2007 Indiana Forest Health Highlights

1. Indiana's Forest Resources

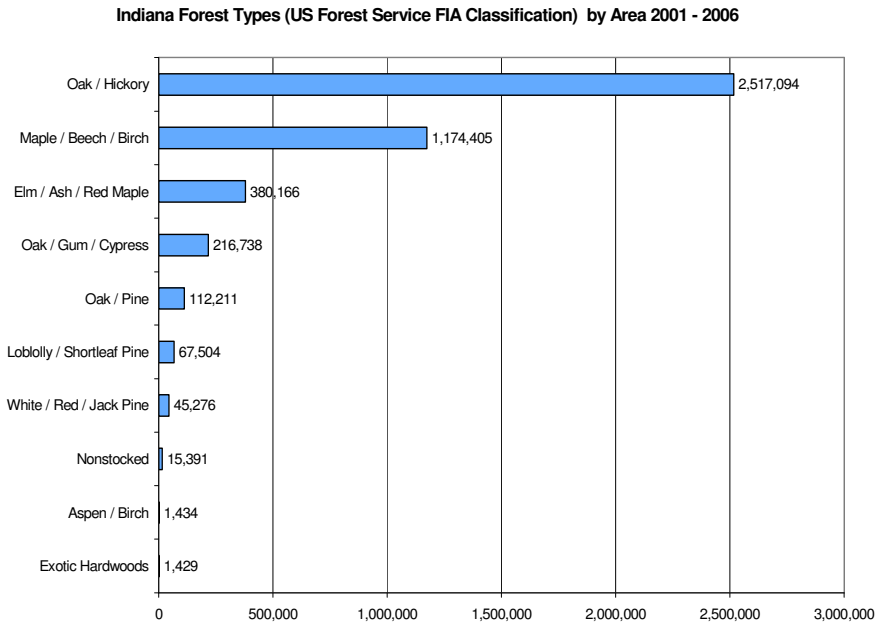
Approximately one of five acres in Indiana — 4.5 million acres — is covered in forest (Figure 1). Since 1950, forestland has increased more than 450,000 acres, and by nearly 52,500 acres between the last USFS Forest Inventory and Analysis (FIA) inventory (1998) and the current one (2003). Indiana has surprisingly diverse forests, encompassing northern maple / beech / birch types to southern bald cypress swamps. More than 85 different tree species grow in Indiana forests. Hardwoods account for 95% of the forest (Figure 2). Reflecting the effect of past glaciations, forests exist in large consolidated blocks chiefly in the hilly southern part of the state. In the northern two-thirds of the state, forests generally occupy scattered woodlots, wetlands, and riparian corridors.

Figure 1 – *Indiana forest areas.*

Growing Stock Volume

The total growing-stock volume on timberland has been increasing steadily since the 1950 inventory and currently is estimated at 8.2 billion cubic feet in 2006 (Fig. 3). The net volume of hardwood species has increased over the last three inventories, except for white oak. Red oaks, followed by yellow-poplar and white oaks, have the largest growing-stock volume across Indiana with roughly 1 billion cubic feet growing stock each. Yellow-poplar, in particular,

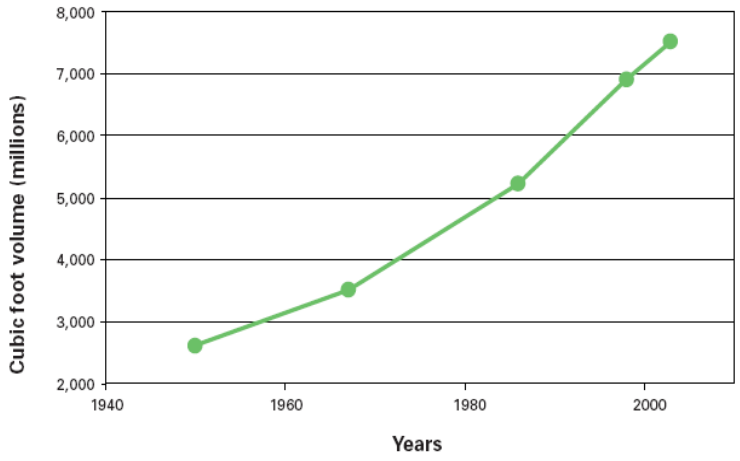
Figure 2: *Indiana Forest Types by Area, in acres*



achieved the greatest gains in overall net volume since 1986. Most hardwood species have shown an increase in larger diameter volumes since 1986 and a stabilization of smaller diameter volumes. Currently, 5.9 billion cubic feet (or 72%) total growing-stock volume is sawtimber.

Acre per acre, Indiana's growing stock volume in 2003 was 11 percent greater than neighboring Michigan's, with board foot volumes 300 percent greater. Indiana's per-acre standing sawtimber volume dwarfs other states in the region, with nearly double the board feet volume per acre of the average found in Michigan, Wisconsin, Minnesota, Illinois, Missouri and Iowa (4,380 board feet versus regional average of 2,328 board feet).

Figure 3 – *Cubic foot volume of Indiana Forests 1950 - 2006*



Annual Growth

Average annual net volume growth of Indiana's forests has increased substantially since 1967 and in 2006 is estimated at 356.2 million cubic feet per year. Average annual net growth in 2006 continues to increase from last inventory cycle of 268.1 million cubic feet.

Forest Products

The contribution of forests to the Indiana economy is over $9 billion annually (Bratkovich et. al. 2003). In 2007, Indiana's primary wood-using industry included 212 sawmills, 13 veneer mills, one handle plant, one pulp mill, and eight mills producing other products. Forest harvest produces a stream of income shared by timber owners, managers, marketers, loggers, truckers, and processors. Almost 9,000 people, with a payroll of $220 million, are employed by primary wood harvesters and processors in Indiana. More than two-thirds of the 84.2 million cubic feet of industrial roundwood harvested in 2007 came from south-central and southwestern Indiana. Saw logs accounted for 90 percent of the total harvest, with other minor products—primarily veneer logs, pulpwood, handles, and cooperage—making up the rest.

Other important contributions from Indiana's forests include recreation and non-timber forest products such as fuelwood, maple syrup, edible fruits berries, nuts and fungi, and medicinal plants. Income from recreation related to Indiana's forests is estimated to be $1 billion of the $6 billion in recreation dollars spent annually in the state.

Further information available at: Indiana's forests 1999-2003 – Part A and Part B and in Forests of Indiana: Their Economic Importance

2. State Forest Health Issues – An Overview

The **2007 growing season's major forest health problems** were related to the April freeze following unseasonably early leaf expansion, and the severe state-wide drought. Forest tent caterpillar, Gypsy moth, and emerald ash borer continue to impact portions of the state's woodlands. While forest tent caterpillar is a native species whose impacts in Southeast Indiana have begun to recede, Gypsy moth and emerald ash borer loom as ever-increasing invasive exotic threats.

Additional Forest Health Issues: 2007 saw the observed effects of aphids, bagworms, conifer bark beetles, fall webworm, fire blight, leafhoppers, leaf miners, Japanese beetles, mimosa webworms, orange striped oak worm, yellow-necked caterpillars, oystershell scale, periodical cicada in NW Indiana, pine bark adelgids, pine needle scale, powdery mildew, various oak and pine galls, tuliptree scale, verticillium wilt, beech blight aphids, and spider mites, as ornamental and forest health problems of a lesser degree.

Recurring forest health issues continue with oak wilt, butternut canker, Dutch elm disease, ash yellows, white pine root decline (*Procera* root rot), overstocked and aging pine plantation mortality, and pine shoot beetles. Other potentially major forest pests of concern (but not yet encountered) for Indiana in 2007 include the exotics, sudden oak death and *Sirex* wood wasp.

Invasive plants have potential to affect Indiana forest regeneration and biodiversity. Japanese stiltgrass (*Microstegium vimineum)*, for example, has spread widely in many southern Indiana forests thereby reducing mineral soil exposure needed for hardwood regeneration and edging out native herbaceous layer plants. In this issue, we will examine state efforts to track and control kudzu (*Pueraria lobata*) as a case study highlighting exotic species control issues.

Finally, **continuing forest mortality** from extended droughts (1999, 2002, late 2005, 2007) and past defoliations (loopers, forest tent caterpillar, anthracnose, frosts and freezes) continue to affect forestlands in south-central and southeastern Indiana, years after the fact.

