

**USDA 2009 Strategic Plan for Control of the  
Cactus Moth, *Cactoblastis cactorum***



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## Introduction

This strategic plan summarizes the background and steps necessary to implement a comprehensive detection, regulatory, and control program involving domestic and international partners. The plan is divided into logical time phases of implementation and includes cost estimates for each phase. Tasks under each phase are identified under the subheadings of survey, identification, regulatory, control, research, and cooperation with Mexico. The mechanisms for funding are still to be determined, but without a specific appropriation, support will necessarily come from contingency funds and contributions from Mexico. Difficulty in securing required funding in a timely manner will hamper the ability to implement an effective program.

## Executive Summary

Detection of *Cactoblastis cactorum* in the Florida Keys in 1989 was recognized by scientists and conservationists as a serious threat to the rich diversity of *Opuntia* spp. in North America. Dispersal of the moth along the Atlantic coast to South Carolina and along the Gulf Coast to Alabama by 2004 led researchers to the prediction that *C. cactorum* would reach the Texas border by 2007. The concern of this potentially rapid dispersal engendered great concern and a sense of urgency from conservationists. Scientists from Mexico are concerned as well, because the cactus is an important agricultural crop. However, due to the success of the USDA APHIS control program and ARS research, *C. cactorum* westward spread has been substantially slowed and there have not been any detections of *C. cactorum* west of Horn Island, Mississippi.

In 2003, USDA/APHIS/PPQ initiated the development of a strategic plan to control, contain, or mitigate the spread of *C. cactorum* from the southeastern U.S. into the desert southwest and Mexico. PPQ is collaborating with the USDA/Agriculture Research Service (ARS) to develop methods to detect (adult trap baited with synthetic lure) and control (sterile insect technique, biological control) *C. cactorum*. Agencies within the U.S. Department of Interior and non-governmental organizations are cooperating with APHIS on detection and monitoring. Secretaria de Agricultura, Ganaderia, Desarrollo Rural, Pesca, y Alimentacion (SAGARPA or Secretary of Agriculture, Livestock, Rural Development, Fisheries, and Food) has been providing funds and cooperating with the USDA due to the economic importance of prickly pear cactus in Mexico and urgency to stop the spread of *C. cactorum*. Detection and control technologies were transferred to Mexico which allowed them to eradicate two populations of *C. cactorum* that had become established on islands off the Yucatan Peninsula.

The cactus moth program was implemented quickly because USDA was able to simultaneously develop methods of control, technology transfer, and surveillance. Detection and delimitation of *C. cactorum* along the Gulf Coast has been implemented and the most appropriate location for the focus of control efforts in 2009 has been determined. Production of insects has expanded from a sole colony of *C. cactorum* at ARS in Tifton, GA to include an additional colony at the Florida Department of Agriculture and Consumer Services (FDACS), Division of Plant Industry (DPI),

Gainesville, FL. Although the number of sterile insects produced increased in 2008, a greater number are needed as soon as possible to provide capacity for improving sterile insect technique (SIT) as a control mechanism for *C. cactorum*. ARS is working toward transferring the primary production of sterile moths to DPI.

## Goal

To monitor, delimit, and contain the artificial and natural spread of *C. cactorum* in the U.S. to prevent its introduction into the southwestern U.S. and Mexico.

## Objectives

- Define the distribution of *C. cactorum* in the continental U.S. and continue to monitor for new infestations.
- Prevent the introduction of *C. cactorum* into new areas in the U.S. by commercial trade of infested *Opuntia* spp. from known areas of *C. cactorum* distribution.
- Create a barrier using an area-wide approach that includes mechanical removal of host plant material, sterile insect technique and other control methods to prevent the natural movement of *C. cactorum* from the southeastern U.S. to the southwest U.S. and Mexico.
- Eradicate *C. cactorum* from the Mississippi barrier islands.
- Suppress *C. cactorum* in Alabama and Florida.
- Support research in detection and control technologies for *C. cactorum*.
- Work cooperatively with Mexico, other agencies, states, industry, and organizations to accomplish the goal and objectives.

## Consistency with PPQ Strategic Plan Goals

The proposed plan uses innovative technological solutions and provides leadership in detection and response to reduce or prevent the impact of an invasive species that could prove to be an important trade issue.

