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"Agricultura bajo ambiente protegido: una opción tecnológica para la competitividad en el Caribe"

"Agriculture sous ambiance protégée: une option technologique pour la compétitivité de las Caraïbe"

United States Department of Agriculture,
T-STAR Sponsored Invasive Species Symposium

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Assessing Accomplishments since the first Symposium in Grenada (2003)
and Coping with Current Threats to the Region

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PEST INFORMATION, DETECTION AND SURVEILLANCE PROJECTS OF THE CENTER FOR PLANT HEALTH SCIENCE AND TECHNOLOGY OF USDA-APHIS

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ABSTRACT. This paper provides a brief overview of the Center for Plant Health Science and Technology (CPHST) of the United States Department of Agriculture and presents selected CPHST projects dealing with the collection, dissemination, or management of information for the purpose of safeguarding against the entry or spread of exotic plant pests. The projects include projects supporting pest identification (IDTools, IDSource, ID Image, ID Mobile), a remote-sensing insect smart trap, pest prioritization, pest prediction (NAPPFAST), the Global Pest and Disease Database (GPDD), and pest biosurveillance (EPICA). The objective of this paper is to raise awareness for CPHST projects and to provide ideas for collaborative efforts among the Caribbean countries and between the Caribbean countries and the United States.

KEY WORDS: Information management, pest information, detection, surveillance

Center for Plant Health Science and Technology. The Center for Plant Health Science and Technology (CPHST) of the United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) is the scientific support division for APHIS/PPQ. As such, CPHST ensures that PPQ has the information, tools, and technology available to make scientifically valid regulatory actions possible and to carry out its safeguarding role through pest exclusion, detection and management. CPHST has over 200 employees working in several units throughout the United States (Figure 1) and one each in Colombia and Guatemala. The CPHST Director's office is located in Raleigh, North Carolina. CPHST project areas include pest risk analysis; phytosanitary treatment technology; emergency response guidelines; weed and pest management methods; biological control; pest information management; and pest detection, identification, and diagnostics. In carrying out its mission, CPHST works closely with other units in PPQ and with universities and Plant Protection Organizations throughout the world.

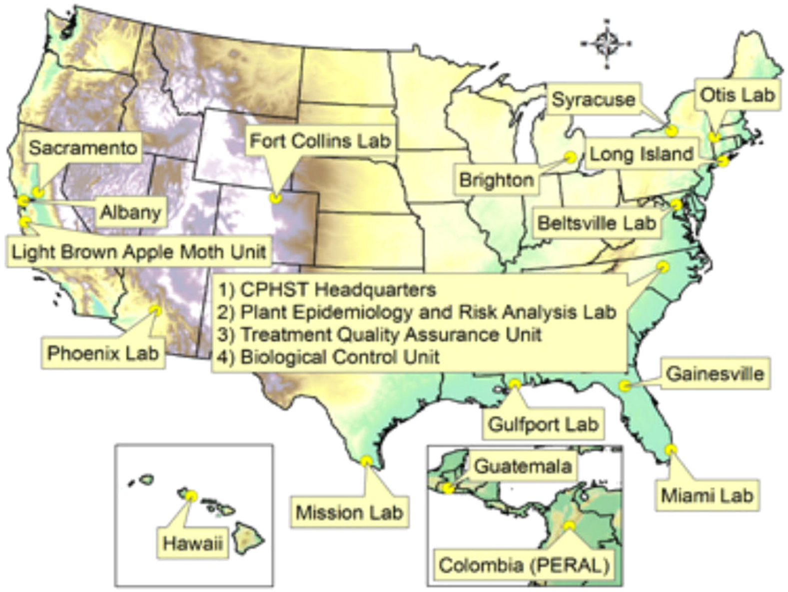

Figure 1. The Center for Plant Health Science and Technology of USDA/APHIS/PPQ
Image source: http://www.aphis.usda.gov/plant_health/cphst/labs.shtml.

PROJECTS SUPPORTING PEST IDENTIFICATION

A project family consisting of the components ID Tools, ID Source, ID Image, and ID Mobile contributes to faster and more accurate pest identification at the ports of entry and elsewhere.

