NATIONAL PARK SERVICE
GREAT SMOKY MOUNTAINS NATIONAL PARK
BRIEFING STATEMENT
August 2010

SUMMARY OF FOREST INSECT AND DISEASE IMPACTS

Forests of the Smokies are known for their diversity, beauty and old growth remnants. Several species of forest insects and diseases introduced from other continents have found suitable habitat and tree hosts here. These pests continue to cause serious damage since genetic resistance and/or biological and environmental controls are limited. Others have not yet arrived but have the potential for future impact. Native forest pests may cause periodic episodes of tree mortality but rarely result in widespread ecological devastation.

Pest Species Currently Present in the Park:

Hemlock woolly adelgid (HWA)

This Asian relative of the balsam woolly adelgid was found in the park in 2002 and has rapidly spread throughout all areas of the park that contain hemlock. HWA was considered an unimportant pest on ornamental hemlocks when it was first discovered in Richmond,VA in 1952. It subsequently spread into natural forest stands throughout the mid-Atlantic states and has become one of the region's most serious forest insect problems, with infestations extending south into Georgia and north into New England. HWA attacks several species of hemlock, but eastern hemlock (*Tsuga canadensis*) is the only hemlock species found in the park. The insect is easily dispersed by birds, wind or infested horticultural material, and all ages of hemlocks from seedlings to old growth are vulnerable to ecological extinction.

HWA feeds at the base of the tree's needles, reproducing exponentially and sometimes causing tree death in as little as two years. Insecticidal control is possible in landscape settings but is difficult for natural stands. The park currently controls HWA with insecticides and release of biological control insects. Biological control holds the best hope for long-term control of HWA at levels that will allow hemlock trees to survive. Early results of biological control with several Asian species of beetles that feed exclusively on HWA show promise. Virgin hemlock stands in the park are particularly vulnerable since they are aging and not vigorous; these stands have been a high priority for treatment with biological controls. For more information about HWA, as well as photographs, visit the USDA Forest Service website at: http://na.fs.fed.us/fhp/hwa/

Vegetation mapping shows a large hemlock resource in the park. Nearly 1500 acres of old growth hemlock have been documented with some trees in excess of 500 years old, six feet across, and 170 feet tall. The park's total hemlock resource has been mapped at more than 137,000 acres with over 14,000 acres of hemlock-dominated forest. The hemlock forests provide unique habitat for plant and animal species, including stream edge (riparian) species. Studies in Delaware Water Gap National Recreation Area showed that hemlocks are important in moderating stream temperatures and influencing overall stream habitat.

Hemlock is a key component of many forest types in the park, and stands where hemlock dominates are not uncommon. No other evergreen species is capable of filling the ecologically critical role of hemlock.

A Finding of No Significant Impact was prepared in December, 2005 in response to the public scoping process and affected agency review of a draft environmental assessment (EA) for Hemlock Woolly Adelgid Control Strategies in GRSM. The EA offered five alternatives: No Treatment, No Action (no change from current level of treatment), Chemical Control Only, Biological Control Only, and Both Chemical and Biological Control. The option of "Both Chemical and Biological Control" was chosen as the Preferred Alternative.

Work to preserve eastern hemlock trees and forests in FY 2010 progressed successfully despite increased tree health decline and obvious mortality of trees throughout the park. Areas of particular focus have been in the Park's eastern areas near Cosby, Big Creek and Cataloochee. Some untreated higher elevation stands over 4,500 ft. continue to survive, perhaps because of colder winter temperatures and rime ice. All front country areas received an annual foliar application of insecticidal soap or oil totaling 600 acres. All trees in the front country campgrounds and heavily visited areas were retreated with systemic insecticides if needed. These were initially treated five years ago when the trees were, for the most part, very healthy and adelgid populations were low. Service contracts completed in 2009-2010 used a new systemic treatment that has shown rapid results in controlling HWA on some of the largest old growth trees in poor health.

