**Component III: Protection of Natural Ecosystems**

# 3a. Terrestrial Forest Insects (U.S. Value: More than $670 billion threat from Asian Longhorned Beetle, alone)

***Problem Statement*:** Major tree species (ash, maples, oaks, pines, etc.) are threatened and/or sustain significant mortality due to the following insect pests:

- Longhorned Beetles (threaten many hardwood species if not eradicated)
- Emerald Ash Borer (killed millions of ashtrees in the Great Lakes Region and is spreading rapidly)
- Asian, European, and related Gypsy Mothspecies (represents a threat to many tree species if it becomes established)
- Lobate Lac Scale [attacks over 200 plant species in Florida, including rare native species in special habitats (Everglades' tree islands and tropical hammocks)]

***Research Needs*:**

1. **Asian Longhorned Beetle and Citrus Longhorned Beetle** (*Anoplophora* spp.)

   **Importance:** The Asian longhorned beetle (ALB) is a polyphagous non-indigenous invasive insect pest species threatening an unusually wide variety of hardwood tree species in North America. ALB has successfully attacked and developed in nine maple species, four willow species, three elm species, three birch species, horse chestnut, and sycamore. These and other susceptible tree species make up approximately 33 percent of the tree cover in all urban areas in the eastern United States. One species, sugar maple, is the symbol of the Northeast and the backbone of the maple syrup and fall foliage tourism industries. ALB has been found infesting trees in New York, Chicago, Massachusetts and New Jersey in the United States, and Toronto, Ontario in Canada. To date, more than 18,000, 22,000, 1,771 and 25,000 trees have been removed in the New York, New Jersey, Illinois and Toronto infestations, respectively. However, while ALB has been declared eradicated in two localized infestations (Chicago and northern New Jersey), the larger ALB infestations in New York and New Jersey continue to pose a significant risk in the United States, and an adult was found in Chicago in August 2008, as well as a new infestation in Massachusetts.

   Potential economic losses to lumber, maple syrup, and tourism industries have been estimated at $670 billion in the United States, if the beetle is allowed to expand beyond its currently known infested areas. At risk are the forests covering approximately 48 million acres from New England westward beyond the Great Lakes. These forests are vitally important to the species diversity and ecological processes of natural and protected areas, and protect public drinking water quality (e.g., for New York City) and many rare species and natural communities. Therefore, ALB could drastically alter the makeup of North American forests and significantly impact natural forests and urban environments.

The citrus longhorned beetle (CLB) is a related polyphagous pest attacking living trees of over 100 species in 40 genera in 26 different families, including species of *Acer* (maple), *Aesculus, Alnus* (alders), *Betula* (birch), *Carpinus* (hornbeam), *Casuarina* (chestnut), *Citrus* (e.g., lime, lemon, oranges, tangor), *Corylus* (hazel), *Cotoneaster* (cotoneaster), *Crataegus (hawthorn), Cryptomeria japonica* (cedar), *Fagus* (beech), *Ficus* (fig), *Hibiscus, Lagestroemi* (crape myrtle), *Litchi, Mallotus, Malus* (apple), *Melia*, *Morus* (mulberry), *Platanus* (sycamore/plane tree), *Poncirus* (Trifoliate orange), *Populus* (poplar), *Prunus* (cherry laurel), *Pyrus* (pear), *Rosa* (rose), *Salix* (willow), *Ulmus* (elm), and *Zizyphus.* CLB was found in trees imported into Washington State, from Italy, the Netherlands and Germany. The beetle has infested and killed thousands of maple and other trees in Italy and was also recently discovered killing hundreds of thousands of citrus trees in south central China. CLB presents a significant threat similar to that of ALB, if not greater, due to the much broader range of tree species at risk, particularly citrus.