## Cactus Moth Strategic Phases

### Phase I- Program Development-

- Large Coordination effort with multiple entities
- Outreach and Education campaign
- Initial Survey Effort and delimitation
- Early SIT validation by ARS
- Collaborator involvement with multiple partners
- GIS mapping and Program integration

### Phase II- Securing the Barrier

- Cooperation with Mexico. Massive host removal in high risk zones
- Increased detection throughout the US

- Search and destroy larval infestations in vulnerable areas
- Early detection and rapid response in program areas
- Increased sterile production with DPI Gainesville
- Program integration of SIT
- Mass rearing development with collaborators
- Ecological studies
- Cooperation with Mexico in eradication of CM in Quintana Roo.
- International Review process implemented

### **Phase III- Establishing the Permanent Barrier**

- Eradication from Mississippi barrier islands
- Identify best location for permanent barrier
- Increased sterile production with filter colony concept
- Improved detection tools and monitoring
- Low level or zero CM in Alabama control zone
- Develop a natural host free area along Pensacola Beach and the Gulf Shores, Alabama coast
- Development of the Preventative Release Zone Concept
- Full time CM staff in Pensacola CM Program headquarters
- SIT production at full capacity in Gainesville
- PPQ methods for field quality assurance in place

### **Phase IV- Maintenance of Program**

- Preventative release in barrier area or leading edge
- Sterile production at full capacity in Gainesville, FL
- Improved rearing techniques implemented
- Sensitive early detection and rapid response in front of leading edge
- Request line item for Cactus Moth
- Strong Cooperator support
- Traps and lures fully developed and integrated in the field
- Regulation preventing the domestic movement, etc

## **2009 Operational Plan**

### **First Quarter (January 2009 to March 2009)**

- Objective:* To survey the leading edge of the infestation along the Gulf Coast and increase capacity for sterile insect application in the next phase. Prepare for the upcoming season and begin monitoring.
- Survey:* Thoroughly and completely survey Horn Island and Petit Bois Island to remove all plants/pads infested with *C. cactorum*. Begin monitoring traps for the season and increase trap densities on leading edge and in new areas.
- Identification:* Distribute identification key to U.S. and Mexico program staff. Translate identification key into Spanish.

- Regulatory:* Move the Domestic Quarantine Rule to RAD for review. Continue to develop draft of Importation Quarantine Rule.
- Control:* Conduct clean-up operations in Pensacola Beach, Fort Morgan and the Gulf Shores. Increase production of the mass-reared insect colony at ARS and DPI for Sterile Insect Technique (SIT).
- Research:* Refine rearing protocols. Continue biological control and life table research.
- Outreach:* Work with the Nature Conservancy on their Fact Sheet. Work with LPA on an Inside APHIS article. Begin to plan a bi-national stakeholders meeting in Mexico.
- Cooperation*
- With Mexico:* Survey host plant material on Horn and Petit Bois Islands, MS for larvae and egg sticks and host plant removal from Fort Morgan and areas of the Gulf Shores, AL. Have a conference call with U.S. and Mexican government officials on current activities of the program.

### **Second Quarter (April 2009 to June 2009)**

- Objective:* To reduce cactus moth populations through survey and control of the first flight. Continue monitoring, host plant removal and sterile moth releases on the leading edge.
- Survey:* Continue monitoring on a weekly basis and more often if there are enough resources. Change lures every four to six weeks rather than every two weeks as in past years. Involve States (e.g., South Carolina, Georgia, Florida, Alabama, Mississippi, Texas and Arizona) in surveys.
- Identification:* Send all traps and larvae needing identification to Dr. Richard Brown at Mississippi State University.
- Regulatory:* Publish Domestic Quarantine Rule. Continue working on Importation Quarantine Rule.
- Control:* Mechanically remove infested host plant material as well as host plant material located near traps that captured *Cactoblastis*. Two releases per week on Horn Island starting with the first flight.
- Research:* Initiate filter colony at ARS lab in Tifton, GA for SIT rearing and technology transfer to FDACS DPI. Continue investigation of diet and improvement of space utilization in production processes. Continue biological control research.
- Outreach:* Update website. Publish article in Inside APHIS on the Cactus Moth Program.
- Cooperation*
- With Mexico:* Meet in Cancun, Mexico to conduct an international review of the program and tour Isla Mujeres and Isla Contoy. Officially declare *Cactoblastis* eradicated from Mexico. Begin ARS research with Dr. Juan Cibrian on improvements to the pheromone.

### **Third Quarter (July 2009 through September 2009)**

- Objective:* To reduce cactus moth populations through survey and control of the second flight. Continue monitoring, host plant removal and sterile moth releases on the leading edge.
- Survey:* Maintain trap densities and monitoring while focusing on the leading edge (Horn Island, MS). Monitor inland movement and along leading edge. Continue to gather plant host distribution and reporting on a regular basis.
- Identification:* Continue identifying moths on traps and sending them to Dr. Richard Brown (MSU) for verification.
- Regulatory:* Continue working on Importation Quarantine Rule.
- Control:* Continue host plant removal of infested plant material. Release sterile insects on Horn Island twice a week during the second and third flights. Release sterile insects on Petit Bois Island during the third flight if moths have been captured on traps during the season. Move leading edge back (eastward).
- Research:* Support survey, control, rearing, and SIT implementation.
- Outreach:* Update Pest Alert and other APHIS Fact Sheets.
- Cooperation*
- With Mexico:* If funding is available, support research of Dr. Cibrian to improve the synthetic pheromone.

