Risk Analysis And Prevention

Executive Summary:

The Risk Analysis and Prevention Working Group considered issues and opportunities to prevent the adverse impacts of invasive species (IS). A comprehensive, systematic strategy to prevent introduction and spread of IS should be based on risk assessments of pathways, organisms, and ecosystem vulnerability. Risk assessments should provide the basis for design, adoption, and implementation of programs to prevent the introduction and spread of IS. They need to be comprehensive, logically sound, practical, conducive to learning, and open to evaluation. A rapid risk assessment approach is needed for timely response to new introductions of IS.

Current efforts in risk analysis and prevention include: risk assessments and databases of known IS that threaten U.S. ecosystems, risk assessments of pathways, quarantine programs, cooperative eradication efforts, and international cooperation to address IS in potential source areas.

The major issues affecting our ability to limit the introduction and spread of IS include:

- Inadequate ability to identify and interdict pathways for introduction and spread of IS;
- Multiple, insufficient, and fragmented oversight for pathways of IS;
- Limited understanding of biological characteristics that enable IS to enter, establish, and spread in new ecosystems;
- Inadequate resources to implement mitigation measures to prevent introduction and spread of IS; and
- Limited understanding of what makes ecosystems vulnerable to IS.

To effectively prevent the introduction and spread of IS we need to:

- Increase efforts to identify and interdict pathways for IS;
- Inventory federal oversight for IS pathways;
- Identify potentially dangerous IS through national and international information systems on global IS distribution;
- Engage the public and stakeholders involved in trade and transport in strategies to prevent movement of IS;
- Develop and use environmentally sound measures to control the spread of IS;
- Identify those ecosystems that are vulnerable to invasion by IS.

Prevention of introduction and spread is the first line of defense against IS. While many current programs have successfully prevented introduction and spread of IS, more clearly needs to be done to maintain the safety net protecting U.S. resources and ecosystems. Specific proposals for new or enhanced projects that should be considered to address critical issues in Prevention include: enhanced IS pathways analysis; enhanced early detection efforts; nationwide detection survey network; enhanced IS identification capabilities; IS early warning systems; a pilot, statewide program for IS in Hawaii; evaluation of IS risk in ballast; ecological risk analysis; and evaluation of lag phase phenomenon in IS.

Scope:

The Risk Analysis and Prevention Working Group explored issues and opportunities in developing a comprehensive, systematic strategy to prevent introduction and spread of invasive species (IS) to United States ecosystems, as such species threaten our environment, agriculture, human health, economy, and quality of life. Components of a successful prevention strategy are:

- Risk assessments of known pathways for intentional and unintentional introductions of IS;
- Organism level risk assessments of known IS independent of pathways;
- Ecosystem level risk assessments to rank ecosystem vulnerability;
- Assessment of gaps in the safety net protecting U.S. ecosystems by arraying results of pathway, organism, and ecosystem risk analyses;
- Evaluation and application of measures to close gaps in the safety net
- Identification of research needs in the area of prevention of IS;
- Recognition of the tendency for many introduced species to exhibit a long (> decades) lag phase between introduction, establishment and expansion and that this lag phase may offer "windows of opportunities" for risk management.

Risk Analysis Philosophy:

Risk analysis traditionally encompasses risk assessment, risk communication, and risk management. Analysis of risks is appropriate throughout various stages of management of IS (Figure 1). Since risk communication and management are the subjects of two other Working Groups, the Risk Analysis and Prevention Working Group focused its efforts on risk assessments for prevention of introduction and spread of IS. Risk assessments for IS should aid decision-makers in the design, adoption, and implementation of mechanisms to prevent the likelihood of adverse introductions of IS. The basic tenants of such risk assessments, based on the Generic Non-indigenous Aquatic Organisms Risk Analysis Review Process developed by the Risk Assessment and Management Committee of the Aquatic Nuisance Species Task Force in 1996,are presented in Appendix 1. In summary, risk assessments should be:

- **Comprehensive** - The assessment should review the subject in detail and identify sources of uncertainty in data extrapolation and measurement errors. The assessment should evaluate the quality of its own conclusions. The assessment should be flexible to accommodate new information.

