USDA Strategic Plan for Control of Cactus Moth, *Cactoblastis cactorum* Berg.

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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. It is divided into logical time phases of implementation, with cost estimates for each phase, broken down by tasks under each component: 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 would 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 significant 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, has lead researchers to estimate *C. cactorum* will reach the Texas border by 2007. This surprisingly rapid dispersal has engendered great concern and a sense of urgency from conservationists. Scientists in Mexico are concerned as well, because the cactus is an important agricultural crop.

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. to the desert southwest and Mexico. PPQ is collaborating with USDA/Agriculture Research Service (ARS) to develop methods to detect (trap and lure) and control (sterile insect technique and insecticides) *C. cactorum*. Research has progressed quickly and implementation is now feasible. 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 products in Mexico) proposed cooperation in funding, adding new urgency to the call to stop the spread of *C. cactorum*.

In order to implement a program quickly, USDA must simultaneously develop methods of control, technology transfer, and surveillance. Detection and delimitation of *C. cactorum* along the Gulf Coast will require increased efforts to define the most appropriate location for the focus of control efforts in the spring of 2005. Production of insects at the sole colony of *C. cactorum* (ARS, Tifton, GA) must increase substantially as soon as possible to provide capacity for implementing

sterile insect technique (SIT) by the spring of 2005. A new colony must be established quickly in order to transfer the rearing technology from ARS to a cooperative implementation program.

Goal

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

Objectives

- Define the distribution of *C. cactorum* in the continental U.S. and establish a monitoring network to detect new infestations
- Prevent the introduction of *C. cactorum* to 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 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.
- 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 (Goal 6) and provides leadership in detection and response (Goal 4) to reduce or prevent the impact of an invasive species (Goal 5) that could prove to be an important trade issue (Goal 3).

Summary of detection and control

Detection and control consists of three phases **[Table format or text format below? PM]** (Table 1.1).

TABLE 1-1: Phase I (October 2004 to February 2005)

Objectives	◆ Delineate leading edge of the infestation along the Gulf Coast ◆ Increase production of insects for SIT
Survey	◆ Define and monitor leading edge on Gulf Coast from Florida panhandle to Texas ◆ Map distribution of *Opuntia* spp. along Gulf Coast ◆ Develop database to map hosts and gather monitoring information
Identification	◆ Gather specimens to aid in development of taxonomic keys to larvae of non-target Lepidoptera on *Opuntia* spp., especially in western U.S.
Regulatory	◆ Consult with personnel at Florida Department of Agriculture & Consumer Services, Division of Plant Industry (DPI), and with agricultural agencies in other infested states, relating to the *Opuntia* spp. nursery industry ◆ Begin regulatory work plan for imports and domestic movement
Control	◆ Conduct clean-up operations at leading edge ◆ Increase production of insects for SIT ◆ Begin setting up infrastructure to establish a colony at a new site
Research	◆ Refine pheromone blend, rearing protocols, and release methodologies for large numbers of insects ◆ Initiate SIT validation studies
Outreach	◆ Work with International Atomic Energy Agency (IAEA), USDA/APHIS/Legislative and Public Affairs (LPA) and other agencies to develop an outreach plan ◆ Plan a bi-national stakeholders meeting in southwestern U.S.
Cooperation with Mexico	◆ Establish methods for cooperation and sharing of costs ◆ Share information on survey, detection and mapping

Phase I (October 2004 to February 2005)

Objectives

- Delineate leading edge of the infestation along the Gulf Coast
- Increase production of insects for SIT

Survey

- Define and monitor leading edge on Gulf Coast from Florida panhandle to Texas
- Map distribution of *Opuntia* spp. along Gulf Coast
- Develop database to map hosts and gather monitoring information

Identification

- Gather specimens to aid in development of taxonomic keys to larvae of non-target Lepidoptera on *Opuntia* spp., especially in western U.S.

Regulatory

- Consult with personnel at Florida Department of Agriculture & Consumer Services, Division of Plant Industry (DPI), and with agricultural agencies in other infested states, relating to the *Opuntia* spp. nursery industry
- Begin regulatory work plan for imports and domestic movement

Control

- Conduct clean-up operations at leading edge
- Increase production of insects for SIT
- Begin setting up infrastructure to establish a colony at a new site

Research

- Refine pheromone blend, rearing protocols, and release methodologies for large numbers of insects
- Initiate SIT validation studies

Outreach

- Work with International Atomic Energy Agency (IAEA), USDA/APHIS/Legislative and Public Affairs (LPA) and other agencies to develop an outreach plan
- Plan a bi-national stakeholders meeting in southwestern U.S.

