FY 2004

Introduction

The Crop Protection and Quarantine National Program (NP304) addresses high-priority insect, mite and weed pest problems in crops, forests and urban trees, postharvest systems, and natural areas. The program is divided into two research mission areas: insects and mites (6 components), and weeds (4 components). Plant pathogens and pest nematodes are excluded, since the Plant Diseases National Program (NP303) addresses them. However, the IR-4 minor use pesticide program, which falls under this National Program, addresses all pests, including plant pathogens and pest nematodes. The overall goal of this National Program is to expand the understanding of the biology, ecology and impact of insect, mite, and weed pests on agricultural production systems and on natural ecosystems, and to develop, improve, and integrate environmentally safe technologies to exclude, eradicate, or manage pest populations, using sustainable and integrated practices that will enhance the safety, quality, and productivity of U.S. agricultural production, while protecting natural resources, native ecosystems, human health, and the environment. Projects in National Program 304 will expire in 2004, and following a peer review process under the auspices of the ARS Office of Scientific Quality Review commencing in October 2004, new replacement projects will be initiated in early 2005.

This National Program specifically emphasizes research not only on long established pests, but also on recent invasive insects and weeds. Invasive insects and weeds, as well as other pests species cost the United States over $137 billion per year, or about $500 per person per year. Invasive species impact production agriculture very significantly, and are second only to loss of habitat in causing negative impacts on environmental areas and loss of biological diversity. There are more than 30,000 invasive species in the United States, many of them undescribed, and the number is growing. This growing threat prompted the formation of the Invasive Species Council in 1999, which provides guidance for agencies to increase their efforts to exclude, detect, and eradicate incipient populations and to manage established species.

Invasive insects such as the glassy-winged sharpshooter, emerald ash borer, silverleaf whitefly and other whiteflies, Asian longhorned beetle, Russian wheat aphid, pink hibiscus mealybug, cereal leaf beetle, Chinese soybean aphid, fruit flies, and many others are high priority targets in this National Program with the ultimate goal of developing areawide and integrated pest management strategies. Arthropod pests destroy 13 percent of crop production each year, costing about $36 billion, with invasive arthropods causing about $14 billion of this total. Another $1.5 billion annually is lost to lawn and garden pests, such as Japanese beetle. New insect and mite pests appear in the United States each year.

Invasive weeds, such as leafy spurge, melaleuca, Old World climbing fern, giant salvinia, salt cedar, hydrilla, waterhyacinth, yellow starthistle, downy brome, Brazilian pepper, jointed goat grass, purple loosestrife, and many others infest at least 100 million acres in the United States. These weed populations increase 8 to 20 percent annually. As aggressive, destructive pests, they are extremely difficult to control, especially because land is often owned in checkerboard patterns, and control actions are not coordinated across boundaries. Challenges to manage weeds safely and economically occur in production agriculture, grazinglands and natural areas. Weeds result in reductions of about 12 percent in crop yields (about $36 billion annually), and 20 percent in forage yields (about $2 billion annually). One hundred million dollars is spent on aquatic weed control alone annually. About half of the threatened and endangered plant species in the United States are primarily at risk because of invasive weeds.

Much of the research on invasive species is in support of action agencies, such as the Animal and Plant Health Inspection Service (APHIS). The research has resulted in exclusion of more potential invasive species, quicker detection, and more effective eradication of new invading species. The research already is resulting in more efficient long-term management of established invasive species. These improvements result from emphasizing systematics, biologically-based areawide and integrated pest management, and ecosystem management.

In 1995, ARS implemented its first areawide integrated pest management (AWPM) partnership project against the codling moth on apples and pears in the Pacific Northwest. Three additional projects were initiated shortly thereafter with corn rootworms, stored wheat insects, and leafy spurge weed as targets. These four projects enjoy great success and have now been completed with adoption of the technologies by end-user. Between 2000 and 2002, ARS initiated five new areawide IPM projects aimed at both invasive and established species: (a) fruit flies (FY 2000) in the Hawaiian Islands in multiple crops, especially fruits and vegetables, using field sanitation, male annihilation, protein bait applications, biological control, and sterile insect technology (Hilo, Hawaii); (b) fire ants (FY 2001) in Florida, Texas, Oklahoma, Mississippi, and South Carolina, on pastures using natural enemies, microbial pesticides, attracticides and GIS/GPS tracking (Gainesville, Florida); (c) Russian wheat aphid and greenbug (FY 2002) on wheat in the U.S. Great Plains using customized cultural practices, pest resistant cultivars, biological control agents, and other biologically-based pest control technologies (Stillwater, Oklahoma); (d) the melaleuca tree (FY 2002) in Florida using natural enemies and microbial biological control (fungus), judicious use of herbicides, mechanical (mowing) and physical (fire) control, and combinations of these tactics (Fort. Lauderdale, Florida); and, (e) the tarnished plant bug (FY 2002) on cotton in the delta of Mississippi and Louisiana using host destruction, host-plant resistance, and remote sensing technology (Stoneville, Mississippi). Most of these projects have received one or more prestigious awards for their customer outreach and technology transfer efforts.