- **Logically Sound** - The risk assessment should be up-to-date and rational, reliable, justifiable, unbiased, and sensitive to different aspects of the problem.

- **Practical** - A risk assessment should be commensurate with the available resources.

- **Conducive to Learning** - The risk assessment should have a broad enough scope to have carry-over value for similar assessments. The risk assessment should serve as a model or template for future assessments.

- **Open to Evaluation** - The risk assessment should be recorded in sufficient detail and be transparent enough in its approach that it can be reviewed and challenged by qualified independent reviewers.

To facilitate quick response to introductions of IS into new ecosystems a rapid risk assessment approach is needed. While this does not obviate the need for the detailed, comprehensive risk assessments discussed above, it would provide for a systematic approach for rapid assessments. A proposed framework, based on a similar approach for response to forest fires, is presented in Figure 2.

Current Programs in Risk Analysis and Prevention:

Risk Analysis and Prevention of IS have been the focus of many programs in the U.S. Many of these have been successful in prevention the introduction and spread of IS by predicting potential threats to U.S. resources and ecosystems, interdicting pathways of movement for IS, responding rapidly to new invasions by IS, and working cooperatively to address IS in source areas. Examples of some current efforts in Risk Assessment and Prevention are presented in Appendix 2, followed by an example of what can happen to an effective containment program when support is eliminated.

Issues and Responses:

A successful Prevention Strategy assesses and mitigates risk of entry, establishment, and spread of IS by considering pathways for movement of IS, characteristics of individual IS organisms regardless of pathways, and inherent vulnerability of ecosystems. The following Issues and Responses are grouped according to relevance at the pathway, organism and ecosystem levels:

- **Pathway - Issue:** Pathways for introduction and spread of IS are many, dynamic in space and time, and subject to multiple, insufficient, and fragmented oversight (Table 1). Our ability to assess and interdict pathways is limited.
- **Pathway – Responses**: To effectively interdict pathways for entry, establishment and spread of IS we need to:
    - Increase resources to identify current and emerging pathways for introduction and spread of IS. Pathway assessments should be risk based and consider current and emerging trade and demographic migration patterns.
    - Assess gaps in IS safety net. Federal agencies should inventory IS pathways within their current purview and identify pathways for which there is no current legislative authority.
    - Partner with other countries to share information on pathways for introduction and spread of IS.
    - Engage stakeholders involved in trade or transport to implement mitigation measures to prevent introduction and spread of IS.

- Continuously evaluate status of potential IS in source areas and changes through time and monitor pathways for global movement of IS.
- Partner with other countries to mitigate pathways for global movement of IS.
- Enhance public awareness and outreach to prevent introductions of IS.
- Conduct forensic research on established IS to identify potential pathways and assess holes in safety net.

- **Organism – Issue**: We have a limited ability to effectively prevent the introduction or limit the spread of IS due to our limited understanding of the biological characteristics that enable IS to enter, establish, and spread in new ecosystems and inadequate resources to implement control strategies.

- **Organism – Responses**: To effectively prevent introduction and spread of IS we need to:
  - Identify potentially dangerous IS by developing risk-based databases. Facilitate development and maintenance of shared national and international information systems on global IS distribution.
  - Identify taxa of potential IS for which there is no current legislative or regulatory authority.
  - Increase resources available for organism level risk analyses.
  - Consider effectiveness of current approaches to evaluating and regulating introduction of IS (e.g. “clean list” vs. “dirty list”).
  - Enhance understanding of biological characteristics of specific IS as they relate to probability of establishment, potential hosts, and vulnerable ecosystems. Identify generic attributes of potential IS. Enhance understanding of the relationship between IS inoculation pressure, reproductive potential and establishment probability.
  - Enhance current taxonomic capabilities and develop new identification technologies (identify current knowledge limitations and improve access to expertise and information).
  - Develop protocols/technologies for early detection of newly established IS.
  - Enhance public awareness and outreach concerning IS. Enlist public involvement in early detection of IS.
  - Engage the stakeholders involved in trade and transport in strategies to prevent establishment of IS.
  - Develop host resistance to IS (where possible).
  - Develop and use environmentally sound measures to control spread and impact of IS and monitor the impacts of the control measures. Need to consider the full range of available measures and understand the trade-offs, relative effectiveness, and unintended consequences and continually strive to minimize adverse consequences.
  - Consider potential range of IS (regional vs. local) and purpose of introduction when assessing risks associated with intentional introductions of alien species.