The **ID Tools** component deals with the development of identification tools, including keys, for various groups of organisms of interest to PPQ and cooperators. The identification keys (Figure 2) are developed using the Lucid software of the Centre for Biological Information Technology. Lucid software is an expert system for identification and diagnostic purposes. In contrast to the more traditional dichotomous keys, Lucid keys are multi-access. This means that organism characters can be evaluated in any order, and successful identification does not depend on any individual character couplet (Figure 3). In addition, multi-media elements, such as photos, videos, and even sound files, can be included in Lucid Keys. These characteristics of Lucid keys make them easier and faster to use than dichotomous keys and allow even non-experts to correctly identify organisms. The keys developed by CPHST, as well as numerous other keys are accessible free of charge on the Lucid internet page (http://www.lucidcentral.org), which provides an invaluable resource for pest identification. Identification tools and keys developed by CPHST that may be of special interest to the Caribbean Region include "Pests and Diseases of Cultivated Palms from the United States and the Caribbean," "Pests and Diseases of Cultivated Citrus in the United States," "Federal Noxious Weed Disseminules," and "Scale Insects."

The **ID Source** component, currently under development, is a web portal that will provide centralized access to websites containing keys, fact sheets, screening aids, and images for identifying pests, weeds, and diseases of concern and potential concern to PPQ and cooperators. All websites featured in ID source will have been carefully checked for accuracy and reliability by the ID Source team. A searchable database will allow users to quickly locate web pages that meet their needs. ID Source will also allow users to share their experiences and opinions by commenting on web pages they have used. ID Source is being developed collaboratively by CPHST and Colorado State University with an initial beta release planned for January 2011.

ID Image ("Identification via Images"), another project currently being carried out by CPHST, will support the identification of pests through the use of images, exploring questions such as "What makes an image useful/valuable for pest identification?," "Do different pest taxa require different types of images?," "How would clients access and use an image database?," "What type of data needs to be associated with an image to support the identification process?," "Can organisms be identified by comparing electronic images to information stored in image databases (image recognition)?."

ID Mobile ("Identification for Mobile Devices") focuses on the development of software for personal digital assistants (PDAs) and tablets for pest screening, detection, identification, and verification support. A PDA is a mobile device that serves as a personal information manager. The availability of identification software for use with PDAs would greatly increase the speed and flexibility of pest screening by allowing field and port personnel to immediately screen specimens on site, thus eliminating the need to preserve, package, and ship specimens to remote laboratories. By allowing the characteristics of live specimens to be used as inputs, on-site identification can further facilitate correct identification.