Cooperation with Mexico

- Establish methods for cooperation and sharing of costs
- Share information on survey, detection and mapping

Phase II (March 2005 to November 2005)

Objectives

- Establishment of a barrier on the leading edge
- Decrease the risk from nursery trade
- Increase detection efforts in new areas of infestation

Survey

- Continue monitoring
- Increase trap densities on leading edge and in new areas of infestation, including along the Atlantic Coast
- Involve states in nursery and residential surveys
- Implement use of database for gathering plant host location information with detailed maps and monitoring at locations in states at risk

Identification
- Continue development and distribution of taxonomic keys to non-target Lepidoptera

Regulation
- Provide Florida nurseries with effective cultural and chemical control methods
- Obtain approval of regulatory work plan

Control
- Implement an integrated approach including pre-application clean-up operations followed by applications of sterile insects to leading edge and to satellite infestations beyond the leading edge

Research
- Collect data to validate SIT during control implementation
- Further refine pheromone blend, and rearing and release methods
- Assist new rearing site in colony development, and begin transfer of technology and methods

Outreach
- Disseminate outreach material
- Hold bi-national meeting in southwestern U.S.

Cooperation with Mexico
- Establish a U.S.-Mexico liaison
- Extend detection network to include Mexico in Gulf Coast areas
- Provide Mexican cooperators with experience in U.S. in detection, rearing, and control methodologies for technology transfer
- Jointly fund survey, control, and research activities

Phase III (December 2005 through 2006)

Objectives
- Establish a national detection network
- Establish a permanent program for barrier establishment to prevent movement further west
- Enforce regulatory program for *Opuntia* spp. hosts of C. cactorum from infested states

Survey
- Maintain trap densities on leading edge
- Monitor satellite sites targeted with SIT
- Expand national detection network
- Monitor inland movement and along leading edge and in South Carolina
- Continue to gather plant host distribution and monitor information in database, reporting on a regular basis

Identification
- Publish outreach materials including photographic images of non-target Lepidoptera

Regulatory

- Implement foreign and domestic regulations
- Control
- Establish permanent rearing colony at new site
- Continue application of area wide controls on westward leading edge and new satellite infestations
- Move leading edge back (eastward) along Florida panhandle

Research

- Support survey, control, rearing, insecticide, and SIT implementation

Outreach

- Maintain and expand awareness in western U.S.

Cooperation with Mexico

- Establish full partnership in funding, implementation, and technology transfer

Funding

In December 2004, APHIS transferred $65,000 to ARS to initiate a validation study of SIT. ARS matched the $65,000 level for FY 2004. ARS will use a portion of the total in the following ways:

- Reimburse researcher contingency funds already spent from other projects
- Pay for additional supplies to increase rearing capacity
- Purchase traps and lures
- Conduct release-recapture experiments and monitoring activities in preparation for next year's validation experiment

The PPQ Deputy Administrator office provided $10,000 to a researcher at CPHST in Tallahassee. The researcher is collaborating with ARS scientists on *C. cactorum* projects.

Researchers must begin to increase capacity in Fall 2004 and Winter 2005 for rearing insects, and to assemble materials and equipment, in preparation for application of sterile moths in the validation study beginning in March 2005. Researchers projected additional funding requirements in FY 2005 to implement the full validation experiment on Santa Rosa Island, and have additional sterile moths to apply to the leading edge at that time. The uncertainty of funding for FY 2005 makes planning and preparations difficult.

Goals have shifted since earlier estimates were presented, with an emphasis from Mexico on the urgency for action and their desire to cooperate on the research and control aspects. The APHIS/PPQ

Executive Team is currently supporting a wider program to begin establishment of the barrier along the Gulf Coast in 2005. This requires additional funding for the following purposes:

- Better delimit the leading edge
- Increase production of the colony at the ARS laboratory in Tifton, GA
- Coordination of pre-treatment cleanup efforts on the ground
- Delivery of sterile insects to the sites
- Monitoring after application
- Public outreach
- Establishment of a new colony for a permanent area-wide SIT program

In order to provide proper support, a program manager at the Eastern Region must dedicate significant or full time to coordination of the program. A seasonal contracted volunteer coordinator will be needed.

Source of funding will be contingency funds combined with funds from Mexico. For longer-term appropriated funds, a request for *C. cactorum* increased funding in the emerging pest line item was submitted as a part of the FY 2006 strategic plan budgeting process. However, the request was rejected by APHIS. The preliminary estimate for an APHIS SIT and monitoring program implementation is approximately $1.5 million per year.

Three assumptions that must be recognized when examining the feasibility of successful implementation of the proposed plan:

- A lure, even if experimental, be made widely available soon
- Funding must be available at the times needed; and
- Mexico is a significant or equal partner in its implementation and support

Economic Assessment

Lynn Garrett, CPHST Agriculture Economist, produced an economic assessment based on findings discussed at a planning meeting held in Miami in December 2003. 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 in marginal areas. A more thorough analysis of the impact on Mexico is needed.