- Consider containment capabilities before permitting new introductions of alien species.

- **Ecosystem – Issue:** Our ability to protect ecosystems from entry, establishment, spread by IS is limited by a lack of understanding of what makes ecosystems vulnerable to IS.
- **Ecosystem – Responses:** To protect ecosystems from IS we need to**:**
  - Expand our knowledge of the factors that affect vulnerability of ecosystems to introduction and reinvasion by IS.
  - Identify those ecosystems that are vulnerable to establishment by IS.
  - Consider effects of management and natural disturbance on ecosystem vulnerability to introductions of IS.
  - Consider effects of climate changes through time on IS and vulnerability of ecosystems.

Proposed Actions:

Prevention of introduction and spread should be the first line of defense against IS. While current programs have successfully prevented introduction and spread of some IS (see section on Current Programs), more needs to be done to maintain the safety net protecting U.S. resources and ecosystems from future IS impacts. The current resources allocated to Prevention of IS by the U.S. government total $251,236,000 (FY 2000 crosscut budgets presented to Invasive Species Council on May 18, 2000). This amount is dwarfed by recent estimates of the damage costs to the U.S. from IS range from $97 billion (OTA 1993) to $122 billion (Pimentel and others 1999) per year. Working Group members feel that base programs for Prevention within the U.S. government should be increased (doubled) to enhance current efforts to prevent introduction and spread of IS. The following are specific proposals for new or enhanced projects that should be considered to address critical issues in Prevention (see section on Issues and Responses). The first five projects are USDA APHIS proposals that have been ranked as highest priority for FY 2002 by the National Plant Board. This is followed by a project being developed by the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) and a proposal for a state-wide IS prevention program developed by Hawaii's Coordinating Group on Alien Pest Species (CGAPS). Additional project ideas are presented for addressing some issues regarding movement of aquatic IS, developing ecological risk analysis approaches, and evaluation of the lag phase phenomenon common to many IS.

Project Title: Pathways Analysis

Project Justification: Prevention of unintentional introduction of IS hinges on risk analyses of pathways for IS entry into the U.S. A major obstacle to conducting risk analyses of pathways has been the lack of reliable information on pathways for IS. A comprehensive approach is needed to develop and implement operational procedures that enhance the ability to identify, evaluate, and prioritize pathways for IS entry into the U.S. This will allow better characterization and

interdiction of the pathways of IS associated with shipments of agricultural and non-agricultural cargo and materials.

Project Coordinators: USDA APHIS Plant Protection and Quarantine in partnership with other federal agencies, States, universities, industry, foreign governments.

Desired Outcomes: .

1. Improve database linkages, infrastructure and architecture of current IS-related data resources by establishing a National Invasive Species Data Center at Center for Plant Health, Science and Technology (CPHST). Objectives are to improve existing databases, define and develop new data linkages with other federal agencies, scientific organizations, and universities.
2. Expand operational systems that identify, evaluate, and prioritize IS pathways. Increase efforts to develop and redesign current port inspection procedures, and provide task-specific training for employees engaged in all aspects of IS pathway analysis, reporting, and monitoring.

Current Resources: FY 2001 – Funded for $3.0 million (in limited activities)

Additional Resources Needed: FY 2002 - $5.5 million

Project title: Cooperative Early Detection Efforts

Project Justification: Early detection of IS is critical in developing and applying successful IS eradication and/or management programs. Proposed project would enhance and improve current early detection efforts.

Project Coordinators: USDA APHIS PPQ and cooperators (including other federal agencies, State Invasive Species Councils, Native American Tribes, Hawaii and Alaska Native organizations, universities, nonprofit organizations, and industry).

Desired Outcomes: Cooperative agreements would be used to:

1. Enhance the quality and quantity of data regarding IS and their distribution within the United States. This would include funds to strengthen surveys that detect and delimit distribution of IS.
2. Strengthen current IS data sources by improving database architecture, validity, and security.
3. Improve accountability for data entry.

