	4	YES
144	Linville Gorge Wilderness	EASTERN	5	1	YES
145	Linville Gorge Wilderness	EASTERN	5	1	YES
146	Shining Rock Wilderness	CAROLINA	7	8	NO
147	Shining Rock Wilderness	EASTERN	7	5	YES
148	Shining Rock Wilderness	EASTERN	7	5	NO
149	Ellicott Rock Wilderness	EASTERN	6	4	YES
150	ChattoogaRiver	EASTERN	6	1	YES
151	Chattooga River	EASTERN	6	1	NO
152	Caney Branch	EASTERN	2	6	YES
153	Joyce Kilmer Wilderness	EASTERN	2	6	YES
154	Joyce Kilmer Wilderness	EASTERN	2	6	NO
155	Joyce Kilmer Wilderness	EASTERN	2	3	NO
156	Joyce Kilmer Wilderness	EASTERN	2	3	NO
157	Joyce Kilmer Wilderness	EASTERN	2	3	YES
158	Sycamore Flats Picnic	EASTERN	7	1	YES
159	Panthertown	EASTERN	6	5	NO

HWA Treatment Areas



#	AREA NAME
79	Llewyllen Cove
80	Brooks Cove-Rhymers Ferry
81	Cable Cove
82	Cable Cove
83	Tsali
84	Tsali Boat Ramp
85	Wolf Laurel Basin
86	Horse Cove
88	Rattler Ford Group Camp
89	JohnsBranch
90	Santeetlah Creek Bluff
92	Cheoah Admin Complex
94	Spirit Ridge
95	Wright Cove
96	Wright Creek
99	Snowbird Creek
152	Caney Branch
153	Joyce Kilmer Wilderness
154	Joyce Kilmer Wilderness
155	Joyce Kilmer Wilderness
156	Joyce Kilmer Wilderness
157	Joyce Kilmer Wilderness

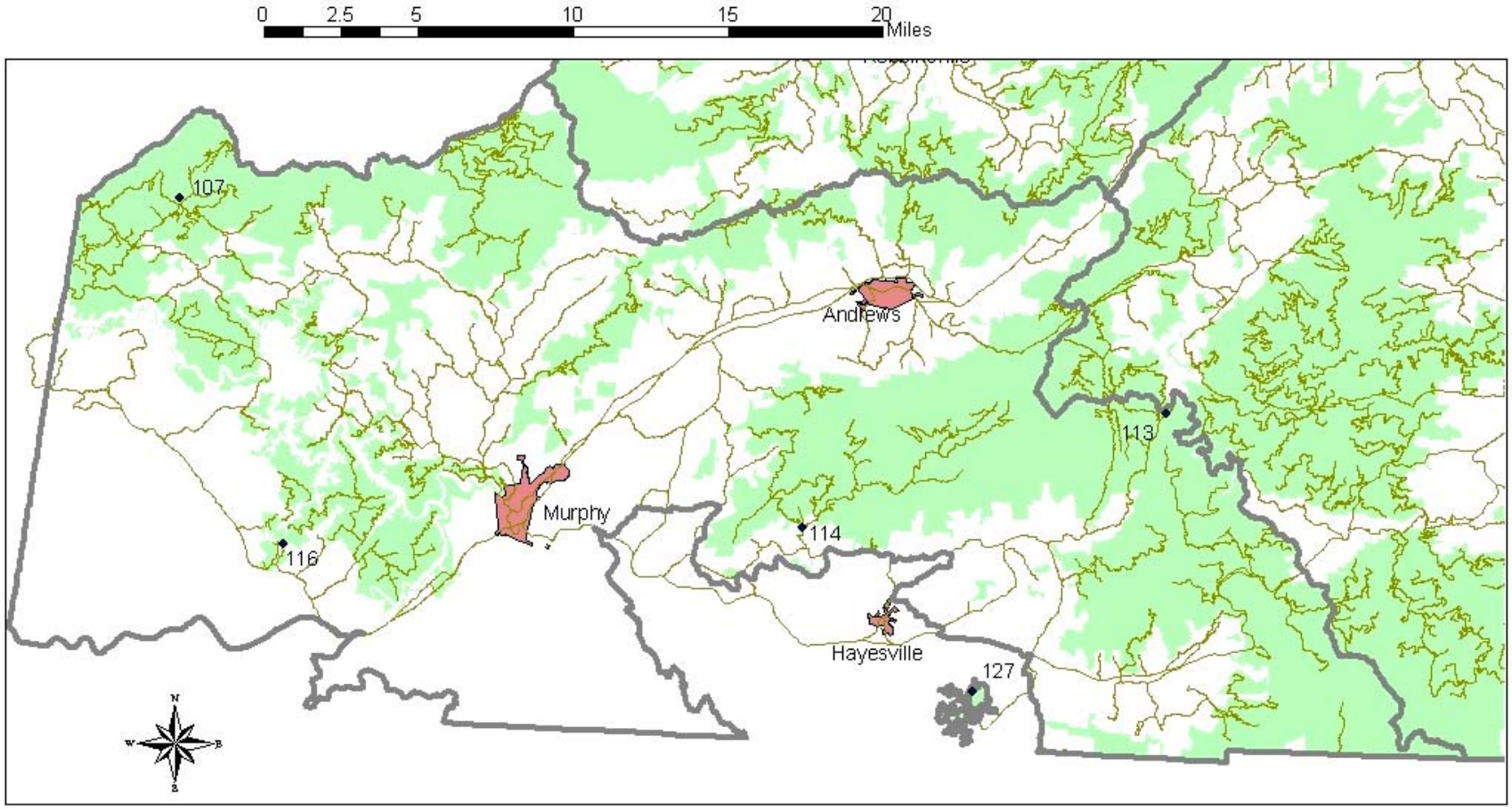
Area locations are approximate due to scale

HWA Treatment Areas

Tusquitee District - Nantahala National Forest

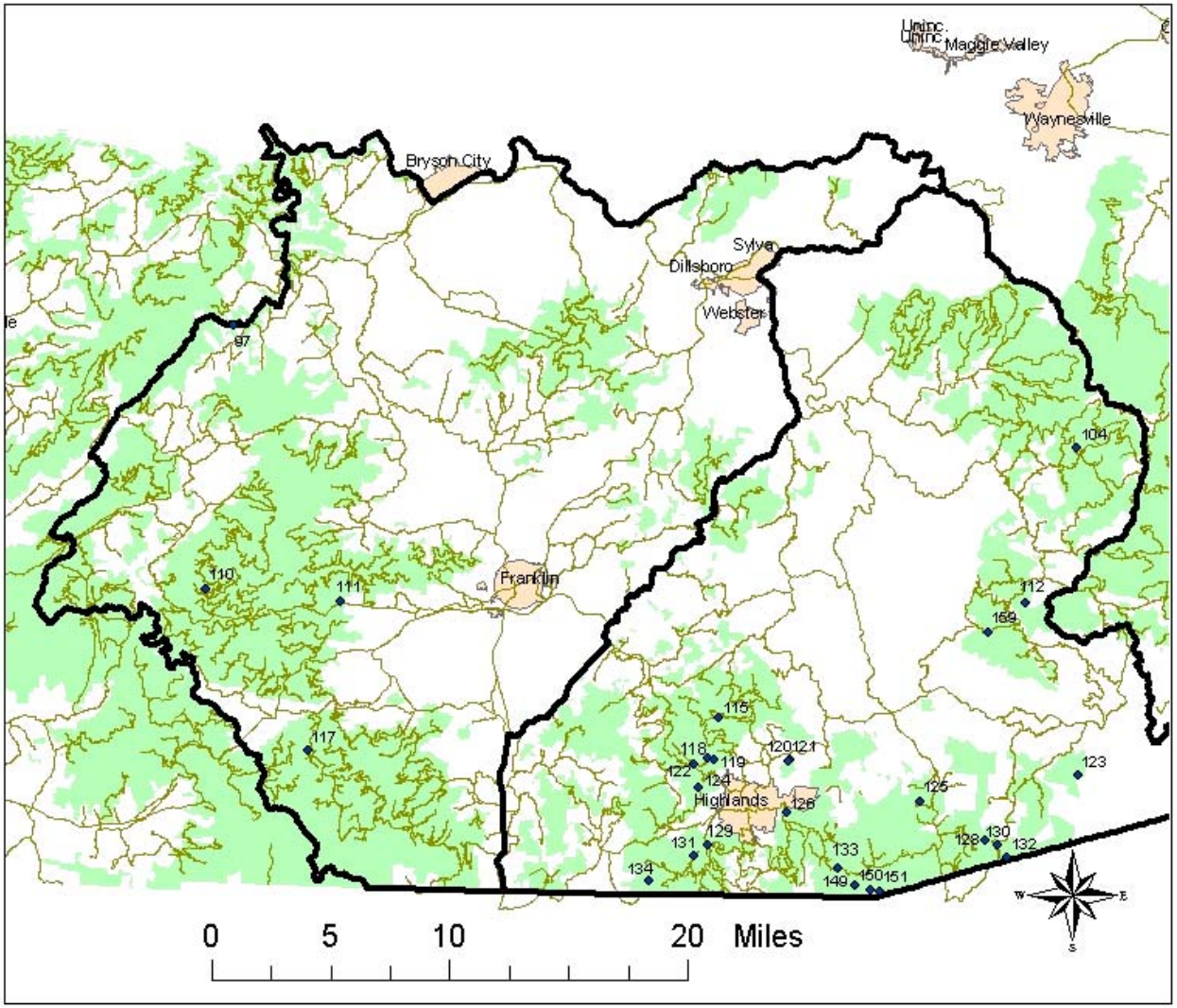
#	AREA NAME
107	Pretty Pine Branch
108	Bratton Creek
113	Clear Creek
114	Fires Creek
116	Cherokee Lake
127	Jackrabbit

Area locations are approximate due to scale



HWA Treatment Areas

Wayah and Highlands District - Nantahala National Forest

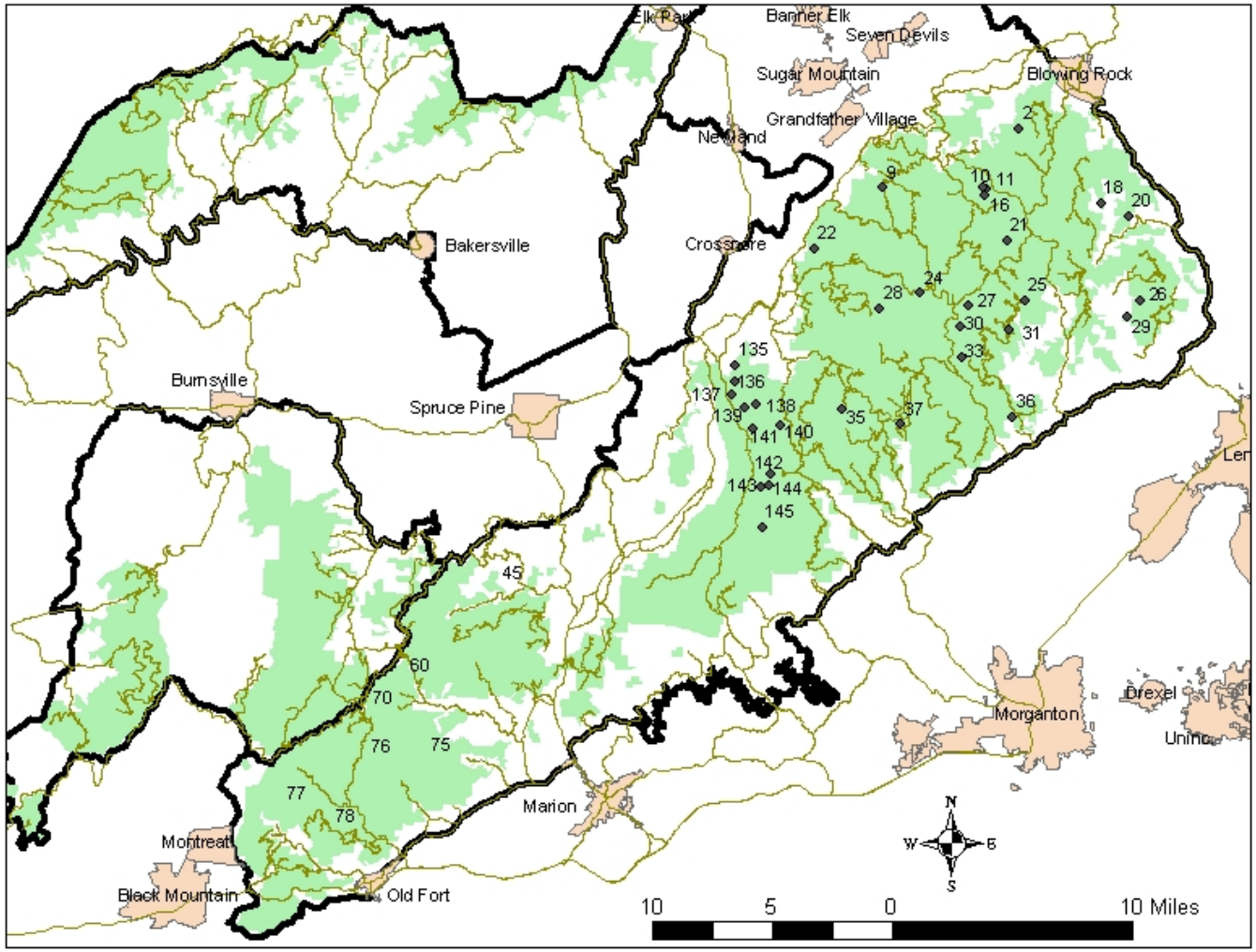


#	AREA NAME	DISTRICT
97	Nantahala River Gorge	11
104	Balsam Lake	6
110	Winesprings Horsecamp	11
111	Arrowood Glade	11
112	Devils Elbow	6
115	Brush Creek	6
117	Kimsey Creek	11
118	Cliffside	6
119	Skitty Branch Cove	6
120	Kelsey Tract	6
121	Kelsey Tract	6
122	McCall Cabin/Homesites	6
123	Horsepasture River	6
124	Dry Falls	6
125	Little Whitewater Crk	6
126	Horse Cove	6
128	Whitewater River	6
129	Blue Valley/Glen Falls	6
130	Whitewater River	6
131	East Fork-Blue Valley	6
132	Whitewater Falls	6
133	Bull Pen Trailheads	6
134	Overflow	6
149	Ellicott Rock Wilderness	6
150	ChattoogaRiver	6
151	Chattooga River	6
159	Panthertown	6

Area locations are approximate due to scale.

HWA Treatment Areas

Grandfather District - Pisgah National Forest

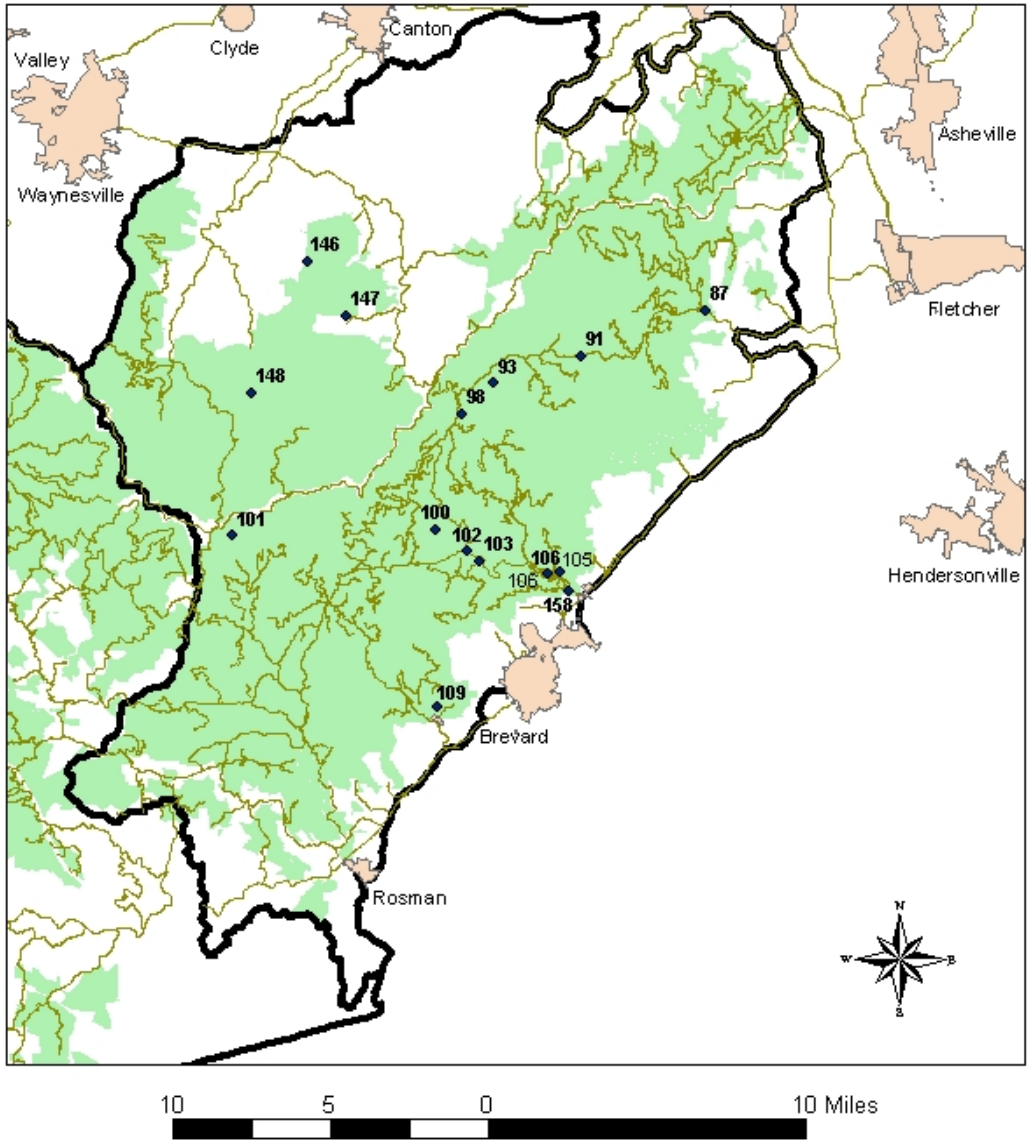


#	SITE_NAME
2	Pack Hill Ridge
9	Gragg Prong
10	Gragg Prong
11	Woodruff Branch
12	Woodruff Branch
16	Woodruff Branch
18	Upper Mulberry
20	Rush Branch
21	Potts Hollow
22	Lost Cove
24	Long Ridge
25	Larken Estes Mill
26	Brown Branch
27	Estes Mill Creek Branch
28	Wilsons Creek
29	Brown Branch
30	Elijah Estes Mill Creek
31	Elijah Estes Mill Creek
33	Wilson Ridge
35	Steel's Creek
36	Carrol Mill Creek
37	Upper Creek
45	Armstrong Creek
60	Beartree Ridge
70	Upper Curtis Creek
75	Mackey Mtn.
76	Buckeye Knob-Curtis Creek
77	Pritchard Creek
78	Deep Branch
135	Linville Falls
136	Linville Gorge Wilderness
137	Linville Gorge Wilderness
138	Linville Gorge Wilderness
139	Linville Gorge Wilderness
140	Linville Gorge Wilderness
141	Linville Gorge Wilderness
142	Linville Gorge Wilderness
143	Linville Gorge Wilderness
144	Linville Gorge Wilderness
145	Linville Gorge Wilderness