ARS has made significant progress in fiscal 2004, in crop protection and quarantine research. Some selected examples of progress are listed below, representing a few of the many accomplishments that have been reported from the numerous in-house and extramural projects assigned to this National Program. Each project's (in-house and those funded extramurally) annual progress report can be accessed at this site. This allows the reader to obtain additional information on the program's progress and accomplishments.

Selected Accomplishments by Component

Component I: Identification and Classification of Insects and Mites

<u>ARS systematists use digital imaging to identify mite species that spread citrus leprosis</u>. A mite-borne plant disease, citrus leprosis, is a virus that substantially damaged Florida's orange crop early last century. It is moving slowly north from South America. Mite species believed to be capable of spreading the disease are already abundant in Florida, California and Texas, three states that are the backbone of the U.S. citrus industry. ARS scientists in Beltsville, Maryland, are collaborating with the Florida Department of Agriculture and Consumer Services to clarify differences among the *Brevipalpus* mite species implicated as leprosis vectors. This work is part of a wider project--funded in part by USDA's Foreign Agricultural Service and APHIS, and led by a University of Florida acarologist--seeking to minimize the virus's impact. During its previous outbreak, the virus had spread to 17 Florida counties by 1925 before being eradicated by

several factors, including citrus growers planting in new locations and controlling mites with sulfur. Using the digital imaging techniques, entomologists can identify morphological variations and identify the mite species that spread citrus leprosies in the U.S.

Insect identification vital in effort to exclude invasive pests from United States. ARS scientists in Beltsville, Maryland, identified over 9,000 insects and mites (3,682 of URGENT priority) including one species that was discovered to be a new immigrant to the United States. These identifications and reports have a direct impact on the movement of billions of dollars of cargo flowing into the U.S. and determine whether or not millions of dollars in quarantine treatments have needed to be applied to incoming goods. These identifications have also been vital in the continuing effort to exclude new invasive pests into the U.S.

Species-specific molecular markers may lead to species identification of insect eggs and immature stages. To assess the effect of natural enemies in controlling beetle pests, species-specific molecular markers are needed to enable correct identification of predators to species. ARS scientists in Beltsville Maryland have successfully amplified fragments of the mitochondrial Cytochrome Oxidase I gene using the polymerase chain reaction. The use of this method will enable scientists to identify eggs and other immature stages as belonging to the correct species.

Component II: Biology of Pests and Natural Enemies (includes microbes)

New listening/detection device for weevils in nursery crops can halt infestations early. The nursery industry is big business in the United States, especially in Oregon where it's worth more than $600 million annually. But the black vine weevil continues to threaten many nursery crops. More than $3 million is spent each year to control these pests, because of strict quarantine regulations that require plant inspectors to reject shipments of nursery crops from other states if just one weevil is found. A new, lightweight device recently developed by ARS scientists in Corvallis, Oregon, and Gainesville, Florida, in cooperation with Acoustic Emission Consulting of Fair Oaks, California, can magnify the noises of tiny, black vine weevils, resulting in their detection. The new device will allow inspectors to search 15-25 plant pots an hour, compared to five to eight pots without it, and will be a huge asset to nursery growers.