Risk Assessment Mapping

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 as high the risk of introduction to the southwestern U.S. and Mexico, and to the environment and economy.

Areas of Risk

According to Comisión Nacional para el Conocimento y Uso de la Biodiversidad (CONABIO), eastern Texas, Arizona, and California are at the greatest risk 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 (NAPPFAST) is using a risk zone mapping program to analyze phenology of *C. cactorum* in the U.S. and Mexico. With the NAPPFAST 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

The U.S. Geological Survey (USGS) is interested in *C. cactorum* from the standpoint of protecting lands managed by agencies of the U.S. Department of the Interior (DOI). USGS oversees funded activities at two universities (Mississippi State University and Colorado State University) directly related to *C. cactorum*. In 2003, USGS initiated cooperation with other DOI agencies and the scientific activities already occurring between ARS and APHIS. The Nature Conservancy has similar concerns and APHIS has been consulting with both groups on detection cooperation. The USGS earmark funding of Mississippi State University's Georesources 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 workshop in 2000 on *C. cactorum* with the USDA/APHIS National Biological Control Institute (NPCI).

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 an impact analysis document (see Simonson et al 2005).

Jorge Hernandez Baeza (Director General, SAGARPA) recently affirmed his government's sincere desire to cooperate and support the research and control efforts undertaken by ARS and APHIS to stop *C. cactorum* from reaching Mexico, as recently expressed to Bill Hawks (Undersecretary, USDA).

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 discussed at the meeting 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.

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. The synthetic lures require replacement every two- three weeks, whereas virgin females need to be replaced every 3-4 days. In field tests, the Pherocon 1-C trap was identified as the most effective. The lure has been used in traps to detect *C. cactorum* along the leading edge of dispersal in the Florida panhandle and on barrier islands in Alabama.

ARS has delayed release of the pheromone for commercial production for the following reasons:

- Much higher doses of the putative pheromone compounds are being used in the lure than are produced naturally by females
- The lure attracts some non-target moth species in addition to the cactus moth
- There is some indication from volatile collections of calling females that the lure is still missing one or more minor components of the true pheromone.
- Fear of raising expectations and being held accountable for the effectiveness of the lure before they have completed the pheromone identification

Since the use of this lure is crucial to determining where the leading edge is for a control program using SIT, some agreement will have to be reached with ARS to facilitate the use of the lure during program implementation while research on the pheromone continues. Without

the lure, a more limited trapping program using sterile virgin females is still possible, but much more labor intensive and logistically difficult.

Mapping of Opuntia distribution

The mapping of *Opuntia* populations in the Gulf Coast area is a critical first step to knowing where to survey. Herbarium records have limited information to help map plant distributions, but research by ARS in Texas shows promise in using infrared reflectance technologies for *Opunita* species. It is proposed that ARS and CPHST collaborate with MSU-GRI to test this technology in Florida and Alabama.

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 US. The Georesources 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 will accommodate the use of hand-held units, produce geo-spatial maps, and send insect survey data to CAPS coordinators in each state for deposition into NAPIS. The following is a dataflow diagram envisioned for the process.

Once the database is available and identification, data collection, and specimen submission methods are drafted, pilot sites along the Gulf Coast and in some western states will be established. Eventually, the detection network will be expanded across the southern US with *Opuntia* sentinel monitoring sites on National Wildlife Refuges, National Parks and Seashores, Bureau of Land Management lands,

National Forests, and US Department of Defense bases. Additionally, The Nature Conservancy and state parks will set up sentinel sites on their reserves with *Opuntia* species.

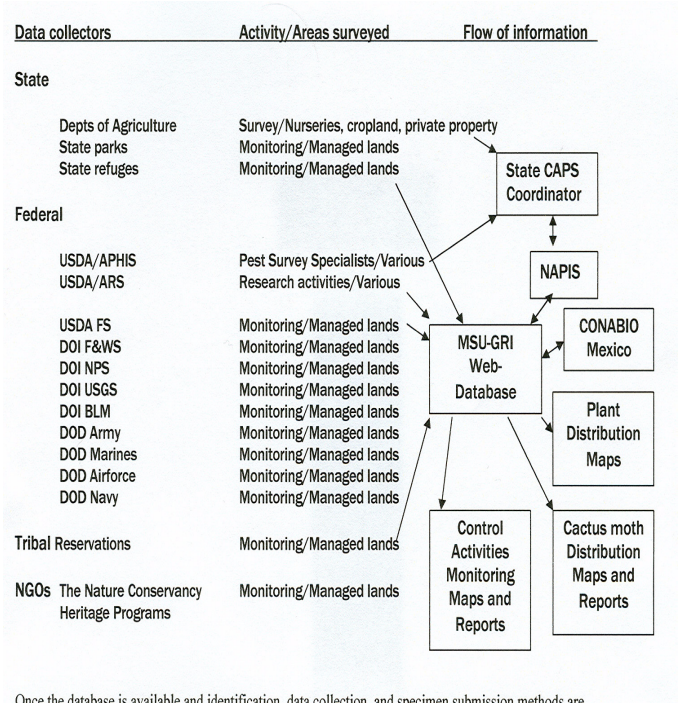

FIGURE 1-1: Flow of data cactus moth detection network.