**Research Gaps:** Urgent solutions are needed for early detection of, and rapid response to, new introductions and incipient populations of ALB and CLB. The most promising strategies identified will be through advances in our knowledge of the host selection and colonization process at both the tree and landscape levels. Collectively, early detection and rapid response are the keys to preventing establishment and to containing established populations, thereby making eradication a viable option. Early detection of ALB and CLB will likely depend on development of strategies for implementation of existing technologies and development of new innovative technologies. Early detection would facilitate the targeting of control methods. Rapid response for containing ALB and CLB infestations may initially be dependent on insecticides, although increased pesticide use for this purpose is undesirable. Attract-and-kill and new strategies represent potential viable alternatives to the use of insecticides. Concurrently, there is need to begin development of long-term, sustainable approaches (e.g., IPM) for managing ALB should it become permanently established in North America, as well as to halt the spread of the existing CLB infestation in Italy. Among these approaches is biological control, developed through comprehensive faunistic and floristic assessments in the countries of origin and countries of invasion to provide a base of understanding for identifying biological control agents with desirable traits, e.g., no significant non-target effects and highly efficient host searching ability and parasitism. In addition, there is a need to expand research on invasive species in areas at the interface between urban and natural areas. More specifically, this includes research on the potential spread of ALB within and between natural ecosystems (e.g., South Korea) and urban areas (e.g., North America, Europe, China) and at their interface (e.g., North America, Europe, South Korea, China); and the potential spread of CLB in agricultural (e.g., citrus), urban, and natural ecosystems, and at their interface.

**Actions:** For ALB and CLB, ARS will:

Attractants

- Discover plant kairomones and insect pheromones that can be used to attract *Anoplophora* species.

- Identify and synthesize promising semiochemicals.
- Evaluate promising semiochemicals.

Monitoring

- Investigate optimal pheromone component blends for attracting and monitoring ALB and CLB.
- Develop protocols for using attractants in eradication and/or management programs.

Detection, Infested Trees

- Investigate new technologies for detection of trees infested by ALB and CLB.

Detection and Control, Attract-and-Kill

- Develop attract-and-kill strategies and protocols for use in eradication and/or management programs, especially for ALB.

Control, Biological

- Explore for new biological control agents for classical biological control of ALB.
- Explore for native natural enemies for enhancing biological control of ALB by existing natural enemies through conservation or augmentation biological control.

Control, Insecticide

- Evaluate promising insecticides for CLB.

## 2. Emerald Ash Borer

**Importance:** The emerald ash borer (EAB), *Agrilus planipennis*, is a buprestid beetle that feeds as larvae in the cambium layer between the bark and wood, producing galleries that eventually girdle and kill trees. Since 2002, when the insect was first found in southeastern Michigan, EAB has killed or infested tens of millions of ash trees in both managed and natural forests of nine northeastern and midwestern states. This relatively new pest spreads rapidly and kills all sizes and even very healthy ash trees. Ash is a "workhorse" species in urban forests, and comprises a substantial portion of forest communities that provide ash products to our local and national economies.

**Research Gaps:** Accelerated research is necessary to develop control strategies for EAB that can be used by homeowners and arborists. Augmentative and inundate biological control programs appear to be the most promising control strategies in areas where the EAB is firmly established. Research is needed to identify and evaluate exotic and native natural enemies, investigate their potential roles in suppressing EAB populations, develop effective rearing methods and technology for mass production of these parasitoids, and to develop life table methods for quantifying the efficacy of the natural enemies used as biological control agents.

Concurrently, other approaches need to be developed if biological control agents fail to provide a sustainable, long-term management strategy for the borer. The most promising of these appear to be host plant resistance and preservation of ash germplasm. Though all North American ash species are highly susceptible to EAB, the Asian ash species, especially Manchurian ash (*F. mandshurica*), appear to be much more resistant. It might be possible to introduce resistance genes into North American forests by developing Asian X American hybrids followed by backcrosses with North American ash species to retain the original characteristics. By preserving germplasm in the form of seeds, it would be possible to repopulate ash species after the existing trees and host specific EAB die out. Control tactics such as biopesticides, soil injection or drenches, and trunk injections with systemic insecticides also need to be developed to provide short term management.