Current Resources: FY2001 $3.5 million

Additional Resources Needed: FY 2002 $10 million

Project Title: Nationwide Detection Survey Network

Project Justification: Prevention of IS introduction and spread will be facilitated by improved information exchange on IS throughout the U.S. and with other countries.

Project Coordinators: USDA APHIS Center for Plant Health Science and Technology (CPHST) and cooperators from universities, nonprofit groups, and State agencies.

Desired Outcomes: Establish a volunteer network of credible individuals and organizations in States and other countries who are willing to participate in surveys and provide periodic IS updates (descriptions, pictures, survey methodologies, etc.) via a website. The network would allow individuals from universities, nonprofit groups, and State agencies to exchange ideas, information, and field observations with the goal of early detection. A detection survey database would be maintained by CPHST.

Current Resources: FY 2001 Not funded

Additional Resources Needed: FY 2002 $ 300 thousand

Project Title: Identification of IS

Project Justification: Accurate and rapid identification of IS is critical to the success of prevention programs. Current taxonomic capabilities need to be expanded and new identification tools need to be developed. For example, some IS plant propagules cannot be distinguished from closely related species by morphological characteristics. High performance liquid chromatography (HPLC) can be utilized to facilitate automation of IS identification.

Project Coordinators: USDA APHIS

Desired Outcomes: Enhance capabilities for IS identification by enhancing current programs, expanding and developing new identification tools and improved coordination among taxonomic experts.

Current Resources: FY 2001 $1.45 million

Additional Resources Needed: FY 2002 $ 1.47 million

Project Title: Invasive Species Early Warning System

Project Justification: Rapid response to new invasions by IS provides the best approach to prevent future losses. There is a need to develop a coordinated approach to locate, delimit, and eradicate new IS before they have the opportunity to spread beyond initially colonized areas.

Project Coordinators: USDA APHIS Plant Protection and Quarantine in partnership with other federal agencies, States, universities, industry, foreign governments.

Desired Outcomes: Predict introductions of IS (insects, plant pathogens, noxious weeds, aquatic organisms, etc.) and develop survey techniques to detect and delimit introductions of high-risk pests when they occur. Components of the IS Early Warning System include:

1. Search available information on high risk IS from ports, international pest reports;
2. Develop new and updated lists of high-risk IS;
3. Develop global intelligence gathering systems that track changes in high risk IS;
4. Develop survey methods to detect and delimit IS introductions using technology targeted at specific organisms;
5. Link in teams with scientists from Agricultural Research Service, USDA Forest Service, universities, industry and State agencies to develop strategies for controlling and/or eradicating pioneer populations of IS;
6. Develop procedures to forecast risk of spread of IS and potential consequences.

Current Resources: FY 2001 – Not funded

Additional Resources Needed: FY 2002 - $ 2.0 million

Project Title: National Early Warning System (NEWS) for Invasive Plants

Project Justification: To help counter the threat posed by introduced invasive plants, a National Early Warning System (NEWS) is needed to ensure that new and emerging invasive plants in the United States are reported, assessed, and addressed as soon as possible. Timely knowledge about new county, state and national plant records will enable local, state, and federal officials, as well as private land owners to take appropriate action against new invasive plants.

Project Coordinator(s): Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW)

Desired Outcomes: Create a nationally coordinated early detection network through State Councils and Local Weed Management Areas. The National Early Warning System for Invasive Plants will contain a number of elements that are implemented by different groups, organizations, or agencies. Functional elements and potential activity areas of the proposed system should include:

1. **Detection and Collection.**

- Creating a volunteer network of people who observe, study, and collect plants in the USA.
- Identifying field scientists/personnel who actively observe, study and collect plants in the USA.
- Determining the type of information that should be included in reporting new plants.
- Providing incentives to encourage detection and reporting of new plants.

2. **Local Coordination** of the Detection and Collection Network.

- Determining which local offices could promote detection and collection of new plants, and could serve as local contacts for plant collectors (suspected new species).