### **Fourth Quarter (October 2009 through December 2009)**

- Objective:* To reduce cactus moth populations through survey and control of the third flight. Continue monitoring, host plant removal and sterile moth releases on the leading edge.
- Survey:* Survey barrier islands for infested host plant material if moths were captured in traps during the season. Finalize and distribute the final report of the year's survey results.
- Identification:* Identify any samples not identified during the previous phase.
- Regulatory:* Continue working on Importation Quarantine Rule.
- Control:* Remove host plant material as needed.
- Research:* Submit annual reports of research and results.
- Outreach:* Complete any outreach materials listed in the first three phases that are incomplete.
- Cooperation*
- With Mexico:* Hold a conference call with USDA and SAGARPA to summarize the years activities.

## **Funding**

APHIS began the Cactus Moth Program in December 2004 when \$65,000 of APHIS funds were transferred to ARS to initiate the SIT validation study. The PPQ Deputy Administrator office also made \$10,000 available to the CPHST researcher in Tallahassee

to collaborate with the ARS scientists on *C. cactorum* projects. ARS matched the \$65,000 level for FY 2004. From 2005 to 2009 APHIS PPQ allocated \$500,000 per year to the Cactus Moth Program for field operations. Mexico/SAGARPA contributed approximately \$450,000 in 2007 and \$500,000 in 2008 and expect to provide funding to the U.S. in 2009. The funding from SAGARPA is predominately used to support research and sterile insect rearing. CPHST and ARS have also contributed funds for research and rearing.

## **Economic Assessment**

Lynn Garrett, CPHST Agriculture Economist, produced an economic assessment (“White Paper”) based on findings discussed at a planning meeting held in Miami in December 2003

([http://www.aphis.usda.gov/plant\\_health/plant\\_pest\\_info/cactoblastis/impact.shtml](http://www.aphis.usda.gov/plant_health/plant_pest_info/cactoblastis/impact.shtml)).

Garrett summarized the potential impact of introduction of *C. cactorum* to the southwestern U.S. The following components would be most significantly impacted:

- Grazing, due to dependence of ranchers on *Opuntia* spp. during drought
- Nursery and landscaping industries
- Ecosystem structure and biodiversity
- Wildlife habitat and hunting
- Tourism in the southwestern U.S.
- Small producers of *Opuntia* spp. fruits in California

In Mexico, concerns are for biodiversity and the ecosystem. Equally important are the potential impacts on agriculture. Two percent of total Mexican agriculture output is based on *Opuntia* spp., primarily for human consumption of fruit and cladodes. *Opuntia* is produced throughout the country, including marginal growing areas where subsistence farmers rely on *Opuntia* for food and fodder. A more thorough analysis of the impact on Mexico is needed.

## **Risk Assessment**

In a preliminary report for The National Institute for Invasive Species Science at Colorado State University, Simonson et al. (2005) used a standard organism risk assessment model to describe and analyze several factors and potential ecological and environmental impacts of *C. cactorum* introduction to the southwestern U.S. and Mexico. Simonson rated the risk of introduction to the southwestern U.S. and Mexico as high, and a high risk of damage to the environment and economy.

## **Areas of Risk**

According to Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), eastern Texas, Arizona, and California are at the greatest risk of economic and ecological damage in the U.S. CONABIO defined areas of risk for the U.S. and

Mexico and produced a map of distribution of *Opuntia* spp. in North America overlaid with predictions of survival for *Cactoblastis cactorum*. The plant data is based on more than 5,000 herbarium records that were assigned georeference points. CONABIO used survival data of *Cactoblastis cactorum* from Argentina, correlated with climatic variables. *Opuntia* spp. were divided into risk categories and distribution was mapped. More data are needed on *C. cactorum* survival in other parts of the world to further validate the model.

NCSU/APHIS Plant Pest Forecast (NAPPFASST) is using a risk zone mapping program to analyze phenology of *C. cactorum* in the U.S. and Mexico (<http://aphis.zedxinc.com/>). With the NAPPFASST program, Dan Borchert (USDA/PPQ/CPHST) has produced maps based on preliminary distribution and developmental data of *C. cactorum* that are factored into climatic parameters. The maps indicate stages of insect emergence and activity of larvae and adults, and the most appropriate time to monitor or survey. More data points are needed to refine the tool.

## **Domestic and International Cooperation**

Due to the importance of prickly pear cacti (*C. cactorum*'s host) to agriculture and the economy in Mexico, SAGARPA has contributed between \$450,000 and \$500,000 to the U.S. Cactus Moth Program annually since 2007. This additional funding is necessary for the success of the U.S. Cactus Moth Program. However, this funding is granted annually and may discontinue in the future particularly since *C. cactorum* has been eradicated from Mexico.