Understanding the biology of the coffee berry borer can help stop it from boring into profits. Worldwide, coffee berry borers cause about $500 million in damage to the crop annually by eating holes in the beans, lowering the crop's quality and reducing the coffee growers' income. ARS scientists in Beltsville, Maryland, are studying the biology of the pest and potential microbial biocontrol agents. The tiny borer spends its entire larval life inside the coffee berry. Only while outside the berry are the adult female borers vulnerable to pest management methods. One potential pest management method is the application of *Beauveria bassiana*, a fungus that is pathogenic to insects. The challenge is to get the fungus in contact with an insect pest that spends most of its life inside the coffee berry. The scientist has found the fungus can become established within plant tissue. The goal is to make the fungus thrive in the coffee plant, thus exposing it to the borer. Also, certain microscopic worms called nematodes may also offer a method to control the borer. In collaboration with scientists in Mexico, ARS found that when the females of a particular nematode genus parasitized female coffee berry borers. Over time, this control method may help reduce the overall population.

Fungus proven to be effective in colonies of Formosan subterranean termites. Many insect pests in the United States are of foreign origin, introduced accidentally with few or no natural enemies. ARS scientists at Montpellier, France, proved that an isolate of an entomopathogenic fungus collected in China proved more virulent than the current commercially available fungus when applied to the Formosan Subterranean termite colony, but not when applied to individual termites. This accomplishment is important because this experimental portal (individual and grouped) and analysis suggests an effective way to compare pathogen virulence among social insects. Also, scientists in Peoria, Illinois have shown that an application of a bioinsecticidal fungus to trees infested with the Formosan subterranean termite significantly reduces the pest numbers and foraging activities.

Foreign Exploration may provide viable biological control agents for olive fruit fly. Many insect pests in the United States are of foreign origin, introduced accidentally with few or no natural enemies. ARS scientists at Montpellier, France, through explorations in Namibia, found that natural enemy fauna of the olive fruit fly was diverse. This accomplishment provides encouraging evidence that good biological control agents for this pest may be found among southern African parasitoids.

Development of sexual reproduction methods for *Beauveria bassiana* may lead to more effective strains for pest control. Corn rootworm is a pest that costs approximately $1 billion annually in crop losses and control costs. ARS scientists in Beltsville, Maryland have demonstrated that the most important insect biocontrol fungus, Beauveria bassiana, is capable of sexual reproduction. This information will help lead to the development of methods for inducing sexual reproduction in the laboratory and the knowledge of mating strains could also lead to sexual breeding to increase virulence for many pest insects.

New cell line will explore process of insect infection. ARS scientists in Beltsville, Maryland have established a new cell line from the Mediterranean flour moth. This cell line will be used to explore the process of insect virus infection. Use of these cells as an artificial diet amendment were also found by researchers in Gainesville, Florida to provide essential factors to the insect predator, *Orius*.

Hormone may improve methods of mass-rearing insects for biological control. Modifications to environmental conditions and food quality can simplify the mass rearing of beneficial insects, but these practices generate a concern about the fitness of insects when reared under different conditions. ARS scientists in Columbia, Missouri, developed an in vitro bioassay to monitor the production of a hormone that regulates development, reproduction and diapause in insects and used it to compare the levels of the hormone under different rearing conditions. This can be used by the beneficial insect industry to help them improve the quantity, quality, and storage of mass reared insects.

Feeding locations of glassy-winged sharpshooter studied. How insects feed and how they select plants for feeding and for oviposition are important in order to help develop new insect resistant plant varieties. ARS scientists in Fargo, North Dakota, while examining the glassy-winged sharpshooter, found previously unreported morphological characteristics including sensilla-like structures on the surface of the labrum and within the labial groove. This discovery accentuates the importance of determining if the glassy-winged sharpshooters are indeed feeding in host cells located between the epidermal layer and the xylem tissue.

Newly tested bacterium kills costly pests. The annual predations of just five plant pests cost U.S. farmers nearly $3 billion annually in crop losses and control expenses. These “bad guys” are the Colorado potato beetle, corn rootworm, diamondback moth, green stinkbug, and silverleaf whitefly. Now, lab tests by ARS scientists in Beltsville, Maryland, have shown that a bacterium called *Chromobacterium suttsuga* produces multiple toxins that kill the pests. It can be combined with other compounds and then applied to soil, plants, or seeds. Since insect pests often develop resistance to synthetic insecticides, biological-control alternatives such as this can be an important component of integrated pest-management programs.