3. Exotic Insect Pests of Indiana Forests

As our economy and current trade practices become increasingly global, so does the potential for more damage by exotic invasive insects. By conservative estimates, over 2,000 exotic insects are now in the U.S., with over 400 of them feeding on woody plants. Almost every tree genus in the U.S. is affected by at least one exotic insect. Currently, only five of the estimated 400 exotic woody plant pests are regulated by federal quarantine. These include the Japanese beetle, pine shoot beetle, Asian longhorned beetle, emerald ash borer, hemlock woolly adelgid, and Gypsy moth.

Three major exotic insects of concern for Indiana, Gypsy moth, emerald ash borer, and *Sirex* wood wasp, currently utilize significant IDNR resources for monitoring and management activities. The former two are present in Indiana and important threats to the forest base. The latter was intercepted in Indiana, and is known to be established in northern New York state and surrounding areas.

1. Gypsy Moth

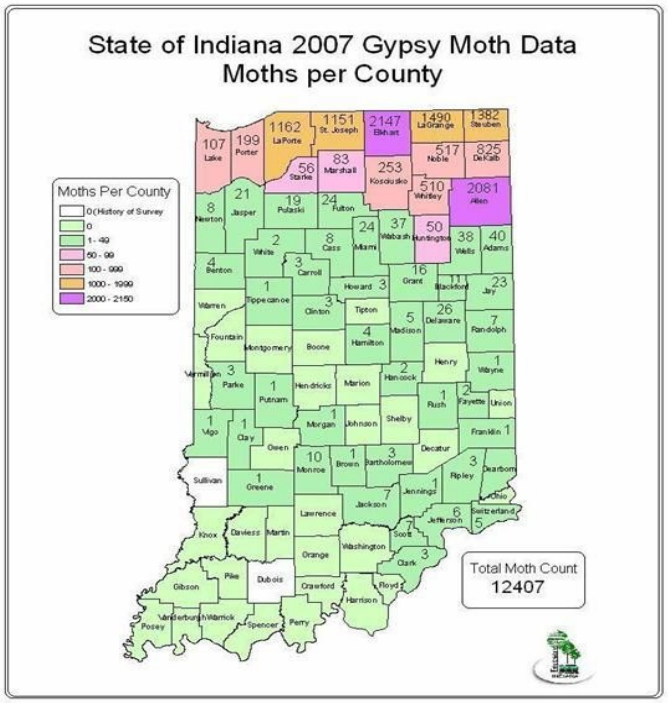
The 2007 Cooperative Gypsy Moth Survey completed its 20th year of statewide survey. The survey is part of the Slow-The-Spread (STS) Program and uses the STS protocol for its design and operation, dividing the state into three zones - the STS Evaluation Zone, the STS Action Zone, and the State Area (Fig. 4). The survey design uses fixed 3 km, fixed 2 km and rotating 3 km grids, respectively, for the three zones. Across all zones, the 2007 survey set 16,054 traps. The survey detected 12,407 moths from 59 counties ranging from 1 to 2,147 moths per county. This is a slight increase from the 2006 total of 12,078 moths.

Figure 4: *Gypsy Moth Slow-the-Spread (STS) survey zones, 2007.*

The results of the 2007 survey (Figure 5) found that 60.6% of the moth catch was in the Evaluation Zone, encompassing the quarantined counties of Steuben, LaGrange, Elkhart, Noble, Allen, DeKalb, and St Joseph. The Action Zone detected 38.1% of the moths, while the State Area detected 1.3% of the moths. In the State Area, the Delaware site, treated in 2007, caught 26 moths in 301 delimit traps. Three of these traps caught 6, 4, and 2 moths respectively, while surveys detected egg masses around the 4 moth trap. In 2007, several positive traps were found in the Hoosier National Forest in Monroe County, fueling concerns that Gypsy moth might become established in the state's heavily wooded southern uplands

Treatments in 2007 to eradicate and slow-the-spread of gypsy moth were conducted on 16 sites totaling 26,910 acres in 5 counties. Thirteen sites totaling 11,260 acres in seven counties were treated with Btk at 25 BIU / acre / application. Eight sites were treated with two applications (7,724 acres). Five sites were treated with one application (3,536 acres). Three sites totaling 15,650 acres in 2 counties were treated with mating disruption. Two sites totaling 10,250 acres and one site totaling 5,400 acres received one application of pheromone flakes for mating disruption at 6 and 15 grams, respectively, in June 2007.

Figure 5: *2007 Gypsy moth trap data*



Proposed treatment acres for 2008 includes 14 sites in the STS zones and 3 eradication sites in the State zone. Of the 14 STS sites, 13 are proposed for Btk (Allen, Elkhart, LaPorte, and St. Joseph

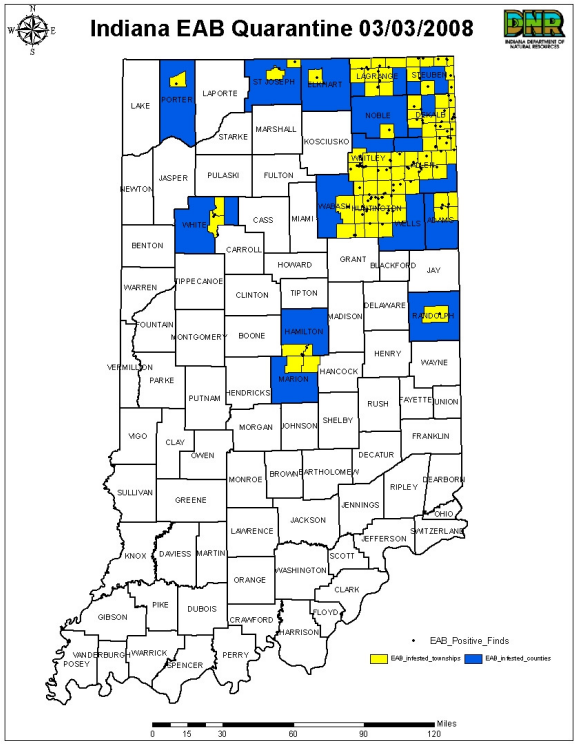
counties at 3,605, 720, 2,503, and 247 acres, respectively) and 1 site (Lake County - 6,907 acres) for pheromone flake mating disruption. For the 3 eradication sites, 2 are proposed for Btk (Scott County - 560 acres, Delaware County - 525 acres) and the other (Monroe County - 1,861 acres) for mating disruption. The mating disruption site in Monroe County is in the Hoosier National Forest.

2. Emerald Ash Borer

Emerald ash borer (EAB), *Agrilus planipennis* Fairmaire, is an exotic beetle that was discovered in southeastern Michigan near Detroit in the summer of 2002. EAB was first detected in Indiana in a Steuben County campground in 2004. The adult beetles feed on ash foliage but cause little damage. The larvae kill ash trees by feeding on the inner bark of ash trees, disrupting the tree's ability to transport water and nutrients. Emerald ash borer probably arrived in the United States on solid wood packing material used to carry cargo from its native Asia.

On its own, EAB moves slowly through the landscape; natural spread of the insect is about 1/2 mile annually. However, humans can greatly accelerate EAB's spread by moving infested ash wood, especially firewood and logs, to uninfested areas.

Figure 6: Emerald Ash Borer quarantined townships and counties as of 3/03/08 *(IDNR – Division of Entomology and Plant Pathology)*



Quarantine

Through 2007, EAB was detected in 17 counties, particularly in northeastern Indiana (Fig. 6). When EAB is found in an Indiana township, the entire township and county are placed under quarantine for ash products that might move the beetle. Regulated articles include ash nursery stock and green lumber; any other ash material including logs, stumps, roots, branches, as well as composted and uncomposted wood chips. Ash products may be moved within the quarantined township and county borders but cannot be taken out of the township or county without a signed Indiana DNR or USDA compliance agreement. In December 2006, the USDA quarantined the entire state of Indiana. Ash products may not be moved out of state without inspection and certification from either USDA/APHIS or IDNR/Division of Entomology inspectors. Development of inspection procedures and compliance agreements is seen as key in managing the spread of EAB.

Figure 7: *EAB trap tree after girdling.*

EAB Survey

More than 25 field personnel from the Division of Forestry and USDA / APHIS were deployed to set 2,570 EAB trap trees and destructive trees (Fig 7). The 2007 survey differed from that of 2006 in two significant ways. The first difference included detection sites on a 3-km grid system across the entire state, as an addition to the previously employed high risk sites. The second change was using destructive sample trees in addition to girdled trees. This was necessitated by the 2007 survey's late start, resulting in survey locations remaining un-girdled before the mid-June cutoff date.