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. Some states are applying to conduct CAPS surveys for *C. cactorum* surveys in 2005, but a more coordinated effort needs to take place so that states on the leading edge (FL Panhandle and coastal AL, LA, and MS) and those most at risk (AZ, CA, NM, and TX) are conducting active surveys in nurseries and on private property. More support from the Gulf Coast state departments of agriculture is needed, and additional funding for CAPS surveys in those states and Southwestern states is included below.

SURVEY, DETECTION, AND MONITORING	**Tasks**	**Roles & Responsibilities**	**Date**	
Phase I (October 2004 to February 2005)				

A.	Define and monitor the leading edge along Gulf Coast from Florida Panhandle to Texas 1. Make initial contacts at managed land sites; 2. Deliver traps/exp lure with instructions for monitoring; Revisit sites	J. Floyd/S. Hight USGS/ MSU-GRI Cacto Res. Team (ARS-CPHST), Pest Survey Spec. in FL, AL, MS, TX	2004 Oct.-Nov Oct.-Nov.	
B.	Map *Opuntia* plant distribution along Gulf Coast 1. Use herbarium records and Heritage databases 2. Test remote sensing and other techniques: Fly-overs in FL, AL, MS with ground truthing	MSU-GRI, USGS MSU-GRI CPHST, ARS	2004 Oct.-Dec. Oct.-Jan.	
C.	Develop database to map hosts and gather monitoring information, develop website for interface, and distribute materials for setting up sentinel sites.	CM Data Group MSU-GRI, CPHST, PDMP	2004 Oct.-Dec.	
D.	Purchase Hand-held units with GPS and Arc-pad software	PPQ Survey Specialists and others	2004 Nov.-Jan.	
Phase II (March 2005 to November 2005)				
A.	Continue monitoring and increase trap densities: 1. along leading edge (FL, AL, MS, LA, and TX) 2. New areas along the Atlantic coast and Western states. SC, NC, AZ, NM, CA	Pest Survey Specialists, public land contacts, ARS	2005 Feb.-Nov.	
B.	Involve States in nursery and residential surveys through CAPS 1. ER: FL, AL, MS, 2. WR: LA, TX, NM, AZ, CA	State Depts. of Agriculture	2005 Mar.-Nov.	

C.	Continue mapping of Opuntia populations on barrier islands and coastal areas with remote sensing technology	MSU-GRI CPHST, ARS	2005	
D.	Implement use of database for gathering plant host location information with detailed maps	CM Data Group MSU-GRI, CPHST, PDMP	2005 Mar.-Nov.	USGS funded
E.	Implement use of database for gathering and reporting monitoring information, sending appropriate info to NAPIS	CM Data Group MSU-GRI, CPHST, PDMP	2005 Mar.-Nov.	USGS funded
Phase III (December 2005 through 2006)				
A.	Continue monitoring and maintain trap densities on leading edge 1. along leading edge (FL, AL, MS, LA, and TX) 2. New areas along the Atlantic coast and Western states. SC, NC, AZ, NM, CA 3. Monitor satellite sites targeted with SIT	Pest Survey Specialists, public land contacts, ARS	2006	
C.	Expand national detection network to include nurseries and other private land areas. 1. ER: FL, AL, MS, 2. WR: LA, TX, NM, AZ, CA, NV, CO	CAPS contacts, Pest Survey Specialists, public land contacts		
D.	Continue to gather plant host distribution and monitor information in database, reporting on a regular basis.	CM Data Group MSU-GRI, CPHST, PDMP		USGS Funded
E.	Remote sensing	CPHST, MSU-GRI		

Identification

Surveyors need more information on larval characteristics and diagnostic characters. Identifiers must develop a taxonomic key based on external morphological characteristics of larvae.

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 US, there is one pyralid species (*Melitara prodenialis*) feeding within *Opuntia* spp., but in the Western US, there are seven *Melitara* spp. and 3 *Ozamia* spp. Other genera may be encountered on cacti, and one *Cactoblastis* (species unknown) was recently submitted from barrel cactus in California, not a recorded host for the genus.

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, the compounds being tested now are only experimental and other non-target Lepidoptera are sometimes detected in traps. Currently only the Cactus moth researchers have access to this lure and other species captured in traps helps refine the lure research. Some monitoring using the experimental lure will be necessary, but handled by the research team until such time as the pheromone is more clearly defined.