ARS scientists discover that silverleaf whitefly natural enemies mark their victims, a behavioral tract important to commercial production and release to manage this pest. The silverleaf whitefly, *Bemisia argentifolii*, causes far more damage than its size suggests it could. The minuscule, 16th- inch fly feeds on many plants, costing growers millions each year. And its emerging resistance to insecticides is necessitating a search for alternatives for controlling the pest. One possibility is a parasitic wasp, *Eretmocerus mundus*. Its heat tolerance, host-specificity, and fecundity make it an appealing bicontrol candidate. Now ARS scientists in Fargo, North Dakota researchers have found the *E. mundus* produces specialized lipids. The female uses these lipids to mark the backs of whitefly nymphs it has chosen for egg deposition. This cue warns away other wasps, thereby avoiding a duplication of reproductive effort. The deposited egg hatches into a wasp larva that then enters and consumes the fly nymph. This discovery may help improve efficiency of mass-producing *E. mundus* as a biocontrol agent.

ARS scientists discover glassy-winged sharpshooters’ hangouts in their attack on this disease-carrying pest of grapes and other crops. ARS scientists are investigating where sharpshooters are most likely--at any given time of the year--to rest, feed, lay their eggs or, perhaps most important, to ingest and transmit *Xylella fastidiosa*, a bacterium harmful to plants. This microbe causes Pierce’s disease of grapes. In other plants, *X. fastidiosa* causes other diseases, such as almond leaf scorch and citrus variegated chlorosis. Glassy-winged sharpshooters that feed on infected plants spread the bacteria. In the past decade, Pierce’s disease has caused approximately $14 billion in crop losses and pest control costs in southern California vineyards. ARS scientists in Parlier, California are meticulously monitoring an extensive network of yellow insect traps that have been established in glassy-winged sharpshooter infested areas of California's central San Joaquin Valley. Results from this research should help growers get more from their pest-control dollars. For example, the investigation may yield new, more precise information about where insects acquire *X. fastidiosa* in the central San Joaquin Valley, at what point they move into vineyards, and when they spread the bacterium into grapes.

Component III: Plant, Pest, and Natural Enemy Interactions and Ecology

Corn plants alert neighboring corn plants when attacked by pests, helping them to protect themselves. Corn plants under attack from insect pests use chemical signals not only to interact with beneficial insects, but also to stimulate early defense responses in nearby plants, according to research by ARS scientists at Gainesville, Florida in collaboration with scientists at the University of Florida and Pennsylvania State University. The results demonstrated the first proof of plant-to-plant warning signals in corn plants. The warning signals are chemical compounds called green leafy volatiles (GLV). Shortly after coming under attack from pests, such as the corn earworm and beet armyworm, corn plants send these volatiles into the air to draw support from the pest's natural enemies. The volatiles attract caterpillar predators and parasitoids, which attack and destroy the pests.

Thwarting new Russian wheat aphids requires constant vigilance and development of new resistant wheat cultivars. Russian wheat aphids are major pests of cereal crops. The original biotype has cost American wheat and barley farmers billions of dollars in losses since first appearing in the United States in 1986. A new biotype, first spotted in Colorado last year, overcomes the genetic defenses of many wheat and barley lines developed to combat the original aphid. These lines were developed by ARS scientists in Aberdeen, Idaho. Now, the new biotype has led the ARS scientists to re-examine breeding lines they developed during the first crisis. About one-third of the barley lines found to be resistant to the original aphid were tested and discovered they were resistant to the new type. Also, four breeding lines of winter barley and three feed barleys set to be released within the next few years show resistance to both aphid biotypes. The scientists have found strong candidates among the advanced wheat lines, including a promising one derived from a wheat-rye line ARS received from a South African scientist, which will help growers to protect their wheat from the new biotype.

Potential new gene for Hessian fly resistance discovered. Hessian fly is one of the most destructive pests of wheat grown in the Great Plains. ARS scientists at Manhattan, Kansas, transferred a Hessian fly resistance gene from a wild relative of wheat to common wheat. Genetic analysis indicated that this gene is either a novel gene or a new allele and provides wheat breeders with a new choice to generate new wheat varieties that are resistant to Hessian fly.

Component IV: Postharvest, Pest Exclusion, and Quarantine Treatment

Sequencing the genome of the red flour beetle. The stored-product pest insect red flour beetle, *Tribolium castaneum*, was successfully entered into the genome sequencing pipeline, an accomplishment that has not been previously achieved for any agronomic pest species. Painstaking accumulation of a large volume of embryonic tissue ensured high-quality sequence data, recently confirmed by the analysis of the first 15,000 sequences from the genomic libraries. This work is a collaborative effort of ARS scientists at Manhattan, Kansas, Kansas State University, and the Baylor College of Medicine Human Genome Sequencing Center. Sequence compilation and assembly is being undertaken currently. The analysis of this sequence will have far-reaching impact on broad knowledge of insect genome evolution, physiological adaptations in pest and beneficial beetle species, and the identification of novel targets for pest control exploitation.