In additional to the trap and destructive tree EAB survey, several complimentary survey methods were also employed: (1) DNR nursery inspectors conducted visual surveys of suspect ash showing woodpecker activity; (2) Delimitation within infested townships, especially outlier infestations, was conducted; (3) Purple canopy traps were evaluated within delimitations; and (4) aerial survey identified areas of declining ash for later examination from the ground.

Survey Results

With the passage of one year, the 2007 Trap, Destructive Tree, and Visual surveys identified five additional counties and 34 new townships.

Trap and Destructive Tree Survey: The 2007 survey found a total of 21 locations infested with EAB life stages. Two new counties, Noble and Elkhart, were determined to be infested through the trap and destructive tree survey, with additional townships detected in currently infested counties.

Visual Survey: EAB was detected in three additional counties – Wells, Wabash, and Whitley - and several new townships in infested counties, through the visual survey.

Table 1: *Suspected EAB - Declining Ash in NE Indiana as Identified in Aerial Survey*

County	Stands of Declining Ash
Allen	8
DeKalb	5
Huntington	1
LaGrange	1
Stueben	3
Wells	1
Whitley	3
TOTAL	**22**

Delimitation within infested townships: Further spread of EAB within the regulated townships was revealed in some instances (e.g. Marion County) while not in others (e.g. White County). The purple canopy traps, evaluated for their efficacy within delimitations, produced mixed results. In one instance, a negative purple panel trap was set next to an adjacent, positive trap tree.

Aerial Survey**:** While it is difficult to distinguish between EAB damage to ash stands against other pathogens such as ash yellows, aerial surveys in Indiana have begun to delineate areas of ash in decline. Following the identification of such areas, DNR personnel visited these areas and investigated ash by either establishing trap trees or destructive sample trees. Table 1 shows the extant and location of EAB-suspect ash stands as identified by aerial survey. EAB was not found in these 22 areas in 2007.

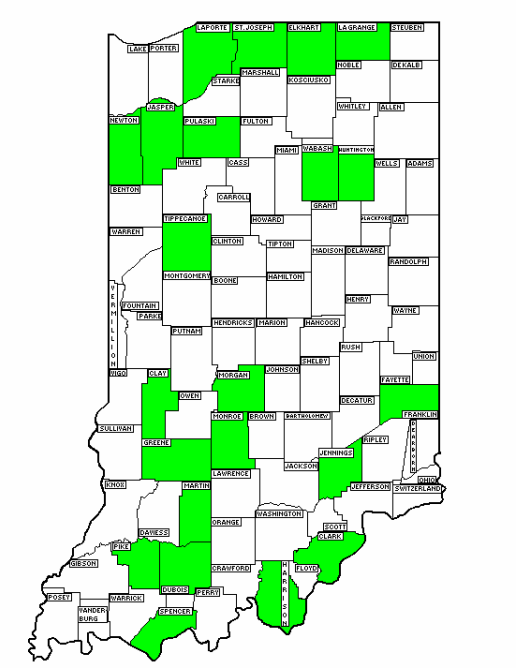
Further links and Information about where EAB is located in Indiana may be found at the IDNR Division of Entomology and Plant Pathology website:

http://www.in.gov/dnr/entomolo/pestinfo/ashborer.htm . Purdue University also maintains website: http://www.entm.purdue.edu/EAB/ with related information.

3: Sirex Wood Wasp

Sirex woodwasp, *Sirex noctilio*: Since the interception of a single adult in Bloomington, IN during the summer of 2002, The Indiana DNR continues to survey for *Sirex noctilio*. Sirex now infests 25 counties in New York, 2 counties in Pennsylvania, 1 county in each in Michigan and Vermont, and 21 counties in Ontario, Canada. To date, *Sirex noctilio* has not been detected in the trees and forests of Indiana.

Figure 8: *Indiana counties surveyed for Sirex noctilio during 2006 - 2007 (IDNR – Division of Entomology)*



Survey Methods

The 2007 survey concentrated on areas where *Sirex noctilio* could be introduced and/or potentially become established (Fig. 8). The survey concentrated on upland pine stands north of the Ohio River, as river shipping may disseminate the insect. Additional traps were placed in northeast Indiana in an effort to detect any spread of the pest from Canada via Michigan. In 2007, thirteen locations utilized three Lindgren funnel traps per location. Traps were all placed by mid July and baited with the Sirex lure (Alpha and Beta pinene). Samples were collected every two weeks and lures were replaced every month.

Results / Analysis

The 2007 survey did not capture specimens of *Sirex noctilio*. The survey did capture specimens of three native wood wasps, including one *Urocerus cressonii* specimen and two of *Tremex columba*.

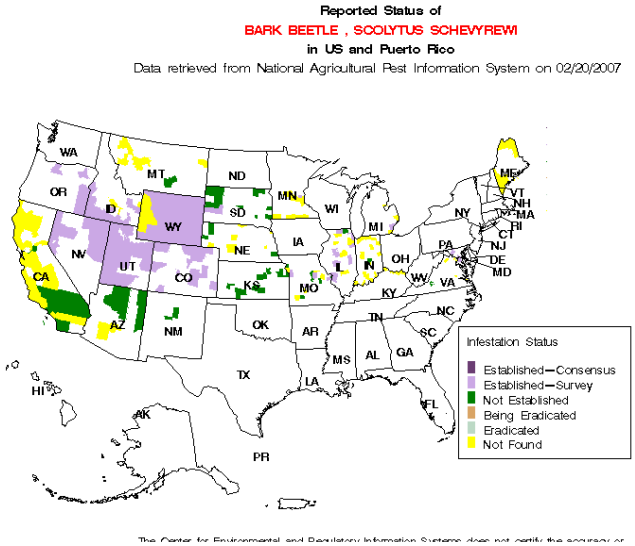
This contrasts greatly with the 99 native siricids (*Sirex nigricornis* [58], *Sirex edwardsii* [41]) and 11 related (*Urocerus cressoni* [6], *Tremex columba* [5]) wood boring wasps captured during the previous year. The severe drought in southern Indiana may have affected the trap efficiency by making stressed trees more apparent than the baited traps. High temperatures also may have caused lures to expire more quickly than anticipated. To date, *Sirex noctilio* has not been detected in the trees and forests of Indiana. For further information, please visit the following informational website:
http://na.fs.fed.us/spfo/pubs/pest_al/sirex_woodwasp/sirex_woodwasp.htm,

4. Secondary Exotic Insect Pests of Concern

a. Banded Elm Bark Beetle - *Scolytus schevyrewi*

Scolytus schevyrewi, the banded elm bark beetle, was first collected in insect traps set near Denver, CO and Ogden, UT, in April 2003. By March 2006 it had been collected in 21 states, including Indiana. The coincident finding of *Scolytus schevyrewi* in many states indicates that it has been established for some time. It is noted to be established in Illinois counties near or adjacent to Indiana, and is likely to be established in Indiana (Fig. 9).

Figure 9: Status of *Scolytus schevrewi* in the US, in 2007 (NAPIS)



The banded elm bark beetle has a similar life cycle to that of *S. multistriatus*, the principal vector of Dutch elm disease. Furthermore it has been observed to be more aggressively colonizing declining elm trees, and poses an unknown risk to Indiana elms both due to its potential harm directly to elms as well as a vector for Dutch elm disease.

More information can be found at: www.na.fs.fed.us/pubs/palerts/banded_elm_beetle/beb.pdf

b. Pine Shoot Beetle - *Tomicus pineperda*

The pine shoot beetle (*Tomicus pineperda*), an exotic species from Europe, was first identified in pine plantations in the northern third of Indiana in 1992 (Figure 10). In Indiana, the primary concern is with Christmas tree growers, who have potential to spread the beetle and the impact of management costs to their industry. Further concern rests with the extensive pine plantation in southern Indiana, which may be more susceptible to damage due to the lack of management and aging.

