

Abstract An invasive species is defined as a non-native species whose introduction does or is likely to cause economic or environmental harm, or harm to human health. Over 50,000 non-native species (vascular plants, plant pathogens, arthropods, mollusks, fishes, reptiles, amphibians, birds, mammals, and animal or human pathogens) have been introduced into the US intentionally or un-intentionally. Only a fraction of them became invasive species with significant impacts on the economy and the environment. Various invasive insects and diseases found their way to our forests and hence pose serious threats to forest health and environmental quality. Increasing globalization and climate change bring additional challenges to the management of invasive species. Community cooperation and proactive prevention, monitoring, control, and restoration measures are the key factors in this process.

Prevention

Sudden Oak Death

Phytophthora ramorum Werres (Oomycetes: Pythiaceae)

P. ramorum is the causal agent of sudden oak death first found in 1995 in California. Tens of thousands of oaks have been killed in central California and southwestern Oregon.



In Pennsylvania, *P. ramorum* was first intercepted in Delaware County in 2006. Since then, terrestrial surveys and stream baiting were conducted. A total of 22 streams have been monitored with no detections.



Asian Longhorned Beetle

Anoplophora glabripennis (Motsch.) (Coleoptera: Cerambycidae)

Asian longhorned beetle (ALB), an exotic pest of many important hardwood species such as maples (*Acer* spp.), was first discovered in the city of New York in 1996. Isolated infestations were also found in Chicago, New Jersey, and most recently in Massachusetts. It attacks both healthy and stressed trees with small and large diameters. Most damage is caused by the feeding of its larvae within the trunks and large branches as the large tunnels created by them lead to structural weakness and eventual death of the trees.

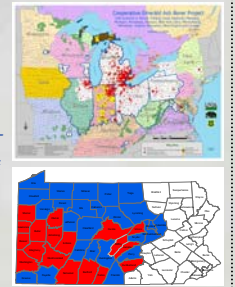
A zipcode based visual survey was initiated in 2010 to examine the campgrounds visited by campers from infested areas. Host trees surrounding the campsites within those campgrounds will be inspected for signs and symptoms of ALB infestations. Aggressive measures will be taken to prevent this devastating pest from establishing in Pennsylvania.



Emerald Ash Borer *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae)

The Emerald ash borer (EAB) is an exotic pest of ash trees in North America. It was first discovered in southeastern Michigan in 2002. Since then it has been found in 15 states in the U.S. and 2 provinces in Canada (Fig. 1). Larval feeding under the bark eventually leads to death of the tree. Millions of ash trees have been killed by this pest throughout the years.

EAB survey and detection in Pennsylvania is coordinated by the Department of Conservation and Natural Resources, Department of Agriculture, and USDA-APHIS. Surveys began in 2003 through visual inspection, trap trees, and purple panel traps in high risk areas. The beetle hunting wasp, *Cerceris fumipennis* (Say) (Hymenoptera: Crabronidae), is also being evaluated as a biosurveillance tool. As a result, EAB was found in Butler County in 2007. Currently, a total of 43 counties in the state are under quarantine, including 18 counties where EAB were detected through our surveys (Fig. 2).



Monitoring

Sirex Woodwasp

Sirex noctilio F. (Hymenoptera: Siricidae)

Sirex woodwasp is a pest of pines native to Europe and Northern Africa. It was first detected in New York in 2005. Infestations in Pennsylvania were found in Tioga and Bradford counties in 2006.

Baited Lindgren traps were used to survey for this pest in 2007 in locations around initial infestations. As a result, Sirex woodwasp was detected in Erie, Elk, McKean, Potter, Sullivan and Monroe counties in 2008.

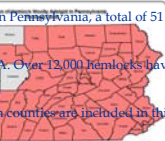
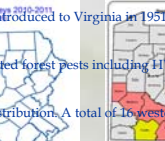
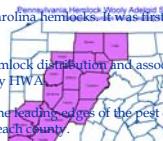
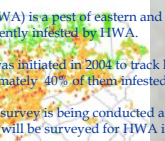
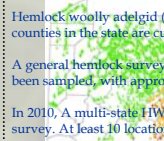


Hemlock Woolly Adelgid, *Adelges tsugae* Annand (Homoptera: Adelgidae)

Hemlock woolly adelgid (HWA) is a pest of eastern and Carolinian hemlocks. It was first introduced to Virginia in 1951. In Pennsylvania, a total of 51 counties in the state are currently infested by HWA.