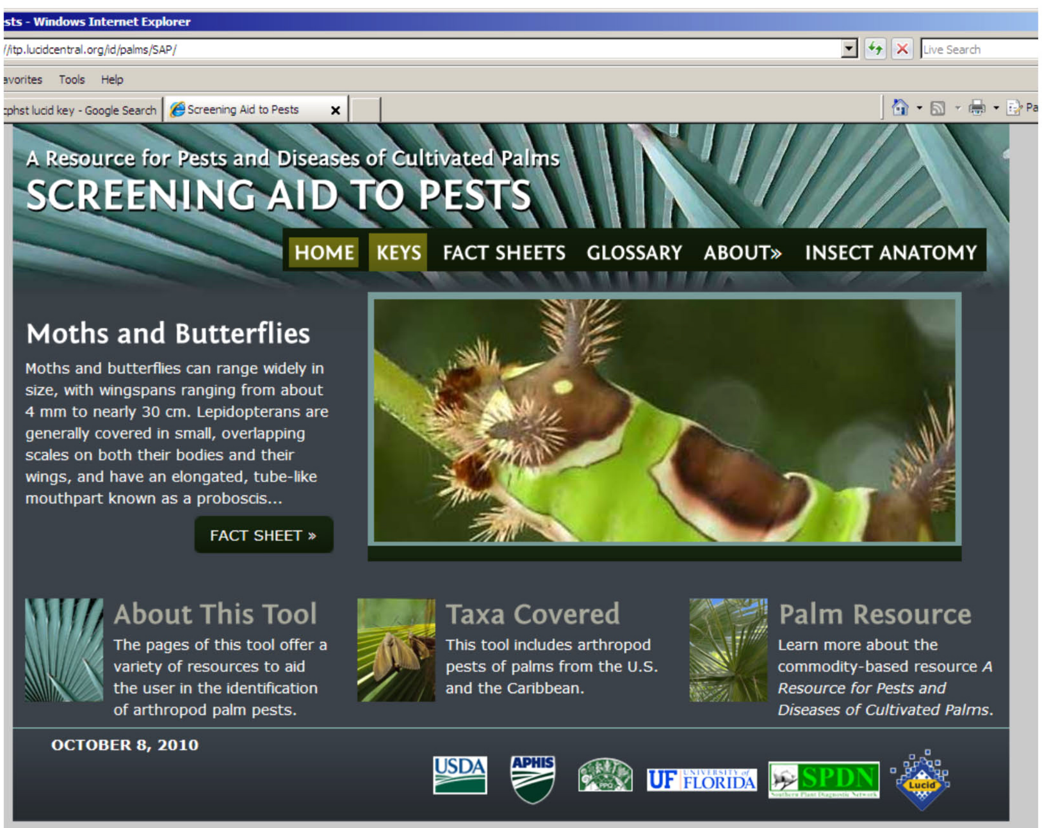

Figure 2. Main page of the "Screening Aid to Pests and Diseases of Cultivated Palms in the United States and the Caribbean," developed by CPHST. This screening aid is publicly available on the Lucid website http://itp.lucidcentral.org/id/palms/SAP/.