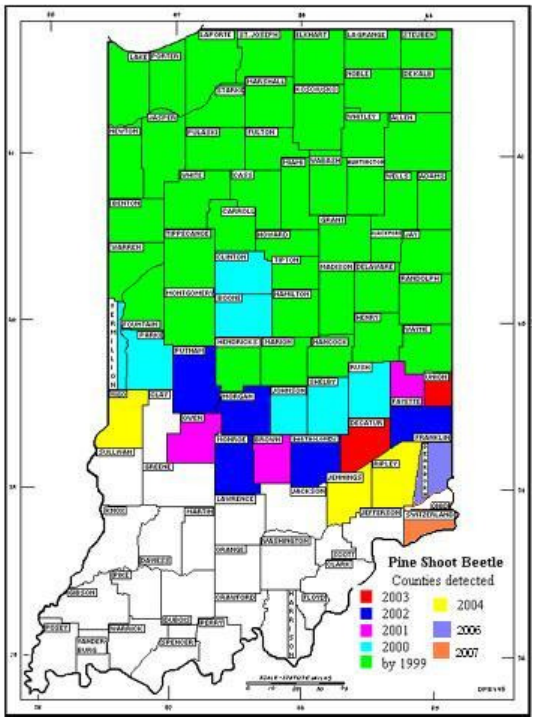


Figure 10: *Indiana pine shoot beetle infestation, by year detected (IDNR – Division of Entomology and Plant Pathology)*

Adults quickly colonize recently cut pine stumps, logs, and the trunks of severely weakened trees. While pesticides are available for high-value crops such as Christmas trees, control in forest stands has been largely cultural. Cultural practices used in Europe, for example, include precise timing of cutting operations and the debarking of cut timber. Yearly surveys for *Tomicus* are conducted by APHIS personnel. In Indiana, *Tomicus*

now is found in 62 of the 92 counties (Figure 7). Dearborn county was added to the list of quarantine counties in 2006, and Switzerland County in 2007.

Under state and federal quarantine law, all nurseries and Christmas tree growers in quarantined counties are required to have an inspection certificate before they can ship pine trees to non-quarantined counties. Pine cut for timber or pulp is also subject to quarantine regulation. It is illegal to move any parts of pine from these counties.

Granulate (Asian) Ambrosia Beetle - *Xylosandrus crassiusculus*

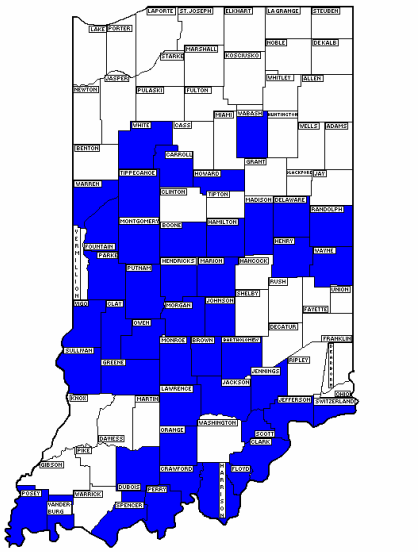


Figure 11*: Asian ambrosia beetle in Indiana – 2007 (Ken Cote, IDNR)*

Granulate ambrosia beetle (GAB) or Asian ambrosia beetle was first found in the U.S. during 1974, on peach trees near Charleston, SC. In 1983, populations were found as far south as Florida and as far west as Alabama. In 1992, the USDA captured adults with Lindgren funnel traps placed in Johnson County on the southeast side of Indianapolis. In 2005, GAB was found in Indiana forests infesting yellow-poplar in Jackson County, in yellow-poplar trees in Jackson County. GAB in 2007 infests nearly half of Indiana's counties in central and southern parts of the state (Fig. 11).

Figure 12*: Asian ambrosia beetle – damage on yellow-poplar. Note the "toothpicks" created by pushing frass out of the holes. K.Cote - IDNR*

GAB attacks many species of hardwoods, and produces small toothpick-like frass projections sticking out of the trunk (Fig. 12). Besides attacking forest trees, GAB can be serious problem to nursery trees. Management for the nursery includes rouging out infested trees after they have served as a trap tree.

Trapping Data - The Indiana DNR, Division of Entomology and Plant Pathology has been collecting trapping data in Perry, Jackson and Owen Counties in attempt to better understand flight activity of the GAB in Indiana. This data found that peak flight occurs when the average daily maximum temperature begins to reach 70 degrees F. In most cases this occurs in early May in southern Indiana and usually coincides with bud break and leaf expansion of native tree species. In some years, a second smaller peak occurs during late summer (personal communication Ken Cote [kcote@dnr.in.gov]).

4. Non-Indigenous Plant Pathogens

Many non-native plant pathogens have either decimated or now threaten Indiana's forests. Among these include dogwood anthracnose, chestnut blight, butternut canker, Dutch elm disease, and sudden oak death. These diseases, mostly introduced by man from other continents, have devastated or threaten to destroy various forest components. State and federal authorities currently are involved to detect and manage known exotic pathogens. Because of the increasing flow of trade, continuing introductions of new forest pathogens can be expected, warranting continued vigilance in monitoring for new introductions.

1. Non-Indigenous Plant Pathogens

Sudden Oak Death (SOD – *Phytophthora ramorum* – [*Pr*]) is a waterborne mold that affects a number of plant species, significantly causing mortality on west coast oak species (Fig. 13).

Concern exists that SOD may be spread through infected plant materials in nursery stock. Predictive models indicate SOD has the potential to infect many forest types found throughout the United States, including the most economically significant portions of Indiana's forest base. Due to the looming economic risk to Indiana oak forests should infestation occur, surveys have been conducted of nurseries and surrounding forest areas for SOD.

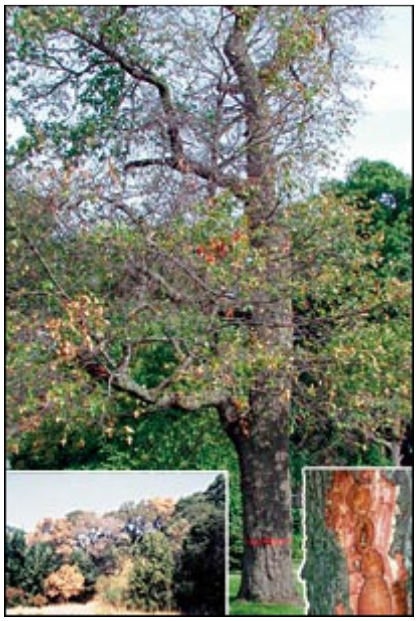


Figure 13*: Stand, tree, and inner bark symptoms of SOD in California (USDA Forest Service)*

Indiana's 2007 SOD Survey

Indiana watersheds and nurseries were surveyed in 2007 for SOD. The purpose of these surveys was early detection of *Phytophthora ramorum* introductions via host nursery stock shipped from CA and OR nurseries, and for any presence in Indiana watersheds.

In Indiana, streams in five watersheds were identified for testing based on SOD risk mapping by the US Forest Service. In each sample, 4 symptom-free rhododendron leaves in a mesh bag were tethered in the stream current. Two bait bags per site were deployed in nearby locations. These were exposed for 1 – 2 weeks per instance over 5 months during the growing season. Samples were sent to local labs to culture leaf bait pieces for *Phytophthora* spp. and *Pr*. Additionally, IDNR Division of Entomology and Plant Pathology collected 431 leaf samples from symptomatic *Pr* host species in 20 nurseries.

Results

Of 50 possible samples from the five watersheds, 2 were lost. Of the remaining 48, *Phytophthora* species were identified in 23 samples. *Phytophthora ramorum*, however, was not identified in the 23 *Phytophthora*-positive samples. IDNR samples from 20 nurseries all tested negative for *Phytophthora ramorum*. Further details are found at: http://fhm.fs.fed.us/sp/sod/sod.shtm.

2. Dutch Elm Disease - *Ophiostoma ulmi (syn. Ceratocystis ulmi)*

Since its introduction into the US, Dutch Elm Disease (DED) has had a devastating effect on native elm populations. With the increasing age classes of Indiana's forests, similarly aging elms are beginning to show a marked mortality increase from DED. Nearly 25% of U.S Forest Service Forest Health Monitoring (FHM) program plot mortality volume was due to elm mortality chiefly due to DED, on FHM plots 1998 -2002 (Krecik, Marshall, and Smith 2003). As Indiana forests continue to age, the incidence of DED will probably increase. Forest managers and land owners should consider marking with prejudice sawtimber-sized elms, particularly in stands already expressing DED symptoms.

The main symptom of DED - red flagging foliage – is evident typically in mid to late summer. From general observations, the incidence of DED appears to have stabilized or decreased compared to the prior 10 years. This may be due to the death of elm over the last 10 – 15 years has reduced the elm population enough to make observations of symptoms more difficult.

3. Oak Wilt - *Ceratocystis fagacearum*

In December 2007, a new report of oak wilt came from Jennings County. This is the latest county with a confirmed identification, increasing the number of counties with oak wilt to 63 (Figure 14).