Alma Solis is the Phycitinae specialist at the US 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. Richard Brown is a moth specialist at Mississippi State University working on the Georesources Institute's cactus moth project. He is developing outreach identification products and consults with Dr. Solis. The need for larvae descriptions of western *Opuntia*-feeding Pyralids is a project he is pursuing. 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.

IDENTIFICATION	**Tasks**	**Roles & Responsibilities**	**Date**	
Phase I (October 2004 to February 2005)				
A.	Gather specimens to develop keys to larvae of non-target Lepidoptera on *Opuntia*, especially in Western US	MSU-GRI Richard Brown ARS Alma Solis & Stephen Hight	2004 Oct.-Feb .	USGS funded
Phase II (March 2005 to November 2005)				

A.	Collect western Phycitinae, continue to develop keys to non-target Lepidoptera and distribute, publish outreach materials	MSU-GRI Richard Brown ARS-SEL Alma Solis, Stephen Hight	2005 March-Nov.	
Phase III (December 2005 through 2006)				
A.	Publish outreach materials with photos of non-target Lepidoptera.	MSU-GRI Richard Brown ARS-SEL Alma Solis & Stephen Hight	2006	USGS funded

Regulation

Cactoblastis cactorum is distributed throughout much of the world.

TABLE 1-2. Current distribution of cactus moth

Area	Description
Africa	South Africa (introduced 1933) Mauritius (introduced, 1950) Tanzania (introduced 1958) Kenya (introduced 1966, establishment unconfirmed) Zimbabwe (unconfirmed) Namibia (unconfirmed)
Asia	Pakistan (introduced 1994, establishment unconfirmed)
Australia	Australia (introduced 1926)
Atlantic Islands	St. Helena (introduced 1971) Ascension Island (introduced 1973)
Pacific Islands	Hawaii (introduced 1950) New Caledonia (introduced 1933)
Europe	Not known to occur
Central America	Not known to occur
North America	Florida (natural dispersal or on imports 1989) Georgia (natural dispersal 2000) South Carolina (natural dispersal 2001) Alabama (natural dispersal 2004)
South America	Argentina (native) Brazil (native) Paraguay (native) Uruguay (native)

TABLE 1-2. Current distribution of cactus moth

Area	Description
West Indies	Nevis (introduced 1957) Antigua (introduced 1950) Trinidad (1956) St. Kitts (date unavailable) Puerto Rico (date unavailable) U.S. Virgin Islands (date unavailable) Montserrat (introduced 1960) Cayman Islands (introduced 1970) Cuba (1980)

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.

The table below is a summary of interceptions from 1989 to 2004 from the PIN309 database and shows interceptions of *C. cactorum* from propagative *Opuntia* cuttings imported through the Miami Plant Inspection Station from Haiti and the Dominican Republic. The interception in baggage from Mexico is questionable. Origin and host data from baggage are not always reliable in PIN309 as inspectors sometimes verify these with observations of flight origin and not passenger origin. In addition, SAGARPA has done extensive surveys for *C. cactorum* and indicate that it does not occur in Mexico, although there are other species of cactus feeding Lepidoptera that may be confused with *Cactoblastis*.

Origin	Port of Entry	Number of Interceptions	Inspection Type	How Imported
Dominican Republic	Miami, FL	3	Permit Cargo	Propagative Material
Haiti	Miami, FL	2	Permit Cargo	Propagative Material
Mexico	Dallas, TX	1	Baggage	Fruit
Hawaii	Lihue Kauai, HI	13	Baggage[1]	Propagative Material
Puerto Rico	Manages, PR	3	Permit Cargo	Leaves
Puerto Rico	May agues, PR	1	Baggage[1]	Leaves

1. Represents predeparture inspections of domestic passenger baggage destined for US mainland.

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.

The lack of a continental US domestic regulation to prevent artificial movement from infested states in the southeastern US creates a risk of introducing *C. cactorum* to other parts of the US in nursery stock and in produce for consumption. Inspectors with the Florida Department of Agriculture and Consumer Services (FDOACS) found *C. cactorum* on an *Opuntia* plant at a national outlet store chain in Pensacola, Florida in 2000 but the extent of production in infested states is unknown. Other Florida nursery infestations have been documented by FDOACS, including one in Hillsborough County in 2000 and in Orange County in 2001.

Most *Opuntia* propagation for the nursery trade takes place in California and Arizona. A large nursery in Homestead, Florida has had importations of *Opuntia* nursery stock infested with *C. cactorum* from Caribbean countries. There is some production of *Opuntia* cactus for consumption in Florida, but the degree of out-of-state shipment is unknown. The FDOACS has recently promoted *Opuntia* growing as a niche crop for areas of Florida to help meet the demand for fruit and cladodes by increasing Mexican-American populations in the US.

