The Effects of Management Practices on the Health of Forest Vegetation

Question 8:

How are current and past management affecting the health and integrity of forest vegetation in the Southern Appalachians?

The assessment focused primarily on forest management activities that involve manipulation of vegetation. Unquestionably, other activities such as land use conversion, mining, grazing, and agriculture can have significant impacts on the structure and composition of the forest. Other reports prepared for the assessment included discussions of some of these impacts.

Four major topic areas were examined: (1) past management, primarily from the early 1900s throughout the 20th century; (2) recent forest management on national forests and private land; (3) current timber markets, growth, and inventory on public and private lands; and (4) three forms of active management that can have significant effect on future forest health–integrated pest management, genetic resource conservation programs, and improved monitoring systems.

History of Forest Management

Timber harvesting in the early 1900s dramatically affected the Southern Appalachian Assessment (SAA) area landscapes. Between 1900 and 1920, roughly 60 percent of the Southern Appalachian forest was cut over. In 1908, the Secretary of State's report estimated 86 percent of the acreage in the Southern Appalachians was cleared; in various stages of regrowth; or in young, secondary forest. According to the report, practically the entire Southern Appalachian forest had been burned. The land-use practices of the late 19th century and early 20th century resulted in large expanses of even-aged forests. Multiple-use management and fire control were instituted on public land after the Great Depression. Tourism and recreational use skyrocketed between 1945 and 1960. In 1963, even-aged management became national forest policy and common practice in the Southern Appalachian national forests (Yarnell 1995). Since that time, even-aged harvesting on national forests has been done on about 0.5 percent of the national forest acreage annually. Thus, about 5 percent has been cut per decade.

Recent Trends in Forest Management

The health of forest vegetation is affected by both past and current management. Past impacts have greatly influenced stand composition and structure. Some current pest problems and predictable future problems may be directly or indirectly the result of past events. An example is found in the current dominance of oak types in the SAA area. Oak has always been an important component of the ecosystem, but probably became more important with the loss of chestnut to chestnut blight in the early 20th century. Other activities of that time, including abusive logging practices, grazing, and wildfire, may have created conditions more favorable for oak regeneration than for pioneer tree species. These young oak stands gave rise to current oak overstory dominance. Many oak stands today, however, are vulnerable to oak decline, a stress-mediated disease complex of mature oak. Now and in the near future, another agent of change, the gypsy moth, threatens to further impact oak forest types because oaks are the preferred food source of gypsy moth. Oak defoliation coupled with decline is likely to cause high mortality rates in oak forest types. As a result, the current trend in vegetation for much of the SAA area is toward a reduction in stocking of oaks, and toward a forest dominated by maple, yellow-poplar, ash, blackgum, and perhaps white pine.

Table 7.1 A summary of the acres of silvicultural activities for private and state owned land by states within the Southern Appalachian Assessment area between October 1, 1989 and September 30, 1994.

	Treatment Acres[1]			
	Tree Planting	Natural Regeneration	Timber Stand Improvement	Prescribed Burning[2]
Alabama	27,689	844	20,935	21,462
Georgia	359,924	780,000	3,500	826,000
North Carolina	10,455	11,114	1,063	2,030
South Carolina	9,810	10,500	1,465	3,197
Tennessee	68,149	226	601	65,064
Virginia	52,691	20,008	30,345	7,854
Total	518,718	822,692	57,909	925,607

[1]Acres derived from state reports collected at the district (multi-county) level. Since state districts do not coincide precisely with counties in the Southern Appalachian Assessment (SAA) area, acres include activities in some counties outside the SAA area.

[2]Includes burning for fuel reduction, hardwood control, wildlife habitat, Threatened and Endangered species and site preparation.
(Source: State Foresters)

Forest Management on Public and Private Land

The possible effects on vegetative structure and composition, and consequent effects on forest health were assessed by compiling information on private land and a sample of SAA national forests. To assess the amount of various forestry activities on private and state land in the SAA area, questionnaires were sent to state foresters. Case studies were done on three national forests with land primarily in the SAA area. Herbicide use from 1991 to 1994 was assessed. Kinds of products, rates of application, and acres treated were determined for the case study on national forests.