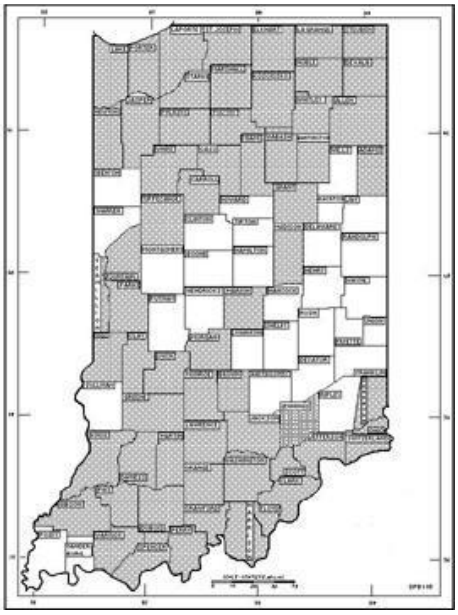


Figure 14: *Extent of oak wilt in Indiana in 2007.*

Oak wilt is predicted to continue as a manageable disease in most forests with heavy soils. The exception in Indiana tends to be the sand ridge areas of northwestern Indiana where oak wilt is commonly found on black oak stands. Special concern in these sand ridge forests should be noted in areas of northwestern Indiana that are being converted to homes and subdivisions, because of the role humans play in spreading this disease through construction injuries and firewood movement.

Pockets of trees infected with the disease should be cut and properly treated. Injury to stems, especially in the red oak group, should be avoided to help prevent oak wilt from expanding. For more information, please view the following sources:

http://www.na.fs.fed.us/spfo/pubs/howtos/ht_oakwilt/toc.htm
http://www.na.fs.fed.us/fhp/ow/states/wi/owm.pdf

4. Butternut Canker - *Sirococcus clavigignenti-juglandacearum*

Butternut is being decimated throughout Indiana by *Sirococcus clavigignenti-juglandacearum*, a fungus most likely introduced from outside of North America. Butternut Canker was first observed in Wisconsin, in 1967, and has since been noted over nearly the entire range of this tree. Cankers develop throughout a tree, and when the resulting callus material encircles the stem, the tree will be girdled and die (Figure 15). The disease is spread by rain-splashed spores, possibly by insects and birds, and perhaps by seeds. In contrast to American chestnut, butternuts usually will not sprout after stem death. Therefore, when a population becomes infected, that particular gene pool has the potential to be permanently lost. The rapid decimation of butternut populations has been considered so severe that the U. S. Fish and Wildlife Service has listed the species as a "species of Federal concern", and by Indiana on their "watch list" of endangered and threatened plants.

Figure 15:*Butternut canker symptoms(USDA Forest Service).*

Butternut canker symptoms include: Dead branches or a dying top; discolored bark which, in spring, has an inky black fluid oozing from cracks in the cankered bark and in summer has sooty patches usually with a whitish margin; young cankers may appear elongated and sunken into the bark; old cankers may have loose bark covering them and several layers of overgrown trunk tissue; stained wood beneath the bark appearing dark brown to black in an oval shape (Fig. 13).

Currently no butternut selections are available that have known canker resistance. A few healthy butternut trees have been found growing among diseased and dying trees and may be resistant to the disease. Landowners are encouraged to locate and report healthy butternut to their District Forester or the Forest Health Specialist.

5. Beech Bark Disease – Disease complex of *Cryptococcus fagisuga* Lind and *Nectria coccinea* var. *faginata* Lohman

In areas to the north and east of Indiana, Beech Bark Disease (BBD) has caused significant mortality and defect in American beech. The non-native beech scale, *Cryptococcus fagisuga* Lind., first attacks beech stems. The wounds made by their feeding are invaded and trees are injured or killed by fungi, primarily *Nectria coccinea* var. *faginata* Lohman, Watson, and Ayers, and sometimes *N. galligena* Bres. According to Forest Service modeling, BBD will likely appear in northern Indiana within the next 10 years. To date, the nearest known infestations are in the western lower peninsula of Michigan. This disease was not detected or reported in Indiana in 2007.

Figure 16: *Hemlock wooly adelgid infesting a branch tip of eastern hemlock (US Forest Service).*

6. Hemlock Wooly Adelgid - Hemlock is an uncommon tree species in Indiana forests, and is found in a few scattered populations where site conditions exist conducive to its growth and

regeneration. Because of the beauty both of the tree and the sites in which it grows, most locations in Indiana are nature preserves, state forests or state parks.

The Hemlock Wooly Adelgid (HWA) is an invasive insect active in the United States since the 1950s. As it has spread over the Appalachians, it has begun to constitute a real danger to our state's hemlock populations, along with the rest of the surrounding the Great Lakes area. HWA, for example, was found at three new sites in Ohio in 2006.

To date, HWA has not been intercepted in Indiana. Concern in Indiana exists that HWA will enter the state on a landscape plant (as has happened elsewhere) and move into natural populations. Interstate nursery shipments are inspected, and it is believed that this will greatly reduce the risk of accidental introduction through the nursery industry. However, the nursery industry, landowners and natural resource managers are encouraged to remain vigilant to the threat of HWA. Should you observe the "white wool" of HWA on the twigs of hemlock, please contact the Indiana DNR Division of Entomology and Plant Pathology.

7. Red Bay Wilt – Risk to Indiana Sassafras and Spicebush caused by *Xyloborus glabratus* and *Raffaelea* sp.

A new disease complex of redbay (*Persea borbonia*), a southern shrub / small tree has been recently described. The disease is caused by a fungus (*Raffaelea* sp.), and is spread by an Asian ambrosia beetle *Xyleborus glabratus,* which is reported as the twelfth introduced ambrosia beetle detected since 1990 (Haack 2006).

The disease was noted in redbay populations in 2002, in South Carolina and Georgia. The disease has also been discovered in related plants in the *Lauraceae* family, including individual plants of the federally endangered pondberry (*Lindera melissifolia*), the threatened pondspice (*Litsea aestivalis*), sassafras (*Sassafras albidum*) and avocado (*Persea americana*). In 2004, those states reported three counties with damage; now the disease has spread to 31 total counties. Officials estimate that natural spread is about 20 miles per year, but movement of infested firewood, wood chips and logs may be a major factor in spreading the disease into new locations not contiguous with main area of infestation.

Redbay wilt was not detected or reported in Indiana in 2007. Natural resource managers and landowners are encouraged to look for declining sassafras and spicebush (*Lindera benzoin*) with toothpick-like frass projections, and report any suspected decline.

5. Native Insect and Disease Concerns

1. Forest Tent Caterpillar (FTC)

The **Forest Tent Caterpillar** (*Malacosoma disstria*) epidemic in Southeast Indiana collapsed in 2007, resulting in greatly reduced defoliation of low levels in four Indiana counties (Table 2, Figure 17). FTC Defoliation last year (2006) had been at an all-time high of 74,199 acres affected. Only 478 acres of defoliation were detected in 2007.

Table 2: ***2007 Indiana Forest Tent Caterpillar Defoliation - Acres defoliated, by severity class and county***

County	Low	Low-Moderate
Clark	15	0
Dearborn	130	0
Ohio	209	0
Dearborn	0	124
SUBTOTAL	**354**	**124**
TOTAL ACRES DEFOLIATED		**478**

Mortality from the past four years of defoliation was apparent from aerial survey (Table 3, Figure 18). The survey recorded mortality on 1,136 acres in 6 counties. FTC primarily defoliates oaks and sugar maple, black cherry and hickory. Mortality to oaks, especially black oak, and sugar maple had started to occur in 2006, but was only observed in scattered individual trees. During 2007 whole stands of trees were seen to be dead. When combined with recent droughts, it is expected that mortality will continue to appear over the next 5 – 8 years from the result of FTC defoliation.

Table 3: ***2007 Indiana Forest Tent Caterpillar Mortality*** **-** ***Acres mortality, by severity class and county***

County	Scattered Mortality	Uniform Mortality
Clark	51	0
Dearborn	12	18
Jefferson	126	10
Ohio	257	162
Ripley	0	3
Switzerland	459	37
TOTAL	**905**	**231**
TOTAL ACRES MORTALITY		**1,136**

Cause of FTC Infestation Collapse: Perhaps the most surprising development has been the effect of late-spring freezes on FTC. While reports of 'Friendly Fly', *Sarcophaga aldrichi*, a native parasite of FTC were noted, it was largely reported that the late April freeze after leaf emergence had devastating effect on FTC caterpillars.