A prerequisite for responding effectively to EAB infestations in new areas is being able to detect them as soon as possible. Although attractants for EAB are under investigation by Federal and state scientists, highly effective chemicals have not been identified. Research should continue into discovering attractant compounds emitted by the beetles and ash trees, followed by attractant synthesis, blending, and formulation for field use and optimum trap design. The roles that vision and other sensory modes play in attracting EAB also need to be investigated. While sensitive monitoring of adults would be the first priority, mass trapping for control could become feasible in the future. Finally, attractants could be important in other areas of research on EAB, for example, monitoring biological control agents. Research on how parasitoids of EAB find their hosts or mates could lead to new tools for detecting and monitoring these beneficial insects.

**Actions:** ARS will:

Attractants

- Isolate, identify, synthesize, and evaluate EAB attractants, e.g., sesquiterpenes, from host ash trees.
- Evaluate the behavioral effect of the putative pheromone of EAB, a sex-specific compound that was previously identified at ARS-Peoria, but for which no function has yet been established.
- Investigate volatiles from EAB eggs, larvae and host plants for attractiveness to EAB parasitoids, and seek to identify pheromones of the parasitoids.

Monitoring

- Improve sampling and monitoring methods for EAB using traps baited with an attractant.
- Develop an insect tracking system using harmonic radar to measure dispersal ability (flight range) for many insect pests, including EAB.

Control, Biological

- Search for new natural enemies in previously unexplored regions of the Far East.
- Determine impact (using a life table approach) of the most effective parasitoid and/or other key mortality factors in regulating populations of EAB.
- Conduct quarantine evaluation and host specificity studies on imported natural enemies.
- Develop effective mass rearing methods for producing host EAB eggs and larvae.
- Develop technology for effective parasitoid exposure, storage, and production of progeny for the most promising species.
- Conduct developmental research needed to implement an area-wide biological control program against EAB.

Control, Biopesticides

- Determine the effectiveness and feasibility of use of microbial control agents in an integrated program for EAB management. Host Plant Resistance *(This research is done by National Program 301)*
- Conduct research to determine if new resistant ash varieties can be identified for use in the landscape.
- Obtain accessions of Asian ash species for use in hybridization experiments.
- Do cytogenetics experiments to see which Asian and North American ash species are likely to have compatible ploidy levels.
- Conduct interspecies hybidizations to see if resultant cultivars are more resistant than native cultivars.
- Preserve ash germplasm.
- Design and organize collections of seed from wild ash populations to capture the biodiversity present over the range of ash species and store seed at National Center for Genetic Resources Preservation in Peoria.

### 3. Asian, European and Related Gypsy Moth Species

**Importance:** The Asian gypsy moth (AGM), *Lymantria. dispar asiatica*, differs from the European gypsy moth (EGM) in several important respects: (1) AGM can attack more tree species (about 500 known hosts, including conifers), (2) they are larger, and (3) females fly and disperse. In addition, AGM can mate freely with the established EGM. These characteristics combine to make the AGM an even greater threat to North American forests than the devastating EGM has been. As a result, Federal policy has been to eradicate Asian gypsy moth infestations whenever and wherever they are found. Several introductions of AGM to the Pacific Northwest and other U.S. regions have occurred in the last 15 years. To date, known infestations have been successfully

eradicated, but the pest continues to pose an invasive species threat to North America. Several other pests in the genus *Lymantria* exist in Eurasia and also represent potential invasive threats to North America: nun moth, *L. monacha*; pink gypsy moth, *L. mathura*; Japanese gypsy moth, *L. dispar japonica*; Indian gypsy moth, *L.* obfuscata; and luna tussock moth, *L. lunata*. EGM continues to spread and move into Midwest and Southern United States regions containing highly vulnerable trees and continues to cause significant management and economic impacts.

**Research Gaps:** Although Asian gypsy moth species have been studied by ARS in terms of taxonomy and nomenclature, description and synthesis of the sex pheromones of most species, and characterization of parasitoid predator/pathogen complexes of two *L. dispar* species (*asiatica* and *japonica*), there are many gaps in research. Almost no genetic information exists for gypsy moths that would enable identification of genes associated with pesticide susceptibility or resistance and help develop novel targets for pest control. New management tools with improved persistence are needed to slow the movement of EGM and abate potential AGM introductions.