Over 3 million acres of public and private land in the SAA area have received some form of vegetation management treatment during the past 6 years. Table 7.1 shows 1989 to 1994 for each state, based on information provided by state foresters: the amount of tree planting, natural regeneration, timber stand improvement, and prescribed burning on private and state land. Over the whole region, 38 percent of the regeneration was accomplished naturally and 62 percent by tree planting. Table 7.2 shows a trend toward natural regeneration since 1988 (Lantz 1994). The implications of this trend for forest health are probably mixed.

Natural regeneration, which is generally associated with less intensive site preparation, will usually result in more vegetatively diverse mixed pine-hardwood stands which should be more resistant to some pests.

Even-age regeneration harvesting (clearcutting, seedtree, and shelterwood systems) on national forests is declining (table 7.3). For the case study forests, only about half as much regeneration harvesting occurred in 1994 as in 1991. Site preparation for artificial regeneration, tree planting, and timber stand improvement acres have declined over the last five years.

Acres treated with herbicides on the three case forests declined dramatically from 1990 through 1994. Methods of herbicide application are shifting from broadcast toward individual stem treatments on public lands.

Table 7.2 The trends of harvested versus planted acres within the Southern Appalachian Assessment area for the years between 1988–1994.

Season	Acres Harvested (M)	Acres Planted (M)	Percent Planted
1988-89	3,675	2,290	62
1989-90	3,660	1,912	52
1990-1991	2,667	1,709	64
1991-1992	3,038	1,721	56
1992-1993	3,392	1,691	50
1993-1994	4,066 (estimated)	1,696	42

Table 7.3 An acreage summary of some vegetation management activities for the Cherokee, George Washington, and Jefferson National forests case study from 1990 to 1994.

	1990	1991	1992	1993	1994
Cherokee National Forest					
Regeneration Cutting (Even–aged method)	N/A	2,928	2,219	1,084	1,036
Thinning	N/A	10	71	220	298
Tree Planting	1,540	1,444	1,488	1,194	1,000
Site Preparation for Natural Regeneration	834	1,096	950	1,288	1,109
Natural Regeneration without Site Preparation	0	0	613	82	108
Site Preparation for Artificial Regeneration	1,810	1,811	1,722	1,150	841
Timber Stand Improvement	3,233	1,390	1,798	1,441	1,219
George Washington National Forest					
Regeneration Cutting (Even–aged method)	N/A	1,950	1,754	1,369	971
Thinning	N/A	304	268	286	294
Tree Planting	736	513	534	340	90
Site Preparation for Natural Regeneration	2,363	2,149	2,373	2,058	1,535
Natural Regeneration without Site Preparation	0	0	0	0	0
Site Preparation for Artificial Regeneration	464	452	328	163	42
Timber Stand Improvement	862	1,429	678	1,010	575
Jefferson National Forest					
Regeneration Cutting (Even–aged method)	N/A	876	694	1,214	489
Thinning	N/A	379	71	72	0
Tree Planting	438	358	259	396	383
Site Preparation for Natural Regeneration	2,087	1,666	1,657	787	597
Natural Regeneration without Site Preparation	0	0	68	614	406
Site Preparation for Artificial Regeneration	459	278	255	244	199
Timber Stand Improvement	1,071	975	969	1,707	907

For national forests in the SAA area, essentially no prescribed burning to control understory species was accomplished between 1990 and 1994. Little or no controlled burning has been done on National Park Service land in recent years.

Changes in Land Use

Changes in land use with regard to the utilization of timber products have a great impact on stand structure and composition which in turn affect forest health. These land use changes are often a result of many factors: “The supply of timber is more complex than the supply of most commodities, because timber is produced by dynamic forests and controlled by a variety of owners. The inventory of timber growing stock can be altered by timber harvests, natural forces, or investments in regeneration and stand improvements. Harvest and investment decisions in turn are influenced by competing demands for forestland and landowner preferences.” (SAMAB 1996C).

Forest acreage has decreased by 2 percent since the mid-1970s. This decrease in forested acres is expected to continue at the same pace through the year 2010. This loss of forest acres is occurring primarily on private lands. Clearing is for development and conversion to agricultural use. See Chapter 3 for additional discussions of changing land use patterns.