A general hemlock survey was initiated in 2004 to track hemlock distribution and associated forest pests including HWA. Over 12,000 hemlocks have been sampled, with approximately 40% of them infested by HWA.

In 2010, a multi-state HWA survey is being conducted at the leading edges of the pest distribution. A total of 16 western counties are included in this survey. At least 10 locations will be surveyed for HWA in each county.



Exotic Bark Beetles

Non-native bark and ambrosia beetles are a serious threat to our nation's urban and rural forests. Early detection is the key to the management of these pests. Detailed information on their occurrence and distribution is needed for rapid response from federal, state, and local agencies for the prevention of pest establishment and associated potential risks.

As part of the multi-state Early Detection and Rapid Response (EDRR) project, a total of 12 sites were selected from wooded areas in locations with high risk due to importing, storing or recycling potentially infested solid wood packing material, dunnage, crating, pallets or other items in Pennsylvania. Three 12-unit funnel traps were used at each site with each trap baited with one of the three types of lures. The trapping period lasted for 12 weeks from late March to mid-June, 2010. Traps were checked every two weeks, with the lures replaced every four weeks. Non-native bark and ambrosia beetles collected from the traps were submitted for identification.

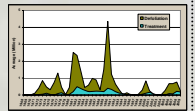


Control

Gypsy Moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae)

Gypsy moth is an important pest of oak forests in Pennsylvania. Outbreaks have been observed every five to seven years since 1968. At its peak in 1990, gypsy moth defoliated 4.3 million acres of forest in Pennsylvania.

Suppression of gypsy moth populations in the state is achieved through the aerial applications of *Bacillus thuringiensis* (Bt). This is a coordinated effort among federal, state, and county governments. A total of 177,668 acres were treated in 2009.



HWA Suppression

In 2005, a chemical suppression program was implemented on state-owned lands (State Forests and State Parks) to protect high-value hemlock trees from HWA. Various formulations of imidacloprid were used through soil drench, soil injection, or trunk injection. Results showed treated trees had lower level of HWA infestation and higher amount of new growth compared with control trees. The suppression program on state lands will continue in 2010 and 2011.



Year	Methods	No. of site	No. of trees	Total DBH (inches)
2005	Soil drench Trunk injection	41	4,572	N/A
2006	Soil injection Trunk injection	30	7,244	97,892
2007	Soil injection	16	5,409	42,299

HWA Biological Control

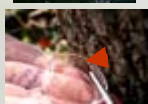
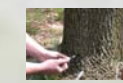
Biological control of HWA in Pennsylvania started with the release of predatory Asian coccinellids *Sasajiscymnus tsugae* (Sasaji&McClure) and *Scymnus sinuanodulus* Yu&Yao. The native tooth-necked fungus beetle, *Laricobius nigrinus* Fender (Coleoptera: Derodontidae) was also included. Both *S. tsugae* and *L. nigrinus* have been recovered through post-release evaluations.



Predator	Year released	No. released
<i>Sasajiscymnus tsugae</i>	1999-2005	238,186
<i>Scymnus sinuanodulus</i>	2005-2007	5,920
<i>Laricobius nigrinus</i>	2003-2010	3,421

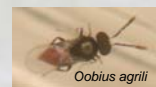
EAB Management

An integrated pest management project for EAB was initiated in 2010. Selected tree removal, chemical treatment, and biological control are being utilized at a selected community. Successful management of EAB in this site will serve as a model for statewide public education & outreach activities.



EAB Biological Control

We are participating in the nationwide EAB biological control project through the field release of three hymenopteran parasitoids: *Oobius agrili* Zhang&Huang (Encyrtidae), *Tetrastichus planipennis* Yang (Eulophidae), and *Spathius agrili* Yang (Braconidae). Site selection is underway.



Restoration

Butternut Conservation

Butternut canker is a fungal disease caused by *Sirococcus clavigeni-juglandacearum*. Perennial stem cankers created by the infection of this fungus will eventually girdle and kill the infected trees.

A multi-state project was initiated in 2009 to locate canker-resistant butternut specimens for butternut conservation. A total of 196 trees have been located throughout the state. Dormant twigs or leaf samples were collected and tested for species identity. Positive identification led to grafted seedlings from 27 pure butternut families. Seedlings will be used for pathogenicity testing.