There is inconsistency in the regulations for preventing the entry of *C. cactorum* into new areas. Any import restrictions and domestic regulations must be consistently applied. Options include prohibition or import restrictions including inspection and certification or treatments from both countries and states where *C. cactorum* is known to occur. Arizona and Nevada have expressed support for a regulation to protect their nursery industry and ecosystems. California did not call for regulation, but thought a control program was appropriate. Other key states where *Opuntia* is prevalent, New Mexico and Texas, have not responded or have not been queried yet.

More information on domestic pathways and an economic assessment of growers in infested states is required in the near future before a regulation can be finalized. With more support of applying sterile insect technique and other mitigations to prevent the spread of *C. cactorum*, a regulation on foreign imports of propagative material and a domestic regulation for all *Opuntia* plants and parts are necessary to consistently apply controls to protect uninfested areas of the US.

Mexico is in the final stages of publishing NOM-084-FITO-2004, which restricts all hosts of *C. cactorum* from countries where it occurs. An additional declaration is required for countries importing host material into Mexico.

REGULATORY	Tasks	Roles & Responsibilities	Date Accomplished	
Phase I (October 2004 to February 2005)				
A.	Consult with Florida DPI and other infested state's nurseries.	J. Floyd	2004 Oct.-Nov.	
B.	Once approved, begin regulatory work plan for imports and domestic movement	J. Floyd	2004 Dec.	
Phase II (March 2005 through November 2005				
A.	Provide Florida nurseries with effective cultural and chemical control methods.	Cacto Res. Team	2005	
B.	Approval of regulatory work plan	RADS	2005	
Phase III (December 2005 through FY 2006)				
A.	Implement foreign and domestic regulations	Regions	2006	

Control

The most urgent concern with *C. cactorum* is the advancing westward front of the infestation along barrier islands in Florida and most recently in Alabama. The infested area consists of a narrow band 2-3 miles wide on a few coastal *Opuntia* species that provide an easy pathway for rapid dispersal further to Louisiana and Texas. 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 Pesticides

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. Investigating the precise timing of

product application is necessary to insure that the most vulnerable stages (eggs, neonate larvae) are killed. Because larger larvae feed internally, there is difficulty in reaching this stage as a target. South Africa would be a good place to conduct the needed insecticide field trials because *C. cactorum* is found throughout the country and they have large commercial plantings of *Opuntia* cactus.

Application of Biological Control

Biological control options are limited because no species specific agent has been identified despite extensive collections in South America. However, additional demographic life-table analyses may be warranted in the native home range of *C cactorum* in South America to identify key mortality factors.

Application of Sterile Insect Technique

The ARS and CPHST researchers 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. Inherited or F1 sterility was shown by ARS researchers to be applicable to *C. cactorum, i.e.,* the dose of radiation applied to mass reared adults that results in 100% sterility in females only partially sterilizes males. Partially sterile males that mate with fertile females produce offspring (F1 generation) that are completely sterile. This makes significantly more sterile individuals available to fertile females and males in order to achieve desired high ratios of sterile insects to fertile. The technique has been tested on *C. cactorum* in field cages and is effective at reducing populations at release ratios as low as 5 sterile moths to1 fertile moth.

Mass rearing has advanced markedly in a few short years 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. 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*.

In order to demonstrate the effectiveness of SIT technology in the reduction or elimination of *C. cactorum* populations in the field, a validation experiment was designed by ARS and CPHST researchers to take place on Santa Rosa Island, Florida, thought to be close to the leading edge of westward expansion of the moth. The experiment seeks to compare populations before and after the application of SIT in combination with clean-up activities (removal of egg sticks and visibly

infected cladodes or plants) in a limited area, with areas receiving cleanup activities only and a control. Volunteers will be used to help with the pre-cleanup activities.

Preparations for the SIT validation study are taking place in 2004, but sterile insect releases will not take place until the 2005 season. SIT will be used during the three generations that occur in the Florida panhandle from March to November. Trapping will be used to monitor the effectiveness of the treatments. If available, sterile moths may also be used in 2005 to help eradicate infestations in front of the leading edge and more broadly around Santa Rosa Island in order to gain some control and prevent further westward dispersal.

Originally, if the validation experiments proved effective at reducing or eliminating populations in the experimental plots on Santa Rosa Island in 2005, applications of sterile moths were to be made part of a larger program that would establish a permanent barrier to the westward movement of the moth and attempt to push the leading edge back eastward. The urgency for action has made it necessary to attempt establishment of a barrier and a scaled down validation study to take place simultaneously beginning in March 2005.

In order to produce enough sterile insects to apply to the known infested barrier islands on the leading edge (Santa Rosa Island, FL and Dauphin Island, AL), it will be necessary to double the existing ARS, Tifton, GA colony. Production at the ARS laboratory in Tifton, GA or at a new location could be augmented by importing large numbers of egg sticks or pupae from South Africa.