Area locations are approximate due to scale

HWA Treatment Areas

Pisgah District - Pisgah National Forest

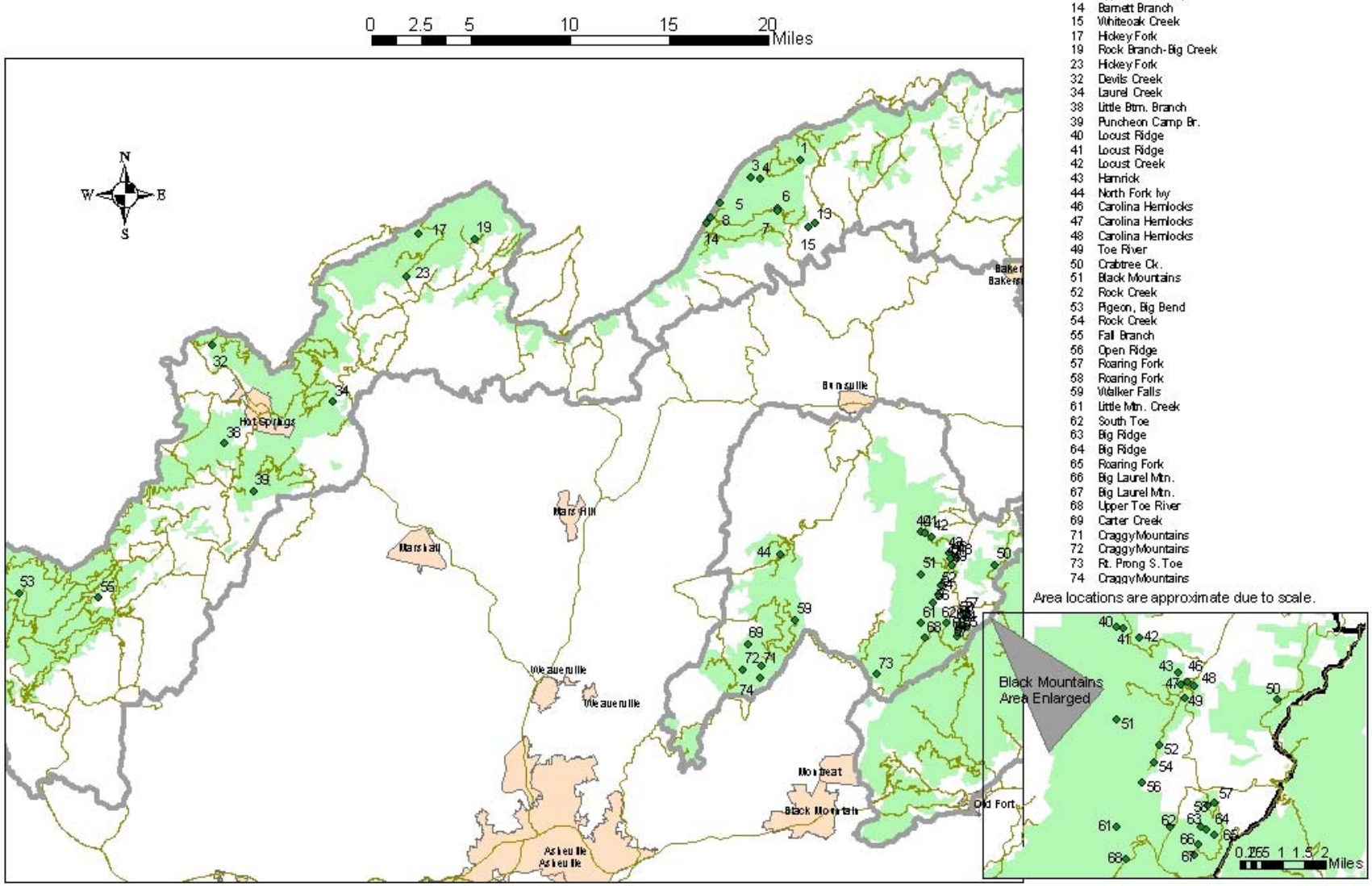


#	AREA NAME
87	North Mills River
91	Bradley Creek
93	Pinkbeds
98	Cradle of Forestry
100	Looking Glass
101	Courthouse Creek
102	Davidson River
103	Coon Tree Pcinic Area
105	Pisgah Admin Complex
106	Davidson River Campground
109	Cathey's Creek
146	Shining Rock Wilderness
147	Shining Rock Wilderness
148	Shining Rock Wilderness
158	Sycamore Flats Picnic

Area locations are approximate due to scale

HWA Treatment Areas

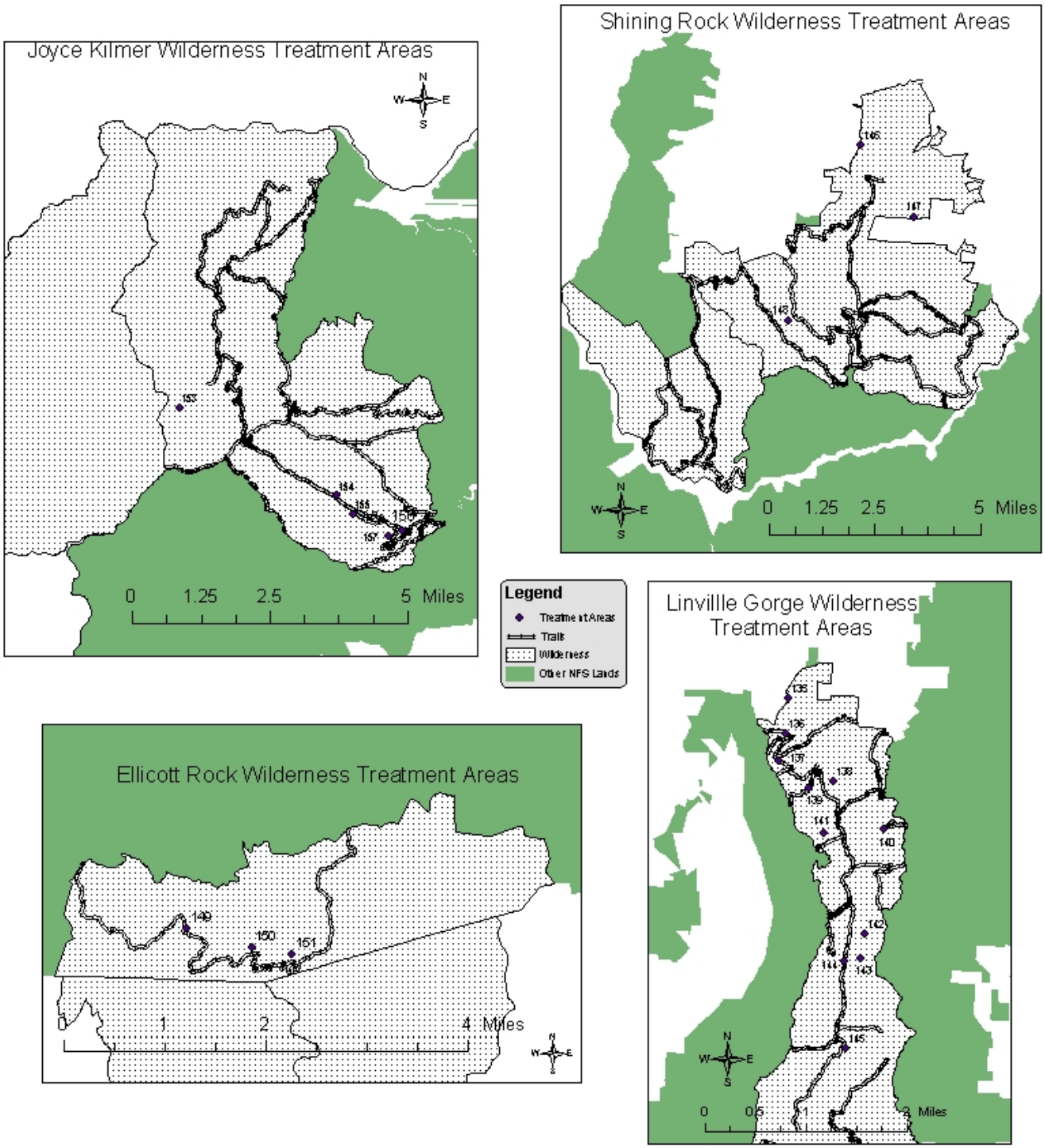
Appalachian District - Pisgah National Forest



#	AREA NAME
1	Shinbone Ridge
3	Nolichucky
4	Nolichucky
5	Devils Creek
6	Flat Top Mtn.
7	Flattop Mtn.
8	Devils Creek Gap
13	Upper Nolichucky
14	Barnett Branch
15	Whiteoak Creek
17	Hickey Fork
19	Rock Branch-Big Creek
23	Hickey Fork
32	Devils Creek
34	Laurel Creek
38	Little Btm. Branch
39	Puncheon Camp Br.
40	Locust Ridge
41	Locust Ridge
42	Locust Creek
43	Hamrick
44	North Fork Ivy
46	Carolina Hemlocks
47	Carolina Hemlocks
48	Carolina Hemlocks
49	Toe River
50	Crabtree Ck.
51	Black Mountains
52	Rock Creek
53	Pigeon, Big Bend
54	Rock Creek
55	Fall Branch
56	Open Ridge
57	Roaring Fork
58	Roaring Fork
59	Walker Falls
61	Little Mtn. Creek
62	South Toe
63	Big Ridge
64	Big Ridge
65	Roaring Fork
66	Big Laurel Mtn.
67	Big Laurel Mtn.
68	Upper Toe River
69	Carter Creek
71	CraggyMountains
72	CraggyMountains
73	Rt. Prong S.Toe
74	CraggyMountains

Area locations are approximate due to scale.

TREATMENT AREAS IN WILDERNESS
Showing Proximity of Treatment Areas to Wilderness Trails



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APPENDIX B
Designing Conservation Areas For Eastern and Carolina Hemlock Forests: a Strategy for Hemlock Woolly Adelgid Control
on the
Nantahala and Pisgah National Forests, North Carolina

Background and Purpose: The Hemlock Wooly Adelgid (*Adelges tsugae*) (HWA) has the potential to infest the entire range of eastern and Carolina hemlock (*Tsuga canadensis*, *T. caroliniana*) in the next 30 years. Even if negative indirect effects from using aerial or systemic insecticides could be avoided, it is not feasible to treat individually all of the millions of hemlock trees across the Nantahala and Pisgah National Forests. Instead, management will require the establishment of biological agents to control HWA populations and reduce long-term impacts to hemlock in the forest environment.

The US Forest Service, National Forests in North Carolina (NFsNC) is proposing to release predator beetles, that prey specifically on HWA, in selected hemlock stands to suppress infestations and some limited systemic insecticide use in a subset of these stands as a stop-gap measure until biological control agents can become established. Determining the location for biological and chemical treatments is critical to ensure predator beetles become well-distributed and established across the NFsNC and for the efficient use of chemical treatments.

The NFsNC is proposing to use a conservation area design to identify and prioritize areas for HWA control. The conservation area would be used to maintain, on portions of the Forests, important hemlock ecosystem functions such as stream shading, large woody debris production, and substrate for non-vascular species and to serve as a genetic reserve to maintain a diverse hemlock gene pool 'in situ'. In short, the strategy for controlling the HWA is to identify critical hemlock conservation areas, up front, and to 'make a stand' in these priority areas using available management tools.

Objectives: The primary objective of the proposal to treat forest stands infested with HWA is to "maintain reproducing populations of eastern and Carolina Hemlock throughout their historical geographic and elevational range across the Nantahala and Pisgah National Forests" (USDA HWA Environmental Assessment 2004). This objective reflects requirements in the National Forest Management Act implementing regulatons (36CFR219.19) that "habitat must be provided to support, at least, a minimum number of reproductive individuals and that habitat must be well-distributed so that those individuals can interact with others in the planning area".

Conservation Strategy: Included in our primary goal to maintain hemlock viability across the Nantahala and Pisgah National Forests are (1) genetic, (2) species, (3) community, and (4) landscape diversity goals. These goals to maintain multiple levels of

diversity may affect the number and distribution of habitats or conservation areas that are necessary in a conservation design. Threats to species viability including demographic stochasticity, environmental stochasticity, catastrophes and genetic drift and inbreeding (Shaffer 1981, 1987), that may also affect the conservation area design, are discussed in later in this appendix.

Genetic conservation goals include maintaining genetic variation within and among populations of hemlock, and assuring that processes such as genetic differentiation and gene flow continue. Without genetic variation and gene flow, populations are less adaptable and their extinction is more probable, all else being equal (Noss 1992). Providing for a baseline genetic makeup of the forest-level hemlock population should be a primary consideration in any conservation area design (Crane 2004).

The species conservation goal is to maintain viable populations of hemlock on the Nantahala and Pisgah National Forests and ultimately across the Southern Appalachians. Eastern hemlock is a widespread species occurring in 5 Canadian provinces and in the United States from New England to the Lake States, Mid-Atlantic States, and Southern Appalachians. On the Nantahala and Pisgah National Forests it occurs primarily at mid-elevation forests in plant communities classified as Acidic Cove Forest or Eastern Hemlock Forest (Schafale and Weakley 1990). Eastern hemlock may be considered a keystone species playing a pivotal role in ecosytems in which it occurs and upon which a large part of the community depends, e.g. in some riparian habitats where they are the primary shade for native brook trout streams. Carolina hemlock is not a widespread species and is limited in its range to southwestern and southcentral Virginia, western North Carolina, northwestern South Carolina and Georgia, and eastern Tennessee (Natureserve 2004, Weakley 2002). The species is listed by the U.S. Forest Service Regional Forester as a Sensitive species because of its rarity and risk of extinction in a portion of its range as evidenced by downward trends in habitat capability or population numbers. Carolina hemlock can occur on a variety of sites but persists as a canopy dominant only along xeric to dry ridges and upper slopes, or in rare situations, on rocky well-drained river banks. It is the characteristic species in plant communities classified as Carolina Hemlock Bluffs (Schafale and Weakley 1990).

Community conservation goals include representing each ecosystem type, across its natural range of variation, within conservation areas. Multiple examples of each type are necessary to encompass variability and provide protection from catastrophe through redundancy. There are numerous species that are associated with hemlock and this "coarse filter" approach to conservation would help to maintain their viability on the Nantahala and Pisgah National Forests and the processes that are most crucial for ecological health. Some of the more important processes are natural disturbances, hydrological cycles, plant-herbivore interactions, predation, mycorrhizal interactions, and soil building. All of these processes affect biodiversity at several levels. Although they will change over time with changing climate and other natural trends, in the short term ecological processes should be maintained within normal limits of variation if native biodiversity is to persist (Noss 1992).

Landscape conservation goals include maintaining or mimicking the natural mosaic of habitats, in terms of spatial arrangement, juxtaposition, patch size distribution, connectivity, and other factors. It also involves maintaining the landscape scale ecological processes that continually create those patterns. Natural disturbance regimes, metapopulation dynamics (interactions between spatially distinct hemlock populations), migratory corridors for large animals, and watershed protection are all ecological functions that can be perpetuated only at landscape and regional scales.

Conservation Area Design: The major challenge of designing conservation areas for hemlock and its associated species on the Nantahala and Pisgah National Forests is determining the proper distribution and number of areas needed to support reproducing hemlock populations and the management actions needed to protect these habitats.

Distribution of Conservation Areas: A primary consideration in designing conservation areas that address multiple levels of species diversity is the natural range of environmental variability of sites that can support the target species, i.e. eastern and Carolina hemlock, and the associated species found on those sites. Conservation areas should reflect this range of variability in equal proportions and distribution of hemlock stands found naturally across the Southern Appalachians to provide for a corresponding wide range of genetic and community diversity. In addition, the silvics of hemlock should be considered in evaluating the distance between areas (Table 6). Because within population genetic variation is often as great as between population genetic variation in forest trees, several small genetic reserves or subpopulations spread over a large geographical area may conserve total genetic diversity more effectively than a single, large reserve (National Academy of Sciences 1991) and will be the model used here.

To evaluate the potential distribution of hemlock conservation areas, we used:

1) Ecological Units of the Eastern United States (Keys et.al. 1995) to stratify the Nantahala and Pisgah National Forests based upon physiographic zones and major environmental influences such as climate, geology, and soils,
2) Elevation zones to reflect major differences in species composition, community structure, and ecological processes, and
3) Ecological Zones (Simon et.al 2004) to identify site capability to support hemlock communities.

Components of the environmental strata for the ecological zones that support eastern hemlock (Acidic Coves) and Carolina hemlock (Pine Oak-Heath) therefore included:

- Three Physiographic zones:
  - Southern Blueridge Escarpment
  - Southern Blueridge Mountains
  - Metasedimentary Mountains
- Three Elevation zones:
  - < 2,500 feet
  - 2,500-4,500 feet
  - > 4,500 feet

Nine environmental strata (3 physiographic zones times 3 elevation zones) were used to locate and calculate their representation across the Nantahala and Pisgah National Forests within the proclamation boundary and within lands administered by the Nantahala and Pisgah National Forests. Tables 1-3 and Figures 1-4 show the amounts and locations of the stratification for potential conservation areas.