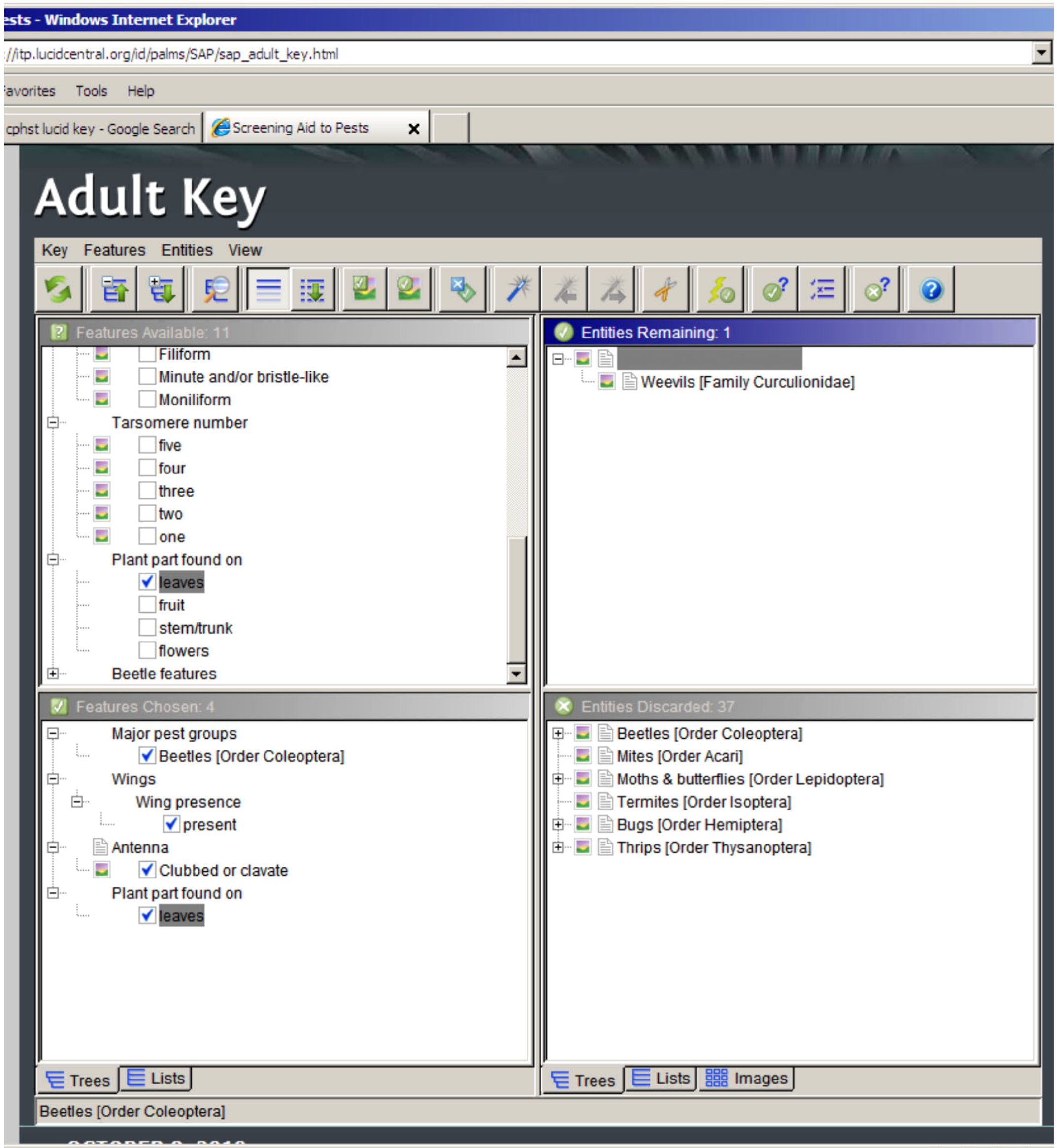

Figure 3. Interface of a Lucid key for the identification of adult palm pests. As the user selects certain characteristics (shape of antenna, presence of wings, etc.) of the pest to be identified, the system creates a list of taxa that fit these criteria and a list of taxa that do not fit the criteria. High-quality color photos and other information is provided to further aid correct identification. Screenshot from http://itp.lucidcentral.org/id/palms/SAP/sap_adult_key.html.

PROJECTS SUPPORTING SURVEILLANCE

Remote-sensing Insect Smart Trap. CPHST, in cooperation with Pennsylvania State University, is laying the groundwork to develop a remote-sensing insect smart trap that would use acoustic technology to identify insect pests and send the information to regulatory officials for monitoring and possible follow up. In many cases, an insect's wing beat frequency is unique and may serve as a "fingerprint" for remote identification. The research carried out thus far has focused on understanding the capabilities of a newly designed active sensor in detecting and analyzing insect wing-beat acoustic signatures. Future development efforts will focus on integrating the acoustic sensor into a trap for European gypsy moth males. If successful, the smart trap may help reduce resource requirements for surveillance programs by remotely alerting staff of suspect trap catches, thus eliminating the need to manually check traps at frequent intervals.

Cooperative Agricultural Pest Survey (CAPS) Support. CAPS is a pest-surveillance program managed cooperatively by USDA/APHIS and the State Departments of Agriculture (Magarey et al. 2009). CAPS personnel survey for over 400 pest species of concern to U.S. agriculture and plant resources nationwide. CPHST provides support for the CAPS program in various ways. First, CPHST uses a scientific approach to decision making, known as the analytic hierarchy process, to develop a priority pest list for the CAPS program. In addition, CPHST is continuously developing survey references and guidelines specifically for CAPS program.

CAPS Priority Pest List. When implementing a surveillance program, the question of which pests to survey has high priority. Because the phytosanitary situation continues to change, this question must be asked on a regular basis, and the survey pest list must be continuously updated to reflect the latest information. CPHST applies a science-based, systematic process for the creation of a priority pest list for the CAPS program, thus ensuring that program resources are focused on those pests most likely to pose a threat, and that the process of pest list compilation is transparent and takes into account reliable, up-to-date information.

The CPHST approach is based on the Analytic Hierarchy Process (AHP), which allows for the use of multiple criteria to aid decision making. The AHP process uses pair-wise comparisons of alternatives to establish priorities (Saaty 2008; Forman and Gass 2001). The process allows for the incorporation of economic and biological components into the decision-making process and can also take into account qualitative worth. CPHST rates pests based on a combination of objective data and the opinion of subject-matter experts. The construction of the AHP model involves the following five steps:

1. Select a goal (i.e., a list of pests, ranked by their likelihood to pose a threat to the United States)
2. List the alternatives (i.e., the number of pests that potentially pose a threat
3. Determine the criteria and sub-criteria that would affect the ranking of the alternatives (i.e., the pests' likelihood to enter the country, the number of hosts present in the country, whether the pest affects human health, the size of the area that provides suitable climatic conditions for establishment of the pest, etc.)
4. Arrange the criteria in a logical hierarchical structure into major criteria and sub-criteria
5. Weight the criteria relative to 100% using a pair-wise comparison process

The same basic approach can be applied by any country to determine which pests to include in a surveillance program and can also be used in other areas of decision making, such as prioritization of safeguarding actions, selection of a contractor or a product, or selection of job candidates.

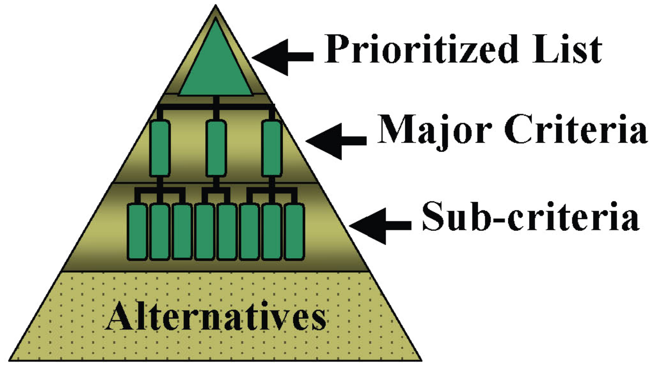

Figure 4. Illustration of the analytic hierarchy process for pest prioritization. The criteria were arranged in a hierarchy and assigned weights based on a series of pair-wise comparisons. Major criteria were compared to each other to determine group preferences. Similarly, sub-criteria within a single node were compared to each other.