3. **Identification and Vouchering of New Plant Specimens.**

- Designating Herbaria for developing State Detection Networks and identifying/vouchering new plant species reported within each state.
- Developing identification aids, Training
- Verifying tentative identifications.
- Maintaining vouchers of new county, state, and national records.

4. **Scientific and Technical Assessments.**

- Providing online technical assistance for assessing species invasiveness, potential impacts, and available response strategies.
- Developing and implementing a classification system based on invasiveness and regulatory categories that permits land managers to assess the threat of a specific taxa in a specific ecosystem to determine a proper course of action.
- Providing on site rapid assessment and technical assistance for appropriate responses
- Developing standard (field tested) protocols and methods for assessing new infestations.
- Determining Federal, State, Universities, and Local Roles in assessments.

5. **Information Management.** One stop shopping on the internet for information on invasive species/issues.

- Contributing to a distributive national information management system consisting of web-based databases that collect and maintain information relevant to documenting and assessing invasive plants in North America.

- Creating and managing an Internet Gateway/Site to link and query internet plant databases, receive new reports, disseminate alerts to high risk areas, and issue periodic online summaries of recent reports of new invasions.

- Creating an online directory of invasive plant specialists.

6. **Rapid Response** to confirmed outbreaks of invasive species.

- Developing protocols and contingency plans for rapid response to new infestations.
- Guiding and conducting response actions upon request.
- Identifying Mechanisms for funding rapid response initiatives.

7. **Interagency Coordination.**

- Identifying/engaging federal interagency partnerships (e.g., FICMNEW, ANS Task Force, Native Plant Coalition Initiative) to coordinate development and implementation of the National Early Warning System for Invasive Plants.
- Establishing State Interagency Partnerships (State Invasive Species Councils, Weed Management Areas) to develop State Early Warning Systems, to coordinate on site assessments, and rapid response to new invasions.
- Developing Weed Management Areas to coordinate response to new infestations.
- Facilitating international cooperation in sharing information and experience about invasive species.

Resources Needed: To be developed by FICMNEW

Project title: Invasive species prevention system for the State of Hawaii.

Project Justification: The U.S. suffers severely from lack of a comprehensive approach to quarantine and prevention. This shortcoming is conspicuously apparent and damaging in Hawaii, a state which contains highly significant federal resources (major national parks and one-third of the endangered species in the U.S.) which are severely threatened by biological invasions. The intent of this proposal is to showcase what a comprehensive approach would look like, building on the current USDA-APHIS-PPQ and State of Hawaii system, using development of quarantine to adequately protect the State of Hawaii as a national pilot project.

Project Coordinators: The steering committee of Hawaii's Coordinating Group on Alien Pest Species (CGAPS). Contacts for this project: Fred Kraus of Hawaii Division of Forestry and Wildlife (fkraus@hawaii.edu), Lloyd Loope of USGS

(Lloyd_Loope@usgs.gov), and Glenn Hinsdale of USDA-APHIS (Glenn.L. Hinsdale@usda.gov).

Desired Outcomes: Build on progress throughout the 1990s in Hawaii toward developing a comprehensive, integrated system designed for prevention of further pest invasion (of all major taxonomic groups), with the purpose of 1) protecting Hawaii's biodiversity, economy, agriculture, health, and quality-of-life, and 2) providing, testing, and refining a potential model system for the rest of the country to consider in part or in its entirety. The system will:

1. Address a broad range of taxonomic groups, including both intentional and non-intentional pathways from both foreign and domestic sources;
2. Build upon existing statutes, regulations, and authorities for the state with the most severe problem with alien invasive species.
3. Include an effort at improvement of existing Hawaii statutes and regulations to make them more comprehensive.
4. Identify pathways by which problem pests arrive and develop means of interdicting them through each of these pathways. It is foreseen that the most effective means of accomplishing this objective may be through building upon the existing USDA-APHIS quarantine system at the Port of Honolulu to develop a federal domestic quarantine protecting Hawaii in close cooperation with the Hawaii Department of Agriculture (HDOA).
5. Fully address legal barriers/opportunities and potential funding mechanisms.