Table 1. Representation of Environmental Strata within the Nantahala and Pisgah National Forests proclamation boundary

Elevation Zone	Southern Blueridge Escarpment	Blueridge Mountains	Metasedimentary Mountains
< 2,500 feet	286,280 acres (11.6%)	226,950 acres (9.2%)	487,710 acres (19.7%)
2,500-4,500 feet	281,420 acres (11.4%)	775,943 acres (31.4%	323,970 acres (13.1%)
> 4,500 feet	5,680 acres (0.2%)	82,750 acres (3.3%)	3,790 acres (0.2%)
All elev. zones	573,390 acres (23.2%)	1,085,637 acres (43.9%)	815,470 acres (33.0%)

Table 2. Representation of **Acidic Coves** within Environmental Strata

Elevation Zone	Southern Blueridge Escarpment	Blueridge Mountains	Metasedimentary Mountains
----- area within the Nantahala and Pisgah NFs proclamation boundary -----			
< 2,500 feet	143,860 acres (25.6%)	50,605 acres (9.0%)	155,385 acres (27.7%)
2,500-4,500 feet	60,190 acres (10.7%)	108,480 acres (19.3%	40,520 acres (7.2%)
> 4,500 feet	180 acres (0.03%)	2,225 acres (0.4%)	127 acres (0.02%)
All elev. zones	204,230 acres (36.4%)	161,310 acres (28.7%)	196,029 acres (34.9%)
----- area within lands administered by the Nantahala and Pisgah NFs -----			
< 2,500 feet	68,050 acres (32.2%)	5,130 acres (2.4%)	47,970 acres (22.7%)
2,500-4,500 feet	38,995 acres (18.4%)	25,820 acres (12.2%	23,870 acres (11.3%)
> 4,500 feet	145 acres (0.1%)	1,480 acres (0.7%)	120 acres (0.1%)
All elev. zones	110,190 acres (50.7%)	32,430 acres (15.3%)	71,960 acres (34.0%)

Table 3. Representation of **Pine-Oak Heath** where Carolina hemlock could potentially occur within Environmental Strata

Elevation Zone	Southern Blueridge Escarpment	Blueridge Mountains	Metasedimentary Mountains[1/]
----- area within the Nantahala and Pisgah NFs proclamation boundary -----			
< 2,500 feet	[1/]	14,630 acres (8.7%)	0
2,500-4,500 feet	44,130 acres (26.2%)	106,275 acres (63.0%)	0
> 4,500 feet	120 acres (0.07%)	3,340 acres (2.0%)	0
All elev. zones	44,250 acres (26.3%)	124,250 acres (73.7%)	0
----- area within lands administered by the Nantahala and Pisgah NFs -----			
< 2,500 feet	[1/]	1,470 acres (2.3%)	0
2,500-4,500 feet	37,050 acres (56.8%)	25,400 acres (38.9%	0
> 4,500 feet	30 acres (0.004%)	1,300 acres (2.0%)	0
All elev. zones	37,080 acres (56.8%)	28,173 acres (43.2%)	0

[1/] Carolina hemlock is extremely rare in these areas

Within these strata, we considered focusing HWA control treatments in hemlock stands within a conservation network in a likely fragmented future landscape based on the current ecological significance and conservation potential of the sites (Lombard et al. 1997; Shafer 1997; Williams-Linera et al. 1998; Schwartz 1999; Tscharntke et al. 2002a).

Hemlock stands in this future landscape would be constrained to relatively small, isolated habitat patches surrounded by a potentially inhospitable matrix but linked through interaction (pollen transfer and therefore gene flow) among stands. The general objectives for these genetic reserve networks are to include representative stands and communities of eastern and Carolina hemlock, to promote the persistence of these targets, support biodiversity throughout the conservation areas, and sustain ecological and evolutionary processes (Noss et al. 1999b; Margules & Pressey 2000).

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Figure 1. Physiographic zones on the Nantahala & Pisgah National Forests

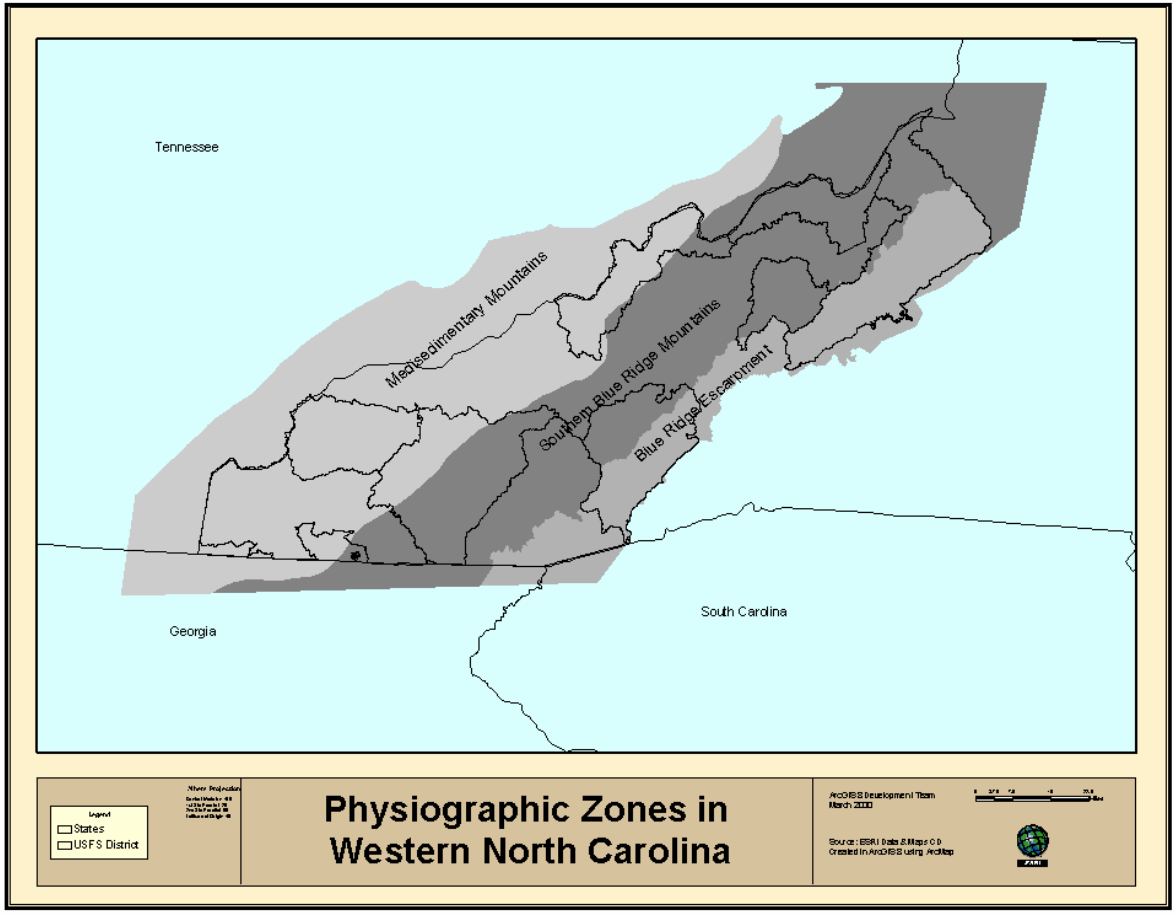


Figure 2. Elevation Zones on the Nantahala & Pisgah National Forests

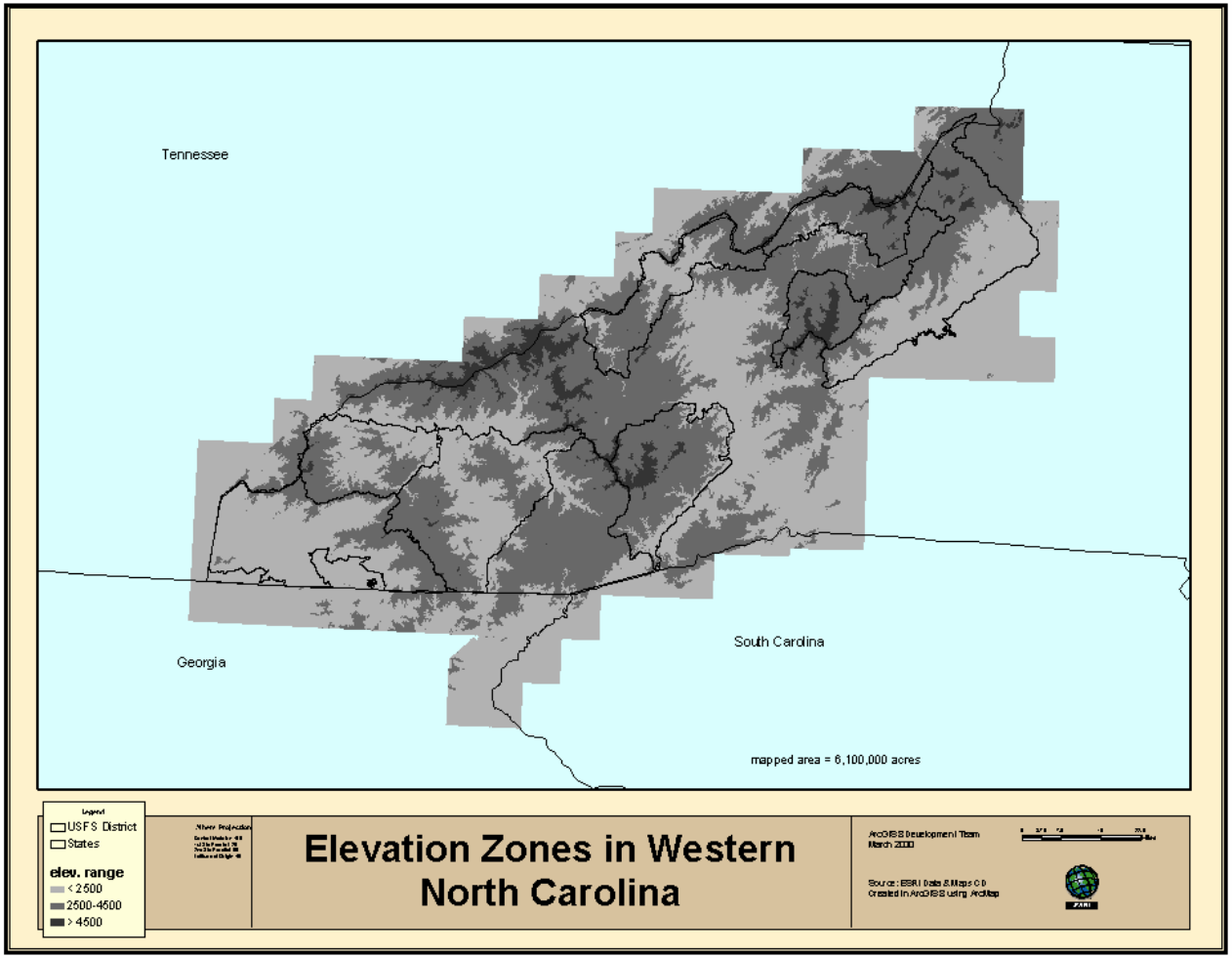


Figure 3. Elevation zones east of Asheville NC

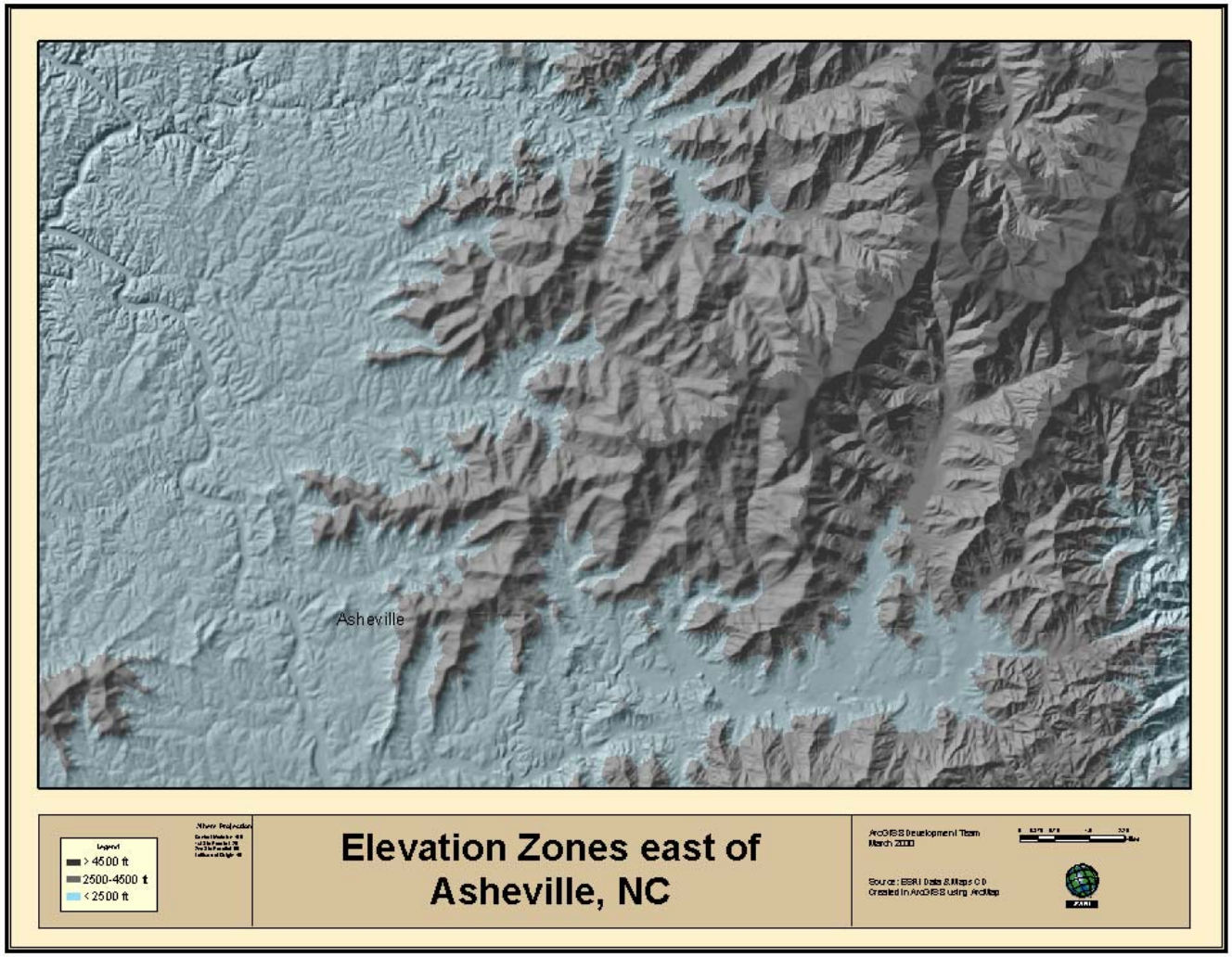
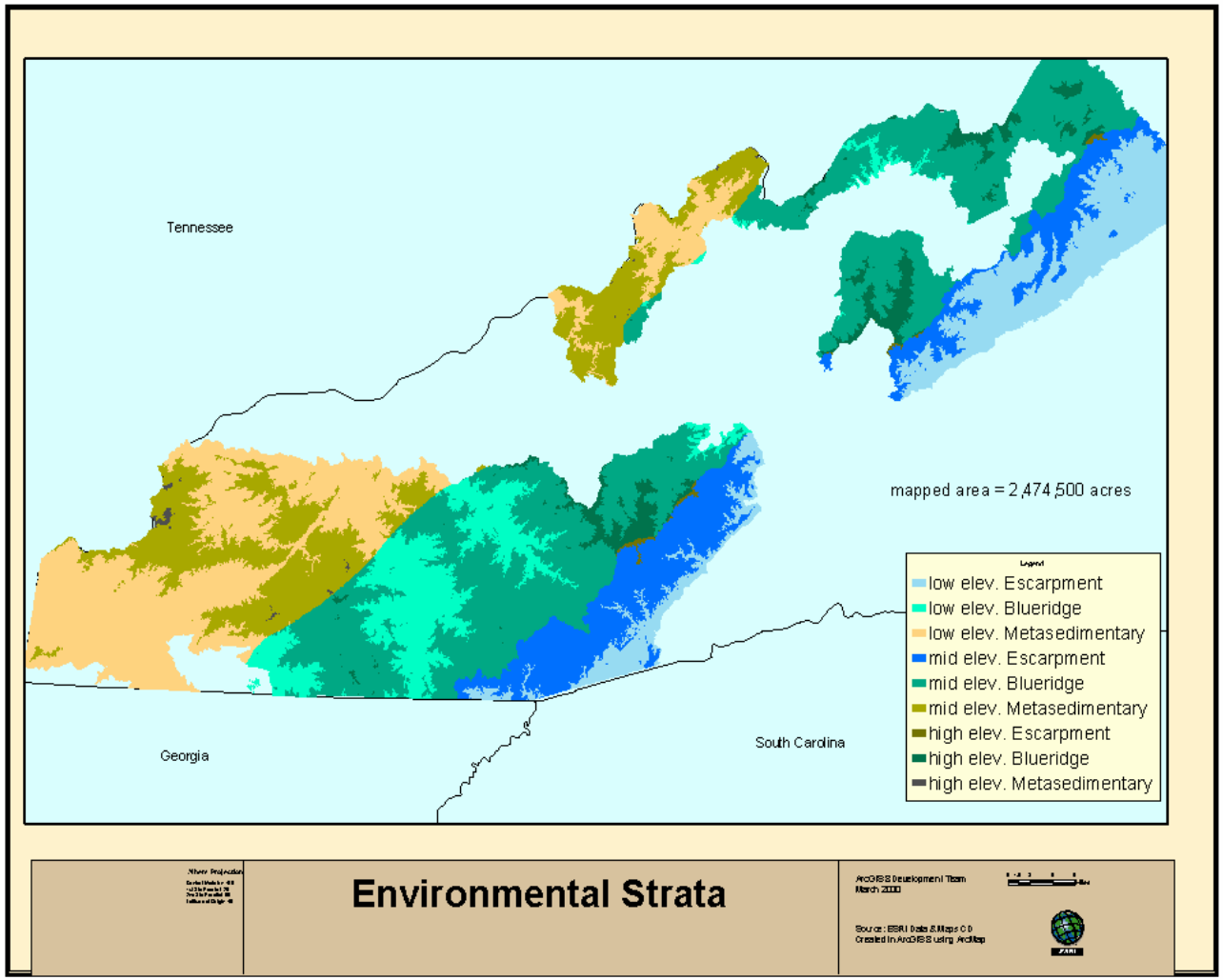


Figure 4. Environmental Strata on the Nantahala & Pisgah NFs



Number of Conservation Areas:

The number of conservation areas to establish across the Nantahala and Pisgah National Forests is primarily dependent upon how many trees and subpopulations are required to maintain hemlock genetic diversity and the diversity of plant communities where hemlock is a primary component, i.e. in Acidic Cove and Pine-Oak Heath ecological zones.