Work in the Conservation Areas (CAs) consisted of applying a second treatment to the very large trees based on research, establishing new CAs, and expanding existing areas. Fifty of the 81 existing conservation areas have received a second treatment. Of the over **132,000** trees systemically treated since the project started over 20,000 of these have been treated in FY 2010 to date. With the returning rains of 2009 many treated trees showned a positive response to past treatments and untreated trees will respond as well if treated within the next two years.

Some of the new CAs of interest are located:

- Adjacent to the Gabes Mtn Trail in Cosby,TN adding an estimated 56 acres
- Adjacent to State Route 284 in Cataloochee,NC adding an estimated 68 acres
- Adjacent to the Enloe Creek trail in NC, adding an estimated 249 acres

To date, 12 new CAs have been created in FY 2010, totaling 700 acres.

In addition to chemical controls, Park resource managers have been releasing biological control insects for HWA control since 2002. *Sasajiscymnus tsugae*, or St, is a tiny beetle native to Japan. *Laricobius nigrinus*, or Ln, is native to the Pacific northwest. *Scymnus sinuanodulus, or Ss,* is native to China and is just beginning to be released for HWA control in the southeast. There were 56 releases of the St predatory beetle totaling 56669, five Ln releases totaling 1134 beetles, and one Ss release totaling 55 beetles. Positive recovery of beetles has been made in multiple Conservation Areas this year from releases as far back as 2002, though overall success

has yet to be determined and will play out over the coming years. Since 2002 the park has released over 500,000 predator beetles as part of the overall control effort.

Sampling of canopy needles to determine effective length of treatment has been a focus of a research project, with trees that were treated up to seven years ago found to be adelgid free. This sampling will give the park a better understanding of proper long term management of the tens of thousands of trees that have been saved. In 2005 nearly 100 monitoring plots were installed throughout the park to determine effectiveness of treatments against plots receiving no treatment. Annual re-measurement of the plots is scheduled for years to come. Analysis of the data is showing a positive effect of the treatments compared to areas with no treatments. Biological controls are expected to take ten years or more to demonstrate effectiveness. New biological controls for HWA are being screened by federal agencies and universities for host specificity and effectiveness.