In 2007, APHIS-PPQ with the North American Plant Protection Organization (NAPPO) and SAGARPA hosted an International *Cactoblastis cactorum* Conference held in Phoenix, Arizona with participation from scientists and a variety of agencies and stakeholder groups from the United States, Mexico, Canada, South Africa, Australia, and Switzerland.

The US Geological Survey (USGS) has been keenly interested in *C. cactorum* from the standpoint of early detection to protect lands managed by various Department of Interior agencies. USGS oversees funded activities at Mississippi State University that are directly related to *C. cactorum*. In 2003, USGS initiated cooperation with other Interior agencies and the scientific activities already occurring between ARS and APHIS. The USGS earmark funding of Mississippi State University's Georesources Institute (now the Geosystems Research Institute) is being used for *C. cactorum* host mapping, remote sensing, and gathering survey data from public managed lands. The Cactus and Succulent Society also helped fund research and co-organized a 2000 workshop on *C. cactorum* with the APHIS National Biological Control Institute.

The International Atomic Energy Agency (IAEA) has held *C. cactorum* research meetings in Vienna, Austria, co-sponsored an international forum in Mexico, and has been active in funding research in South Africa and outreach campaigns in Mexico. The IAEA also funded pheromone characterization work with ARS and the impact analysis

document referred to above produced by Colorado State University's National Institute for Invasive Species Science.

## **Detection and Delimiting Surveys**

Habitat and host information from other infested countries clearly indicates that *Cactoblastis cactorum* has wide climatic tolerances. Survival of *C. cactorum* in climates and habitats further inland is expected if hosts are available as indicated by risk mapping. In Florida, the moth has dispersed inland within the peninsula. However, *C. cactorum* is not thought to have spread significantly inland from the Florida panhandle or from Atlantic coastal areas. Additional surveys are required to determine both the distribution of *C. cactorum* and vulnerable populations of *Opuntia* spp. Researchers believe the *C. cactorum* populations are concentrated in coastal areas due to the availability of abundant hosts on barrier islands and mainland upper dune areas. Host plants are available to a much lesser degree in habitats inland from infested areas. Dispersal along the coast is believed to be facilitated by large air mass movement. Older residential areas on the coast and on barrier islands were often landscaped with ornamental *Opuntia* species in the 1950's and these have acted as hosts for *C. cactorum* infestations.

## **Survey Tools**

The survey's immediate objective is to increase trapping densities in front of the leading edge and in newly detected areas away from the leading edge. This will help define the extent of the problem and track the movement in order to focus control or mitigation efforts in the future. Appropriate sentinel monitoring sites with identified *Opuntia* species beyond the leading edge will be established and identified with Global Positioning System coordinates. The sites will be monitored visually for larval feeding damage during the spring, summer, and fall. Pheromone baited traps will be monitored weekly or biweekly during the peak emergence times in March/April, July/August, and October/November. Pheromone lures will be replaced every four weeks.

## **Trapping with Pheromone Lures**

ARS researchers in Miami and Gainesville, Florida have produced an effective synthetic lure for use in sticky traps. Field tests by ARS and APHIS scientists in Tallahassee, FL and Tifton, GA have shown that traps baited with the synthetic lure capture male cactus moths at a similar or higher rate than traps baited with two virgin cactus moth females. However, after 4 years of work to define the lesser components of the *Cactoblastis* pheromone blend, ARS researchers in Miami, Florida have been unsuccessful in their attempts. Research by ARS in Tallahassee, FL has shown that the current synthetic lure requires replacement every four to six weeks. In field tests, the Pherocon 1-C trap was identified as the most effective. The lure is being used in traps to detect *C. cactorum* dispersal.

## Mapping of *Opuntia* Distribution

The mapping of *Opuntia* populations in the Gulf Coast area is a critical first step to knowing where to survey. Mississippi State University's Geosystems Research Institute has been actively mapping *Opuntia* populations and databasing this information in a effort to make host information available to cactus moth stakeholders. Sentinel sites which are monitored by volunteers have been established in Florida, South Carolina, Alabama, Mississippi, Texas and Arizona. Information can be found online at the Cactus Moth Detection Monitoring and Network at [www.gri.msstate.edu/cactus\\_moth](http://www.gri.msstate.edu/cactus_moth). Dataforms and certain other information is password protected, but maps and other resources are available without an account.