We considered metapopulation and Minimum Viable Population (MVP) concepts in evaluating the number of conservation areas and number of hemlock trees needed for genetic reserves. There are no "magic numbers" but there are three general approaches to address MVP. They include:

- Estimating the effective population on the basis of ability to withstand loss of genetic variability due to small populations. For animals, Frankel and Soule (1981) calculate the minimum population size to be 50; generally sufficient for a few generations in time. This estimate is probably not applicable to trees where more individuals are needed to account for random loss in the population due to HWA.
- Estimating the effective population on the basis of the number required to maintain the evolutionary potential of the population. Franklin (1980) estimated a population of 500 individuals is not likely to lose genetic variance due to drift and can retain enough variation to respond to altered selection pressures. For outbreeding, monoecious species such as hemlock, the number is 1500-2000 individuals.
- Calculate the population size that will minimize the sampling loss of alleles that occur in low frequency. Namkoong (1984) estimated that in species with known levels of inbreeding and population structure, a sample size of 1000 will keep the probability of loss of an allele to an acceptable frequency.

The population size necessary to avoid loss of genetic variation due to genetic drift is much larger than needed to avoid inbreeding depression, at least for animals. Franklin (1980) first proposed that an effective size of 500 individuals would allow maintenance of long-term viability, because loss of genetic variation from drift would be offset by the creation of new variation through natural mutation. Recently, however, this number has been a topic of some debate (Lande 1995, Franklin and Frankham 1998, Lynch and Lande 1998, Alendorf and Ryman, in press). Lande (1995) indicated that only populations with an effect size of over 5000 individuals can be expected to maintain viability in the absence of immigration, because not all mutations are beneficial. Others argue that an effective population size of 500 to 1000 individuals is sufficient (Franklin and Frankham 1998). At issue is the potential effects of harmful mutations: Franklin and Frankham (1998) consider these effects negligible, but others have suggested that slightly deleterious mutations are capable of causing population extinction even at effective sizes of several hundreds (Lynch et al. 1995, Lynch and Lande 1998). The debate will likely continue, but a reasonable conclusion is that only populations with actual sizes in the thousands, rather than hundreds, can maintain long-term viability and evolutionary potential in the absence of immigration (Allendorf and Ryman, in press).

Metapopulation biology is concerned with the effects of local population dynamics on the regional persistence of a species and thus has achieved its widest application in conservation biology. A metapopulation is a set of local populations (subpopulations) within some larger area that are connected via migration; where a population is a collection of individuals, a metapopulation is a collection of local populations. This approach is useful, and sometimes necessary, in studying the dynamics of species that occur in patchy or frequently disturbed habitats. In such cases, the movement of individuals and genes between local populations will make an important difference to species persistence.

For easily managed species such as hemlock, the viability of single populations may be maintained with effective subpopulation sizes of 50 to 100 reproductive individuals, and it would be possible to contain a total of a few thousand in as few as 50 or so subpopulations (National Academy of Sciences 1991). Maintaining a minimum of 500 individuals in multiple genetic reserves (subpopulations in close proximity) is adequate for maintaining genetic diversity of hemlock on the Nantahala and Pisgah National Forests especially when the feasibility of manual transfer of pollen among areas is considered (Crane 2004).

Based upon these references, we have chosen 50 as the number of subpopulations or reserves needed to maintain genetic diversity of Canada hemlock and 25 as the number of subpopulations or reserves needed to maintain genetic diversity of Carolina hemlock on the Nantahala and Pisgah National Forests. At least for hemlock, this design will provide for a forest-wide population in the thousands, which should result in a high likelihood for viability (given effectiveness of control treatments). A smaller number of reserves for Carolina hemlock are considered adequate because of the natural rarity of the species in relation to the availability of sites where it can be supported.

Maintaining the diversity of communities where hemlock is a primary member would require significantly more conservation areas because of the variety of associated species that include known aquatic and presumed terrestrial wildlife members. Viability risk to all species in the community cannot be as easily assessed as viability risk to hemlock because of variable numbers of species occurrences and population densities. It is estimated that the MVP for these multiple species would require at least double (100) that for hemlock reserves to maintain species and community diversity in Canada hemlock communities and 50 reserves in Carolina hemlock to reduce the risk to these species.

Process for selecting conservation areas: The following steps were used to select hemlock conservation areas on the Nantahala and Pisgah National Forests:

1) Identify hemlock stands across the Forests using existing information from:
    a. North Carolina Natural Heritage Program element occurrences records,
    b. Southern Appalachian Vegetation Dataset (Ulrey 1999)
    c. Nantahala and Pisgah continuous inventory of stand condition (CISC)
    d. Recreation area inventories, and
    e. District personnel and Shared specialists.

2) Rank stands to evaluate the significance of each site and its value for inclusion using the following criteria:
    a. Ecological significance as defined by the NC Natural Heritage Program site occurrence rank of A or B = rank 1.
    b. Stands adjacent to brook trout streams having superior brook trout genetic strains or in watersheds with high brook trout diversity = rank 1.
    c. Stands containing Regional Forester's Sensitive species with fewer than 3 occurrences on the Forests = rank 1.
    d. Stands with permanent plots sampled using the NC Vegetation Survey protocols = rank 2.
    e. Stands identified in CISC as Hemlock (05), Hemlock-Hardwood (08), or White Pine-Hemlock (04) = rank 2.
    f. Significant hemlock sites identified by District personnel and shared specialists not recorded in CISC = rank 3.
    g. Recreation sites identified by District personnel where hemlock is either an important ecological or cultural component = rank 3.
    h. Sites adjacent to brook trout streams having moderate brook trout genetic strains = rank 3.

3) Distribute conservation areas in proportion to environmental strata using the following guidelines:
    a. Areas should be no closer than 1,320 feet apart to reduce overlap of dispersing predator beetles. Consider the effective predator beetle dispersal distance of ¼ mile from the point of release, i.e. the HWA control treatment area is approximately 125 acres in size (assuming effectiveness of this control treatment).
    b. Areas should be no greater than 5 miles apart to increase the probability of pollen exchange between hemlock trees. Consider each area identified for chemical treatment will include up to 3 groves of trees with up to 20 trees treated with systemic insecticide in each grove (50-60 trees total) and that treatment is approximately 80% effective.
    c. Strive to balance the significance of sites identified at step 2 with the genetic requirements of maintaining hemlock trees in close proximity to maximize inclusion of high-ranking areas and allow for well-distributed hemlock subpopulations.

Results and Discussion of site selection: Nearly 400 hemlock stands were identified on the Nantahala and Pisgah National Forests using existing information. Approximately 20% were documented in North Carolina Natural Heritage Program element occurrences records or in the Southern Appalachian Dataset, 43% were listed in CISC and mapped in the Geographic Information System (GIS) and 37% were derived from recreation area inventories or from information provided by District personnel and shared specialists.

These locations were digitized and evaluated in a GIS along with other pertinent information such as topography, land ownership, rare species locations, brook trout streams, environmental strata, roads, and management area. Nearly 160 conservation

areas were selected, 112 for eastern hemlock and 47 for Carolina hemlock. They are shown in tables 4 and 5 within the environmental strata and displayed in figures 5 and 6 in relationship to other ownerships in the Southern Appalachians.

Table 4. Distribution of target eastern hemlock stands in a conservation area network designed to capture genetic, species, and community diversity (number and percent of total areas).

Elevation Zone	Southern Blueridge Escarpment	Blueridge Mountains	Metasedimentary Mountains
Genetic reserves			
< 2,500 feet	16 (29%)	1 (2%)	12 (22%)
2,500-4,500 feet	10 (19%)	6 (11%)	7 (13%)
> 4,500 feet	0	1 (2%)	1 (2%)
All elev. zones	26 (48%)	8 (15%)	20 (37%)
Conservation areas			
< 2,500 feet	35 (31%)	2 (2%)	24 (22%)
2,500-4,500 feet	18 (16%)	16 (14%)	12 (11%)
> 4,500 feet	0	3 (3%)	1 (1%)
All elev. zones	53 (47%)	21 (19%)	37 (33%)

Table 5. Distribution of target Carolina hemlock stands in a conservation area network designed to capture genetic, species, and community diversity (number and percent of total areas).

Elevation Zone	Southern Blueridge Escarpment	Blueridge Mountains	Metasedimentary Mountains
Genetic reserves			
< 2,500 feet	0	3 (13%)	0
2,500-4,500 feet	5 (21%)	15 (62%)	0
> 4,500 feet	0	1 (4%)	0
All elev. zones	5 (21%)	19 (79%)	0
Conservation areas			
< 2,500 feet	0	5 (11%)	0
2,500-4,500 feet	12 (25%)	28 (60%)	0
> 4,500 feet	0	2 (4%)	0
All elev. zones	12 (25%)	35 (75%)	0

Eastern hemlock conservation areas are distributed in the environmental strata in roughly the same proportion as the current distribution of sites suitable for hemlock on the Nantahala and Pisgah National Forests (Tables 2 and 4). For example, approximately 31% of hemlock sites on the Nantahala and Pisgah National Forests occur within the Southern Blueridge Escarpment below 2,500 feet in elevation and an equal proportion of conservation areas (35 of 112 or 31%) have been selected in this zone. Carolina hemlock conservation areas are not distributed in environmental strata in the same proportion as the current distribution of sites suitable for the species on the Forests. However, they are roughly in proportion to hemlock sites within the proclamation boundary that includes private land (Tables 3 and 5). For example, approximately 60% of Carolina hemlock sites on the Nantahala and Pisgah National Forests occur within the Blueridge Mountains

between 2,500 and 4,500 feet in elevation and an equal proportion of conservation areas (28 of 47 or 60%) have been selected in this zone.

There are three areas on the Pisgah and two on the Nantahala where conservation areas are in close enough proximity to allow for natural gene flow among a sufficient number of eastern hemlock trees to improve the probability of genetic diversity of the species (Figure 5). The highest probability of maintaining eastern hemlock genetic diversity exists in two of these areas, one centered near Highlands NC and the other at the Joyce Kilmer wilderness area. Each contains at least 10 conservation areas that include chemical treatments. Assuming 50-60 treated trees per area, up to 600 trees could be maintained in each of these areas until predator beetles become established and in equilibrium with HWA populations. In addition, gene flow can be facilitated by manually transporting pollen among the 12 small genetic reserves and the 5 large genetic reserves (Figure 5)

The highest probability of maintaining Carolina hemlock genetic diversity exists in two areas, one centered on the Nolichucky Gorge and the other at the Linville Gorge wilderness area (Figure 6). Only Linville Gorge contains at least 10 conservation areas that include 10 chemical treatments and therefore greater than 500 chemically treated trees, the minimum required to maintain genetic diversity.

Figure 5. Eastern hemlock conservation areas (dots and x's) and 5-mile pollen dispersal zones (heavy and light buffer lines)

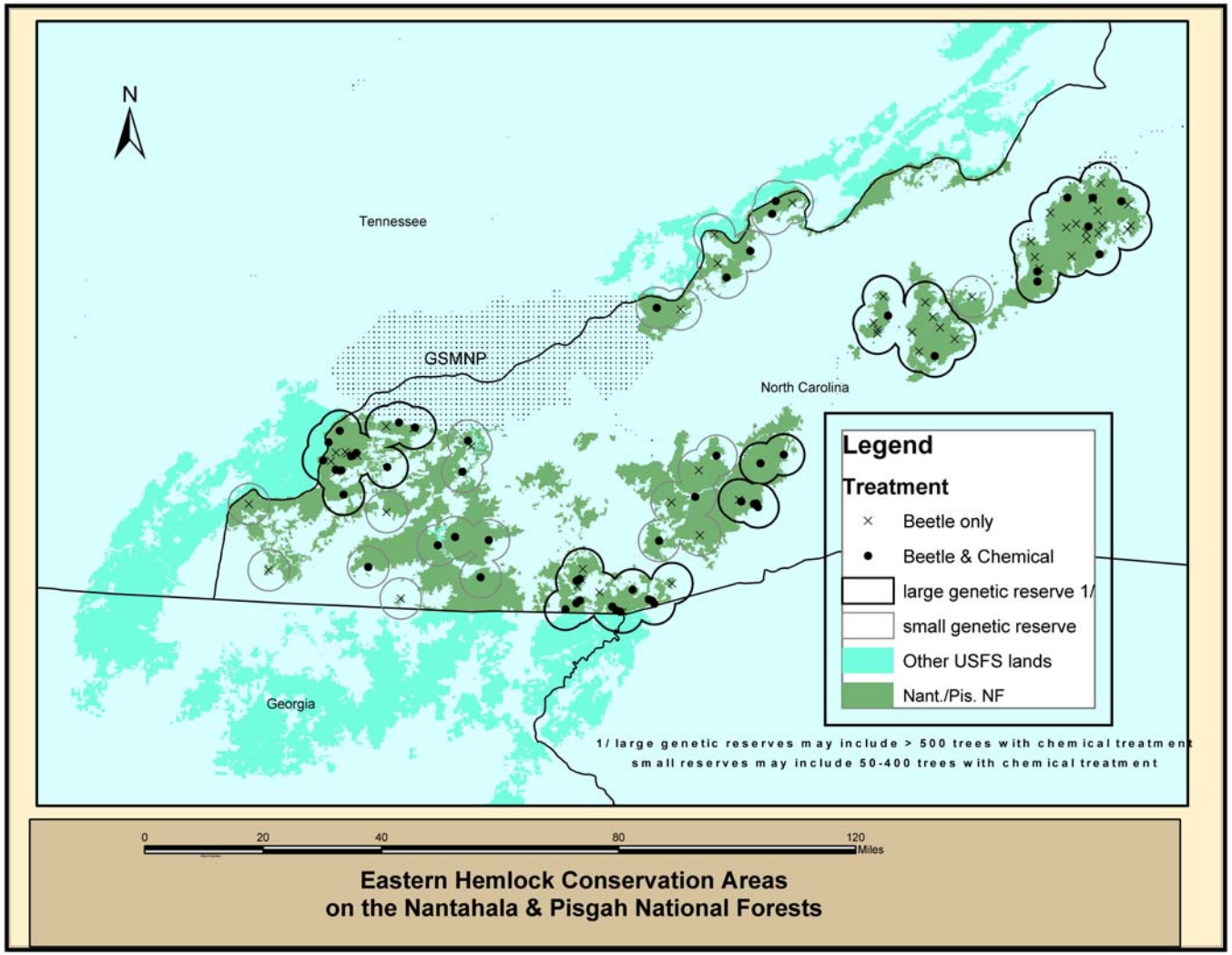
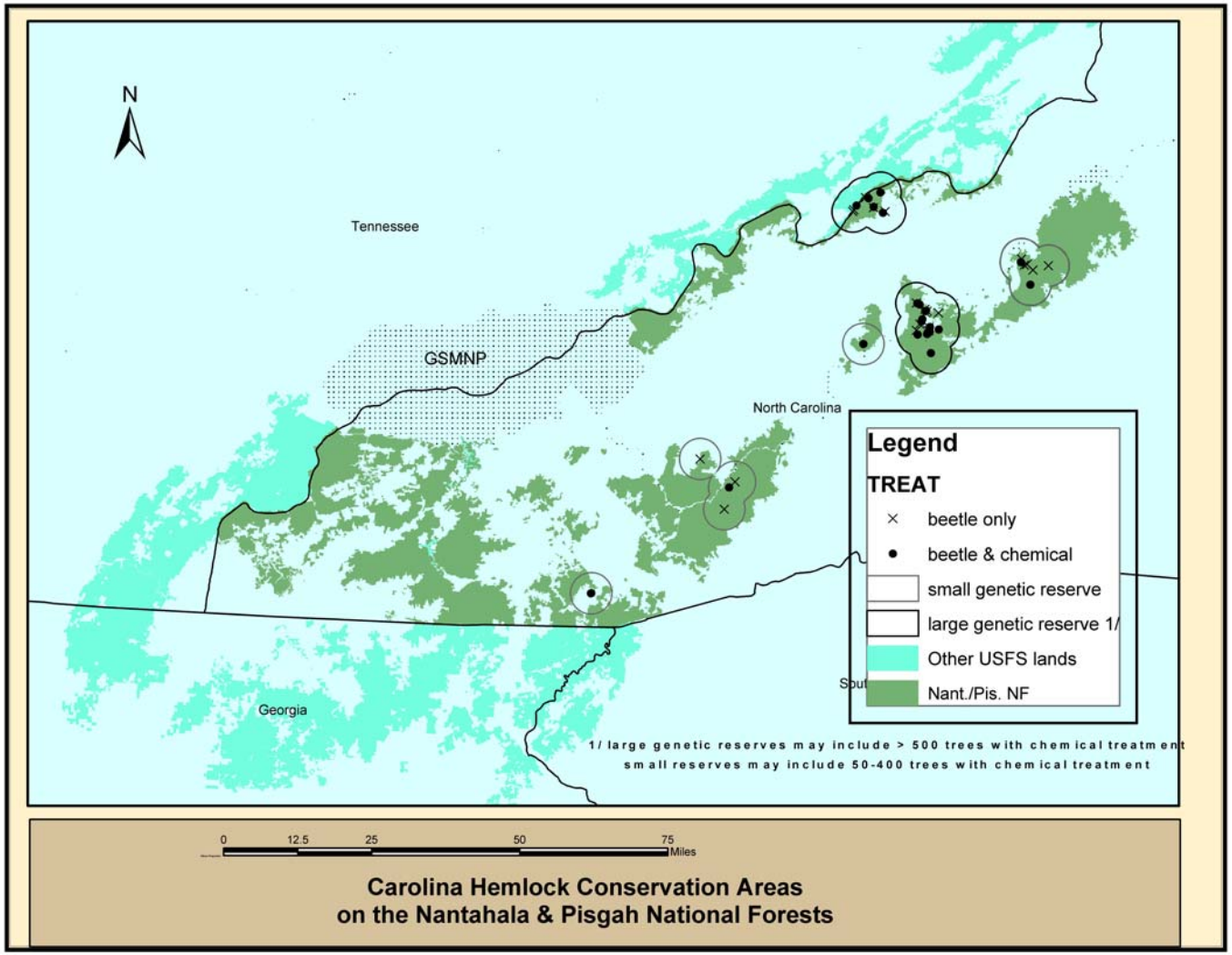


Figure 6. Carolina hemlock conservation areas (dots and x's) and 5-mile pollen dispersal zones (heavy and light buffer lines



MVP is defined as the smallest isolated population having a [90% or 95%] chance of surviving for [100, 500, or 1000] years despite the foreseeable effects of demographic, environmental and genetic stochasticity, as well as natural catastrophes.