CAPS Survey References and Guidelines. Survey references contain information on the biology, host-range, and distribution of CAPS pests, while survey guidelines provide detailed pest- or commodity-specific instructions for survey and pest identification. The objectives of these documents are to standardize survey methodology, improve homogeneity of the CAPS data set, and increase statistical confidence in the designation of "pest-free" status. While designed specifically for the U.S. CAPS program, these survey references and guidelines may provide useful information for Caribbean countries planning to implement a survey program (see http://www.aphis.usda.gov/plant_health/plant_pest_info/pest_detection/pestlist.shtml).

PROJECTS DEALING WITH PEST INFORMATION MANAGEMENT

NCSU/APHIS Plant Pest Forecast System (NAPPFAST). The NCSU/APHIS Plant Pest Forecast System (NAPPFAST) (Magarey et al. 2007) is a joint venture among APHIS, North Carolina State University (NCSU), and the information technology company ZedX, Inc. (Bellefonte, PA). NAPPFAST is used to generate risk maps for the top 50 pest targets in the CAPS program. NAPPFAST is also used to support the pest risk assessment (PRA) activities and emergency program activities of PPQ in addition to pest detection needs. NAPPFAST employs a web-based graphical user interface to link climatic and geographic databases with interactive templates, which allows users to create deductive models to yield spatially explicit risk products.

The NAPPFAST database contains daily weather data sets from 1978 onwards. The weather variables include daily maximum temperature, minimum temperature, precipitation, evaporation, relative humidity, radiation, two- and four-inch daily average soil temperatures, snow depth, and wetness hours. For North America, a weather station database compiles observations from approximately 2,000 stations supplied by government and commercial sources, including the NOAAPORT (Russo 1999). Station data are interpolated at a 10 km^2 resolution using a multivariate, regression-based interpolation approach that accounts for elevation (Splitt and Horell 1998). NAPPFAST also includes a daily global 32 k grid data derived from the NCEP Reanalysis 2 grid (Kalnay et al. 1996), which can be used to validate pest models with overseas data. NAPPFAST data sets encompass both observed and derived variables. The derived variables including leaf wetness, evaporation and soil temperature, and are calculated using proprietary algorithms. The algorithms used for leaf wetness have been validated elsewhere (Magarey et al. 2007). ZedX Inc. uses a series of proprietary quality control algorithms for error checking and filling-in missing station values.

Degree day models can be useful for risk analysis of exotic arthropods (Baker 2002) and occasionally other taxa when developmental requirements are known. To model the potential number of generations a pest may complete, NAPPFAST includes a day degree model template. Day degrees are calculated with a single sine curve (Allen 1976) and are used to estimate the number of generations a pest may achieve (Nietschke et al. 2008). For some pests, their survival is determined by exposure to extreme heat or cold. Threshold values above or below which a pest experiences mortality can be found from sources such as the GPDD and from PPQ treatment manuals (PPQ 2010). A survival model can be created using this threshold in the NAPPFAST generic template using simple logical statements (Magarey et al. 2007). Using a survival model, a risk gradient can be calculated by generating the frequency of days below or above specific threshold(s).

Many plant diseases are caused by fungi, and most fungi, with the exception of powdery mildews and some 'wound' pathogens, have environmental requirements (Magarey and Sutton 2007). While many plant pathogenic processes are temperature driven, infection also requires moisture, and moisture is limiting in most terrestrial environments (Magarey et al. 2005a). In addition to fungi, some bacteria also have a moisture requirement to cause infection. To model plant pathogens, NAPPFAST includes a generic infection model based on a temperature-moisture response function to estimate the number of infection days per year (Magarey and Sutton 2007; Magarey et al. 2005b).

For most weeds and mollusks, there are usually insufficient experimental data to construct deductive models. Instead, for these pests, we use the Bioclimatic Appraisal and Modeling (BAMM) tool to perform inductive climate matching based on both the pests' observed distributions (Schlegel, 2010) and a climate pattern matching approach (Venette et al. 2010).