Figure 17: *2007 Forest Tent Caterpillar(FTC) defoliation in southeastern Indiana.*

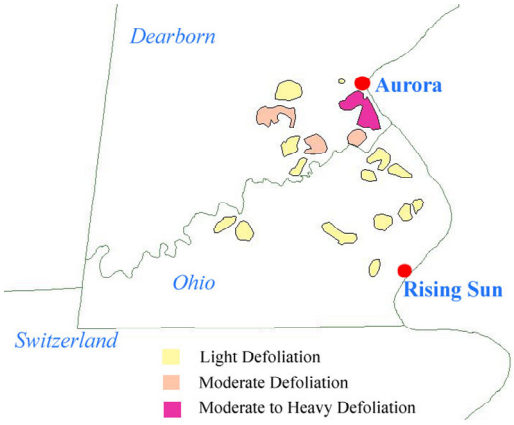
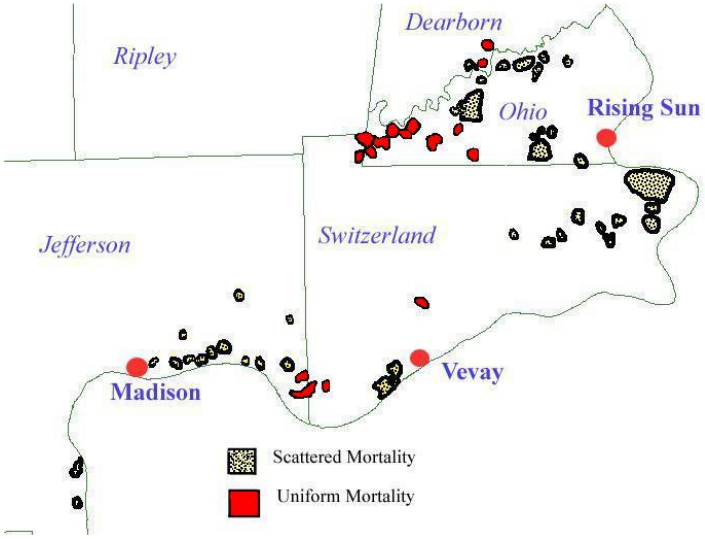


Figure 18: *2007 Forest Tent Caterpillar(FTC)-elated mortality in southeastern Indiana.*



Management Response: It is recommended that management activities - salvage harvests - be conducted within one year and no longer than three years after trees die to optimize recovery of timber value and to return the forest to a healthy state. Thus, management should begin in 2008 and continue through 2010. It is also recommended that management activities be conducted in a manner to prepare the future stand for gypsy moth by using the Gottschalk's Silvicultural Guidelines for Forest Stands Threatened by Gypsy Moth.

2. Ash Yellows

Ash yellows (also known as ash decline) continues to be found across the state primarily affecting white and green ash. The disease is caused by a microbe that resembles bacteria which

lack cell walls. These microbes are called phytoplasma-like organisms (PLO), and are possibly transmitted by leafhoppers. Symptoms of the disease, especially crown dieback and growth loss, are more prevalent in the northern part of the state. It is generally more common to observe the disease on wetter sites, but witches'-brooms (a diagnostic symptom) also can be found on trees growing on dryer sites.

Landowners and forest managers should approach ash yellows as a chronic condition requiring long-term rather than immediate attention. Removal of affected ash trees can be considered over a long-term (e.g. 10 year) planning horizon, which coincides with cutting cycles for uneven-aged management on better-quality Indiana woodlands. General observations by Indiana natural resource managers do not indicate they are more likely to attract EAB.

3. White Pine Root Decline - *Verticicladiella procera*

Procera Root Rot (White Pine Root Decline) has been noticeably killing white pine across the state for many years. During 2007, mortality from this disease continued its role as a common request for assistance. It continues to kill windbreak, yard and plantation trees. This disease is the most common forest pest that landowners request assistance, and as such has the status of the number one disease in Indiana.

Trees from 4 to 30 feet tall and 3 to 6 inches in diameter are commonly killed. Trees can turn brown in color at any time of the year, but do so more commonly in the spring and fall (Figure 19). Infected trees appear light green and sparse or thin at first. Then the trees turn brown in a short period of time. Most landowners do not recognize the early symptoms of the disease. They usually see the dead brown tree and sawdust from woodborers that attack the dead tree. Management of the disease is done by using sanitation measures. There is no cure or preventative treatment for the disease.

USDA, Forest Service, S&PF

Figure 19: *Procera Root Rot tends to affect single trees in windbreaks*

4. Anthracnose

The late freeze, short wet spring and long dry summer produced reduced sycamore anthracnose defoliation compared to prior years. The only anthracnose reported by DNR nursery inspectors, for example, was late summer walnut anthracnose in northeastern Indiana. Although present in Indiana, dogwood anthracnose was not reported in 2007 to IDNR Forest Health personnel.

Anthracnoses affect several genera of hardwood tree species in Indiana. In wet cool years such as 2006, it was possible to see widespread effects on many species. The causal fungi for hardwood anthracnoses encompass several genera, and not all hardwoods are affected equally. Sycamore is the most susceptible species, and is the gauge that is used to determine the severity of anthracnose each year. Other species vary as to their susceptibility. For example, most oaks in the white oak group are more susceptible to anthracnose than those in the red oak group. Pin oak, swamp chestnut oak (a white oak group member), and bur oak are only rarely affected.

It is impractical and impossible to control anthracnose in forest stands. For urban forests and nursery stock, anthracnose may be regulated by raking leaves and pruning infected twigs and branches. This reduces the amount of overwintering fungi in plant materials that is available to cause infection during the next growing season.

5. White Oak Mortality

Several reports of white oak and chestnut oak groups dying have been received from 2004 until the present. Receiving reports of white oak dying is unexpected. Normally the white oak group is more resistant to death from various stress factors compared to the red oak group.

Figure 20: *Typical gallery of the two-lined chestnut borer A. bilineatus (USDA Forest Service)*

Examination of two sites during 2005 - 2006 in southern Indiana (Orange & Putnam Counties) and one in northern Indiana (Lake County) found that Two Lined Chestnut Borer and Armillaria Root Rot were involved in the decline and death of the white oak. Again, making the report of white oak mortality unusual was that the red oak group species observed in the sites were not declining or dying.

A. bilineatus attacks primarily oaks trees, weakened by various stress factors including drought and defoliation. The larvae bore into the inner bark, begin feeding and form meandering galleries in the inner bark and outer wood (Figure 20). The feeding galleries of many larvae effectively girdle the tree by blocking the movement of food to the roots and water to the shoots. These borers first infest the upper crown; later infestations are lower and often reach the base of the tree. The combined actions of the borer in the stem and the fungus in the roots can bring about rapid decline and death.

Scattered white oak mortality has been observed in 2007 in Morgan, Jackson, and Orange counties and is probably more widespread than reported. In areas were groups of white oak trees are dying, salvage harvest operations should be implemented to preserve the timber value and contain further spread of two-lined chestnut borers.

6. Decline in Yellow-poplar and Hickory

Tree decline is a complex disease with no single cause. In recent years, Indiana foresters have observed trees with dieback and decline symptoms at all ages and sizes of yellow poplar and bitternut/pignut hickories. Reports of decline in these species was reduced in 2007, however, decline is still a concern in localized situations.

The IDNR concluded a study of yellow-poplar decline (Krecik and Marshall 2005) in south-central and south-eastern Indiana in 2005. Through this research, it was reaffirmed that yellow-poplar decline is strongly associated with prolonged drought events. In particular, decline symptoms were most pronounced on exposed southern slopes, and first appeared after the 1999 and 2002 droughts. Decline symptoms and mortality were most pronounced on smaller-diameter trees with suppressed crowns, but there was no correlation between high stand density and decline symptoms.

Foresters have reported hickory decline primarily in southeastern Indiana during recent years, particularly with bitternut and pignut hickories. Recently described fungal species *Ceratocystis smalleyii*, and *C. caryae* are suspected causal agents. Recent greenhouse research has confirmed that *C. smalleyii* as a causal agent in hickory mortality. A current multi-state study by the Forest Service, in which Indiana cooperates, is underway to examine the role of *Ceratocystis* fungi in hickory decline and gain more information on its status and the risk from these fungi.

7. **Looper Complex** – Linden Looper *Erannis tiliaria* and Half Winged Geometer *Phigalia titea*

Dramatic, cyclical defoliation events in southern Indiana, caused by the native half-wing geometer and linden looper (hence the name "Looper Complex"), for over 30 years (Fig. 21). Hosts of these insects include most hardwood trees, including various oaks, hickories, and red maple. Their populations exist at low to moderate levels, and then expand dramatically every 20 to 25 years.