## Cooperative Network

The beginnings of a cooperative detection network for the Gulf Coast were assembled at a meeting in June 2004 in Pensacola, Florida. The meeting included researchers and several PPQ Pest Detection Specialists from the southern U.S. The Geosystems Research Institute at Mississippi State University (MSU-GRI), through a grant from the USGS, is cooperating with APHIS and ARS to assemble mapping and data collection methods and protocols in order to set up a monitoring and detection network for *C. cactorum*. The initial stages are focused on the Gulf Coast to track the leading edge in Florida, Alabama, Mississippi, Louisiana and Texas. Parameters for data collection of host-plant distributions, survey and monitoring information, and control activities were the subject of a Cactus Moth data collection meeting held September, 2004. A Cactus Moth Data Working Group was formed for collaboration at MSU-GRI to build a web-based database that accommodates the use of hand-held units, produce geo-spatial maps

## Cooperative Agricultural Pest Survey

*Cactoblastis cactorum* is identified as a target pest for the Cooperative Agriculture Pest Survey (CAPS) in which cooperative agreements with state departments of agriculture are made to survey nurseries and homeowner properties. CAPS surveys for *C. cactorum* in 2009 will take place in nurseries and on private property in states on the leading edge ( FL Panhandle; coastal AL, LA, and MS; MS barrier islands) and those most at risk (AZ, CA, NM, NV, TX and UT).

## Identification

While the colorfully banded larvae of *C. cactorum* appear to be easily identified, specimens of Lepidoptera larvae collected on *Opuntia* are still at times collected by amateurs who believe them to be *C. cactorum*. In the Southeastern U.S., there is one pyralid species (*Melitara prodenialis*) feeding within *Opuntia* spp., but in the Western U.S., there are seven *Melitara* spp. and 3 *Ozamia* spp. The adults of *C. cactorum* are relatively non-descript gray moths and the larvae have characteristic reddish pink or orangish-red color with dark spots or banding. If the pheromone is properly characterized, it will be specific enough to only catch adult *C. cactorum* males.

Verification of adults in sticky traps with pheromone should be made by an authority on Pyralidae, especially new State records. However, other non-target Lepidoptera are often detected in traps. Dr. Alma Solis is the Phycitinae specialist at the U.S. Natural History Museum (Smithsonian) for the Systematic Entomology Laboratory in Washington DC. She currently receives suspect *C. cactorum* from Western states on a regular basis and is interested in the *Cactoblastis* identification issues referred to above. Dr. Solis confirms any new state records. Dr. Richard Brown is a moth specialist at Mississippi State University working on the Geosystems Research Institute's cactus moth project. Dr. Brown receives all prescreened and unprescreened trap material from states conducting *Cactoblastis* surveys. He developed outreach identification products. The need for larval descriptions of western *Opuntia*-feeding Pyralids is a project he is pursuing, along with molecular characterization in cooperation with other researchers. The existing keys are all using color and host as characteristics for identification, while what is needed is a key using external morphological characteristics of larvae.

## Regulation

Nursery stock from foreign countries that have *C. cactorum* is not restricted by PPQ quarantine CFR 319.37; however, all imported propagative material since 2002 requires phytosanitary certification and inspection at USDA, APHIS plant inspection stations. *Cactoblastis cactorum* is considered an actionable quarantine pest, so if intercepted in commercial shipments, the plant material will require fumigation, destruction, or return to the country of origin.

*Opuntia* fruit and pads (cladodes) for human consumption are permitted from certain countries after a risk assessment is conducted. Currently 7 CFR 319.56 allows *Opuntia* fruit and pads for consumption from Mexico and pads from Colombia are allowed, with fruit imports requiring treatment.

Currently, USDA, APHIS, PPQ's quarantine 7 CFR 318.58 prohibits the movement of cactus plants and cactus parts from Puerto Rico and the Virgin Islands and 7 CFR 318.13 to the US mainland because of *C. cactorum*. There are no other domestic regulations restricting the movement of potentially infected *Opuntia* nursery stock or products for consumption within the continental US.

A final rule will be published by APHIS in the Federal Register in 2009 that amends the domestic quarantine regulations to establish regulations to restrict the interstate movement of South American cactus moth host material, including nursery stock and plant parts for consumption, from infested areas of the United States. APHIS prepared an environmental assessment (EA) that analyzes the potential environmental consequences of amending the domestic quarantine regulations to establish regulations to restrict the interstate movement of South American cactus moth (*Cactoblastis cactorum* Berg) host material, including nursery stock and plant parts for consumption, from infested areas of the United States (Florida, South Carolina, Georgia, Alabama, and Mississippi). A Finding of No Significant Impact (FONSI) was signed in October 2008 ([http://www.aphis.usda.gov/plant\\_health/ea/cactus\\_moth.shtml](http://www.aphis.usda.gov/plant_health/ea/cactus_moth.shtml)). This action will help

prevent the artificial (human-assisted) spread of the South American cactus moth into uninfested areas of the United States.