Hot bath foils lychee and longan insect foes. Two exotic tropical fruits--lychee and its smaller cousin, longan--have sweet, slightly firm flesh with a pleasing texture that's been likened to that of a fresh, peeled grape. A packing house procedure, developed by ARS scientists in Hilo, Hawaii, in cooperation with MMG Manufacturing, Inc., a Fresno, California, commercial equipment fabricator; a Fresno designer of agricultural equipment; and Kahili Farms, Kilauea, Hawaii, for preparing these tropical fruits for shipment from Hawaii to mainland U.S. supermarkets doesn't harm the texture or flavor. At the same time, the process ensures that each lychee or longan is free of live insect pests such as the litchi fruit moth or oriental fruit fly. If these insects were to stow away in shipments, they could pose a threat to crops in other warm-weather states. The scientists designed, built and tested a twin-tank system that provides a hot-water bath to kill the insects, followed by a cooling bath to prevent spoilage and protect the fruit's flavor and fragrance. The hot-water tank is calibrated precisely to meet federal requirement that the fruit be submerged for 20 minutes in water heated to 120 degree F. Kahili Farms is in the final stages of obtaining federal approval for the unit.

A unique method to attack Indianmeal moths with microbial biocontrol agent developed. Insects, like people and other mammals, depend on proteins to protect them from attack by fungi and bacteria. In mammals, these proteins are called antibodies. ARS scientists at Manhattan, Kansas, have discovered and characterized a large protein that circulates in the blood of Indianmeal moths and activates the insect's immune system when under attack by microorganisms. The scientists have demonstrated that specific regions of this molecule have unique biochemical characteristics that are responsible for the immune system activation. Understanding how such proteins work to protect the insect offer an opportunity for the scientists to design small compounds that can interfere with the normal functions of the insect immune system, making them much more vulnerable to attack by biocontrol microorganisms.

Component V: Pest Control Technologies

Sex pheromone of pink hibiscus mealybug identified, synthesized, and transferred to Federal and State Action programs. The pink hibiscus mealybug (PHM) can destroy more than 200 plant species by injecting them with toxic saliva while sucking their sap. The exotic insect pest recently invaded California and Florida, and has proven difficult to track and monitor. ARS scientists in Beltsville, Maryland, have discovered two compounds that together make up the female PHM's sex pheromone. The compounds provide a timely method with which to monitor and ultimately reduce infestations. Officials with USDA's Animal and Plant Health Inspection Service (APHIS) are using the new pheromone as a sex lure to survey the degree of mealybug pest infestations in Florida and California and to track the effectiveness of biological control efforts against the pest. ARS has applied for patent protection for the invention and already has received requests to license the technology. The new blend of synthetic pheromones also could help crop producers manage the pests safely through either mass-trapping or disruption of mating activity.

New insect lures doom crop damaging caterpillars attacking field and orchard crops. Enticing new lures developed by ARS scientists at Wapato, Washington, in cooperation with Washington State University, could make backyard gardens, fruit orchards and crop fields places of no return for pesky caterpillars that cause losses in the millions of dollars. The lures, derived from molasses and floral odors, tantalize both male and female moths, and have been developed as an alternative to chemically controlling the pests—loopers, cutworms, fruitworms, armyworms and corn earworms. The insects fly into the opening of a lure-dispensing trap, never to escape. The molasses-derived lure is now commercially available for garden use as the product SMARTrap. The floral based lures are in their second year of field tests. So far, use of the floral lures in a "killing station" reduced the number of alfalfa loopers by 75 percent.

Promising biological control combination for Colorado potato beetle. Fundamental research on fungal pathogens including how these pathogens survive and successfully infect their insect hosts in field and greenhouse environments will foster the development of safe, effective alternatives to chemical insecticides. Scientists in Ithaca, New York, have found that a single application of *Bacillus thuringiensis* (Bt) together with the fungus *Beauveria bassiana* has resulted in an 81% reduction in target populations of large larvae of the Colorado potato beetle. These results indicate the strong potential for using these agents as the key components of an integrated biological control program for Colorado potato beetle management.