**Actions:** ARS will:

- Provide identifications of Lymantriid tussock moths as needed by APHIS.
- Provide quality control analyses of pheromones provided by industry for use by APHIS and state regulatory agencies.
- Characterize expressed gene profile of GM to identify genetic vulnerabilities.
- Develop new microbial GM management tools with improved persistence.

## 4. Lobate Lac Scale

**Importance:** The lobate lac scale (LLS), *Paratachardina lobata*, a recent introduction (discovered in the late 1990's) to Florida, is an extremely dangerous pest, because it is known to attack over 300 species of woody plants. Trees and shrubs in many important natural areas of southern Florida have been damaged, including Everglades National Park, Big Cypress National Wildlife Refuge, and Loxahatchee National Wildlife Refuge. High value indigenous and horticultural plants such as wax myrtle (*Myrica cerifera*) and coco plum (*Chrysobalanus icaco*) have been killed in many localities. Redbay (*Persea borbonia*), an attractive evergreen tree common along the coasts of the southeastern United States, is highly susceptible to the scale. LLS also occurs in the Bahamas, where a recent survey found that two-thirds of plant species examined were infested.

**Research Gaps:** Pesticides are not a control option in natural areas because of statutory restrictions, probable adverse effects on non-target organisms, and the large acreages involved. Many non-indigenous scale insects have been successfully controlled by importation of the natural enemies that suppress their populations in their land of origin. The best long-term solution for controlling LLS is using its natural enemies. However, little is known about the identity and biology of most natural enemies of LLS and its close relatives. A chalcidoid wasp that parasitizes LLS was found in India; it also

parasitizes true lac scales in its native range. Foreign exploration for additional co-adapted natural enemies needs to be conducted in India and Sri Lanka. Although these wasps have a very narrow host range, research must confirm the host specificity of these parasites before they can be used in Florida. Candidate natural enemies from overseas must be subjected to host specificity testing with native scales to determine their safety.

**Actions:** ARS will:

Control, Biological

- Conduct surveys in India and Sri Lanka to discover specialized natural enemies of LLS.
- Obtain natural enemies of LLS for quarantine evaluation and conduct host-specificity testing of candidate biological control agents for LLS to assess potential risk to non-target species.
- Develop techniques for mass rearing promising LLS natural enemies, and release approved agents.
- Evaluate post-release colonization, spread and impact of the biological control agents on LLS and non-target scales.

***Anticipated Products:***

- Development of practical lures, for use by land managers (local, state, and federal agencies) for detection of ALB, EAB and other invasive insect pests.
- New semio-chemicals for insect monitoring and control.
- Improved tools for studying dispersal ecology, host preference, and other epidemiological issues.
- Identification of plant traits that might be used to develop pest-resistant trees.
- Development of trees with pest resistance.

***Potential Benefits (Outcomes):***

- Strategies for improved control of insect pests in natural ecosystems.
- Reductions in damage to trees in natural ecosystems by insect pests.
- Improved technologies for detection of invasive species at ports of entry.
- Successful eradication of insect pests (ALB and AGM) with limited distribution or that are not yet established.
- Permanent biological control of established insect pests (EAB and LLS) by introduction of specialized natural enemies from the regions of their origin.
- Reductions in expenditures, including application costs, to manage insect pests.
- Management technologies that are biologically based and ecologically sound.

- Saving native tree species (e.g., ash) from extinction.

***USDA ARS Resources:***

- Application Technology Research Unit, Wooster, Ohio
- Beneficial Insects Introduction Research Unit, Newark, Delaware
- Biological Integrated Pest Management Research Unit, Ithaca, New York
- Crop Protection Research Unit, Peoria, Illinois
- European Biological Control Laboratory, Montpellier, France
- Invasive Insect Biocontrol and Behavior Laboratory, Beltsville, Maryland
- Invasive Plant Research Laboratory, Fort Lauderdale, Florida)