Current resources: The APHIS-PPQ annual operating budget for Hawaii is roughly $12 million. These resources are formidable, but to date are overwhelmingly focused on protecting mainstream agriculture in the U.S., not on protecting ecosystems, agriculture, economy, and quality-of-life in Hawaii. The state of Hawaii, Hawaii Department of Agriculture, Plant Quarantine Branch, has an annual budget of about $2million. Other agencies are involved, but these two are the primary ones.

Additional resources needed: The planning exercise initiated by CGAPS in mid-April will shed better light on details of what additional resources are needed. A reasonable ballpark estimate at this stage may be $15 million in new funding for improved quarantine effort.

Project Title: Evaluation of seawater ballast exchange.

Project Justification: Mandatory seawater exchange of ballast water was implemented for vessels entering the Great Lakes from overseas in 1993. While the U.S. Coast Guard monitors and enforces compliance with this law, the actual effectiveness of ballast water exchange as a preventive measure has not been adequately tested, especially for the special case of the Great Lakes, where fresh-

and brackish-water and euryhaline species pose the greatest risk. The theory behind ballast water exchange is that organisms that can survive in the freshwater environment of the Lakes will not likely survive in seawater. However, in spite of the implementation of mandatory exchange, new nonindigenous fresh- and brackish-water species have become established in the Great Lakes, e.g. Echinogammarus amphipods (1996), Cercopagis waterfleas (1998). Although some tests of the effectiveness of ballast water exchange have been performed, most of these tests have not involved vessels in ballast with fresh or low-salinity water originating from regions such as the Baltic Sea. The effectiveness of seawater ballast exchange in preventing successful entry to the Great Lakes of aquatic species originating from eastern Europe (Ponto-Caspian basins) and the Baltic Sea, needs to be determined.

Desired Outcomes

Initiate a joint NOAA-Coast Guard study of the effectiveness of seawater ballast exchange in eliminating organisms in ballast water originating from the Baltic Sea and eastern Europe fresh- and brackish-water ports.

Project Title: Evaluation of risk of invasions associated with No Ballast On Board (NOBOB) vessels

Project Justification: Many vessels transiting the globe, and entering U.S. ports, especially in the Great Lakes, report "no ballast on board" (NOBOB) and are not subject to any form of scrutiny or regulation, and are exempt from voluntary or mandatory seawater exchange. Yet, the ballast tanks of NOBOB vessels are often not completely empty and dry, but contain residual water and sediment (slop) that can include a large number and diverse array of living organisms. Relatively little information exists regarding live biota, or the presence and viability of dormant or resting stages (spores, cysts, resting eggs and ephippia) that may exist in either the water or sediment of NOBOB vessels. Dormant stages are formed as a natural defense mechanism when organisms encounter adverse conditions, and may remain dormant for years before reemerging or hatching when exposed to favorable conditions. We lack the necessary data 1) to understand and assess the risk of invasions associated with NOBOB vessels, and 2) to make sound, scientifically-based management decisions that will prevent or minimize the risk of invasions associated with NOBOB vessels.

Desired Outcomes: Initiate a research and risk assessment project focused on NOBOB vessels entering or operating in U.S. waters, especially the Great Lakes, involving NOAA, U.S. Coast Guard, and U.S.E.P.A. Identify and document the living biota contained in ballast tank residual mud and water from a broad array of oceanic and coastal vessels; test for and assess the presence and viability of resting/dormant stages in residual sediment and water; conduct field experiments to assess what happens when an empty NOBOB ballast tank is filled with local U.S. port/harbor water, to be discharged at another location. Use this information

to assess the risk posed by NOBOB operations; identify appropriate treatment options and regulatory responses.

Project Title: Ecological Risk Analysis

Project Justification: Ecological risk assessment has been developed over the last two decades as a tool to evaluate the potential for risk of chemicals in the environment, and the approach has gained prominence at the national, regional and local level in providing a framework for documenting the various options for managing the risks. The approach has validity in evaluating invasive species although there are several aspects that warrant re-casting to address some of the unique problems associated with invasive species.