Foreign parasitoid found to control tarnished plant bug. The tarnished plant bug injures a large number of crops throughout the United States, including fruits, vegetables, forestry nurseries, fiber crops, and seed crops. ARS scientists in Newark, Delaware, have completed a long term study documenting that a foreign parasitoid (*Persistenus digoneutis*) permanently controlled and reduced the tarnished plant bug and also demonstrated that a native parasite was not eliminated by this new introduction. These findings should increase current confidence in the safety of classical biological control methods used against pest insects.

Grain sorghum is shown to trap southern stink bugs. Stink bugs have emerged as important pests in cotton as the use of broad-spectrum insecticides have diminished due to successful eradication of the boll weevil. ARS scientists from Tifton, Georgia, were able to establish that by planting a strip of grain sorghum between a corn and cotton field, the grain sorghum effectively trapped the southern green stinkbugs and prevented them from moving into the cotton field. The team also found that parasitization of adult stinkbugs by a fly was high in sorghum where these pests congregated.

Research contributes to make minor use pesticides available to growers. ARS scientists at Tifton, Georgia, Charleston, South Carolina, Beltsville, Maryland, Weslaco, Texas, Salinas, California, Wapato, Washington, Prosser, Washington, Corvallis, Oregon Urbana, Illinois, and Wooster, Ohio, initiated 186 food use trials and 381 ornamental trials to support minor use pesticide registrations. This research will provide growers with safer and more effective chemical pesticides necessary to reduce pest losses and maintain yield and quality with less impact on the environment in production of minor food crops as well as ornamentals.

ARS scientists learn more about mass migrations of grasshoppers and how to prevent them. During grasshopper outbreaks, which are often driven by droughts, grasshoppers can gobble up valuable crops, forage and ornamental plants, costing millions of dollars in damage. Two fungi may represent a natural solution to the problem of millions of grasshoppers leaping across parts of the western United States each summer. ARS scientists at Sidney, Montana, are studying these fungi and other microbes in hopes of keeping soaring hopper populations in check. One fungus, *Beauveria bassiana*, is already registered in the United States for the control of a variety of insects. Once grasshoppers pick up its spores on their feet and other body parts, the fungus grows quickly inside their bodies, usually killing them within a week. The scientists found that an effective way to deliver the *B. bassiana* spores and make them, attractive to grasshoppers is to mix them with raw canola oil. The scientists envision the mixture of canola oil and fungal spores being sprayed on targeted strips of rangelands from the air or on the ground. Because the oil attractant lures hoppers to the strips from a wide distance, only small amounts of the fungal spores are needed. The other fungus, *Metarhizium anisopliae* var. *acridum*, is much more host-specific than *Beauveria*, affecting just grasshoppers and their close relatives. Coupled with the raw canola oil carrier, it could also become a valuable tool for controlling grasshoppers.

Insect virus targets the codling moth in apples, walnuts, pears and fruit. Codling moths attack apples, walnuts, pears and other fruit, with the larvae damaging the fruit by boring deep inside it, ruining marketability. Until integrated approaches to controlling codling moths were adopted in the Pacific Northwest – including use of sex pheromones to disrupt the moths' mating—the standard defense was to spray orchards with insecticide. But such spraying is costly, ecologically worrisome and dangerous to beneficial insects. A virus that infects and kills codling moth larvae can offer fruit growers an insecticide alternative for fighting the pest. ARS scientists at Wapato, Washington, conducted tests at four Washington State apple orchards, where they sprayed trees with the codling moth granulovirus. The treatment killed moth larvae for up to 14 days, with 94 percent becoming infected within the first few days of application. Fruit growers have been slow to use this virus due to formulation, quality and other problems tied to early granulovirus products. The recent study compares the persistence and effectiveness of three new or improved formulations, which the manufacturers registered for use on apples, pears, walnuts and plums. The key is timing the applications of granulovirus so they prevent larvae from penetrating the fruit. The granulovirus poses no threat to humans, other mammals or non-host insects.