NAPPFAST includes a request function to generate probability and average history maps from saved models. Probability maps show the frequency of years meeting specific criteria as defined by model output variables for a ten-year period. The average history maps show the average accumulated model output for a ten-year period. Mapped NAPPFAST products can be exported as geotiffs into a geographic information system where they can be further manipulated into a final climate risk map

Risk maps for the CAPS top 50 pest targets are publically available at http://www.nappfast.org. We are in the process of developing a new version of NAPPFAST that includes role-based access and an online interactive GIS environment. An early example of this technology is the Pest Information Platform for Extension and Education, which was developed for soybean rust (Isard et al. 2006). Role-based access allows users to see data, products, and to use tools depending on their job, geographic location, and organization (Sandhu and Coyne 1996). Role-based access allows modelers to create risk products and to publish completed risk products that can then be viewed by users in other roles. For example, program managers and survey specialists can use the Exotic Pest Targeting tool to overlay data sets such as survey observations on top of the risk maps.

Global Pest and Disease Database (GPDD). The GPDD is a collection of information on over 2,000 pests of U.S. quarantine significance. Selection of species for inclusion in the database is based on a number of factors, including their presence in other key lists and databases. Prioritized lists have come from professional societies and governmental groups, quarantine manuals, and others. Pest information stored in the GPDD covers taxonomy, nomenclature, host range, plant parts affected, distribution, detection, economic and environmental impact, phytosanitary risks and measures, pathways of introduction, survey and control methods, and other elements. A permanent, full-time GPDD staff systematically adds new pests to the database and updates already existing pest information. Information is entered into the database as it is presented in the original sources, without any interpretation or evaluation. This makes the GPDD a system for the expert user who has the subject matter knowledge to evaluate and interpret information and who prefers a comprehensive and unbiased presentation of all information available. All cited source texts are stored in the GPDD in pdf format for easy access and full transparency. In addition to scientific publications, website excerpts and other publicly available sources, the GPDD also contains a collection of government-internal documents related to specific pests. Multi-tiered access controls ensure that documents can be viewed only by authorized users. Being fully integrated with several other APHIS/PPQ information systems, the GPDD serves as a central repository for pest information in APHIS/PPQ. Apart from providing pest-specific information, the GPDD can also be queried for country- and host-specific pest lists. A module aiding with the preparation of pest risk assessments is currently under development. The GPDD can be accessed at https://www.gpdd.info. Unregistered users must first request access, which is granted automatically to certain U.S. government users. All other access requests are approved on a case-by-case basis.

Exotic Pest Information Collection and Analysis (EPICA). EPICA is a cooperative effort between CPHST and North Carolina State University to systematically and continuously search for relevant online information about pests of quarantine significance to the United States, and to evaluate, interpret, summarize, distribute, and archive this information. The EPICA staff of three full-time analysts scans over 100 scientific journals, as well as government webpages, listservs, and other information sources for new pest information relevant to U.S. safeguarding. Of special interest is any new information on host and distribution ranges and new methods that have an application in safeguarding. EPICA reports on the new information in a weekly email notification. Source information is not presented verbatim, but is summarized, supplemented by additional background information and placed in a safeguarding-relevant context. All EPICA reports are archived in the GPDD, where they can be queried by date, pest name, category of information (new host, new location, etc.), and keyword. Since its inception in April 2007, EPICA has produced almost 700 pest news articles, several of which have led to safeguarding actions by APHIS/-PPQ. EPICA is featured in a separate paper in these proceedings, so no further details are provided here.

CONCLUSIONS

CPHST has a large staff of scientists who provide scientific support to PPQ's safeguarding mission. These scientists work on a variety of projects, many of which may have applicability in the Caribbean Region. Resources available for this type of work are generally scarce, not only in the Caribbean countries, but also in the United States. Significant cost and time savings, as well as considerable improvements in safeguarding can be achieved by establishing effective collaborations, both among the Caribbean countries and between the Caribbean countries and the United States. To protect its own plant resources, the United States has a strong interest in preventing the entry of exotic pests into the Caribbean Region and is thus supporting collaboration and coordination of safeguarding efforts with and in the Region. Tools and methods that have already been developed may be shared with others at minimal additional cost. A wider use and broader application of these tools and methods would benefit the scientific community by allowing for more rigorous testing and fine-tuning. Improved coordination, communication and leadership for safeguarding in the Caribbean Region are keys to establishing successful, long-term collaborations.

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