To assess population viability and MVP, generally four threats are considered: (1) demographic stochasticity, (2) environmental stochasticity, (3) catastrophes and (4) genetic drift and inbreeding (Shaffer 1981, 1987). Demographic stochasticity refers to effects of random events on the reproduction and survival of individuals, whereas environmental stochasticity refers to effects of unpredictable events that alter vital rates. For example, if every individual has a 50% probability of annual survival, in a population of 20 individuals 10 will not die each year. Instead some years by chance nine will die, in others eleven and so forth. This is demographic stochasticity, which is analogous to sampling error. It may be that in years with severe winters the probability of survival is only 30%, whereas in years with mild winters the probability of survival is 70%. This is an example of environmental stochasticity (RCW Recovery Plan 2003).

There are two genetic threats to population viability. The first, inbreeding depression, threatens all population sizes of trees and only small populations of animals, whereas the second, genetic drift, can threaten even large populations (Lande 1995). Inbreeding depression reduces the survival and productivity of individuals, and results from the segregation of partially recessive, deleterious alleles. The resulting negative effect on population dynamics increases vulnerability of extinction. The amount of inbreeding depression depends on the rate of inbreeding and opportunity for selection to purge recessive lethal and semi-lethal mutations (Lande 1995). Genetic drift results in the loss of genetic variation, which may reduce a species' ability to adapt and persist in a changing environment, and thereby its viability over long time periods. The rate of loss is inversely related to population size and mutation rate, and viability is achieved when the population size is large enough that loss to drift is in equilibrium with gain from mutation.

Cross-pollenation appears to be the most desired condition for plants, it maintains a level of variability and herterozygosity that provides the opportunity for evolutionary change if environments change (Hartmann and Kester 1983). For many plants (barley, oats, wheat, rice, peanuts, soybeans, many grasses, tomatoes, tobacco) a self-pollenation strategy has proven most successful. However, cross-pollenation is necessary for trees to reduce the devastating effects of inbreeding depression.

The "50/500" rule of thumb initially advanced by Franklin (1980) and Soule (1980) comes the closest of any to attaining "magic number" status. This rule prescribes a short-term effective population size (N_e) of 50 to prevent an unacceptable rate of inbreeding, and a long-term N_e of 500 to maintain overall genetic variability. The N_e=50 prescription (termed "the basic rule" by Soule 1980) corresponds to an inbreeding rate of 1% per generation, approximately half the maximum rate tolerated by domestic animal breeders (Franklin 1980). The N_e=500 prescription is an attempt to balance the rate of gain in

genetic variation due to mutation with the rate of loss due to drift (Franklin 1980). Practical applications of the 50/500 rule have been made by Foose (1983), LaCava and Hughes (1984), Lehmkuhl (1984), the U.S. Fish and Wildlife Service (1985), Allendorf and Servheen (1986), Reed et al. (1986), Dawson et al. (1987), and Reed et al. (1988). However, these numbers may not be entirely applicable to trees.

Relationship of USFS Viability Evaluations to Population Viability Analysis

Definitions of population viability in the scientific literature have focused on the probability of a populations' persistence for a biologically meaningful period of time. For example, Soulé (1990) defines viability in terms of the capacity of the population to maintain itself without significant demographic or genetic manipulation for the foreseeable ecological future – centuries – with a certain degree of certainty and adaptation. Adaptation requires that the population "maintains a normal level of immediate fitness (individual vigor, fertility, fecundity) and has sufficient genetic variation to adapt by natural selection to changing environmental conditions within the predicted range of frequency and amplitude of disturbance and change of a species or population" Soulé (1990). Population vulnerability analyses (PVA) are used to estimate minimum viable populations (MVPs). These analyses consider the effects of demographic stochasticity, genetic stochasticity, environmental stochasticity, and catastrophes. They evaluate life history of the species (population), the temporal and spatial distribution of its resources, its level of genetic variation, and the consequences of habitat fragmentation (Gilpin and Soulé 1986). Shaffer (1981) defined MVP as "the smallest isolated population having a 99% chance of remaining extant for 1000 years despite the foreseeable effects of demographic, environmental, and genetic stochasticity, and natural catastrophes".

Table 6.
Silvics of Southern Appalachian hemlock species

	Eastern Hemlock	Carolina Hemlock
flowering period	April-June	same
seed production	cones mature in one year, good crops every 2-3 years; one of the most frequent cone producers among the eastern conifers	larger cones and more seeds
seed dissemination	wind dispersed up to 4,500 ft., wide dispersal favored by hygroscopic cone scales	same
pollen dissemination	wind dispersed up to 5 miles	same
seedling establishment	periodic, mostly during years of greater than normal rainfall	same
moisture requirements	best @ 32-> 56” /year	drought tolerant
site affinity	acidic coves (streamside zones)	pine-oak heath
reaction to competition	most shade tolerant of all species, can survive in suppressed position for decades	Intermediate, and presumed ability to survive suppression
genetics	heritable differences in characteristics of seed germination and development from different regions / sites	same

APPENDIX C. HEMLOCK FREQUENCY TABLE

Merchantable volume of live trees on all forest land for National Forests and Other Owners, Hemlock and Other

Species Mountains of NC 2002

		All	DC									
			2	4	6	8	10	12	14	16	18	20 +
		Mil.cu.ft.	Mil.cu.ft.	Mil.cu.ft.	Mil.cu.ft.	Mil.cu.ft.	Mil.cu.ft.	Mil.cu.ft.	Mil.cu.ft.	Mil.cu.ft.	Mil.cu.ft.	Mil.cu.ft.
		Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum
owngrp	sppgrp											
National Forest - hemlock is 4.73% of alltrees	Hemlock	126.668	0	0	7.585	10.091	7.392	11.498	7.619	14.684	10.271	57.528
	Other Species	2553.194	0	0	142.085	218.105	260.088	283.43	299.059	249.727	291.077	809.623
	All	2679.862	0	0	149.67	228.196	267.48	294.928	306.678	264.411	301.348	867.151
Other Owners - hemlock is 3.04% of alltrees	sppgrp											
	Hemlock	246.881	0	0	15.726	18.33	15.094	23.786	28.359	27.975	10.547	107.064
	Other Species	7875.5	0	0	467.568	754.435	914.049	991.961	1049.979	942.914	732.605	2021.989
	All	8122.381	0	0	483.294	772.765	929.143	1015.747	1078.338	970.889	743.152	2129.053
All	sppgrp											
	Hemlock	373.549	0	0	23.311	28.421	22.486	35.284	35.978	42.659	20.818	164.592
	Other Species	10428.694	0	0	609.653	972.54	1174.137	1275.391	1349.038	1192.641	1023.682	2831.612
	All	10802.243	0	0	632.964	1000.961	1196.623	1310.675	1385.016	1235.3	1044.5	2996.204

Number of live trees on all forest land for National Forests and Other Owners, Hemlock and Other Species

Mountains of NC 2002

		All	DC									
			2	4	6	8	10	12	14	16	18	20 +
		Thous.trees	Thous.trees	Thous.trees	Thous.trees	Thous.trees	Thous.trees	Thous.trees	Thous.trees	Thous.trees	Thous.trees	Thous.trees
		Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum
owngrp	sppgrp											
National Forest - hemlock is 5.53% of all trees	Hemlock	31897	15004	8371	3665	1975	820	721	315	383	194	449
	Other Species	544753	285859	100322	51785	35530	22839	15681	11201	6780	5900	8856
	All	576650	300863	108693	55450	37505	23659	16402	11516	7163	6094	9305
Other Owners - hemlock is 3.52% of all trees	sppgrp											
	Hemlock	63551	32728	13202	7564	3738	1725	1671	1240	789	216	678
	Other Species	1743704	887878	333670	167874	120037	78733	53358	38394	25106	14755	23899
	All	1807255	920606	346872	175438	123775	80458	55029	39634	25895	14971	24577
All	sppgrp											
	Hemlock	95448	47732	21573	11229	5713	2545	2392	1555	1172	410	1127
	Other Species	2288457	1173737	433992	219659	155567	101572	69039	49595	31886	20655	32755
	All	2383905	1221469	455565	230888	161280	104117	71431	51150	33058	21065	33882

APPENDIX D – BIOLOGICAL ASSESSMENT/EVALUATION

Introduction

Native to Japan, the Hemlock Wholly Adelgid (*Adelges tsugae*) (HWA) is a serious pest of eastern hemlock (*Tsugae canadensis)* and a threat to Carolina hemlock (*T. caroliniana)* in the United States. Carolina hemlock is listed by the U.S. Forest Service Regional Forester as a Sensitive species because of its rarity and risk of extinction in a portion of its range as evidenced by downward trends in habitat capability or population numbers. The 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, National Forests in North Carolina (NFsNC) is proposing to release predator beetles, that prey specifically on HWA, in selected hemlock stands to suppress infestations and some limited systemic insecticide use in a subset of these stands as a stop-gap measure until biological control agents can become established. This Biological Assessment / Evaluation (BA/BE) documents the effects that implementing HWA control treatments could have on Threatened, Endangered, and Sensitive species. This BA/BE incorporates the species level evaluations from Chapter 3 of the EA and the Aquatic, Botanical, and Terrestrial Wildlife Analysis reports available from the project file.

Consultation History

The USDI Fish and Wildlife Service on April 28, 1999 (USDA 1999) concurred that the use of *P.tsugae* as a biological control agent for the HWA in infested hemlock stands in North Carolina, West Virginia, Maryland, Pennsylvania, New York, Massachusetts, Rhode Island, Virginia, and Connecticut will have no effect on any federally listed or proposed listed species or critical habitat.

The USDI Fish and Wildlife Service, Asheville Office, on June 24, 2004 responded to comments on the proposed action. They stated that 'The loss of large numbers of hemlock trees and eastern hemlock forests would have a negative effect on overall ecosystem processes; specifically, we believe the loss would significantly affect the microclimate, soil conditions, and streams within these unique habitats. Furthermore, we believe the risks of introducing the exotic *S. tsugae* are worth the potential benefits the species may have on controlling the HWA.' They also asked that the NFsNC consider monitoring HWA predator beetles for any indication of a shift in choice of prey.

The USDI Fish and Wildlife Service, Asheville Office, in August 2004, during informal consultation, concurred that there would be no effect of releasing predator beetles within ¼ mile of Rock Gnome Lichen (*Gymnoderma lineare*), the only treatment proposed near this species, because the beetles feed exclusively on HWA, and not on lichens.

Proposed Action

The US Forest Service, NFsNC is proposing to release a suite of predator beetles, that prey specifically on HWA, in 159 hemlock stands to suppress infestations and some limited systemic insecticide use in about 80 stands as a stop-gap measure until biological control agents can become established. The predator beetles include *Sasjiscymnus tsugae* [formerly *Pseudoscymnus tsugae*], *Laricobius nigrinus*, *Scymnus sinuanodulus*, and *Scymnus ningshanensis*. The proposed methods for systemic insecticide application include stem and soil injection.

The NFsNC is proposing to use a conservation area design to identify and prioritize areas for HWA control. The conservation area would be used to maintain, on portions of the Forests, important hemlock ecosystem functions such as stream shading, large woody debris production, and substrate for non-vascular species and to serve as a genetic reserve to maintain a diverse hemlock gene pool 'in situ'.

Species Considered and Species Evaluated

All proposed, threatened, endangered, and Regional Forester's sensitive (TES) species were evaluated. This includes 14 endangered, 10 threatened, and 201 Regional Forester's sensitive species (Table D-1). These species represent the following numbers and lifeforms: 5 amphibians, 4 birds, 6 crustaceans, 8 fishes, 11 mollusks, 9 mammals, 22 terrestrial insects, 6 aquatic insects, 68 nonvascular plants, and 104 vascular plants.

Species were considered for review if the species or their habitats were documented on the Nantahala and Pisgah National Forests within 1,320 feet of predator beetle release sites (the treatment zone). This is believed to be the maximum dispersal distance of predator beetles and was therefore considered the effects analysis area. Assuming a 1320-foot radius, each treatment zone is approximately 125 acres in size and would also include the individual hemlock trees proposed for chemical treatment. Therefore, nearly 20,000 acres (159 treatment zones times 125 acres) were evaluated for TES species or TES species habitat occurrence.

Species Evaluated for Further Review

Fifty-four species were considered for further review because the species or its habitat is documented within the 20,000 acre combined treatment areas. This includes 5 threatened or endangered species:

Carolina Northern Flying Squirrel (*Glaucomys sabrinus coloratus*),
Bog Turtle (*Clemmys muhlenbergii*),
Noonday Globe (*Mesodon clarki nantahala*),
Rock Gnome Lichen (*Gymnoderma lineare*),
Appalachian elktoe (*Alasmidonta raveneliana*)

And includes 49 Sensitive species:

Peregrine Falcon (*Falco peregrinus*)
Junaluska salamander (*Eurycea junaluska*)
Oconee stream crayfish (*Cambarus chaugaenis*)
Little Tennessee Crayfish (*C. georgiae*)
Bennett's Mill slater (*Caecidodotea carolinensis*)
Diminuitive clubtail (*Gomphus diminutus*)
Pygmy snaketail (*O. howei*)
Carolina hemlock (*Tsuga caroliniana*)
Mountain heartleaf (*Hexastylis contracta*)
Northern Oconee bells (*Shortia galacifolia brevistyla*)
Tellico Salamander (*Plethodon aureolus*),
Bidentate Dome (*Ventridens coelaxis*)
Hiwassee headwaters crayfish (*C. parrishi*)
French Broad crayfish (*C. reburrus*)
Yancy sideswimmer (*Stygobromus carolinensis*)
Edmund's snaketail (Ophiogomphus edmundo
Brook floater (*Alasmidonta varicose*)
Piratebush (*Buckleya distichophylla*)
North Fork heartleaf (*Hexastylis rhombiformis*)
Southern Oconee bells (*S. galacifolia galacifolia*)

Taylor's filmy fern (*Hymenophyllum tayloriae*)
West Indian polypody (*Grammitis nimbata*)
A hornwort (*Megaceros aenigmaticus*)
Appalachian pocket moss (*Fissidens appalachiensis*)
A liverwort (*Drepanolejeunea appalachiana*)
A liverwort (*Acrobolbus ciliatus*)
A liverwort (*Lejeunea blomquistii*)
A liverwort (*Marsupella emarginata latiloba*)
A liverwort (*Plagiochila caduciloba*)
A liverwort (*P. sullivantii spinigera*)
A liverwort (*P. virginica caroliniana*)
A liverwort (*Radula sullivantii*)
Dwarf apple moss (*Bartramidula wilsonii*)
Carolina plagiomnium (*Plagiomnium carolinianum*)
Pringle's platyhypnidium (*Platyhypnidium pringlei*)
Piedmont barren strawberry (*Waldsteinia lobata*)
Ambiguous ditrichum (*Ditrichum ambiguum*)
An aquatic lichen (*Hydrothyria venosa*)
A foliose lichen (*Anzia americana*)
Highlands moss (*Schlotheimia lancifolia*)
A liverwort (*Aneura sharpii*)
A liverwort (*Lophocolea appalachiana*)
A liverwort (*Pellia appalachiana*)
A liverwort (*P. echinata*)
Sullivant's liverwort (*P.sullivantii sullivantii*)
Appalachian porella (*Porella appalachiana*)
A liverwort (*R. voluta*)
Gorge moss (*Bryocrumia vivicolor*)
A peat moss (*Sphagnum flavicomans*)

The remaining species listed in Appendix A were not considered for further analysis because these species do not occur in the treatment areas or the species is not associated with hemlock dominated stands or stands where hemlock is a major component. There will be no effect to these species from the proposed HWA control treatments because predator beetles are unlikely to disperse beyond treatment areas and because chemical treatments applied to individual trees are unlikely to affect an area larger than the tree crown or rooting zone which is well within the individual approximately 125 acre treatment zones.

Evaluated Species Survey Information

For TES aquatic and terrestrial wildlife species, information on species occurrence and distribution was obtained from existing databases and Forest Service personnel. Additional information specifically addressing aquatic and terrestrial wildlife TES species was obtained from North Carolina Wildlife Resources Commission biologists, North Carolina Natural Heritage Program records, and US Fish and Wildlife Service biologists. No new surveys or inventories for TES wildlife were conducted for this project.

The North Carolina Natural Heritage Program records, the Biological Conservation Database (BCD), NatureServe records, the Southern Appalachian Database (Ulrey 1999), and survey results for other vegetation management projects that have occurred in the past 10 years were used to determine species occurrence and distribution for TES plants in the project area. No new surveys or inventories for TES plants were conducted for this project.

Environmental Baseline

The proposed HWA treatment areas are distributed across the range of sites that hemlock occurs on the Nantahala and Pisgah National Forests and reflects the composition, structure and diversity of species and the cool, moist, and shaded environmental conditions found at these sites. Eastern hemlock is the dominant species on only about 1.4% (13,770 acres) of the approximately 1,010,000 acres of the Nantahala and Pisgah National Forests (CISC 2004, Brown 2002). It shares dominance with other conifers or hardwoods in Acidic Cove Forests that occupy nearly 20% of the Nantahala and Pisgah National Forests. Carolina hemlock is a major stand component on only a very small portion of the National Forests but can occur as individuals in more extensive xeric pine and pine-oak forest types within the Pine-Oak Heath ecological zone (see Botanical Resources, Chapter 3).