Figure 21: *2003 Looper complex defoliation in Washington County (S. Krecik – IDNR)*

The last epidemic started in 2001, and collapsed by the spring of 2005. Aerial and field surveys in 2007 did not detect noticeable defoliation. However, scattered mortality was observed over the forests, with greater mortality in areas that had been heavily defoliated in the past. Management responses should continue to salvage stands with significant mortality. The salvage window to capture higher quality wood is closing in 2008 and after. Thus, salvage harvests in the future lose economic value and are done to return the stand to a better health status for future management goals. For more details on the epidemic, see the 2003 and 2004 Indiana Forest Health Highlights.

8. Conifer Bark Beetles and Pine Plantation Mortality

Figure 22: *Southern Pine Beetle*

The 2007 growing season saw a rising number of concerned landowners calling about groups of hard pines, such as shortleaf and red pine, dying in their established plantations and wind breaks. There were also several similar reports for white pine as well. Many of these forests, planted from the 1930's through the 1960's, are reaching maturity and in many situations have increased in density from a lack of management activity. As the density increases, the competition and weather stress make trees more prone to attack and death from bark beetles.

There are several pine bark beetle species in Indiana that are starting to take advantage of this tree stress to attack Indiana pines and build a population that will grow in capacity to attack healthy trees as well. Bark beetles involved include *Ips* bark beetles, *Ips pini* or *Ips grandicollis*,

and turpentine beetles, *Dendroctonus tenebrans* and *D. valens*. They typically produce 2-3 generations in one growing season, and can expand their populations quickly, sometimes attacking remaining healthy trees. (http://www.ces.purdue.edu/extmedia/BP/BP-35.html)

The management of this forest health problem is best achieved by monitoring pine stands, and quickly applying salvage harvests. Preventative measures, such as thinning high-density pine stands, help increase crown size thereby increasing tree vigor. Because attacked pines usually die within one growing season and secondary insects and fungi reduce wood quality, salvage operations should be rapidly executed.

The future for pine stands across Indiana includes the increased presence of pine bark beetles and the death of pines in groups or scattered individual trees. Forest management activities that reduce stand density and promote radial growth are measures that can manage the impact of pine bark beetles.

9. Miscellaneous Forest Insect and Disease Concerns in 2007

The following miscellaneous insect and disease pests were reported by landowners and natural resource professionals for 2007. Their appearance was reported in some instances to be locally destructive, but overall they were not a widespread concern to the forest base. Hypertext links to forest pest factsheets may be linked to by following the imbedded links in the common names of each pest:

Insects:

Aphids: A number of aphids were noted by IDNR Nursery Inspectors on woody plants. Specific species noted included balsam twig aphid, birch aphid, witch-hazel gall aphid, woolly apple aphid, and beech blight aphid, though there were other species at work. Because of their size and chronic rather than acute effects on forest health, they fell below the radar for most landowners and other natural resource professionals. Host plants observed in 2007 included: birch, ash, maple, burning bush, spruce, hawthorn, *Spirea*, oaks, crabapples, *Amelanchier*, walnut, fir, yellow-poplar, and *Rhododendron*.

Figure 23: *Bagworm pupal case (US Forest Service)*

Bagworms (*Thyridopteryx ephemeraeformis*) – From the late 1970's to the 1990's, bagworms were limited in the northern half of Indiana. With increasingly warmer winters and recently dry summers, bagworms have become more pronounced and range further north in the state. IDNR Nursery Inspectors reported bagworms statewide in 2007. They fed on a wide variety of hosts, including pine species, Norway and Colorado blue spruce, sweet gum, red maple, arborvitae, junipers, honey locust, cherry, pin oak, bald cypress, Douglas-fir and white fir. Damage was reported to be widespread but light to moderate in severity.

Spider Mites (various species) – The dry summer weather decreased plants abilities to deal with attacks from various pests, including mites. Numerous calls from homeowners were received

with concern over their spruce trees. Branches, when examined under a hand lens revealed the presence of spruce spider Mites. In 2007, other tree species besides spruce were affected by specific spider mite species, including European red mites (serviceberry and crabapple), maple gall mites (maple species), honeylocust mites (Honeylocust), two-spotted spider mites (various tree species).

Tuliptree Scale (*Toumeyella liriodendri*) and other **Scale Insects** - The tuliptree scale is one of the largest soft scale insects in the United States. The tuliptree scale is a key pest of yellow-poplar or tuliptree, magnolia, and occasionally linden. This soft scale insect is so prolific that it often completely covers twigs and branches. In 2007, tuliptree scale was noted especially in southwestern and central Indiana. Scale insects, like many others pests, have increased prolifically in response to weakened plants due to the 2007 drought. Ash scurfy scale (*Chionaspis* sp.) had a first-ever observation in the state, for example. Other scales observed include cottony maple scale (*Pulvinaria innumerabilis)*, golden oak scale (*Asterodiaspis variolosa*), juniper scale (*Carulaspis juniperi*), oystershell scale (*Lepidosaphes ulmi*), pine needle scale (*Chionaspis pinifoliae*), and Putnam scale (*Diaspidiotus ancylus*).

Fall Webworm (*Hyphantria cunea*): Numerous instances of fall webworm were reported in 2007, especially in southwestern Indiana. It was reported in Hancock County (central Indiana) on June 5th by an IDNR Nursery Inspector. Usually the webs are not noticeable until the second generation that appears in August or September.

Eastern Tent Caterpillar (*Malacosoma americanum)* was reported at much lower levels in south-central Indiana than the epidemic levels of 2000 to 2002. Low levels are expected to continue in 2008.

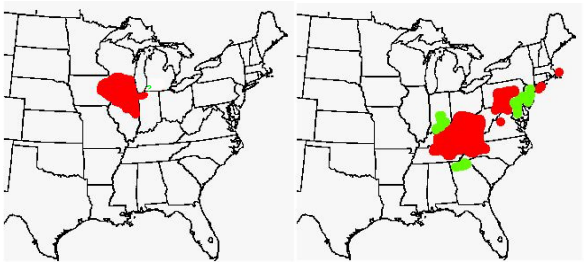
Locust Leaf Miner: (*Odontata dorsalis*): Following outbreaks in southern Indiana during the early 2000's, the brown-colored foliage created by larvae and adult feeding has receded in intensity. Compared to reports from past years, IDNR Forest Health Program did not receive calls concerning this pest, nor did IDNR Nursery Inspectors note damage. This native insect is a low population cycle, and will likely return to noticeable levels in the next few years.

Zimmerman Moth (*Dioryctria zimmermani*) is an exotic invasive species. The dead branches and pitch masses on red, Scotch, and other conifers created by larval tunneling at branch whorls were encountered in nurseries and Christmas tree plantations in southwest, west-central, and central Indiana during 2007. This moth caused low to moderate damage levels where encountered.

Summer Caterpillars: Walnut Caterpillar (*Datana integerrima*); Various Saturniids (Polyphemus Moth, Prometheus Moth, Hickory Horned Devil, Spiny Oak worm, Orange Striped Oak worm), Mimosa Webworm (*Homadaula anisocentra*), Ugly Nest Caterpillar (*Homadaula anisocentra*), and Yellownecked caterpillar (*Datana ministra*) were observed in 2007 in Indiana. Some noticeable defoliation was noted, especially with yellownecked caterpillars and walnut caterpillars.

Periodical Cicada: Brood XIII arrived in northwestern Indiana in May of 2007. Damage to twigs and branches from

Figure 24 *Periodical Cicada Brood XIII (left) and XIV(right) maps. Areas in green have less established records than in those in red.*



ovipositing was evident within 6 – 8 weeks as weakened branches broke, turned brown, and created "flagging" across forest and ornamental trees. Cicada Killer wasps were noted as well, in response to increased periodical cicada numbers. Brood XIV will visit south-central Indiana in May 2008.

Diseases:

Bacterial Leaf Scorch : Natural resource personnel made numerous observations in 2007 of leafhoppers infesting a wide range of woody plants. Leafhoppers are known to transmit bacterial leaf scorch, a bacterial vascular plant disease. The bacterium (*Xylella fastidiosa*) multiplies rapidly within plant xylem, clogging it and depriving the leaf of water and producing scorch-like symptoms. Plants damaged by the bacterium include sycamore, mulberry, red maple, sugar maple, sweetgum, elm, oak and a number of other species. IDNR Division of Forestry's Forest Health Program is currently assessing whether enough concern exists to make a formal survey of the extent of this plant health problem.