To facilitate the broader application of SIT to stop the spread of the moth, the rearing technology must be transferred from ARS to a more permanent mass rearing facility as soon as it is feasible. Because of the necessary lead time to set-up a Cooperative Agreement that would cover the mass-rearing responsibilities and to renovate space to meet the rearing requirements of the cactus moth, and because of the moth's long developmental time (90 days), significant production at a new facility likely would not be possible for at least a year or more.

Discussions with Florida- FDOACS, Division of Plant Industry, (DPI) indicate interest in establishment of a permanent *C. cactorum* facility at their existing rearing laboratory in Gainesville, Florida.

CONTROL	**Tasks**	**Roles & Responsibilities**	**Date**	
Phase I (October 2004 to February 2005)				
A.	Conduct clean-up operations in known leading edge area 1. eliminate infected pads/eggs 2. apply chemicals where approp.	Cacto. Res.Team ARS-CPHST, Region State of Florida	2004 Oct.-Feb.	

B.	Scale up production at Tifton, GA 1. Purchase egg sticks from SA 2. Diet and labor 3. Space/equipment 4. Refurbish irradiator	ARS	2004 Oct.-Dec.	
C.	Begin setting up infrastructure for rearing at Florida DPI-Gainesville 1. Renovate space 2. Equipment	CPHST-PPQ Region	2004 Dec.	
			Total	
Phase II (March 2005 to November 2005)				
A.	Continue application of controls on leading edge to establish barrier 1. Coordinate cleanup operations before applying controls. 2. Production of sterile insects w/ weekly applications over 16 linear miles. 3. Packaging, irradiation, and transport of steriles 4. Release Equipment: a. Ground: 2 ATV's, b. 3 release devices c. Aerial application contracts	 Region PPQ PPQ w/ ARS-CPHST ARS PPQ w/ ARS-CPHST PPQ	2005 Jan-Nov.	
B.	Eradicate new satellite infestations. 1. Coordinate cleanup operations before applying controls. 2. Apply sterile insects to infestations.	Cacto. Res.Team ARS-CPHST, Region, States	2005	
C.	Establish a colony at DPI	Region/CPHST		
Phase III (December 2005 through 2006)				
A.	Establish permanent rearing colony in Gainesville, FL	DPI Support by Region/CPHST	2005 Dec.-Sept 2007	
B.	Continue application of controls on leading edge to establish barrier. 1. Clean-up 2. Packaging/irradiation/transport 3. Application of steriles (ground)	ARS-CPHST, Region, States		
C.	Eradicate new satellite infestations	ARS-CPHST, Region, States		
D.	Move barrier eastward along Florida panhandle.	ARS-CPHST, Region, States		

Research

To the credit of members of the Cactus moth research team (Jim Carpenter, ARS, Tifton, GA, Stephen Hight and Stephanie Bloem, ARS, Tallahassee, FL, and Ken Bloem, PPQ-CPHST, Tallahassee, FL) in 2000, they recognized *C. cactorum* as a candidate for a research model applying sterile insect techniques for controlling a non-agricultural invasive species. In a short period of time, and with the collaboration of chemists and entomologists Bob Heath, Nancy Epsky, Barbara Dubin, and Peter Teal with ARS in Florida, they achieved substantial progress in time in having developed and tested potentially effective survey and control technologies.

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.

RESEARCH	Tasks	Roles & Responsibilities	Date	
Phase I (October 2004 to February 2005)				
A.	Refine pheromone blend	ARS, CPHST	2004 Dec.	
B.	Refine rearing	ARS, CPHST		
C.	Refine release methods	ARS, CPHST		
D.	Preparations for SIT validation	ARS, CPHST		
E.	Continue insecticide studies	ARS, CPHST		
Phase II (March 2005 to November 2005)				
A.	Refine pheromone blend.	ARS, CPHST	2005	
B.	Refine rearing methods and assist with technology transfer	ARS, CPHST		
C..	Refine release methods	ARS, CPHST		
D.	Validate SIT	ARS, CPHST		
E.	Host testing	ARS/Mexico		
F.	Continue insecticide studies	ARS, CPHST		
H.	Explore biological control alternatives	ARS		
Phase III (December 2005 through 2006)				
A.	Further refinement for rearing and SIT technology	CPHST		
B.	Biological control alternatives	ARS		
C.	New technology development	CPHST/ARS		

Outreach

In the US, awareness of the problem is not high, although several AP Wire Service stories have appeared in newspapers. The IAEA plans to implement a publicity campaign and has produced a book explaining the problem of *C. cactorum* translated into English and Spanish. Also, a video in Spanish is complete and the English version is still in production. Their campaign will be 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 is being produced by the National Institute of Invasive Species Science with contributions from CPHST. The IAEA publicity campaign is being coordinated in its timing with the concurrence of APHIS, and our Legislative and Public Affairs staff will collaborate to the extent they can. The plan, if funded by IAEA, will focus on a list of stakeholders in the federal government, state governments, industry, and conservation groups. They hope to implement the plan in the winter of 2004-2005.