Over 90% of all hemlock forests on the Nantahala and Pisgah National Forests are greater than 60 years in age and about 40% of eastern hemlock stands and 20% of stands that could support

Carolina hemlock are greater than 100 years in age. Tree cover and the combined cover of all lifeforms (trees, shrubs, herbs, vines) in the proposed HWA control stands often well exceeds 100% due to overlapping crowns in different canopy layers. In
eastern hemlock stands proposed for HWA treatment, eastern hemlock averages 64% cover, and at mid-elevations (2500-4500 feet) great rhododendron (*Rhododendron maximum*) is often the dominant member of the understory shrub layer. The combined cover of all species in Carolina hemlock stands proposed for HWA treatment also often exceeds 100% and Carolina hemlock crown cover is high (68%). Rhododendron species (*R. maximum*, *R. catawbiense*, *R. minus*) also dominate the understory shrub layer. In Carolina hemlock stands however, total vegetation cover is less due to fewer vegetation layers, and the average number of species is significantly less than in eastern hemlock stands.

Approximately 10% of all plant species documented on the Nantahala and Pisgah National Forests occur within eastern hemlock stands proposed for HWA treatment (Danley and Kauffman 2000, Ulrey 1999). These 245 species include 46 trees, 31 shrubs, 160 herbs, sedges, and grasses, and 8 vines. Species diversity is even greater in Acidic Coves, an ecological zone where eastern hemlock is often a major stand component. Overall, there is less species diversity in Carolina hemlock stands. There were only 56 different species in sample plots versus 245 found in eastern hemlock stands (Ulrey 1999). The 56 species included 20 trees, 20 shrubs, 14 herbs, sedges, and grasses, and 2 vines.

Approximately 14% of all coldwater streams are associated with hemlock forests. About 132 miles of these coldwater stream habitats are associated with hemlock forests that support brook trout. Over 80% (105 miles) of these areas are proposed for HWA control treatments; predator beetles will be released in all of these areas and additional chemical treatments will occur in ½ of the areas. Approximately 4% of the 168 miles of coolwater streams on the Nantahala and Pisgah National Forests are associated with hemlock forests.

There are no TES species that depend entirely upon eastern or Carolina hemlock for substrate, shade, or other habitat requirements. There are, however, many species that spend a portion of their lifecycle in hemlock stands and those that thrive in conditions found in these moist forests.

Effects of the Proposed Management Action

Direct Effects of Biological control treatments

Direct effects to rare species from releasing predator beetles to control the HWA is unlikely because these beetles feed almost exclusively on HWA; they do not feed on any TES plants or terrestrial wildlife species nor on the prey these species depend upon. The biology of *P. tsugae* and other HWA predator beetles limits their potential to directly impact any species other than its prey, the HWA. It is highly unlikely that these non-native species will prey on native species for several reasons:

1) The *P. tsugae* is a scymnine lady beetle about the size of a poppy seed (Rhea 2004) and belongs to an insect group that attacks only aphids, adelgids, and scale insects (Pang and Gordon 1986). There are no endangered, threatened, proposed, sensitive, or locally rare species that belong to these groups of prey insects.
2) Studies in the field in Japan of the feeding preference of *P.tsugae* found that bark lice, flies, homoterands, moths, thrips, and mites were not attacked by this predator beetle

despite their frequent close association with it on the same tree branches. Studies of the same types of insects in the laboratory in Connecticut confirmed field observations made in Japan (McClure, unpubl.).

3) In natural conditions, *P.tsugae* is known to attack only the HWA. The beetle's life cycle consists of the egg, four larval stages, the pupa, and the adult. Three overlapping generations per year are produced, and these coincide well with the two HWA generations. Adult and larval beetles feed on all life stage of the HWA.
4) The demonstrated ability of *P.tsugae* to locate populations of HWA even at low prey densities is evidence of the beetle's specialized adaptation to its prey. Such specialized adaptations seldom occur in predators that attack a broad range of prey species.
5) Other scymnine lady beetles (i.e., *Diomus* spp., *Nephus* spp.) have been introduced into the U.S. for biological control of citrus mealybugs without adverse impacts on non-target species (Gordon, 1985).
6) Other predator beetles *Laricobius nigrinus*, *Scymnus sinuanodulus*, and *Scymnus ningshanensis* have similar feeding preferences as *P. tsugae* and specialized adaptation to the HWA.

It is also highly unlikely that the non-native *P.tsugae* and other HWA predator beetles will eliminate a food source used by native species. There are no arthropod species listed as TES species on the Nantahala or Pisgah National Forest that utilize HWA as a food source. If they did, there would presumably be no reason to introduce *P.*tsugae and other predator beetles as control agents for HWA.

Direct Effects of Chemical control treatments

Direct effects to rare species from using systemic insecticides to control the HWA are unlikely because: (1) there are no TES wildlife species that feed on hemlock and therefore little possibility of these species ingesting insecticides, (2) there are no TES plant or wildlife species that live on the bark of hemlock at the point of the proposed stem injection of insecticide and therefore there will be no impact to these species, (3) wildlife species associated with the soil and litter such as the Tellico salamander, Junaluska salamander, and Bidentate dome, live and move through the litter above the soil zone where chemical injections will occur and therefore will not come into direct contact with the insecticide, (4) the use of soil chemical injection will be restricted to areas away from streamside zones and excessively drained soils therefore avoiding the risk of groundwater contamination and movement of insecticides into aquatic habitats where they could harm aquatic TES species, and (5) the systemic chemicals proposed for use are not herbicides and therefore are not intended to kill plants but rather to be safely absorbed by plants.

Indirect and Cumulative Effects of Biological and Chemical control treatments

In general, HWA control measures will help to maintain habitat suitability in hemlock stands for all TES species that require cool, moist and shaded conditions. This beneficial impact, however, will be offset by degradation of habitat for these same species outside of HWA control stands. Although the location of HWA control treatments are oriented to stands with known TES species occurrences, it is not feasible to protect individually all of the hemlock trees across the Nantahala and Pisgah National Forests and therefore all the associated TES species. Therefore, some indirect injury to sensitive species associated with hemlock stands is likely even with the proposed HWA control treatments especially in those areas farthest away from treated stands.

Past and present timber harvest and prescribed burning activities on the Nantahala and Pisgah National Forests have affected sites that could support eastern hemlock such as Acidic Coves. These activities have altered habitat suitability for hemlock-associated species, however, no TES species have been adversely affected by these activities. Many of these activities will continue in the future but the resulting individually minor effects are insignificant when compared with the major indirect impacts expected from the HWA. They are therefore unlikely to add or combine measurably with the impact resulting from an expanding HWA population over time.

During the past 11 years, 16 projects may have impacted portions of *Hydrothyria venosa* populations on the Nantahala National Forest. These projects included ten timber sales with associated road building, three road improvements including widening, constructing one new horse trail and developing a commercial rock quarry. None of these activities were expected to eliminate *Hydrothyria venosa* from the respective analysis area (Kauffman 2004). Seven of these timber sales and the four road improvement and trail projects occur within areas of the Nantahala National Forest where *Hydrothyria venosa* is abundant. The Nantahala and Pisgah National Forests contain over 55 other *Hydrothyria venosa* populations that are undisturbed and without anticipated impacts for the foreseeable future.

During that same time period, there have been six timber sales with associated road building, both on the Wayah Ranger District and the Cheoah Ranger District that have impacted portions of *Megaceros aenigmaticus* populations. A horse trail and two road improvement projects have impacted three other populations. One population no longer occurs within federal lands due to a recent land exchange. Four of the timber sales and the three other road and trail projects occur within the Nantahala National Forests where *Megaceros aenigmaticus* is abundant. None of these projects are anticipated to result in the loss of this species from the immediate areas provided proper installation of erosion control measures was implemented. Twenty-five other populations occur on federal land across the range of this species within North Carolina with no known or anticipated impact from any upcoming project.

A recreational use closure was implemented across portions of Roan High Bluff at Roan Mountain in 1998. Recent monitoring indicates the closure improved site conditions for *Gymnoderma lineare* (Danley 2004). A wildfire within Madison County near the Tennessee border affected a small *Buckleya distichophylla* population. The population was relocated and found to be as persistent as prior to the fire (Danley 2004).

There will be no cumulative affect or loss of viability across the Forest for *Megaceros aenigmaticus, Hydrothyria venosa, Buckleya distichyophylla,* and *Gymnoderma lineare* with implementation of the HWA control measures. There are no other projects across the Nantahala and Pisgah National Forests that have affected any of the other TES species evaluated for this HWA control project.

Determination of Effects

Sensitive Species

The release of predator beetles and use of systemic insecticides will have no direct impact on any Regional Forester's Sensitive plant, aquatic or terrestrial wildlife species. This includes: Oconee stream crayfish, Little Tennessee River crayfish, Hiwassee headwaters crayfish, French Broad crayfish, Bennett's Mill cave water slater, Yancey sideswimmer, Diminuitive clubtail, Edmund's snaketail, pygmy snaketail, brook floater, Peregrine falcon, Tellico salamander, Junaluska

salamander, Bidentate dome, Carolina hemlock, Piratebush, Mountain heartleaf, North Fork heartleaf, Northern Oconee bells, Southern Oconee bells, Taylor's filmy fern, Piedmont barren strawberry, West Indian polypoly and the following nonvascular species: *Acrobolbus ciliatus, Aneura sharpii, Anzia Americana, Bartramidula wilsonii, Bryocrumia vivicolor, Buckleya distichophylla, Ditrichum ambiguum, Drepanolejeunea appalachiana, Fissidens appalachensis, Grammitis nimbata, Hexastylis contracta, Hexastylis rhombiformis, Hymenophyllum tayloriae, Lejeunea blomquistii, Lophocolea appalachiana, Marsupella emarginata var. latiloba, Pellia appalachiana, Plagiochila caduciloba, Plagiochila echinata, Plagiochila sullivantii var. spinigera, Plagiochila sullivantii var. sullvantii, Plagiochila virginica var. caroliniana, Plagiomnium carolinianum, Platyhypnidium pringlei, Porella appalachiana, Radula sullivantii, Radula voluta, Schlotheimia lancifolia, Sphagnum flavicomans,* and *Taxiphyllum alternans.*

The release of predator beetles and use of systemic insecticides will have beneficial impacts to all Regional Forester's Sensitive species listed above by reducing hemlock mortality and therefore maintaining habitat suitability for these species in hemlock stands. However, loss of hemlock due to HWA infestations away from treatment areas on the Nantahala and Pisgah National Forests will continue in the near future. The resulting increase in humidity and light intensity could indirectly affect those species that are unable to move and avoid the unfavorable change in environment, i.e. plants. Therefore, even with HWA control treatments, impact to individuals may occur to most all of the above listed sensitive plant species but this will not lead to a trend in federal listing or loss of viability on the Nantahala and Pisgah National Forests. The only exceptions are those nonvascular plants that are associated with moist stream boulders (*Megaceros aenigmaticus*, *Hydrothyria venosa*, *Fissidens appalachensis*) that are unlikely to be impacted because they are adapted to higher light conditions and because humidity levels will be maintained due to their proximity to water.

Loss of hemlock due to HWA infestations on public and private land will continue in the near future until HWA control measures are implemented. This may result in cumulative effects to all sensitive species associated with moist and shaded hemlock environments especially immobile species, i.e. plants. Sensitive plants associated with hemlock (listed above) will likely decline in numbers but this will not cause a trend to federal listing or loss of viability on the Nantahala and Pisgah National Forests.

Federally Threatened and Endangered Species

The release of HWA predator beetles is not likely to adversely affect any threatened or endangered species because these beetles feed exclusively on HWA; they do not feed on plants or terrestrial wildlife species nor on the prey these species depend upon.

The use of systemic insecticides will have no effect on Rock Gnome Lichen because this species, although it does occur within one of the treatment areas, is not associated with hemlock. The use of systemic insecticides is not likely to adversely affect the Noonday Globe because this species lives and moves through habitat near but not within the soil zone where chemical injection will occur. The use of systemic insecticides is not likely to adversely affect the Bog Turtle or Appalachian elktoe because chemical treatments will be restricted to areas away from streamside zones and excessively drained soils therefore avoiding the risk of groundwater contamination and movement of insecticides into aquatic habitats where these species exist. The use of systemic insecticide on hemlock trees is not likely to adversely affect the Carolina Flying Squirrel because this species does not feed on hemlock or on any insects that may feed on hemlock.

In summary, the proposed action – release of HWA predator beetles and treating individual hemlock trees with systemic insecticide will have no effect on the Rock Gnome Lichen and is not likely to adversely affect the Noonday Globe, Bog Turtle, Appalachian elktoe, and Northern Flying Squirrel. USDI Fish and Wildlife Service concurrence is required for the not likely to adversely affect determination.

Prepared by:

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Table D-1.: Threatened, Endangered, and Sensitive Species that occur or are likely to occur on the NFsNC

Group	Designation	*Scientific Name*	Common Name	G-Rank
Bird	Threatened	*Haliaeetus leucocephalus*	Bald Eagle	G4
Fish	Threatened	*Cyprinella monacha*	Spotfin Chub	G2
Insect	Endangered	*Microhexura montivaga*	Spruce-fir Moss Spider	G1
Mammal	Endangered	*Canis rufus*	Red Wolf	G1
Mammal	Endangered	*Corynorhinus town. Virginianus*	Virginia Big-eared Bat	G4T2
Mammal	Endangered	*Felis concolor cougaur*	Eastern Cougar	G1
Mammal	Endangered	*Glaucomys sabrinus coloratus*	Carolina Northern Flying Squirrel	G5T1
Mammal	Endangered	*Myotis sodalis*	Indiana Bat	G2
Mollusk	Threatened	*Mesodon clarki nantahala*	Noonday Globe	G2T1
Mollusk	Endangered	*Pegias fabula*	Little-wing Pearly Mussel	G1
Nonvasc. Plant	Threatened	*Gymnoderma lineare*	Rock Gnome Lichen	G2
Vascular Plant	Endangered	*Geum radiatum*	Spreading Avens	G1
Vascular Plant	Threatened	*Helonias bullata*	Swamp Pink	G3
Vascular Plant	Threatened	*Hexastylis naniflora*	Dwarf-flowered Heartleaf	G2
Vascular Plant	Endangered	*Houstonia montana*	Mountain Bluet	G5T2Q
Vascular Plant	Threatened	*Hudsonia montana*	Mountain Golden-Heather	G1
Vascular Plant	Endangered	*Isotria medeoloides*	Small Whorled Pogonia	G2G3
Vascular Plant	Threatened	*Liatris helleri*	Heller's Blazing Star	G2
Vascular Plant	Endangered	*Sagittaria fasciculata*	Bunched arrowhead	G1
Vascular Plant	Endangered	*Sarracenia jonesii*	Mountain Sweet Pitcher Plant	G3T1
Vascular Plant	Endangered	*Sarracenia oreophila*	Green Pitcher Plant	G2
Vascular Plant	Endangered	*Sisyrinchium dichotomum*	White Irisette	G2
Vascular Plant	Threatened	*Solidago spithamaea*	Blueridge Goldenrod	G1
Vascular Plant	Threatened	*Spiraea virginiana*	Virginia Spiraea	G2
Amphibian	Sensitive	*Desmognathus santeetlah*	Santeetlah dusky salamander	G3Q
Amphibian	Sensitive	*Eurycea junaluska*	Junaluska salamander	G3Q
Amphibian	Sensitive	*Plethodon aureolus*	Tellico salamander	G2G3Q
Amphibian	Sensitive	*Plethodon teyahalee*	Southern Appalachian salamander	G2G3Q
Amphibian	Sensitive	*Plethodon welleri*	Weller's salamander	G3
Bird	Sensitive	*Falco peregrinus*	Peregrine Falcon	G4
Bird	Sensitive	*Lanius ludovicia migrans*	Migrant loggerhead shrike	G5T3Q
Bird	Sensitive	*Thryomanes bewickii altus*	Appalachian Bewick's wren	G5T2Q
Crustacean	Sensitive	*Caecidotea carolinensis*	Bennett's Mill Cave water slater	G1G2
Crustacean	Sensitive	*Cambarus chaugaensis*	Oconee stream crayfish	G2
Crustacean	Sensitive	*Cambarus georgiae*	Little Tennessee River crayfish	G1
Crustacean	Sensitive	*Cambarus parrishi*	Hiwassee Headwaters crayfish	G1
Crustacean	Sensitive	*Cambarus reburrus*	French Broad crayfish	G3
Crustacean	Sensitive	*Stygobromus carolinensis*	Carolina seep scud	G1G2
Fish	Sensitive	*Etheostoma acuticeps*	Sharphead darter	G2G3
Fish	Sensitive	*Etheostoma collis*	Carolina darter	G3
Fish	Sensitive	*Etheostoma mariae*	Pinewoods darter	G3
Fish	Sensitive	*Etheostoma vulneratum*	Wounded darter	G3
Fish	Sensitive	*Percina burtoni*	Blotchside logperch	G2
Fish	Sensitive	*Percina macrocephala*	Longhead darter	G3
Fish	Sensitive	*Percina squamata*	Olive darter	G2
Insect	Sensitive	*Callophrys irus*	Frosted elfin	G3
Insect	Sensitive	*Cicindela ancocisconensis*	A tiger beetle	G3
Insect	Sensitive	*Hypochilus coylei*	A cave spider	G3?
Insect	Sensitive	*Hypochilus sheari*	A lampshade spider	G2G3
Insect	Sensitive	*Melanoplus divergens*	Divergent Melanoplus	G2G3
Insect	Sensitive	*Melanoplus serrulatus*	Serrulate Melanoplus	G1G3
Insect	Sensitive	*Nesticus cooperi*	Lost Nantahala Cave spider	G1?
Insect	Sensitive	*Nesticus crosbyi*	a cave spider	G1?
Insect	Sensitive	*Nesticus mimus*	Cave spider	G2
Insect	Sensitive	*Nesticus sheari*	Cave spider	G2?
Insect	Sensitive	*Nesticus silvanus*	Cave spider	G2?
Insect	Sensitive	*Scudderia septentrionalis*	Northern Bush Katydid	G3?
Insect	Sensitive	*Semiothisa fraserata*	Fraser Fir Angle	G2?
Insect	Sensitive	*Speyeria diana*	Diana fritillary	G3
Insect	Sensitive	*Speyeria idalia*	Regal fritillary	G3
Insect	Sensitive	*Trechus carolinae*	A ground beetle	G1?
Insect	Sensitive	*Trechus luculentus unicoi*	A ground beetle	G2T2?
Insect	Sensitive	*Trechus mitchellensis*	A ground beetle	G1?
Insect	Sensitive	*Trechus rosenbergi*	A ground beetle	G1?
Insect	Sensitive	*Trechus satanicus*	A ground beetle	G1?
Insect	Sensitive	*Trimerotropis saxatilis*	Rock-loving grasshopper	G2G3
Insect (aquatic)	Sensitive	*Gomphus diminutus*	Diminuitive clubtail	G3
Insect (aquatic)	Sensitive	*Gomphus septima*	Septima's clubtail	G2
Insect (aquatic)	Sensitive	*Macromia margarita*	Mountain river cruiser	G2G3