Desired Outcomes: Develop a risk assessment and risk management framework that adapts the existing model (largely based on chemical toxics) to use with IS accounting for the uniqueness of the risk, responsiveness of the ecosystems (managed and natural), and management options. Of particular concern are the development of (i) more rapid risk assessment modules to address fast response needs and (ii) the unique transport, fate and effects aspects of invasives in aquatic and terrestrial ecosystems.

Project Title: Evaluation of the Lag Phase Phenomenon in Invasive Species and its Role in Risk Management

Project Justification: The lag phase phenomenon has been documented in several terrestrial plant IS but has been poorly investigated for its features and commonality across taxa. The most notable feature of the lag phase is that for many IS that become established in a new area, there is often a lag period of one to several decades before the species exhibits an aggressive behavior. Understanding this lag phase and what controls the process (biological and ecological) might help identify a number of tools for management of species that fail to be screened from the entry-level risk process.

Desired Outcomes: Initiate a Research & Development effort involving the public and private sectors to understand the dimensions and mechanisms of the lag phase phenomenon and to apply that understanding to the risk management strategies available for controlling invasive species.

Figure 1.

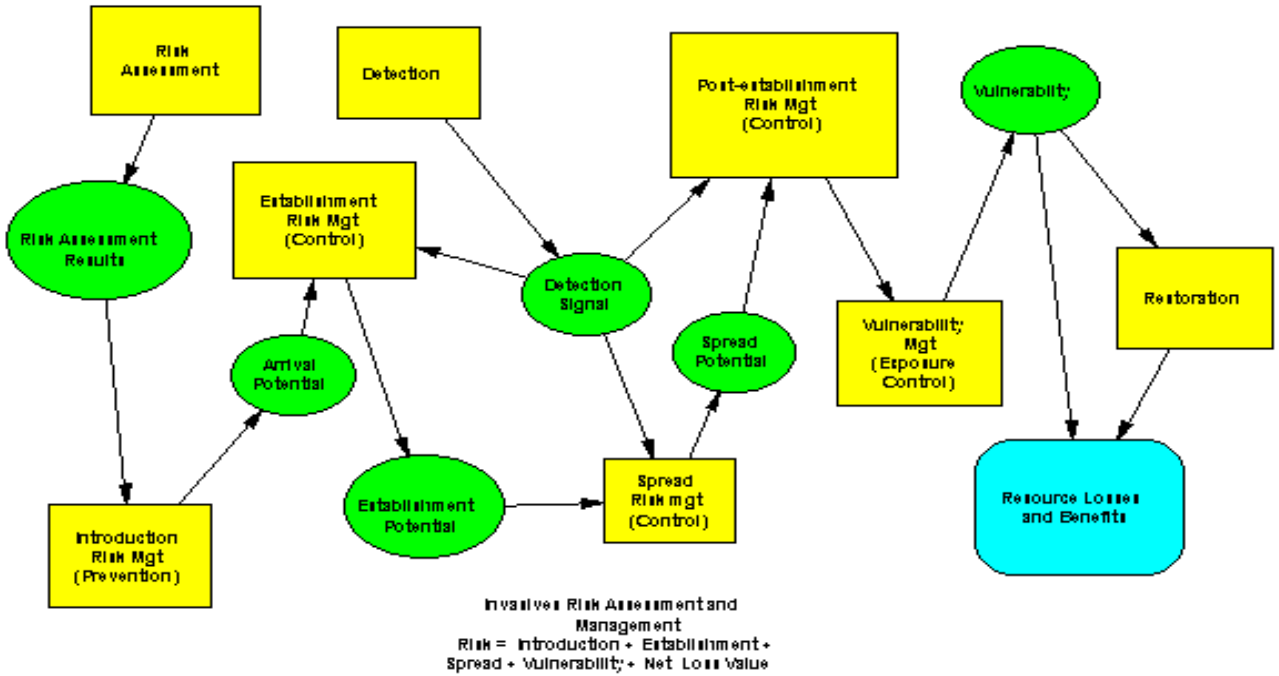
Risk Assessment
Detection
Post-establishment Risk Mgt (Control)
Vulnerability
Risk Assessment Results
Establishment Risk Mgt (Control)
Detection Signal
Restoration
Arrival Potential
Spread Potential
Vulnerability Mgt (Exposure Control)
Establishment Potential
Spread Risk mgt (Control)
Resource Losses and Benefits
Introduction Risk Mgt (Prevention)
Invasives Risk Assessment and Management
Risk = Introduction + Establishment + Spread + Vulnerability + Net Loss Value