Verticillium Wilt (*Verticillium dahlia)*: Verticillium wilt was reported in 2007 by IDNR nursery inspectors in central and south central Indiana, in maples, redbud, and smoketree. Damage ranged from dieback to mortality. Other areas of the state also experienced verticillium wilt, but may have been identified as decline because of the drought. Because of the 2007 drought and other stress conditions, verticillium wilt is expected to be observed in 2008.

Oak Tatters: The tattered foliage of oak has been reported in Indiana since 1983. The tattered foliage, primarily of white oak and other oaks, was not reported in 2007 as in prior years.

The cause of oak tatters has been investigated since the 1980s, finding several suspect causes. Recent greenhouse research in Illinois (Samtani, Masiunas, and Appleby 2005) exposed two year old potted white oaks to varying concentrations of choloracetamide herbicide products, and produced the tatters symptoms on the treated oaks. Oak tatters, while not reported recently in Indiana, may appear again in 2008 as Indiana's fragmented woodlots often border crop fields where herbicides are commonly used.

Fire Blight (*Erwinia amylovora*): IDNR Nursery Inspectors noted that 2007 was an especially severe year for fire blight and that the disease affected even normally resistant cultivars such as Bradford pear. Other resource professionals also noted that the disease was prevalent on pear trees in the urban forest. While native apples and crabapples are very minor components of Indiana's forest resource, both they and domesticated trees constitute important food sources for wildlife and are components of urban forests. Landowners and resource managers should expect a continued presence of fire blight in 2008.

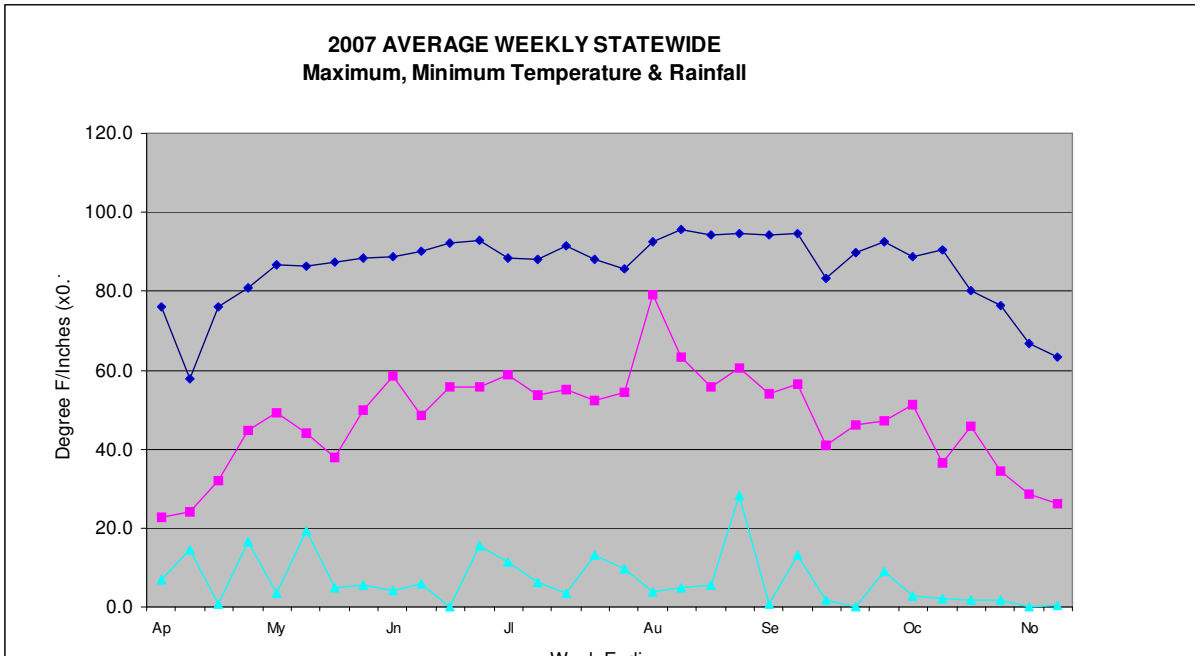
6. Weather-Related Issues in Indiana Forests

Weather – Tornados, flooding, drought and other weather events commonly stress and damage Indiana forests. The last major growing season floods to seriously impact forests occurred in 2003 along the Wabash and its tributaries. The last notable tornado damage (to several hundreds of acres) occurred in 2004 in Clark County on and around Clark State Forest.

2007 Drought - 2007 (Figure 25) saw drought affect much of the State of Indiana. This drought follows record droughts in 1988 and 1999, while other seasons (e.g. - 2002 and 2005) have shown reduced rainfall levels as well. Forest managers and landowners should continue to look for drought-related mortality in 2008 and beyond.

2007 April Freeze: Following an abnormally warm period in late March, a week-long freeze followed in early April. This affected trees in the southern 1/3 of the state especially hard, as leaf expansion was 50% expanded for oaks and other hardwoods. The most noticeable damage occurred in counties along the Ohio River, and occurred primarily on oaks. The freeze effectively defoliated trees, causing them to draw on stored reserves and reducing their overall vigor. Once the 2007 drought set in, this additional stress factor further reduced tree vigor. Some light, scattered weather-related mortality was already evident by the end of the 2007 season. Forest managers and landowners should continue to look for further mortality in 2008 and beyond.

Figure 25: *Average Indiana weekly maximum temperature, minimum temperature and rainfall for 2007*



7. Invasive Plant Species

Invasive exotic plant species are non-native plants that form self-sustaining and expanding populations within a natural plant community with which it had not previously been associated. Invasive exotic plants constitute a threat to native plant communities and forests in Indiana. They displace native plants, eliminate food and cover for wildlife, and threaten rare plant and animal species. However, among natural resource professionals there exists difference in opinions over which species constitute the greatest threat to natural areas. Consequently, species that are considered a grave threat by some resource professionals are still recommended by other resource professionals and sold by nurseries. Burning bush, for example, forms portions of the forest understory near suburban areas due to seed dispersion by birds, yet it remains a highly desired landscape species. Many species of invasive exotic plants are generally regarded as

economically disruptive to agriculture and thus regulated by state law as noxious weeds. This law requires property owners to control noxious weeds, including listed invasive plant species. Among those plant regulated is Kudzu (*Pueraria lobata*), an Asian native normally associated as an engulfing invasive vine in the Southern U.S.

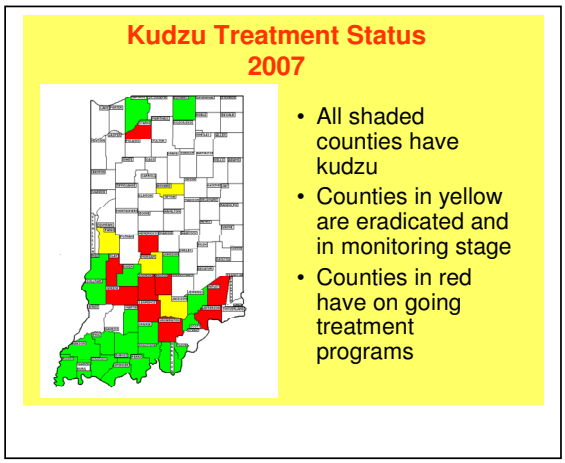


Figure 26 – *Indiana kudzu eradication treatment status (K. Cote – IDNR)*

Kudzu provides a good snapshot of the efforts being made by natural resource agencies to control invasive exotic species. Starting in 2003, Indiana began surveying for the location and extent of kudzu. By 2007, more than 100 acres at 102 sites in 35 counties had been identified. During 2007, The Indiana DNR, Division of Entomology and Plant Pathology treated 18 kudzu sites in 13 different counties (Fig. 26). Treatments were conducted in Brown, Clay, Greene, Hendricks, Jackson, Jefferson, Lawrence, Monroe, Morgan, Parke, Ripley, Starke and Washington counties. 12 of the sites received their second treatment and 6 of the sites were new treatment sites. Transline (Clopyralid) has provided an estimated 85% suppression in the first year at most sites. However re-growth did occur and all of the sites and second applications were necessary and it is likely that a third of spot treatment applications will be needed.

In addition to treatment, IDNR continues to survey for kudzu. Five new sites totaling 2.91 acres were confirmed in 2007, and additional reports continue to be investigated. The IDNR Division of Entomology is continuing to work with the USDA NRCS, the DNR Division of Forestry, Purdue University and local landowners and organization to assist in kudzu eradication throughout the state by providing technical support and site information. Current cost estimates to completely eradicate kudzu from Indiana are between 1 and 2 million dollars.

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