Insect (aquatic)	Sensitive	*Ophiogomphus edmundo*	Edmund's snaketail	G1
Insect (aquatic)	Sensitive	*Ophiogomphus howei*	Pygmy snaketail	G3
Insect (aquatic)	Sensitive	*Ophiogomphus incurvatus*	Appalachian snaketail	G3
Mammal	Sensitive	*Corynorhinus rafinesquii*	Rafinesque's big-eared bat	G3G4
Mammal	Sensitive	*Microtus chrotorrhinus carolinensis*	Southern rock vole	G4T3
Mammal	Sensitive	*Myotis leibii*	Eastern small-footed bat	G3
Mammal	Sensitive	*Sorex palustris puntculatus*	Southern water shrew	G5T3
Mollusk	Sensitive	*Alasmidonta varicosa*	Brook floater	G3
Mollusk	Sensitive	*Elliptio roanokensis*	Roanoke slabshell	G2
Mollusk	Sensitive	*Fusconaia barnesiana*	Tennessee pigtoe	G2G3
Mollusk	Sensitive	*Helicodiscus triodus*	Tallus coil	G2
Mollusk	Sensitive	*Lasmigona holstonia*	Tennessee Heelsplitter	G3
Mollusk	Sensitive	*Pallifera hemphilli*	Black mantleslug	G3
Mollusk	Sensitive	*Paravitrea placentula*	Glossy supercoil	G3
Mollusk	Sensitive	*Ventridens coelaxis*	Bidentate dome	G3
Mollusk	Sensitive	*Villosa vaughaniana*	Carolina creekshell	G2
Nonvasc. Plant	Sensitive	*Acrobolbus ciliatus*	A liverwort	G3?
Nonvasc. Plant	Sensitive	*Aneura maxima (= A. sharpii)*	A liverwort	G1G2
Nonvasc. Plant	Sensitive	*Anzia americana*	A Foliose Lichen	G2
Nonvasc. Plant	Sensitive	*Aspiromitus appalachianus*	A Hornwort	G1
Nonvasc. Plant	Sensitive	*Bartramidula wilsonii*	Dwarf apple moss	G3?
Nonvasc. Plant	Sensitive	*Bazzania nudicaulis*	Bazzania moss	G2G3
Nonvasc. Plant	Sensitive	*Brachydontium trichodes*	Peak moss	G2
Nonvasc. Plant	Sensitive	*Bryocrumia vivicolor*	Gorge moss	G2
Nonvasc. Plant	Sensitive	*Buxbaumia minakatae*	Hump-backed Elves	G2G3
Nonvasc. Plant	Sensitive	*Campylopus paradoxus*	Paradoxical campylopus	G3?
Nonvasc. Plant	Sensitive	*Cephalozia macrostachya ssp australis*	A liverwort	G4T1
Nonvasc. Plant	Sensitive	*Cephaloziella massalongi*	A liverwort	G2G3
Nonvasc. Plant	Sensitive	*Cheilolejeunea evansii*	A liverwort	G1
Nonvasc. Plant	Sensitive	*Diplophyllum apiculatum var. taxifolioides*	A Liverwort	G5T1Q
Nonvasc. Plant	Sensitive	*Diplophyllum obtusatum*	A Liverwort	G2?
Nonvasc. Plant	Sensitive	*Ditrichum ambiguum*	Ambiguous ditrichum	G3?
Nonvasc. Plant	Sensitive	*Drepanolejeunea appalachiana*	A liverwort	G2?
Nonvasc. Plant	Sensitive	*Entodon concinnus*	Lime entodon	G4G5
Nonvasc. Plant	Sensitive	*Ephebe americana*	A Fructicose Lichen	G2G3
Nonvasc. Plant	Sensitive	*Fissidens appalachiensis*	Appalachian Pocket Moss	G2G3
Nonvasc. Plant	Sensitive	*Frullania appalachiana*	A Liverwort	G1?
Nonvasc. Plant	Sensitive	*Frullania oakesiana*	A liverwort	G3?
Nonvasc. Plant	Sensitive	*Homaliadelphus sharpii*	Sharp's homaliadelphus	G3
Nonvasc. Plant	Sensitive	*Hydrothyria venosa*	An aquatic lichen	G3
Nonvasc. Plant	Sensitive	*Hygrohypnum closteri*	Closter's brook-hypnum	G3
Nonvasc. Plant	Sensitive	*Hypotrachyna virginica*	A Foliose Lichen	G1G3
Nonvasc. Plant	Sensitive	*Lejeunea blomquistii*	A liverwort	G1G2
Nonvasc. Plant	Sensitive	*Leptodontium excelsum*	Grandfather Mountain leptodontium	G2
Nonvasc. Plant	Sensitive	*Leptohymenium sharpii*	Mount Leconte moss	G1
Nonvasc. Plant	Sensitive	*Lophocolea appalachiana*	A liverwort	G2
Nonvasc. Plant	Sensitive	*Mannia californica*	A Liverwort	G3?
Nonvasc. Plant	Sensitive	*Marsupella emarginata var. latiloba*	A Liverwort	G5T1T2
Nonvasc. Plant	Sensitive	*Megaceros aenigmaticus*	A hornwort	G2G3
Nonvasc. Plant	Sensitive	*Metzgeria fruticulosa (= M. temperata)*	A Liverwort	G2Q
Nonvasc. Plant	Sensitive	*Metzgeria furcata var. setigera*	A Liverwort	G4T1
Nonvasc. Plant	Sensitive	*Metzgeria uncigera*	A liverwort	G3
Nonvasc. Plant	Sensitive	*Pellia X appalachiana*	A liverwort	G1?
Nonvasc. Plant	Sensitive	*Physcia pseudospeciosa*	Rosette lichen	G1?
Nonvasc. Plant	Sensitive	*Plagiochasma intermedium*	A Liverwort	G3?
Nonvasc. Plant	Sensitive	*Plagiochasma wrightii*	A Liverwort	G3?
Nonvasc. Plant	Sensitive	*Plagiochila austinii*	A liverwort	G3
Nonvasc. Plant	Sensitive	*Plagiochila caduciloba*	A liverwort	G2
Nonvasc. Plant	Sensitive	*Plagiochila echinata*	A liverwort	G2
Nonvasc. Plant	Sensitive	*Plagiochila sharpii*	Sharp's leafy liverwort	G2G3
Nonvasc. Plant	Sensitive	*Plagiochila sullivantii var spinigera*	A liverwort	G2T1
Nonvasc. Plant	Sensitive	*Plagiochila sullivantii var sullivantii*	Sullivant's leafy liverwort	G2T2
Nonvasc. Plant	Sensitive	*Plagiochila virginica var caroliniana*	A liverwort	G3T2
Nonvasc. Plant	Sensitive	*Plagiochila virginica var virginica*	A liverwort	G3T3
Nonvasc. Plant	Sensitive	*Plagiomnium carolinianum*	Carolina plagiomnium	G3
Nonvasc. Plant	Sensitive	*Platyhypnidium pringlei*	Pringle's platyhypnidium	G2
Nonvasc. Plant	Sensitive	*Polytrichum appalachianum*	Appalachian haircap moss	G3
Nonvasc. Plant	Sensitive	*Porella japonica ssp appalachiana*	Appalachian porella	G5?T1
Nonvasc. Plant	Sensitive	*Porella wataugensis*	Watauga porella	G2
Nonvasc. Plant	Sensitive	*Porpidia diversa*	A crustose Lichen	G2G3
Nonvasc. Plant	Sensitive	*Porpidia herteliana*	A crustose Lichen	G2G3
Nonvasc. Plant	Sensitive	*Radula sullivantii*	A liverwort	G2
Nonvasc. Plant	Sensitive	*Radula voluta*	A liverwort	G3
Nonvasc. Plant	Sensitive	*Rhachithecium perpusillum*	Budding totula	G3?
Nonvasc. Plant	Sensitive	*Riccardia jugata*	A liverwort	G1G2

Nonvasc. Plant	Sensitive	*Schlotheimia lancifolia*	Highlands moss	G2
Nonvasc. Plant	Sensitive	*Scopelophila cataractae*	Agoyan cataract moss	G3
Nonvasc. Plant	Sensitive	*Sphagnum flavicomans*	A peatmoss	G3?
Nonvasc. Plant	Sensitive	*Sphenolobopsis pearsonii*	A liverwort	G2
Nonvasc. Plant	Sensitive	*Splachnum pennsylvanicum*	Pennsylvania dung moss	G2?
Nonvasc. Plant	Sensitive	*Sticta limbata*	A Foliose Lichen	G3G4
Nonvasc. Plant	Sensitive	*Taxiphyllum alternans*	Japanese yew-moss	G3?
Nonvasc. Plant	Sensitive	*Tortula ammonsiana*	Ammons' tortula	G2?
Nonvasc. Plant	Sensitive	*Xanthoparmelia monticola*	Xanthoparmelia lichen	G2
Vascular Plant	Sensitive	*Aconitum reclinatum*	Trailing white monkshood	G3
Vascular Plant	Sensitive	*Allium cuthbertii*	Striped garlic	G3
Vascular Plant	Sensitive	*Amorpha schwerinii*	Schwerin's false indigo	G3
Vascular Plant	Sensitive	*Arabis patens*	Spreading rockcress	G3
Vascular Plant	Sensitive	*Asplenium X ebenoides*	Scott's spleenwort	HYB
Vascular Plant	Sensitive	*Aster avitus*	Alexander's rock aster	G3
Vascular Plant	Sensitive	*Aster georgianus*	Georgia aster	G2G3
Vascular Plant	Sensitive	*Aster mirabilis*	Bouquet aster	G2G3
Vascular Plant	Sensitive	*Astragalus michauxii*	Sandhills milkvetch	G3
Vascular Plant	Sensitive	*Berberis canadensis*	American barberry	G3
Vascular Plant	Sensitive	*Botrychium jenmanii*	Dixie grapefern	G3G4
Vascular Plant	Sensitive	*Buckleya distichophylla*	Piratebush	G2
Vascular Plant	Sensitive	*Calamagrostis cainii*	Cain's reed grass	G1
Vascular Plant	Sensitive	*Cardamine clematitis*	Small mountain bittercress	G2G3
Vascular Plant	Sensitive	*Carex biltmoreana*	Stiff sedge	G3
Vascular Plant	Sensitive	*Carex communis var. amplisquama*	Fort Mountain sedge	G3
Vascular Plant	Sensitive	*Carex impressinervia*	Ravine sedge	G1G2
Vascular Plant	Sensitive	*Carex misera*	Wretched sedge	G3
Vascular Plant	Sensitive	*Carex radfordii*	Radford's sedge	G2
Vascular Plant	Sensitive	*Carex roanensis*	Roan sedge	G1
Vascular Plant	Sensitive	*Carex schweinitzii*	Schweinitz's sedge	G3
Vascular Plant	Sensitive	*Chelone cuthbertii*	Cuthbert's turtlehead	G3
Vascular Plant	Sensitive	*Cleistes bifaria*	Small spreading pogonia	G3G4
Vascular Plant	Sensitive	*Coreopsis latifolia*	Broadleaf tickseed	G3
Vascular Plant	Sensitive	*Coreopsis X delphiniifolia*	Larkspur Coreopsis	G3?Q
Vascular Plant	Sensitive	*Danthonia epilis*	Bog oat-grass	G3?
Vascular Plant	Sensitive	*Delphinium exaltatum*	Tall larkspur	G3
Vascular Plant	Sensitive	*Desmodium ochroleucum*	Cream tick-trefoil	G2G3
Vascular Plant	Sensitive	*Diervilla rivularis*	Riverbank bush-honeysuckle	G3
Vascular Plant	Sensitive	*Euphorbia purpurea*	Glade Spurge	G3
Vascular Plant	Sensitive	*Fothergilla major*	Large witchalder	G3
Vascular Plant	Sensitive	*Gentiana austromontana*	Appalachian gentian	G3
Vascular Plant	Sensitive	*Geum geniculatum*	Bent avens	G2
Vascular Plant	Sensitive	*Glyceria nubigena*	Great Smoky Mountain mannagrass	G2
Vascular Plant	Sensitive	*Grammitis nimbata*	West Indian polypody	G4?
Vascular Plant	Sensitive	*Hasteola suaveolens*	False Indian-plantain	G3
Vascular Plant	Sensitive	*Helianthus glaucophyllus*	Whiteleaf sunflower	G3
Vascular Plant	Sensitive	*Heuchera caroliniana*	Carolina Alumroot	G3
Vascular Plant	Sensitive	*Heuchera longiflora var. aceroides*	maple-leaf alumroot	G4T2Q
Vascular Plant	Sensitive	*Hexastylis contracta*	Mountain heartleaf	G3
Vascular Plant	Sensitive	*Hexastylis rhombiformis*	North Fork heartleaf	G2
Vascular Plant	Sensitive	*Hymenophyllum tayloriae*	Taylor's filmy fern	G1G2
Vascular Plant	Sensitive	*Hypericum graveolens*	Mountain St. Johnswort	G3
Vascular Plant	Sensitive	*Hypericum mitchellianum*	Blue Ridge St. Johnswort	G3
Vascular Plant	Sensitive	*Ilex collina*	Longstalked holly	G3
Vascular Plant	Sensitive	*Isoetes virginica*	Virginia quillwort	G1
Vascular Plant	Sensitive	*Juglans cinerea*	Butternut	G3G4
Vascular Plant	Sensitive	*Juncus caesariensis*	New Jersey Rush	G2
Vascular Plant	Sensitive	*Liatris turgida*	Shale-barren blazing star	G3
Vascular Plant	Sensitive	*Lilium grayi*	Gray's lily	G3
Vascular Plant	Sensitive	*Lindera subcoriacea*	Bog spicebush	G2
Vascular Plant	Sensitive	*Lotus helleri*	Heller's bird-foot trefoil	G3
Vascular Plant	Sensitive	*Lysimachia fraseri*	Fraser's yellow loosestrife	G2
Vascular Plant	Sensitive	*Malaxis bayardii*	Appalachian adder's-mouth	G2?
Vascular Plant	Sensitive	*Marshallia grandiflora*	Large-flowered Barbara's buttons	G2
Vascular Plant	Sensitive	*Marshallia trinervia*	Broadleaf Barbara's buttons	G3
Vascular Plant	Sensitive	*Monotropsis odorata*	Sweet Pinesap	G3
Vascular Plant	Sensitive	*Narthecium americanum*	Bog Asphodel	G2
Vascular Plant	Sensitive	*Penstemon smallii*	Small's beardtongue	G3
Vascular Plant	Sensitive	*Plantahera integrilabia*	White Fringless Orchid	G2G3
Vascular Plant	Sensitive	*Poa paludigena*	Bog bluegrass	G3
Vascular Plant	Sensitive	*Prenanthes roanensis*	Roan Mountain rattlesnakeroot	G3
Vascular Plant	Sensitive	*Pycnanthemum beadlei*	Beadle's mountain mint	G2G4
Vascular Plant	Sensitive	*Pycnanthemum torrei*	Torrey's mountainmint	G2
Vascular Plant	Sensitive	*Rhododendron vaseyi*	Pinkshell azalea	G3
Vascular Plant	Sensitive	*Robinia viscosa*	Clammy locust	G3

Vascular Plant	Sensitive	*Robinia viscosa var.hartwegii*	Hartweg's locust	G3T1
Vascular Plant	Sensitive	*Rudbeckia triloba var pinnatiloba*	Pinnate-lobed black-eyed Susan	G4T2?
Vascular Plant	Sensitive	*Rugelia nudicaulis*	Rugel's Indianplantain	G3
Vascular Plant	Sensitive	*Sabatia capitata*	Appalachian rose gentian	G2
Vascular Plant	Sensitive	*Saxifraga caroliniana*	Carolina saxifrage	G2
Vascular Plant	Sensitive	*Scutellaria altamaha*	A skullcap	G2G3
Vascular Plant	Sensitive	*Scutellaria arguta*	hairy skullcap	G2?Q
Vascular Plant	Sensitive	*Scutellaria pseudoserrata*	A Skullcap	G3
Vascular Plant	Sensitive	*Scutellaria saxatilis*	Rock skullcap	G3
Vascular Plant	Sensitive	*Senecio millefolium (Packera millefolium)*	Divided-leaf ragwort, Piedmont ragwort	G2
Vascular Plant	Sensitive	*Shortia galacifolia var. brevistyla*	Northern Oconee bells	G2T1Q
Vascular Plant	Sensitive	*Shortia galacifolia var. galacifolia*	Southern Oconee bells	G2T2
Vascular Plant	Sensitive	*Silene ovata*	Mountain catchfly	G2G3
Vascular Plant	Sensitive	*Solidago plumosa*	Plumed goldenrod	G1
Vascular Plant	Sensitive	*Solidago simulans*	Fall goldenrod	G1
Vascular Plant	Sensitive	*Stachys clingmanii*	Clingman's hedge-nettle	G2Q
Vascular Plant	Sensitive	*Thalictrum macrostylum (=T.subrotundum)*	Piedmont meadowrue	G1G2Q
Vascular Plant	Sensitive	*Thaspium pinnatifidum*	Cutleaved meadow parsnip	G3?
Vascular Plant	Sensitive	*Thermopsis mollis var. fraxinifolia*	Ashleaf goldenbanner	G4?T3?
Vascular Plant	Sensitive	*Trillium rugelii*	Illscented trillium	G3
Vascular Plant	Sensitive	*Trillium simile*	Jeweled trillium	G3
Vascular Plant	Sensitive	*Tsuga caroliniana*	Carolina hemlock	G3
Vascular Plant	Sensitive	*Verbena riparia*	Riverbank vervain	G1G3
Vascular Plant	Sensitive	*Viola appalachiensis*	Appalachian violet	G3
Vascular Plant	Sensitive	*Waldsteinia lobata*	Piedmont barren strawberry	G2

APPENDIX E – WILDERNESS CONSIDERATIONS

Evaluation of Potential Treatment for Hemlock Woolly Adelgid in Wilderness and Wilderness Study Areas

Steps in the Evaluation

This evaluation follows the logic steps of the Minimum Requirement Decision Guide (MRDG) for Wilderness in addressing two key questions involving the potential treatment of Hemlock Woolly Adelgid (HWA) in designated Wildernesses and Wilderness Study Areas in Western North Carolina.