Existing Timber Inventory and Markets

A number of key findings included in the timber economy chapter of the SAA Social/Cultural/Economic Technical Report is relevant to this issue of current management and its effect on forest health (SAMAB 1996c):

1. National forests, on average, produce less timber than private lands in the region. As a result, national forests have more timber inventory per acre, less removal, less growth, and slightly higher mortality than private land in the area.
2. While holding 17 percent of the timberland in the SAA area, the national forests hold a disproportionately high share of the highest-valued sawtimber. It is likely that national forests will continue to have a dominant influence over the production, and therefore the prices, of high-quality oak sawtimber in the Southern Appalachians.

3. Timber production from the national forests of the region expanded from the late 1970s through the mid-1980s. After peaking in 1985, timber sale levels have declined in the region, especially in 1991. (See table 7.4 for acres of harvest for the SAA national forests from 1991 to 1994.) Current sale levels are now roughly comparable to those of the 1970s.

Forest Health and Timber Supply

Ultimately, increased mortality and reductions in growth resulting from forest health problems could have important effects on forest management and timber supply in the Southern Appalachians. Three forest health issues are particularly relevant to timber supply: (1) gypsy moths in the northernmost part of the region, (2) oak decline from southern Virginia to northern Georgia, and (3) southern pine beetles in the southern quarter of the SAA. Mortality and forest growth rates across the timber subregions were examined for evidence of these impacts, but none was found. There may be a substantial lag between pest incidence and growth/mortality effects measurable in regional surveys. Continued monitoring and further research of pest impacts on timber supplies are warranted.

The assessment of timber markets in the SAA indicates that markets for high-quality oak species are especially strong. In addition, it indicates that markets for low-quality material for pulp and composite board manufacture are also expanding. Taken in combination, these findings suggest that more intermediate treatments of oak stands could become economically viable in the future. Intermediate treatments could also improve stand vigor, thereby mitigating the effects of oak decline in these stands. Evolving markets may therefore provide an opportunity to improve forest health.

Integrated Pest Management

Native insects and pathogens are normal parts of functioning forest ecosystems and can profoundly influence forest structure, species composition, and diversity. Some of these functions include regulating populations of woody and herbaceous plants and, hence, regulating forest succession, carbon, and nutrient cycling; serving as a food source for vertebrates and invertebrates; creating wildlife habitat; pollinating; and acting as mycorrhizal symbionts. It is neither desirable nor possible to eradicate them on a broad scale.

By contrast, introduced insects, pathogens, animals, and weeds are not normal parts of the invaded ecosystems. For the most part, their effects are similar to natives, but the magnitudes of the changes they cause are more extreme. This is due to the lack of co-evolved resistance mechanisms in their new hosts and the absence of the parasites, predators, and diseases that served to regulate their populations in their native ecosystems. A few beneficial parasites have been introduced to control other introduced insect pests.

Some of the insects and pathogens introduced into the SAA area include the chestnut blight fungus, the European gypsy moth, the beech bark disease insect-pathogen complex, the hemlock woolly adelgid, the balsam woolly adelgid, the dogwood anthracnose fungus, the butternut canker fungus, the Dutch elm disease fungus, and the Asiatic oak weevil.

Insect and pathogen populations fluctuate over time. Examples of extreme population sizes from the SAA are an outbreak of elm spanworm (a native insect defoliator) that occurred between 1954 and 1964 in north Georgia, western North Carolina, and eastern Tennessee (Ciesla and others 1963, Ciesla and others 1965) and the chestnut blight epidemic that covered the SAA during the 1920s and 1930s. In the former case, the outbreak collapsed due primarily to a native wasp parasite of elm spanworm eggs. A previous outbreak of this insect was recorded between 1878 and 1881, when about 1.5 million acres were defoliated. Chestnut blight had no prior history in the SAA area before being detected in 1908. The blight did not abate until virtually all American chestnut trees in the SAA were killed. The tree persists today as small stump sprouts in the understory, growing for a few years until it is killed back to the ground.