Component VI: Integrated Pest Management Systems and Areawide Suppression Programs

ARS cooperative areawide Melaleuca project shows Florida how to oust an invasive pest. *Melaleuca quinquenervia* was introduced to South Florida in the late 19th century as an ornamental plant, but this fast-growing, fast-spreading tree has displaced native plants and animals, dried up wetlands and created major fire hazards. The spread of the invasive tree Melaleuca is being thwarted in Florida, thanks to a cooperative program that includes enlisting the help of the tree's natural enemies in Australia. The collaborative effort (TAME) is being carried out by ARS in cooperation with the University of Florida's Institute of Food and Agricultural Sciences, and the South Florida Water Management District. The purpose of TAME is to demonstrate the effective integration of biological control into other management strategies, including use of herbicides and mechanical removal of Melaleuca, to achieve long-term results. The first natural enemy released against Melaleuca was the melaleuca leaf weevil. More than 8,000 of the weevils were released at 13 locations in 1997. Today, millions of the quarter-inch-long weevils are eating the young leaves of melaleuca trees. The second biological control agent, an aphid-like psyllid has also been effective. To date, approximately 350,000 psyllids have been released at a variety of South Florida locations.

ARS' integrated pest management/areawide program strives to solve agricultural problems. The concept behind areawide pest management is that existing technologies are most effective when used over a multistate or multiregional area. Crucial to success is to have all or most of the farmers in a large area simultaneously implement the program so that pests have no safehaven or alternative food source. ARS launched the first areawide IPM attacks against the codling moth, a pest in apple and pear orchards, on 7,700 acres in the Pacific Northwest. Other programs include a major assault against the corn rootworm on over 40,000 acres in the Corn Belt, fruit flies in the Hawaiian Islands, and leafy spurge in the Northern Plains area. In 2001, an areawide IPM project began for fire ants in Florida, Mississippi, Oklahoma, South Carolina, and Texas on pastures using natural enemies, microbial pesticides, and attracticides. In 2002, ARS scientists in Stillwater began an areawide IPM project on Russian wheat aphid and greenbug on wheat in the U.S. Great Plains using customized cultural practices, pest-resistant cultivars, biological control agents, and other biologically based pest control technologies. Also in 2002, an areawide IPM project began for Melaleuca in Florida using mechanical, herbicidal, and biological control, and for tarnished plant bug on cotton in the delta of Mississippi and Louisiana using host destruction, host-plant resistance, and remote-sensing technology. Awards have shown the success of these projects. For example, in May 2004, the U.S. Pacific Basin Agricultural Research Center in Hilo won a Federal Laboratory Consortium Award for Excellence in Technology Transfer for work with the fruit fly IPM. In 1999, the Yakima (Washington) Agricultural Research Laboratory won this same award for work with codling moth. Four programs have won the top technology transfer award from ARS: in 1998, the codling moth project; in 1999, the corn rootworm project; in 2003, TEAM Leafy Spurge; and in 2004, the Hilo fruit fly project. Three projects have won USDA's Group Honor Award – fruit flies, codling moths, and leafy spurge. One goal of ARS is to help bring more and more of the nation's farmland under biointensive integrated pest management. By implementing areawide projects that strike these and other pests, the goal is being met each year.

Component VII: Weed Biology and Ecology

Genetic identification of red rice ecotypes, rice cultivars and their crosses. Intercrossing between rice and ecotypes of weedy red rice, a dominant weed in the southern United States, may reduce yield when herbicide-resistant rice systems are used. DNA/PCR microsatellite fingerprinting analyses were conducted to quantify rates of outcrossing between rice x red rice crosses (including imidasolinone-resistant rice cultivars), foreign rice cultivars, and red-seeded rice relatives from throughout the world at the ARS Dale Bumpers National Rice Research Center, Stuttgart, Arkansas. A method was developed enabling distinguishing crosses using DNA marker analysis. These analyses may allow the rice industry to identify (or rule out) the parental lines that are responsible for development of an unwanted population of herbicide-resistant rice x red rice hybrids, a key management consideration in herbicide-resistant rice systems.

Discovery of a new weed in Lake Tahoe, California. Using aerial surveillance, ground-truthing, and underwater video technology, ARS scientists at Davis, California, discovered the presence of a highly invasive exotic weed, curlyleaf pondweed (*Potamogeton crispus*) in Lake Tahoe. This weed has been extremely damaging in other countries, and has the potential to significantly affect aquatic systems in the West, as it has done in the Northeastern U.S. An Early Detection-Rapid Response team has been established to attempt to determine the extent of infestation, and to try to eradicate this weed.