(1) Should treatment for the Hemlock Woolly Adelgid be considered in any Wildernesses or Wilderness Study Areas in North Carolina and would this action be consistent with the Wilderness Act?

(2) If treatment for HWA is considered, which type(s) and amount of treatment will have the least impact to the Wilderness resource while accomplishing the purpose of the proposed action?

Current Situation and Description of Significance of Hemlock Populations in Wilderness and Wilderness Study Areas

Eastern Hemlock (*Tsuga canadensis*) is present in all Wildernesses in Western North Carolina including Joyce Kilmer, Linville, Shining Rock, Middle Prong, Ellicott Rock, and Southern Nantahala. Carolina Hemlock (*Tsuga carolina*) is rarer but is present in all of these Wildernesses except for Joyce Kilmer (it has been found in the same county but its has not been confirmed in Joyce Kilmer).

Both of these species are long-lived, reaching ages of 800 years or more in some cases. Eastern hemlock is found primarily in acidic coves and related slope areas and is a dominant feature in a distinct plant community. This plant community is important ecologically in supplying shade for riparian areas as well as contributing significantly to wilderness character as a distinct visual attribute. Carolina Hemlock is located primarily on xeric slopes and is much rarer but also serves as a distinct visual attribute to wilderness character.

Within Linville Gorge, Joyce Kilmer, Shining Rock, and Ellicott Rock Wildernesses detailed plant surveys have been conducted in recent years (Newell and Peet, 1995,1996,1997 and Patterson 1994). Eastern Hemlock is generally found as a component of acidic cove and slope forests and riparian areas. It is associated with a variety of plant communities that contain species such as black and yellow oak, birch, fraser magnolia, yellow poplar, rhododendron, and others. These Eastern Hemlock community associations comprise approximately 20% of Joyce Kilmer, 25% of Shining Rock, 20% of Linville Gorge, and 20% of Ellicott Rock. Carolina Hemlock is less abundant and is found primarily on xeric slopes and rock ledges. The Carolina Hemlock community associations comprise approximately 3% of Shining Rock, 10% of Linville Gorge, and 1% of Ellicott Rock.

The quantity of both Eastern and Carolina Hemlock is estimated to be less in Southern Nantahala and Middle Prong Wildernesses than in Shining Rock Wilderness. Craggy Mountain, Lost

Cove, and Harper Creek Wilderness Study Areas have significant populations of hemlock although detailed inventories have not been conducted.

Infestations of HWA have been confirmed in all of these Wildernesses and Wilderness Study Areas. The infestation and resulting mortality may eventually reach up to 100% of both species of hemlock.

Guidance in the Wilderness Act and Forest Service Manual for Control of Insects and Disease

Specific direction regarding treatment for insects and disease is located in the Wilderness Act and in the Forest Service Manual.

Section 4(d)(1) of the Wilderness Act of 1964 states that…"such measures can be taken as may be necessary in the control of fire, insects, and diseases, subject to such conditions as the Secretary deems desirable."

The conditions and direction for insect and disease control are specified in the Forest Service Manual:

Section 2324.12 of the Forest Service Manual (FSM) states "Do not control insect or plant disease outbreaks unless it is necessary to prevent unacceptable damage to resources on adjacent lands or an unnatural loss to the wilderness resource due to exotic pests."

FSM Section 2324.15 states: "When control of insect and disease is necessary in National Forest Wilderness, it shall be carried out by measures that have the least adverse effect on the wilderness resource and are compatible with wilderness management objectives. Meet the requirements in FSM 2324.04, FSM 2151, FSM 3430, and FSM 1950 in carrying out insect and disease control projects in wilderness. Special care must be taken in the use of chemicals inside wilderness because of the possible effects on the total biological complex. Consider other alternatives to chemical use in the environmental analysis."

Hemlock Conservation Areas

Using concepts of metapopulation and Minimum Viable Population (MVP), conservation reserve areas have been identified on National Forest lands in Western North Carolina as the best places in which to maintain genetic reserves of both hemlock species and their associated plant communities. Out of 159 conservation areas identified, 29 of these areas occur in Wilderness or Wilderness Study Areas.

The conservation reserve areas in wilderness are important for several reasons. The reserve areas in wilderness are high quality hemlock populations with a wide distribution of tree ages ranging up to 500 years old. The reserve areas in Linville Gorge Wilderness are key to the genetic distribution of Carolina Hemlock. Joyce Kilmer-Slickrock Wilderness is important for its high quality Eastern Hemlock and is one of only two known areas with a high concentration of non-vascular species diversity related to hemlock plant communities. Likewise, Ellicott Rock and Shining Rock Wildernesses are important for genetic distribution in the overall design of the conservation reserve areas.

Key Questions Regarding Need for a Management Action in Wilderness

The Minimum Requirement Decision Guide (MRDG) adopted by the Forest Service, Park Service, Bureau of Land Management, and Fish and Wildlife Service outlines six key questions

to answer in determining if management action is necessary within wilderness. If the answer to several or all of the questions is "yes", then management action should be considered.

If the problem/issue is not resolved, or action is not taken, will the natural processes of any Wilderness in Western North Carolina be adversely affected?
Yes. Hemlock stands comprise a significant portion of several wildernesses and are generally considered an important component of wilderness character and an important part of wilderness as a biological "benchmark." There is a chance that both species of hemlock will be permanently eliminated in North Carolina. Loss of most or all of the hemlock plant community would be considered to adversely affect the natural process through the infestation of an exotic pest. Also, with many of the proposed hemlock conservation reserves occurring within Wilderness, the genetic viability between Wildernesses is spatially linked.

However, treatment of HWA chemically or with biological control is a human intrusion within Wilderness even though the treatment is intended to mitigate the influence of the HWA on the natural processes within Wilderness. Treatments would in essence reduce the "wildness" of the Wilderness resource by the use of chemicals or biological control to allow natural systems to operate more freely. The benefit of treatments to the operation of natural processes must outweigh the loss of "wildness" for treatments to be undertaken.

If the issue/problem is not resolved, or action is not taken, will the values of solitude or primitive and unconfined type of recreation be threatened?
Although the naturalness of the wilderness resource would be reduced, primitive and unconfined recreation would still be available. Hemlocks contribute to solitude in the sense they provide all-season vegetative screening.

If the issue/problem is not resolved, or action is not taken, will evidence of human manipulation, permanent improvements, or human habitation be substantially noticeable?
There would be no greater evidence of human habitation or manipulation to the casual observer. However, a well-informed observer would realize that the inadvertent human importation of HWA in the 1950's to the Eastern US indirectly caused the infestation and death of the hemlocks. Also, trail-clearing saw-throughs of large dead hemlocks would eventually be evident.

Does addressing the issue/problem or taking action protect the Wilderness as a whole as opposed to a single resource?
Yes. The objective of taking action would be to protect the integrity of the natural processes of wilderness ecosystems and wilderness character as much as possible.

Does addressing this issue/problem or taking action contribute to protection of an enduring resource of wilderness for future generations?
Yes. The action would be designed to mitigate the long-term effects of the HWA infestation in wilderness. At a minimum, some older hemlock plant communities would have a much better chance of being in place in the future. Quicker recovery of a significant population of both hemlock species and their associated plant communities in the future would be much more likely if components of these plant communities were maintained until the most effective methods of adelgid control are confirmed. Some treatment of the adelgid offers the best chance of these plant communities being maintained as part of the "biological benchmark" of the wilderness ecosystems without an overwhelming influence of an exotic pest.

Is this an issue/problem for reasons other than convenience or cost of administration?
Yes. Loss of the all or most of the hemlock populations is a threat to wilderness character and the integrity of the ecosystem.

Answer to Question (1)

(1) Should treatment for the Hemlock Woolly Adelgid be considered in any Wildernesses in North Carolina and would this action be consistent with the Wilderness Act?

Yes. Treatments should be considered to protect the operation of the natural systems within Wilderness by mitigating to some degree the overwhelming influence of HWA on the hemlocks and hemlock associated plant communities. The purpose of the treatment is to prevent an unnatural loss of the wilderness resource due to the expanding infestation of an exotic pest as noted in FSM 2324.12. Eastern and Carolina Hemlock and associated plant communities are significant components of wilderness character and ecosystems in Joyce Kilmer, Shining Rock, Linville, Ellicott Rock Wildernesses and is threatened with up to 100 percent mortality.

However, the benefit of treatment for HWA for protecting the "naturalness" of the wildernesses must be weighed against the loss of "wildness" from the human intrusion of the treatments. This proposal to treat or not treat in wilderness will be made in the context of the Environmental Assessment.

Consideration of the Minimum Tool Needed for Treatment of Hemlock Woolly Adelgid in Wilderness
If a proposal is made to treat for HWA in the EA, then the treatment or combination of treatments (minimum tool) with the least impact on wilderness will be chosen in the proposal. Following are the treatment options presently available for HWA.

Treatment Options
There are several options for the control of HWA through treatment
Including insecticidal soap, biological controls, and chemical treatments.

Soap Applications
Soap spraying is the application of insecticidal soap to the entire tree. It requires mechanical equipment and motorized transport of large special spraying equipment. The soap is then sprayed, soaking trees up to 150-feet tall. This is not a realistic option for wilderness due to the conflicts with mechanized/motorized equipment and the difficulty of wilderness terrain. The soap mixture is only effective in killing the HWA on the tree at that moment.

Biological and chemical applications are more effective in remote settings. These options are discussed below.

Biological Controls
Several types of beetles have been found to be predators of HWA, although the beetles are non-native. Research is on-going for biological controls. Beetles are being raised by several universities for HWA control, but the production of beetles is limited. The production level is expected to increase in the next few years. The types of beetles being raised have been found to eat only HWA or other types of adelgid. If no HWA or other adelgid is present, these types of beetles will cease to exist in that location. Once introduced in the landscape, there are still some questions regarding how quickly they can control the HWA infestations.

Chemical Treatments
Two general types of chemical treatments using imidacloprid are effective for HWA control. Tree injection is recommended for trees on stream banks to prevent any possible leaching of chemical into the soil and being transmitted in detrimental concentrations to the stream. Ground injection of imidacloprid is effective in being absorbed in hemlock roots and small groups of hemlocks away from the edge of streams can be treated in this way. The effects are documented in the EA.

Answer to Question (2)

(2) If treatment for HWA is necessary, which type(s) and amount of treatment will have the least impact to the Wilderness resource while accomplishing the purpose of the action?

The answer to this question constitutes the selection of the "minimum tool" for treatment in wilderness. The selected proposal will include the appropriate minimum tool for wilderness. The following discussion summarizes the advantages and disadvantages outlined in the previous section:

Treatment using a soap mixture is virtually impossible unless trees are directly adjacent to a road that allows access of large equipment. Biological controls are the most promising on a large scale although the production of beetles will need to increase and the overall effectiveness is being monitored. Chemical treatments using imidacloprid offer the surest method of treatment at a smaller scale. It is impractical to treat more than certain selected hemlock stands in this manner because of time and expense.

Biological control appears to be the most subtle and potentially effective means of treatment of HWA at a large scale. While biological control will be emphasized in wilderness, it may be necessary to assure a minimum level of protection of genetic distribution of hemlocks through chemical treatment in several areas to fully accomplish the purpose of the proposed action.

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APPENDIX F

Economics Assumptions for HWA Suppression on Nantahala and Pisgah National Forests

Scope of Treatments:

There are approximately 150-160 designated "significant hemlock conservation areas" on the Nantahala and Pisgah National Forests. Within all of these areas, predator beetles (as they become available) would be released. Selection of sites would be based on importance ranking of the conservation areas, degree of infestation, abundance of hemlocks, health of trees, and accessibility of live branches. A total of 1,500 to 2,500 predator beetles would be placed on 1-4 trees at each site.

Within each of approximately 70-80 of the designated "significant hemlock conservation areas" on the Nantahala and Pisgah National Forests, two to three small sites would be treated with insecticide if hemlock trees are infested with HWA. It is not feasible to save entire stands of hemlocks with the chemical methods we have at this time. High cost of insecticides, environmental protection considerations, and limited availability of HWA suppression funds will affect how many trees are treated in a given year. Within a site, only a fraction of the hemlock trees would be treated. Approximately 5-40 hemlock trees on an area up to one acre in size (209' by 209' or radius = 118') would be treated at each site. A fully-stocked hemlock stand (basal area 130 sq ft/ac) with an average diameter of 13" dbh would have about 140 trees per acre. If 100 of these trees on that acre were hemlocks, and we treated 20 trees per acre, then 20% of the hemlocks on that acre would be treated. If three sites were treated within a 125 acre conservation area, then (3/125) x 0.20 = ½ of one percent of the trees in the 125 acre conservation area would be treated.

Since the systemic effect of insecticide (imidacloprid) in hemlock needles lasts up to two years, only half of the areas selected for chemical treatment would be treated each year. Therefore, an average of 20 trees per acre would be treated each year on 3 sites within 35-40 conservation areas per year. We estimate that between 2,100 and 2,400 trees per year would be treated on less than 120 acres. Treated trees would be marked or tagged with a tree number. Also, the site name, tree #, date, diameter, and method would be recorded.

We anticipate that 90% of the chemical suppression would be done using soil injection, and less than 10% would be done by tree injection. Tree injection would be used only where proximity to water and/or lack of soil substrate would prevent the use of the soil injection method. This is because tree injection wounds the trees, costs more, requires more skill, takes longer to perform, and the effectiveness of tree injection is more dependent on environmental conditions and individual tree physiological characteristics affecting transport of insecticide to the foliage. Therefore, only high value hemlocks would be treated by tree injection.

Release of predator beetles in stands of HWA-infested hemlocks:

In advance of releasing beetles, sites must be identified, located on the ground, GPS'd, mapped and marked. We estimate $10,000 will be required in FY 2005 to check for level of infestation or to monitor the effectiveness of a previous beetle release. This would cover about 20 days each for two District people, one on the Nantahala NF and one on the Pisgah NF. Forest Health Protection might contribute an additional $5,000 in labor for their employees.

The actual job of obtaining, transporting, and releasing predator beetles would be primarily done by Forest Health Protection personnel. They would probably request a District person to accompany them to the sites to guide and assist them. Next to the cost of the beetles themselves (about $1.00 each or $2,000/site), transportation to and from these remote and scattered areas would be the most expensive aspect. We estimate that 3 release sites could be visited per day at a cost of $200 per site. The National Forest's share of this would be $15,000 (150 sites x $100/site).

Total cost for beetle releases at 150 sites would be approximately $300,000 for beetles, $15,000 for identifying sites, and $30,000 for placing beetles on infested trees, or about **$2,300 per site**. More than one year would probably be required to accomplish releases at all 150 sites.

Soil injection with Merit 75WP (imidacloprid) insecticide:

Soil injection with Merit 75 WP is the most effective treatment for long-term control, and it is the least labor-intensive of the chemical methods. According to label directions, a maximum of 8.6 ounces of Merit 75 WP (which would cost about $165) can be applied per acre per year to reduce risk of groundwater contamination. Where many infested trees occur per acre, trees-to-be-treated would need to be identified and measured in advance to prevent us from exceeding 8.6 oz/ac/year.

Each 2-ounce bottle of Merit 75 WP (75% imidacloprid) powder is mixed with sixty (60) ounces of water, so 8.6 ounces would make 266 ounces of suspension (2.4% imidacloprid). Using soil injection with a Kioritz Soil Injector, one ounce of mixture is applied to the root zone of a hemlock per inch of tree diameter at breast height (dbh). Therefore, a maximum of 266 cumulative dbh inches can be applied to an acre in a given year. This could be 44 six-inch trees or 8 thirty-three-inch trees @ $0.62/inch for insecticide.

We estimate that about 6 hours ($375) would be needed by two people to tag, measure, and inject the soil around 18 trees at each of 3 sites within a conservation area. This would require about 6 gallons of insecticide in water to be mixed, carried, and loaded into the injector at a cost of $495. As with the beetle releases, transportation to and from the site is a major cost, perhaps about $270 per day for mileage plus labor. At the end of a day, equipment would need to be cleaned, calibrated, and properly stored for use the next day, costing about $60 per day. Therefore, **soil injection cost would be roughly $1,200 per day, or $400/site, or $22 per tree.** Total cost for soil injecting on 3 acres within each of 35-40 conservation areas (1,890-2,160 trees) would be approximately $45,000 in FY 2005.

Tree injection with imidacloprid insecticide on selected trees where soil injection cannot be used:

Using an approved insecticide tree injection system, product would be injected at approximately 4 ml/inch DBH, so 256" (20 trees) would require about 1 liter at a cost of $650. In addition, 4 plugs per tree would be needed at $1 each, so for 20 trees the cost would be $80. Approximately 3-6 trees can be injected per hour, so 6 trees per area (10% of 60 trees) would cost **$300 per area, or $50 per tree**, not including transportation or cleanup cost. If tree injection alone is being used on an area, the $330 per day for transportation and cleanup would be added. **Treating 20 trees by tree injection alone would cost approximately $1,300 or $65 per tree**. Total cost for tree injecting 6 trees within each of 35-40 conservation areas (210-240 trees) would be approximately $11,250 in FY 2005.

Summary of annual suppression costs:

The funds needed for chemical suppression of HWA in NFsNC in a given fiscal year would be **$56,250**, which is $45,000 for soil injection and $11,250 for tree injection. This would be approximately **$1,500 per conservation area treated.**

The funds needed for predator beetle releases of HWA in NFsNC in a given fiscal year would be **$345,000.** This includes $300,000 for beetles, $20,000 for Forest Health Protection salaries, and $25,000 for District costs, or about **$2,300 per conservation area.**

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