Implementation of this quarantine would stop the spread of the South American cactus moth from infested areas to uninfested areas through human actions (artificial spread), thus preventing economic, environmental, and recreational impacts as a result of loss of cacti species in the United States. Human health risks due to use of program insecticides (spinosad, imidacloprid, *Bacillus thuringiensis* var. *kurstaki*, and carbaryl) would be minimal due to the method of application and adherence to label recommendations that will minimize exposure to humans, and in particular applicators. Risks to the environment are extremely low since all applications will occur in greenhouses and shadehouses which will eliminate the potential for exposure and risk. APHIS prepared a biological assessment and has determined that applications of insecticides will have no effect on federally-listed threatened and endangered species at the five nursery locations that have requested to ship regulated articles interstate.

APHIS is also drafting a Proposed Rule that will propose to amend the foreign quarantine regulations to restrict the importation of South American cactus moth host material, including nursery stock and plant parts for consumption from any country or portion of a country infested with South American cactus moth. The Proposed Rule will also address amending the territorial quarantine regulations to restrict the movement of South American cactus moth host material, including nursery stock and plant parts for consumption to the mainland and Guam from Hawaii, Puerto Rico, and the U.S. Virgin Islands, and to allow South American cactus moth host material to be moved between Hawaii, Puerto Rico, and the U.S. Virgin Islands. These actions are intended to help prevent the spread of South American cactus moth into noninfested areas of the United States, to relieve unnecessary restrictions on movement of host material between infested areas of the United States, and to provide consistency to the regulations.

## **Control**

The most urgent concern with *C. cactorum* is the advancing westward front of the infestation along barrier islands in Florida, Alabama and most recently in Mississippi. If the moth spreads into Texas, the options for applying a control will be greatly reduced because of the wider area of *Opuntia* distributions and densities. Researchers believe that a sustainable control strategy can be applied at the leading edge by creating a barrier to halt further advance of the moth to the west.

### **Application of Mechanical Control**

Cactus removal has been a key control tactic throughout the program area with massive amount of the host being removed from areas that served as breeding grounds and colonization sites for the cactus moth pest. Dauphin Island and Fort Morgan in Alabama have been mostly cleaned of cactus host plants (more than 200 tons of cactus removed since 2006) with only a few stands left where property owners wanted to maintain the plants and some regrowth occurring. A large portion of the regrowth was removed from Fort Morgan in February 2009. Pensacola Beach was cleaned of most host cactus at the

end of the summer of 2008 which has further reduced the host and pest load that was threatening the delicate barrier program around the Mobile Bay. The goal is to create an area with low amounts of host cactus between Dauphin Island, Alabama and Pensacola Beach, Florida. In this manner a barrier program can be maintained that should stop the natural westward spread of cactus moth into the western US and Mexico.

### **Application of Sterile Insect Technique**

The ARS, CPHST, and Cactus Moth Program officials in Florida and Georgia began looking at the application of the sterile insect technique (SIT) to establish a barrier to prevent the spread of *C. cactorum* westward along the Gulf Coast in 2000. Inherited or F1 sterility was shown by ARS researchers to be applicable to *C. cactorum*, *i.e.*, a dose of radiation is applied to mass reared adults that results in 100% sterility of females but only partially sterilizes males. Fertile females that mate with these partially sterile males produce primarily male offspring (F1 generation) that are completely sterile. The production of F1 sterile individuals in the field results in beneficially higher ratios of sterile to wild insects and better control. The technique has been tested on *C. cactorum* in field cages and has been shown to be effective at reducing populations at release ratios as low as 5 sterile moths to 1 fertile moth.

Mass rearing has advanced in a few short years under the leadership of ARS with assistance from work done in South Africa that was supported in part by the International Atomic Energy Agency (IAEA). An artificial diet adapted from a diet for a stemborer species is used for laboratory rearing at the ARS laboratory in Tifton, Georgia and the FDACS DPI. Rearing efficiency with the diet is greater than on *Opuntia* pads (cladodes), however the adults produced are slightly smaller. Various protein sources are being tested to increase the weight of adult moths. Flight and mating experiments of reared adults show equal competitiveness with wild *C.cactorum*.

SIT releases began in 2005 on a small scale and more recently has been incorporated into the overall CM barrier strategy for control during the three generations that occur each year in the Florida panhandle to the Mississippi barrier islands from March to November. Trapping is used to monitor the effectiveness of program operations and to determine precise locations for the field releases of sterile moths.

The use of sterile moths is part of the overall program goal to establish a permanent barrier to the westward movement of the moth and attempt to push the leading edge back eastward. In order to accomplish this goal and produce enough sterile insects to eradicate the known infested barrier islands on the westward leading edge, it will be necessary to increase current production levels. Mass rearing in support of sterile moth releases is ongoing at the ARS laboratory in Tifton, GA, and FDACS DPI in Gainesville, FL. A strategy is being investigated in which a small reproductive "filter" colony would be maintained in Tifton. The filter colony would undergo stringent disease and quality control management and supply clean stock (eggs) for use in high density rearing that would support the field release program. The high density rearing, sterilization of moths, and shipment of sterile moths to release sites would take place at FDACS DPI.