OUTREACH	Tasks	Roles & Responsibilities	Date Accomplished	
Phase I (October 2004 to February 2005)				
A.	1. Identify stakeholders and work with IAEA, LPA, and other agencies to develop an outreach plan. 2. Develop materials, 3 min video, posters 2. Plan a bi-national stakeholders meeting in Southwestern US			
Phase II (March 2005 to November 2005)				
A.	Begin to disseminate outreach material through various means, targeting Southwestern states.			
B.	Hold bi-national meeting in Southwestern US			
Phase III (December 2005 through 2006)				

A.	Maintain and expand awareness in new areas in Western States.			

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. The following are elements of a proposed plan of cooperation.

COOPERATION WITH MEXICO	**Tasks**	**Roles & Responsibilities**	**Date**	
Phase I (October 2004 to February 2005)				
A.	Establish methods for cooperation, sharing of costs, and funds transfer	PPQ and SAGARPA, FAO?	2004 Dec.	
B.	Share information on survey and detection and *Opuntia* mapping.	CONABIO, PPQ and MSU-GRI	Oct.-Feb.	
Phase II (March 2005 to November 2005)				
A.	Jointly fund survey, control, and research.	PPQ/SAGARPA	2005	

B.	Establish a US-Mexico Liaison	SAGARPA-IAEA	Jan.	
C.	Extend detection network to Mexican Gulf Coast areas.	SAGARPA-PPQ/ MSU-GRI (for data)	Feb.	
D.	Provide Mexican cooperators experience in US with detection, rearing and control methodologies for technology transfer.	SAGARPA-ARS/ CPHST	Mar.-Oct.	
Phase III (December 2005 through FY 2007)				
A.	Establish full partnership in funding, implementation, and technology transfer	SAGARPA-PPQ	2006	

Further Opportunities for Cooperation

By using employees of other agencies and non-traditional stakeholders, it is possible to establish new relationships with other agencies and groups to prepare outreach materials, to conduct detection and monitoring studies, create a mapping and data collection system, and to develop training materials for volunteers. Later, as the program progresses, it is possible to widen the detection network to all southern US states including new cooperators and trained volunteers with data collection and a reporting system implemented. These relationships can be beneficial to other detection programs where we wish to rely on other agencies, non-governmental organizations, and volunteer networks.

The Interagency Committee on Invasive Terrestrial Animals and Pathogens (ITAP) is a newly formed group under the auspices of the National Invasive Species Council. It brings together all federal agencies to cooperate and communicate on invasive species issues whose concern crosses departmental and agency lines. At their recent planning

retreat held in Shepherdstown, WV, the cactus moth cooperation that has already occurred with Department of Interior agencies was used as an example of how federal agencies with different mandates can work together to tackle a common problem. At that meeting, a Cactus Moth Working Group was formed, in principal, to be the first working group under the Invertebrates Subcommittee.

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

- Action to detect *C. cactorum's* westward movement along the US Gulf Coast must be taken immediately to define the leading edge.

- Cooperation of State department's of agriculture is needed to help survey nurseries and residential properties along the Gulf Coast from the Florida Panhandle to the Texas-Mexico border.

- The existing colony at the ARS Tifton, GA facility must obtain additional resources in the very near term to increase the colony significantly to have enough sterile moths in time for a control program to be implemented on the leading edge beginning in March of 2005.

- APHIS must explore options for establishing a *C. cactorum* mass-rearing colony for an SIT program at another location soon to increase capacity and prevent the moth's introduction into Texas and Mexico where control options are more limited and costly.

- 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.

- Funding is needed immediately for research to step up the pheromone characterization, rearing techniques, and SIT validation.

- An organizational structure and management infrastructure for program implementation needs to be developed before February 2005.

- Mexico's SAGARPA requires a proposal and mechanism for cooperation and support of USDA's research and control program for *C. cactorum*.

References

Preliminary assessment of the potential impacts and risks of the invasive cactus moth, Cactoblastis cactorum Berg, in the U.S. and Mexico
Final Report to the International Atomic Energy Agency, April 25, 2005 © IAEA 2005

By Simonson1, Sara E.; Stohlgren, Thomas J. 2; Tyler, Laura1; Gregg, William P.2*; Muir, Rachel 2*; and Lynn J. Garrett3

Common Names of Insects & Related Organisms

ESA Common Names Database Search Results

Searched Common Names Database for "**Cactoblastis**".

Results: 1 records sorted by Scientific Name.

Print This Window Close This Window

Scientific Name	Common Name	Order	Family	Genus	Species	Author
Cactoblastis cactorum (Berg)	cactus moth	LEPIDOPTERA	Pyralidae	Cactoblastis	cactorum	(Berg)

Dissatisfied with your search results? Please try another search.

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