In an ecological context of ecosystems, the term “pest” is meaningless. Only when human values are introduced does “pest” acquire meaning: an insect or pathogen that reduces natural resources that are valued by humans. Pest management is the application of techniques to protect human values against impacts that are in conflict with human values. Integrated pest management (IPM) “is an

Table 7.4 A summary of acres by cutting method for national forests within the Southern Appalachian Assessment area for 1991 to 1994.

	Acres Sold by Cutting Method				
	Regeneration Cutting[1]		Thinning		Total
Forest	(Acres)	(%)	(Acres)	(%)	(Acres)
FY 1991					
Talladega	1,305	53	1,167	47	2,472
Chattahoochee	3,686	66	1,879	34	5,565
Cherokee	2,928	78	10	22	2,938
George Washington	1,950	87	304	13	2,254
Nantahala/Pisgah	1,639	81	396	19	2,035
Andrew Pickens	0	-	0	-	0
Jefferson	876	70	379	30	1,255
Total	12,384	75	4,135	25	16,519
FY 1992					
Talladega	1,134	37	1,928	63	3,062
Chattahoochee	2,855	66	1,469	34	4,324
Cherokee	2,219	97	71	3	2,290
George Washington	1,754	87	268	13	2,022
Nantahala/Pisgah	1,936	72	747	28	2,683
Andrew Pickens	17	18	79	82	96
Jefferson	694	91	71	9	765
Total	10,609	70	4,633	30	15,242
FY 1993					
Talladega	243	17	1,198	83	1,441
Chattahoochee	1,718	42	2,353	58	4,071
Cherokee	1,084	83	220	17	1,304
George Washington	1,369	83	286	17	1,655
Nantahala/Pisgah	1,512	68	712	32	2,224
Andrew Pickens	0	0	339	100	339
Jefferson	1,214	94	72	6	1,286
Total	7,140	58	5,180	42	12,320
FY 1994					
Talladega	668	12	4,708	88	5,376
Chattahoochee	1,557	44	1,997	56	3,554
Cherokee	1,036	78	298	22	1,334
George Washington	971	77	294	23	1,265
Nantahala/Pisgah	1,353	64	776	36	2,129
Andrew Pickens	16	11	129	89	145
Jefferson	489	100	0	0	489
Total	6,090	43	8,202	57	14,292

[1]Includes clearcut, seedtree, and shelterwood methods

ecological approach to pest management where all available necessary techniques are consolidated into a unified program, so that populations can be managed in such a manner that economic damage is avoided and adverse side effects are minimized." (National Academy of Sciences 1969). IPM arose out of concern over widespread use of non-selective pesticides in the 1960s with little regard for ecosystem impacts. It has evolved from a simplistic blending of biological control agents with more traditional chemical insecticide treatments and acknowledges the many interactions that exist between insects, plant diseases, and the environment.

In the above definition, the word "economic" could be replaced by "scenic, biologic (as in biodiversity), wildlife habitat, human health and safety," or any other management objective (i.e. social value) alone or in combination. However, the actual or perceived economies of these social values determine whether an IPM program and implemented. Social values without easily quantified economies will support IPM programs only when a high level of difficult-to-obtain social consensus exists. The vast majority of epidemics and outbreaks of forest insects and pathogens is not managed either before the fact as prevention, or after the fact as suppression or attempted eradication.

As defined by the National Academy of Sciences (1969), the basic principles of IPM are:

- consideration of ecosystem functions;
- utilization of indigenous natural control agents;
- maintenance (or enhancement) of ecosystem complexity;
- avoidance of ecologically disruptive actions;
- application of minimum selective hazards;
- exclusion from new areas;
- host plant adaptability to ecosystems;
- prediction of population trends; and
- maintenance of sub-economic (or other social value) thresholds.

IPM methods can be classified into four categories: prevention, silvicultural, biological, and chemical.

Preventative methods include such activities as risk rating of landscapes prior to infestation, training personnel, detection, diagnosis, and evaluation of those threats, and exclusion of threats from areas of interest where they do not yet exist.