Development and testing of this rearing strategy is being supported by scientists at ARS Tifton, FDACS DPI and through a contract with Dr. Alan Cohen, Insect Diet and Rearing Research LLC, Raleigh, NC.

The specific objectives at FDACS DPI are: to continue to increase and optimize production (mass rearing) of the cactus moth and to provide the resources to further investigate rearing the cactus moth on artificial diet in conjunction with the USDA ARS facility in Tifton, Georgia; development of an effective disease management strategy for rearing the cactus moth on artificial diet; coordinate the shipping and distribution system for mass-reared sterile moths for FL and other regional states as needed; provide irradiation services (linear accelerator at F.A.S.T.) for sterilization or partial sterilization of cactus moths prior to shipments to the field for SIT release.

### **Application of Pesticide**

Chemical controls are not appropriate in wildland situations or natural areas, but may be appropriate for nurseries, cultivated areas, or residential situations. Field efficacy of materials and application methods are not known. Laboratory results show promise with some commonly available insecticides. Present treatment methods have limited efficacy and are not considered economical

([http://www.aphis.usda.gov/plant\\_health/plant\\_pest\\_info/cactoblastis/downloads/conference/abstracts/zimmermann\\_insecticide\\_abstract.pdf](http://www.aphis.usda.gov/plant_health/plant_pest_info/cactoblastis/downloads/conference/abstracts/zimmermann_insecticide_abstract.pdf)). Investigating the precise timing of product application is necessary to insure that the most vulnerable stages (eggs, neonate larvae) are killed. Larger larvae are difficult to kill because they feed internally.

### **Application of Biological Control**

Biological control options have been considered limited because species specific agents have not been identified from past collections in South America. However, detailed demographic life-table analyses are underway in the native home range of *C. cactorum* in South America to identify key mortality factors, including natural enemies. Although additional studies are needed, the outlook of identifying host specific natural enemies has improved.

### **Research**

To the credit of members of the ARS and APHIS Cactus moth research team in 2000, *C. cactorum* was recognized as a candidate for a research model applying the sterile insect technique for controlling a non-agricultural invasive species. In a short period of time, and with the collaboration of ARS chemists and entomologists in Florida and Georgia, effective survey and control technologies have been developed and tested.

Improvement to the survey tool (sticky trap baited with sex pheromone) may be possible with collaborative research between Mexican and ARS scientists on developing an improved pheromone. While the currently used pheromone lure does attract male *C. cactorum* into the traps, the commercial blend does not completely emulate the female *C.*

*cactorum* sex pheromone. An improved synthetic pheromone would increase the attractiveness of the lure and the number of captures. In addition, research is needed to calibrate the traps and identify the efficiency of the monitoring traps. Trap efficiency includes information on the behavior of approaching males to the traps and the mechanics of capture at close range. Trap calibration will identify longer distance measures of approaching males such as the distance that males are drawn to the trap and the relationship of the number of males captured to the size of the wild moth population.

Ongoing research by ARS and CPHST will need continued support in the refinement of all aspects of activities that support the sterile insect technique. At some point in the process, as funding becomes available and the techniques are transferred to an implementation program, CPHST methods support can take over ongoing technical support.

## **Outreach**

In the U.S., awareness of the problem is not high, although several AP Wire Service stories have appeared in newspapers. The IAEA produced a book explaining the problem of *C. cactorum* translated into English and Spanish. Also, a video in Spanish and English titled The Cactus Moth, *Cactoblastis cactorum*, An Economic, Social and Ecological Threat was produced by the IAEA and FAO. The IAEA campaign was launched in conjunction with the release of the “Preliminary Assessment of the Potential Impacts and Risks of *Cactoblastis cactorum* in the US and Mexico” that was produced by the National Institute of Invasive Species Science with contributions from CPHST.

In August of 2005, APHIS published three fact sheets on cactus moth that will be updated and published in 2009. The cactus moth identification guide and Pest Alert fact sheets can be accessed on at [http://www.aphis.usda.gov/plant\\_health/plant\\_pest\\_info/cactoblastis/index.shtml](http://www.aphis.usda.gov/plant_health/plant_pest_info/cactoblastis/index.shtml). In addition, a fact sheet in the form of a door hanger is available and used as a source of information that is easily left at individual’s homes. Since 2005, the cactus moth has been the subject of many newspaper and magazine articles and was highlighted in the May 2009 issue of the Inside Aphis Newsletter.