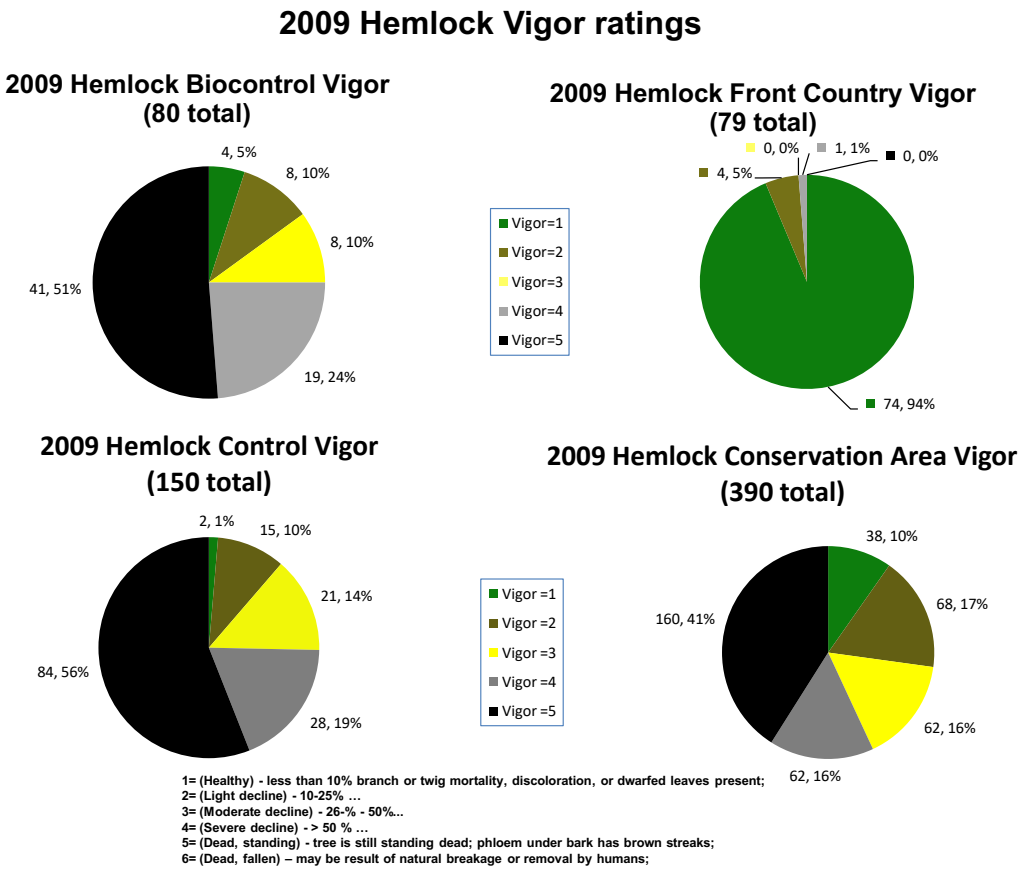

Figure 1. 2009 hemlock Vigor ratings by treatment type. Biocontrol treated sites include either species of biocontrol insect. Control sites are untreated. Front country and Conservation Area sites are Imidacloprid soil drench treated.

The park continues to share information and experience acquired during the program with neighbors such as state park managers, private landowners, and national forests in a cooperative effort to preserve this unique tree. Even though great loss of hemlock forests continues, the HWA program in GSMNP will preserve many valuable areas of the hemlock forest for decades to come.

Balsam woolly adelgid (BWA)

This insect from Europe has devastated Fraser fir stands found at the park's highest elevations. Approximately 74% of all the spruce-fir forest type in the southern Appalachians is found in the Great Smoky Mountains. An estimated 91% of the park's mature firs have died since BWA was first discovered in 1962. Fraser fir has been listed as a candidate species of special concern, and the spruce-fir ecosystem is also at risk. Fraser fir is the primary host for several nationally and globally rare bryophytes (mosses and liverworts) and the fir forest is also essential habitat to the very rare spruce-fir moss spider, now listed as a federally endangered species.

Young fir are generally not attacked until they are large enough to produce roughened bark in which BWA take shelter. Roughened bark can develop at approximately 20 years and this is also about the time they start to produce cones. In some areas fir reproduction is very good, resulting in dense stands of young, small firs, of which some may survive long enough to sustain at least a small population of mature firs. Some other sites are choked with blackberry and other competing shrubs. When population monitoring shows the need, park resource managers may treat mature fir with an insecticidal soap along Clingmans Dome Road and summit, and along Balsam Mountain Road. Adelgid populations had been low at Clingmans Dome for several years, while Balsam Mountain Road has supported populations high enough warrant foliar soap spray treatments. BWA populations are also monitored on Mt. LeConte, Mt Guyot and Mt. Sterling.

BWA densities on Fraser fir trees fell dramatically at three of four mountaintop monitoring sites in 2009 compared to 2008 (Figure 2). Firs at one site (Balsam Mountain) continue to decline and die due to high densities at the site over the last five years. Insecticidal soap treatments were again conducted at Balsam Mountain to reduce adelgid densities of roadside trees. Unlike 2008, cone production was practically non-existent in 2009, except at Balsam Mountain. Reproduction is not consistent at all sites but where present will likely become infested when the trees age and the bark becomes fissured enough to provide protection for newly settled wingless immature adelgids. Small stands of unaffected firs are documented in the park. The mechanism of resistance in these trees is not understood but may be a combination of production of a juvenile growth hormone analog called juvabione that prevents feeding adelgids from maturing, and/or physical characteristics of the bark that prevent infestation.

Fir regeneration, survival and species composition data was collected in 2010 at 36 plots established in 1990 and re-sampled in 2000. This long term monitoring project is conducted through cooperative agreement with the University of TN and will provide useful information on the future of Fraser fir forests.