Silvicultural methods involve maintaining or enhancing resistance to and resilience after stress. These can include the improving of tree and/or stand vigor by thinning, salvage of individual trees or stands that pose threats to surrounding forests, proper selection of harvest method and scheduling, and the use of prescribed fire. Applied genetic methods of silviculture include: matching tree species to the sites that they are best adapted, selecting the most competitive individuals, and using genetically improved stock.

Biological methods include the use of behavioral chemicals such as sex or aggregation pheromones; the use of viruses, bacteria, or fungal pathogens; and the use of parasitic or predatory insects. Since behavioral compounds are synthetic, sufficient quantities are available for large scale detection surveys and eradication projects.

Chemical methods involve the application of direct chemical control agents such as insecticides, fungicides, or in some cases, herbicides.

IPM approaches are rarely applied in the SAA area due primarily to economic and political considerations. The public generally has incomplete knowledge of, and/or lacks consensus on the threats to economic or social values of most forest insects and pathogens, although millions of acres are affected each year. Where sufficient perception, knowledge, and a degree of consensus exist (such as for gypsy moth and southern pine beetle management) IPM programs are employed. These programs are detailed in Environmental Impact Statements (EIS) that guide federal cost sharing for detection, evaluation, and treatment of infestations of these two pests (USDA FS 1987, USDA FS 1995). Several steps are common to both programs. These are:

- survey and detection;
- evaluation of resources at risk;
- economic analysis;
- project proposal;
- National Environmental Policy Act (NEPA) analysis (environmental analysis, public involvement, evaluation of alternatives, selection of preferred alternative);
- project implementation; and
- post-eradication or post-suppression evaluation.
- Monitoring of project results is used to guide and inform research and development of new technologies.

Appendix G includes IPM techniques for Gypsy moth and SPB.

Genetic Conservation Programs

Several tree species in the Southern Appalachians are at risk of extinction or significant genetic loss because of exotic pests. These include American chestnut, chinkapin, butternut, eastern and Carolina hemlock, Fraser fir, flowering dogwood, and American beech. Gene conservation strategies and adequate support are needed to address both short-term and long-term concerns. A small amount of genetic material is conserved in national seed conservation facilities and arboretums, but there is no coordinated, funded strategy to address the gene conservation for most of the imperiled or potentially imperiled woody plants in the Southern Appalachian area.

There is an obvious dilemma in considering what species should be chosen for protection when there are many in need. One criterion must be rarity. Some taxa are naturally rare, whereas others are artificially rare as a result of human actions. Species that have not evolved under situations of rarity may be biologically less stable than those that are naturally rare. Off-site protection may be the best approach for conserving hemlock, butternut, chestnut, chinkapin, Fraser fir, high-elevation samples of flowering dogwood, and American beech. A combination of seed banking germplasm and the outplanting of samples in operational seed orchards would be necessary to conserve genetic material.

The threats from exotic pests for species of most concern in the SAA are particularly menacing. These species are showing little to no host resistance and many (if not all) may be lost as ecosystem components within the next two decades. Due to the severity of pest effects and a low probability of natural resistance, adequate onsite protection is not feasible. Because many of the species are not commercially important, they are not included in typical federal, state, or private genetic resource programs. Two of the species, Fraser fir and American beech, are important components of unique ecological communities–Fraser fir as a component of high-elevation spruce-fir and pure Fraser fir types and American beech as a component of high-elevation beech/birch/maple types, beech gaps, and beech boulderfields. Weakened or nonexistent populations of the above species will have great ecological ramifications.

Historically, tree breeding programs are fairly young. In 1958, the USDA Forest Service (FS), Region 8 Tree Improvement Program was begun. Currently, the Southern Region has readily available, high-quality tree seeds. Established seed orchards are capable of producing most of the seeds needed for reforestation.

Oaks

Northern red oak and white oak are the two most valuable hardwood species found growing in the southern Appalachians and the Piedmont. Both of these species occur widely, and both are very valuable for timber and for wildlife habitat. Neither species is adequately regenerating, either naturally or artificially. A considerable amount of effort and funds is being expended on silvicultural methods to regenerate these species of oak naturally. These methods have not been developed to the point that they can be easily applied. In stands impacted by disease and insects and in stands that have been harvested or will be harvested in the near future, no known methods exist to regenerate oak consistently. Oak seedlings can be planted and generally have adequate survival probabilities. Problems with initiating height growth occur in plantings. In addition, oak seedlings that are being produced in state and private nurseries are extremely variable in quality, and many times seed source and genetic quality are not known. There are currently no standards for acceptable oak seedlings.