## **Cooperation with Mexico**

The IAEA and Mexico’s SAGARPA sponsored an International Forum on the Cactus Moth in Mexico City in July 2004. The USDA cactus moth researchers presented their findings and the news on progress using SIT technology and the development of a pheromone lure were well received. In August 2004, the Director of SAGARPA Drs. Jorge Hernandez Baeza and Javier Trujillo met with USDA Undersecretary Bill Hawks in Hawaii and expressed their strong desire to work with the US, including providing resources, to prevent *C. cactorum* from entering Mexico by spread from the Southeastern US. There was agreement that this cooperation could take place and a plan for how this would be accomplished will be drafted.

APHIS PPQ hosted a Cactus Moth International Review during the summer of 2008 in conjunction with colleagues from APHIS, ARS, NAPPO, FDACS DPI, MSU and Mexico (SAGARPA SENASICA). Mexico is conducting their own CM eradication program in Quintana Roo, Mexico. The review team found the US program conducting appropriate program actions and also made recommendations to improve the sterile release production and the research and development component of the program. A follow-up to this review will be hosted by SENASICA in Mexico in June of 2009.

From February 9 to 11, 2009, five SENASICA staff travelled to the U.S. to assist in removal of cactus moth host plant material from Ft. Morgan National Historic Landmark and the Perdue Unit - Bon Secour National Wildlife Refuge. In addition, the SENASICA staff assisted an APHIS survey of cactus plants on Petit Bois Island, Mississippi, and Horn Island, Mississippi, for *Cactoblastis* infestations. The group was able to complete a thorough survey of these two barrier islands and found no *Cactoblastis* egg sticks or larvae. SENASICA will also be sponsoring a university professor, Dr. Juan Cibrian, to travel to the U.S. to conduct research on improvements to the pheromone used in lures.

## **Actual and Potential Cactus Moth Stakeholders, Collaborators**

### International

International Atomic Energy Agency (IAEA)  
Mexico SAGARPA  
CONABIO

### Federal

US Department of Agriculture  
-Animal and Plant Health Inspection Service  
-Agriculture Research Service  
-US Forest Service  
-Cooperative Extension, Education and Research Service  
US Department of Interior  
-US Geological Survey  
-National Park Service (national parks, national seashores)  
-US Fish and Wildlife Service (national wildlife refuges)  
-Bureau of Land Management (managed ranged lands)  
US Department of Defense  
-US Army, US Marines, US Air Force, US Navy (military bases)  
ITAP (Interagency Committee on Invasive Terrestrial Animals and Pathogens)  
National Invasive Species Council (NISC)

### State

State Departments of Agriculture (The National Plant Board and Regional Plant Boards)  
State Parks, State Forests, Fish and Game Refuges  
Native Plant Societies in different states  
State Invasive Species Councils

Regional

Western Governors Association  
US/Mexican Border Governors Association

Tribal Governments

Universities

Florida A&M University  
Mississippi State University, Georesources Institute,  
Colorado State University, National Institute for Invasive Species Science

Non-Governmental

The Nature Conservancy  
NatureServe  
The Cactus and Succulent Society of America  
Entomological Society of America  
Industry  
American Nursery and Landscape Association (ANLA)  
Florida Nurserymen and Growers Association  
Arizona Nurseries Association  
Gardeners (private citizen associations)  
The Garden Club of America  
American Horticultural Society  
Master Gardeners  
Landowners / Ranchers

**Conclusions and Recommendations**

- Westward movement of the cactus moth along the US Gulf Coast must be stopped and moved back eastward. Preventing movement beyond the current leading edge is a priority.
- Cooperation of State department's of agriculture is needed to help survey nurseries and residential properties along the Gulf Coast and at inland sites from the Florida Panhandle to the Texas-Mexico border. The islands off the Louisiana coast need to be surveyed more intensively to ensure there are no undetected satellite infestations.
- The ARS Tifton, GA rearing facility will establish a filter colony and provide egg sticks to FDACS DPI. The ARS lab will continue transferring technology to DPI so that the Florida facility will become the primary source of moth production.
- Consistency in regulation for *C. cactorum* needs to be applied as soon as possible on nursery stock and plant parts for consumption is necessary to prevent further introductions from foreign countries and its domestic dissemination in the nursery

trade or other commerce. A domestic quarantine rule should be published in 2009 and an importation quarantine rule should be drafted.

- Seek permanent funding from APHIS for long-term control of the westward spread of *C. cactorum*.
- Agency primary responsibilities include:
  - APHIS leads field operations including monitoring for adult moth captures, mechanical removal of host plant material, surveying the Mississippi barrier islands, and release of sterile moths.
  - ARS leads research initiatives in biological control, improved lures and trapping methods, and increased production of moths.
  - FDACS DPI leads sterile moth production.