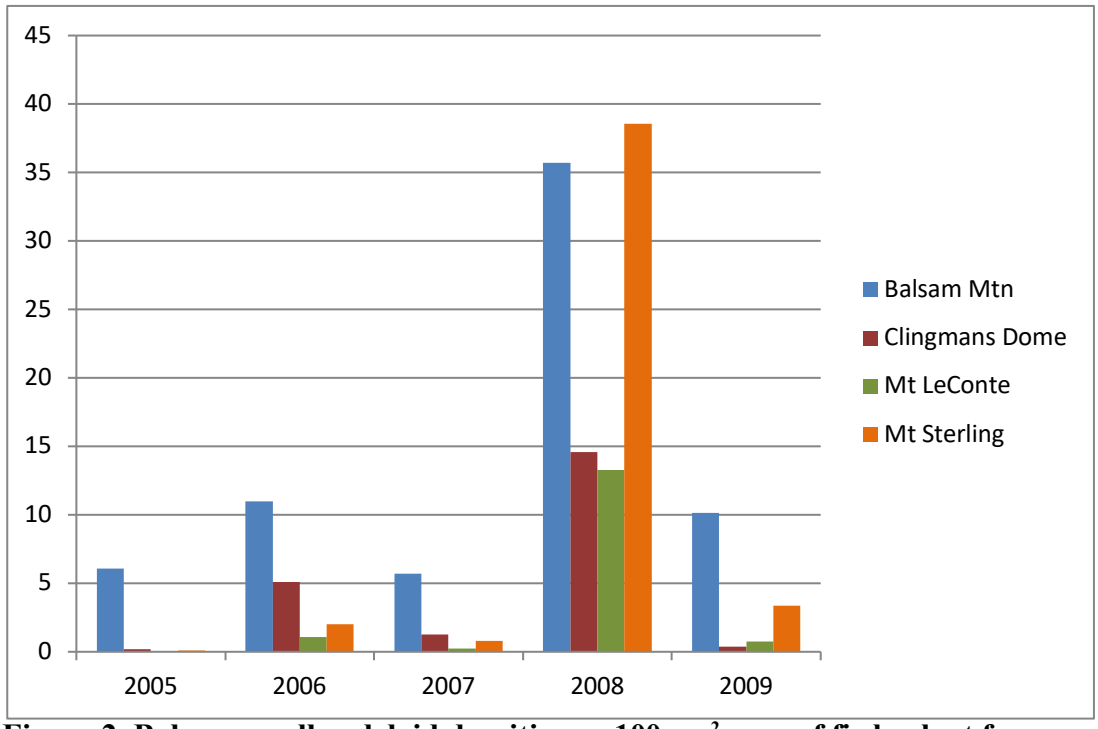

Figure 2. Balsam woolly adelgid densities on 100 cm^2 area of fir bark at four monitoring locations in Great Smoky Mountains National Park.

The Fraser fir genetic preservation planting at Purchase Knob is doing well. In 1995, 600 Fraser fir seedlings, grown from seeds collected in the park, were planted on this recently donated property east of Cataloochee Divide. While some have become infested with BWA, they are annually monitored, and if needed, treated with the insecticidal soap or a dormant oil spray mix. Trees are generally over fifteen feet tall now. The plantation is a cooperative effort between the park and the University of Tennessee (UT) Department of Forestry, Wildlife and Fisheries. The planted trees are managed as a reservoir of the park's Fraser fir genetic material.

Dogwood anthracnose

The fungus known as dogwood anthracnose (*Discula destructiva)* was first found in the U.S. at Chehalis, Washington, in 1977 and shortly thereafter in the New York City area. Recent DNA studies indicate that the fungus is an introduced pathogen. The fungus spread southward and was found in Maryland in 1983 and in north Georgia in late 1987. While the disease creates scattered mortality in landscape settings, it is most severe in the cool, moist areas, particularly in the understory, conditions that characterize much of the tree's habitat in the park. Wet, cool conditions during springtime are needed for infection by the *Discula* fungus. In some watersheds, nearly all dogwoods have died.