Component VIII: Chemical Control of Weed

Development of in-crop herbicidal options to control grass and broadleaf weeds in sugarcane. In-crop herbicidal options, especially herbicides that can be applied to control a broad-spectrum of grass and broadleaf weeds at the start of a growing season when weeds have their greatest impact on sugar yields, are limited. ARS scientist at New Orleans, Louisiana, evaluated herbicides alone and in mixtures for control of bermudagrass, itchgrass, morningglory, and seedling johnsongrass when applied as single and sequential applications. They found that morning glory in particular could be controlled under sugarcane crop canopy. Results of this research were used to support manufacturer petitions to the Environmental Protection Agency for labels for two herbicides, which were received in time for the 2004 growing season.

Component IX: Biological Control of Weeds

Biological control of salt cedar**.** Invasive saltcedar (*Tamarix* spp.) shrubs from Eurasia infest many Western U.S. waterways where they cause significant economic and environmental losses. Detailed studies on foreign exploration and host-specificity testing for natural enemies of saltcedar were conducted by ARS scientists at Montpellier, France, and at Temple, Texas. The first biological control agent for saltcedar, the beetle *Diorhabda elongata*, was released in 1999 at 10 sites in six States. The beetle has spread over 100 miles since release. Use of aerial imagery and ground assessments shows that the beetle has totally defoliated saltcedar at many sites, and is beginning to damage severely saltcedar on a landscape basis. Impact of natural enemies is being evaluated on saltcedar and on native plant communities (cottonwoods and willows). This research is important as it interfaces with on-going investigations of biological control, and provides revegetation strategies for land managers that are interested in removing and replacing saltcedar, and assists in evaluation of the impact of the program on an endangered bird.

Release of a plant pathogen for biological control of yellow starthistle. Yellow starthistle (*Centaurea soltitiialis*) is an extremely aggressive invasive weed in California and other Western States, affecting 10-15 million acres in California alone. Chemical, cultural and earlier biological control methods have not been able to manage yellow starthistle on a landscape basis. ARS scientists at Frederick, Maryland, along with partners from the California Department of Food and Agriculture, released the rust fungus *Puccinia jaceae* in 22 Counties in California in 2004. This pathogenic fungus has been shown in laboratory tests to kill yellow starthistle. It became established in the field very quickly, and is spreading to new locations. Significantly, *P. jaceae* is the first pathogen to be approved as a weed biological control agent in the Continental U.S. for over 16 years, and offers the best option for management of this invasive weed.

New bacterium discovered with potential to manage Canada thistle. Using a polymerase chain reaction protocol that was developed by ARS scientists at Beltsville, Maryland, and the analysis of specific regions of ribosomal DNA, a new strain of the bacterium, *Pseudomonas syringae* pv. *tagetis*, was discovered. The strain causes apical chlorosis in Canada thistle. This strain will be evaluated for potential as a new biological control agent for Canada thistle, one of the most invasive weeds in North America.

Component X: Weed Management Systems

Successful biological control of melaleuca in South Florida. The Australian melaleuca tree (*Melaleuca quinquenervia*) is an extremely aggressive invasive plant that alters the drainage of South Florida, and affects natural areas, outcompeting valuable native species. Restricting the invasiveness of melaleuca requires reducing its ability to produce massive amounts of seeds. ARS scientists at Fort Lauderdale, Florida, in collaboration with Florida Department of Environmental Protection, U.S. Army Engineers, and South Florida Water Management District personnel and other partners, released two biological control agents: a tip-feeding weevil (*Oxyops vitiosa*; 1997) and a sap-sucking psyllid bug

(*Boreioglycaspis melaleucae*, 2002). Both species are contributing to successful biological control of *melaleuca*. In particular, the psyllid has spread throughout the infestation of *melaleuca*, and is significantly affecting growth and survival of the weed; in fact, *melaleuca* is almost gone from public lands.

<u>Development of a conservation cropping system for winter annual grass weed</u>. The winter wheat-fallow production system in the Pacific Northwest is characterized by winter annual grass weeds and wind erosion. There are no economically viable conservation cropping systems to solve these problems. ARS scientists at Pullman, Washington, along with two university partners, developed a system for planting facultative spring wheat in November (rather than the normal March planting) in lieu of late-planted winter wheat when conditions are dry in the Fall. During the drought year of 2002-2003, this system was used. It was more competitive against weeds, improved grain quality, and yielded 20% more compared to winter wheat. Adoption of this alternative conservation cropping system would reduce the impact of weeds and erosion susceptibility, and increase air quality.