Butternut

Butternut is being eliminated from our ecosystems by *Sirococcus clavigigenti-juglan-dacearum,* an exotic fungus that causes a lethal canker. Harvest of all butternut is restricted on federal lands.

There is one ongoing butternut project in the SAA area. The University of Tennessee (UT), FS - Region 8 (Genetic Resources Program and Forest Health), National Park Service–Great Smoky Mountains National Park (GSMNP), and the Tennessee Division of Forestry have been cooperating on butternut conservation. In 1994, butternut genetic conservation/disease screening plantations were established at the Beech Creek Experiment Station, Bent Creek Experimental Forest; North Central Forest Experiment Station experimental farm at Carbondale, Illinois; Francis Marion Seed Orchard; and UT. Another butternut genetic conservation test (nursery phase) performed at the East Tennessee State Nursery (Tennessee Division of Forestry) will be outplanted in the winter of 1995 to 1996. A butternut breeding orchard has been established at UT also. The test and grafted clones contain susceptible butternut, putative resistant butternut, and heartnut (Japanese walnut cultivar), which has resistance to butternut canker.

Future plans are to continue to survey for resistant and immune butternut and butternut x heartnut hybrids (buartnut or butterjap). Nuts will be collected and materials placed in genetic conservation/disease screening tests. A research group in the FS in the Lake States is actively working on a screening program for disease resistance. Any materials collected and propagated in orchards would be made available for their testing and breeding.

Hemlock

The hemlock woolly adelgid is an exotic pest that is destroying eastern hemlock over a considerable portion of its range. Hemlock is being killed by the adelgid in the George Washington National Forest, Jefferson National Forest, Shenandoah National Park, and along the Blue Ridge Parkway in northern Virginia. Its range increases along the Blue Ridge Mountain chain each year. It is anticipated that the Carolina hemlock will be similarly impacted. Due to the restricted habitat of the Carolina hemlock, it is highly probable that it will soon achieve endangered status.

Eastern hemlock shows no observable levels of resistance and there are no known biological controls for this pest. The adelgid appears to have the potential to eliminate eastern hemlock from major portions of its range. The Carolina hemlock, a close relative of eastern hemlock, could be in danger of extinction if the pest moves into western North Carolina and east Tennessee.

A passive conservation approach would be to collect samples of the native hemlock, either seed or cuttings for grafting, and establish the material in genetic conservation areas that can be protected from the insect with IPM practices. The area would need to be established where chemical pesticides could be used for protection from the insect.

A more active conservation approach would be to establish a selection and breeding program. Some work has been done and some information has been gathered by the National Arboretum. The insect, imported from China has a variable effect on native species of hemlock in China and Japan. In the U.S., western hemlock (*Tsuga heterophylla*) may also be resistant to this pest. It is possible that resistant hybrid hemlocks can be produced. Hemlock also produces steady cone crops at reasonably young ages which facilitates testing.

Dogwood

Flowering dogwood is a small tree occurring in the understory of eastern North American forests. The species is an important

valuable. It is also widely planted into landscapes. In the late 1980s, a fungal disease, dogwood anthracnose, began killing individual trees in the northern United States.

The FS annually looks for potentially resistant trees throughout the National Forest System to contribute to the Resistance Screening Center at Asheville, North Carolina.

Despite 5 years of work and testing of 300 seed lots (each seed lot represents one parent tree), very few potentially resistant seed lots have been identified (Young 1995). Nevertheless, some closely related species, both North American and Asian, and some individuals of the native flowering dogwood have been found to be resistant to the fungus. If breeding and screening procedures prove successful, it may be feasible for a full-scale program to be developed to restore dogwood to the landscape. In a program of this type, existing personnel, equipment, and available land at the Genetic Resource Management facilities could be utilized as a breeding/genetic conservation area for the production of resistant dogwood seed.