Ecologically, the flowering dogwood plays an important role in the park. Its foliage, twigs and fruits are higher in calcium (2-3% total calcium) than almost any other forest species, and it is therefore a prime soil builder. Migratory birds depend on its reliable, high protein fruit in the autumn, and its leaves and twigs are preferred browse for herbivores from deer to invertebrates. Research shows that the last dogwoods to succumb in a site are those in sunny locations, and dogwoods continue to bloom along many roads, in glades at old homesites, and in drier forest types. Trees are dying in most watersheds along streams, on northerly slopes and the cooler,

moister high elevations of the park. There is no treatment known to be practical, affordable, or environmentally advisable for use in natural zones in the park.

Butternut canker

This stem-canker fungus (*Siroccus clavigigenenti-jugulandacearum*) is believed to have been introduced into the United States around 1960 on the East Coast. Although it can infect black walnut, it has a lethal impact only on butternut (white walnut). Elongate lens-shaped cankers appear on the trunk, limbs, and twigs and even penetrate the immature nut, causing it to abort. This fungus went unnoticed in the southeastern U.S. until about 1986.

Butternut populations are declining, and in 1990 the U.S. Fish and Wildlife Service added butternut to its list of candidates for protection under the Endangered Species Act. The U.S. Forest Service has restricted the harvest of butternuts on lands it manages and is collecting and testing wild butternut genetic material for resistance to the disease.

In September 1987, the park located 70 trees for long term monitoring. Monitor trees are evaluated every three years. All study trees appear to be infected with butternut canker but some trees that receive full sun are growing vigorously and healing old cankers. Reproduction is restricted to these remaining healthy individuals. Seedlings must have full sun to grow and such conditions require natural disturbance, i.e. floods, treefalls, etc.

A statistical model was created in cooperation with the University of TN to predict the location of butternut trees. The model uses site characteristics at locations of known trees, was tested at 130 sites in 2001 and proved to be useful in predicting butternut locations.

In 2008, the Park contributed 100 nuts from seven Park trees to the butternut germplasm conservation program run by the Hardwood Tree Improvement and Regeneration Center based at Purdue University. A Purdue graduate student began field work in 2010 to determine the genetic background of the Park's remaining butternut trees.

Thousand Cankers Disease of Walnut

Within the past decade an unusual decline of black walnut (*Juglans nigra*) and other species of *Juglans* has been observed in several western states. Initial symptoms involve a yellowing and thinning of the upper crown, which progresses to include death of progressively larger branches. During the final stages large areas of foliage may rapidly wilt. Trees often are killed within three years after initial symptoms are noted. Tree mortality is the result of attack by the walnut twig beetle (*Pityophthorus juglandis*) and subsequent canker development around beetle galleries caused by a fungal associate (*Geosmithia* sp.) of the beetle. A second fungus (*Fusarium solani*) is also associated with canker formation on the trunk and scaffold branches. This disease was not known in the eastern U.S. until July 2010, when a well established infection with significant mortality was identified in Knoxville, TN.

Chinese chestnut blight

This Asian disease has eliminated the American chestnut as a full-sized tree from the park. Until the blight arrived in the 1930s, the chestnut was the most common canopy tree at most mid-elevations. Many dead stumps re-sprout because the fungus does not kill the roots, but almost no reproduction from nuts occurs. Allegheny chinquapins and scarlet oaks are also affected by chestnut blight. The park cooperated in a project with the University of Tennessee

and the American Chestnut Foundation to produce a disease resistant American chestnut. Cuttings are taken from American chestnuts and grafted onto other rootstock of a highly blight-resistant Asian species, then back-crossed to American parents, in an effort to produce a tree that is close to the native chestnut but retains the blight-resistance genes. This technique has worked for annual agricultural crops but in untried in tree species. The process will take 10-15 years.

A survey to document surviving American chestnut trees was conducted in the park in 2003 and found 288 chestnut trees larger than nine centimeters in diameter, 157 of which were flowering, and 31 of which were fruiting. Using that location information, two university based projects explored other aspects of chestnut. One involves sampling the cankers on infected trees and screening for hypovirulence- a naturally occurring virus that stops the growth of pathogenic cankers and converts them to superficial wounds. A project completed in 2008 involved creating and field testing a predictive statistical model of where other chestnuts could be found based on locations of known chestnut trees, and in 2010 research progressed to identify hypovirulent strains of the disease in Park trees.

Emerald ash borer (EAB)

This small green beetle from Asia was discovered in Michigan in 2002 and has since spread to 3000 square miles in Michigan, and is infesting portions of Ohio, Indiana, West Virginia, Maryland, Iowa, Kentucky, Massachusetts, Minnesota, Missouri, Pennsylvania, New Jersey, New York, Virginia, Wisconsin, and the Canadian provinces of Ontario and Quebec. EAB attacks all ash species. Three species of ash are known in the park, with white ash found most commonly. Trees newly infested with EAB are difficult to detect. Infested trees are often visited by woodpeckers that tear into the trunk searching for the EAB larvae. Infested trees can die in three to four successive years of limb die-back. Systemic insecticides have shown some control but are not practical on a forest-wide scale. Controlling firewood movement from infested quarantine areas is important in slowing the spread of this damaging insect.

Starting in 2008 and continuing in 2010 Park managers deployed purple sticky EAB detection traps in ash trees in high risk areas in an attempt to locate any new infestations as part of an APHIS detection grid. Adults may emerge from infested trees as early as April 15 with estimated peak activity the week of May 15.

Current Park policy to educate campers on risks associated with firewood and to request immediate burning of firewood from quarantined states. Emerald ash borer was discovered nearby in Knox County, TN in July 2010. The insect had apparently been established near a truck stop for several years and wood from the site removed to unknown locations as firewood. State and Federal agencies are determining new quarantine policies.

American beech

Diseased American beech trees were noted at high elevation in the central part of the park in the late 1980s, but no factor was clearly identified as the cause. In September 1993, both the beech bark scale insect from Europe and the *Nectria* fungus were found and confirmed to occur in the park. Together, the insect and fungus cause beech bark disease (BBD). BBD has now killed high elevation beech forests throughout the park and the disease has moved to individual

trees at lower elevations. In New England, where BBD was documented in the 1930s, about half of the beech trees are dead or dying, and most of the rest are severely deformed. Ten long-term monitoring plots were established in 1994 where baseline condition measurements have been recorded for beech and associate species. The plots are sampled in alternate years. Evaluations in 2004 showed increased severity of the disease. One plot moderately infected in 1994 now has 100% mortality of the overstory beech (37 trees). Other areas have varying levels of decline and mortality. Some areas with high mature tree mortality have prolific regeneration of beech sprouts from the parent trees roots. Since these are genetically identical to the parent tree these offspring will also be susceptible to BBD. Plots were resampled in 2010.

Beech scale predators, parasitoids, and *Nectria* species identification and biology were studied in cooperation with the University of Tennessee (UT) during 1994-1997. No natural controls were found, although park-wide a species of predatory mite (a previously undescribed species) was found feeding on beech scale. A graduate student at UT studied the genetics of beech in beech gaps during 1998-2000. Her work looked at clonality (identical genes) in beech gaps and at resistance to beech bark disease. Essentially no resistance to BBD was found.

Dutch elm disease/Elm yellows

Both of these diseases have been found in the park. Dying elms were first noticed along Little River starting in the late 1980s. Dutch elm disease (DED) is a fungal disease that originated in Europe, and is transmitted to American, slippery, and winged elms by elm bark beetles. Elms become especially susceptible to the disease when beetles carrying the fungus reach the canopy and start to feed.

Tree geneticists at the USDA Agricultural Research Service have identified American elms resistant to Dutch elm disease. DED-resistant American elm seedlings should now be available. Elm yellows is a mycoplasma-like organism (MLO) disease transmitted by leafhoppers. Initial visible symptoms of the disease include yellowing of foliage in summer. Elms susceptible to the disease do not recover.