American Chestnut and Allegheny Chinkapin

The chestnut blight fungus devastated American chestnut and Allegheny chinkapin populations in the 1920s and 1930s. Although the above-ground portion of the trees were killed, the chestnut blight fungus does not affect the root systems. American chestnut now exists as a relatively short-lived sprout and Allegheny chinkapin forms small bushes. Observations of chestnut sprouts and chinkapin bushes over time indicate that there is a continuing population decrease.

No methods of controlling the blight are known. The abundance of species is rapidly declining. Both chestnut and chinkapin depend on disturbance to replenish the root reserves and/or stimulate abundant fruiting. If active gene conservation of these species is not undertaken soon, both will probably become extinct. The most feasible means would be to collect specimens of both species and propagate them for genetic conservation until a solution to the blight arises. A crossing program with Asian species may be developed, biotechnology might provide relief in the form of a resistant tree or an altered disease organism, or virulent form.

Some active breeding work in various locations and research into altering the disease to one less virulent that could displace the present strain is being performed. Genetically engineered resistance has been accomplished for an extremely limited number of crop species. No adequate tissue culture system, however, is now available for these species and any alleles that may provide resistance are unknown. From a technical perspective, funding molecular research at this time appears to be a poor choice over traditional research. Regardless of research approaches, it is imperative that some genetic material be preserved now for the future opportunities to work with these species.

Table Mountain Pine

Table Mountain pine has relatively no commercial value as a timber species due to its poor form. It is relatively rare to find stands of this fire-dependent, serotinous-coned species today in the Southern Appalachians. The species is currently being lost to bark beetles, stand decadence, and the marked absence of stand replacement fires. Without intervention and/or direct management of the species, much of the remaining genetic diversity in the species could be lost over the next decade.

American Beech

American beech is currently threatened by beech bark disease, an exotic pest problem. Because beech occurs over a very large geographic area, the disease isn't a problem throughout its range. Where affected, beech stands have been greatly impacted. In the Great Smoky Mountains National Park, a few stands have been affected.

Although there is a greater likelihood for some natural genetic resistance because the species is widespread throughout the southern United States; so far, natural resistance has not been documented, and the threat posed by the disease could be as great as was the threat from chestnut blight. (Chestnut also had a large geographic range.) The species is as ecologically important as a hard mast producer; as a den tree; as a component of beech, birch, and maple communities; and as a keystone species in high elevation beech gaps and beech boulderfield plant communities. Resistance screen-

undoubtedly be needed for this species in the future.

American Elm

The loss of American elm from the exotic Dutch elm disease is well documented for urban and historical settings. Little is documented regarding the role of elm as an ecosystem component. Some efforts have been made to cross Siberian and other Asian elms with American elm to produce a disease resistant variety. Further research could be done to determine the feasibility of reintroduction of American elm into its historical range where it is now absent.

Improved Monitoring Systems

Forest monitoring systems should be able to provide information to landowners and managers on the ecological status of forests; what changes are occurring; what the causal agents of the change are; if changes indicate a trend; what the expected outcome is if trends continue; and what effect management decisions might have on existing conditions. To enable land owners and managers to manage forest ecosystems in a sustainable manner, both spatially and temporally, intensive and extensive monitoring systems are needed. In addition, sustainable management of forests needs to consider the socioeconomic benefits of healthy forests and the legal, institutional, and economic infrastructure that will be necessary.

A forest monitoring system should provide annual reports on the condition of forests. Forest ecosystems are dynamic, and forces acting upon those dynamics can change quickly.

The Forest Health Monitoring (FHM) program is a multi-agency program led by the FS. This program has four main components: Detection Monitoring, Evaluation Monitoring, Intensive Site Ecosystem Monitoring, and Research on Monitoring Techniques. The focus of FHM is to evaluate the condition, changes, and trends in indicators of U.S. forest ecosystem health; monitor indicators of pollutant exposure and habitat condition; seek associations between human-induced stresses and the ecological condition of the forests; and provide annual reports and periodic interpretive assessments on the ecological status and trends to