Southern pine beetle (SPB)

This native insect has a major role in the pine forest ecosystems of the south. SPB populations are cyclic and are controlled by native predators and parasites as well as weather patterns. Pines, especially the yellow pine group, cannot reproduce well without some sort of disturbance. Research in the park suggests that pine forests, SPB, and fire form an ancient triangle of interaction, in which the beetle dramatically increases dry, resinous fuels in spots on south facing slopes. Fire burns more intensely there, creating the mineral soil "seedbed preparation" required for pine germination.

Park biologists map SPB-killed areas of trees (spots) by air and report findings to state agencies. SPB infestations tend to be cyclic; natural predators, parasites and environmental factors (such as very cold winter temperatures) end outbreaks in a few years. Several years ago mild winters combined with some moisture stress allowed SPB populations to increase and kill susceptible pines. The populations crashed by 2003 and few new attacks have occurred. One concern with respect to SPB is the decline in occurrence of Table Mountain Pine, *Pinus pungens*, a species that requires fire to open its cones and release seeds. For 60 years, the park

suppressed fire so that even when beetle- killed trees provided openings in the tree canopy, no new Table Mountain Pines germinated. The park is now reversing this trend, through prescribed burns and allowing lightning ignited fires in certain zones to burn, to restore natural processes.

Recently several newly introduced exotic pine beetles have been discovered in the U.S., and the park is cooperating with other federal and state agencies to monitor them for rapid detection and response programs.

Pests of Future Concern:

Gypsy moth

This infamous European import has generally infested the eastern United States as far south as northeastern North Carolina and Virginia (north of Roanoke), and is spreading into the Midwest. Gypsy moth is known for its defoliation of oaks but will feed on nearly 300 species of trees and shrubs. Spot infestations have been discovered all around the park in east Tennessee, western North Carolina and northern Georgia — all of these infestations have been or soon will be eradicated. An exotic fungus, *Entomophaga maimaiga*, has been controlling gypsy moth populations further north for several years, and may now slow the movement of gypsy moth.

In 2009 no male moths were captured in the 40 pheromone traps placed by park Resource Management staff in park campgrounds and picnic areas. The states of Tennessee and North Carolina also place traps for monitoring.

The All Taxa Biodiversity Inventory, a project to identify all life forms in the park, has tallied nearly 1000 Lepidotpera species including 72 species that are new to science and never described before. Gypsy moths would compete with native lepidopterans that feed on forest trees, and non-target impacts are a primary factor in integrated pest management decisions. Old growth oak stands and other forest types, which have attracted researchers from around the world, are at special risk since they are not as vigorous. A three-year project to inventory old growth oak forests in the park was completed in 1994. Old growth oak types in the park were measured at 1640 acres.

Asian Long-Horned Beetle (ALB)

This large black beetle with white markings is native to China, and was accidentally introduced to North America through fresh wooden shipping material. Eradication programs in Brooklyn, NY and Chicago, IL have been in place for several years. A new and well-established infestation was found during 2009 in western Massachusetts, and a smaller infestation discovered in the Boston area in 2010. Initial controls were limited to cutting infested trees and chipping them. Systemic insecticides are used in landscapes. This insect is not yet found in natural areas so its potential host trees are unknown. ALB could pose a serious threat to the park's hardwood trees.

Sudden Oak Death (SOD)

In 2004 the park cooperated with the U.S. Forest Service and the TN Dept of Agriculture in conducting emergency surveys for *Phytopthora ramorum*, the non-native pathogen causing a disease known as Sudden Oak Death. SOD was discovered in California in 1995; since then tens of thousands of oaks have been killed. The pathogen can be carried on a wide variety of trees and shrubs common in the nursery trade (including rhododendron, camellias and mountain laurel). In 2004 infected camellias were shipped to southeastern states from a large nursery in California, and plant protection specialists fear the pathogen may spread into natural areas. *P. ramorum* has been found in north Georgia nurseries. Making the jump from the landscape setting to natural areas requires presence of pathogen, available suitable hosts and correct conditions for infection. Surveys were conducted in the park during 2004 and no samples from rhododendron, mountain laurel or oak returned positive for the pathogen. Starting in 2006, a different detection technique involving host leaves contained in mesh bags and secured in flowing streams was used.

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