Figure 2. Rapid Assessment Model for Prioritizing Invasive Species(IS) Programs and Activities

Evaluate the probability and severity of consequences that could be caused by the invasive species in question on the following qualitative scales:

RAPID RISK ASSESSMENT FOR _____(Species X)_____:

STATUS	*----------*----------*	Potential Threat ... Established Populations
RATE OF SPREAD	*----------*----------*	Slow ... Fast
POTENTIAL EXTENT	*----------*----------*	Localized ... Widespread
POTENTIAL ECONOMIC IMPACTS	*----------*----------*	Localized ... Multi-regional or National in Scope
POTENTIAL ECOLOGICAL IMPACTS (including critical habitats)	*----------*----------*	Benign ... Catastrophic
POTENTIAL SOCIAL IMPACTS (includes legal implications and political sensitivity)	*----------*----------*	Broad Agreement ... Highly Controversial
TREATMENT OPTIONS	*----------*----------*	Few ... Many
TREATMENT COSTS	*----------*----------*	Low ... High
SUMMARY ASSESSMENT	*----------*----------*	Defer Action ... Immediate Action

Table 1. Examples of Known Pathways for International and Interstate Movement of Invasive Species (IS).

Invasive species	Known pathways
Weed plants and seeds (unintentional)	Human transport on vehicles (terrestrial) and boats (aquatic); carried by birds, mammals, water (including irrigation, floods), wind; contaminants in hay and straw mulch, feed, soil, grain, seed preparations; contaminants in container or balled and burlap plants; as understock for grafted plants; escape from horticultural plantings
Weed plants and seeds (intentional – e.g. kudzu, tamarisk)	Direct human releases for erosion control, distribution of seed for plant exploration, botanical research, physiological studies
Birds	Direct human releases
Zebra mussel	Hulls of ships, barges, boats
Marine invertebrates	Ballast water
Brown tree snakes	Aircraft
Large mammals (e.g. oryx, fallow deer, nilgai, etc.)	Direct human releases (for “game farms”)
Feral mammals (cats, dogs, hogs, etc.)	Escape from domestication, migration
Fish	Intentional introductions (sport, biological control), bait
Insects of crops	Hay and straw, within fresh produce, wind, traveling public, Soil carried on roots of nursery stock, sod, bedding plants, transplants, etc.
Diseases of plants	Hay, straw, travelers, wind, water, soil, commerce in fresh produce and live plants
Gypsy moth (and other tree defoliating moths)	Hitchhike as egg masses on ships, vehicles, outdoor furniture
Asian long-horned beetle (and other wood borers and bark beetles)	Solid wood packing materials, wooden pallets, untreated logs, firewood
Dutch elm disease (and other tree disease causing fungi)	Solid wood packing materials, wooden pallets, untreated logs, firewood
Port-Orford-cedar root disease	Moving water and soil on vehicles and animals
Red imported fire ant	Nursery stock, straw from stables
Formosan termite	Ships (in freight)
Mosquitoes	Aircraft, ships/boats, used tires

Appendix 1. **Basic tenants of Invasive Species Risk Assessments,**
(based on the Generic Non-indigenous Aquatic Organisms Risk Analysis Review Process developed by the Risk Assessment and Management Committee of the Aquatic Nuisance Species Task Force in 1996)

- **Purpose of Risk Assessments**
  - Process to identify and estimate dimension, characteristics, and types of risks associated with the introduction of invasive species via assessments of:
    - Pathways
    - Specific organisms
    - Ecosystem vulnerability
  - Process to aid decision-makers in design, adoption and implementation of mechanisms to prevent or minimize the likelihood of adverse introductions of invasive alien species
  - Process to identify the uncertainties or the degree of uncertainty involved and where appropriate, recommend mitigation measures to reduce risk of adverse introductions
  - Provide Model/Template for future assessments
    - Carry-over value for similar assessments
    - Standardized assessment process:
      - Probability of establishment
        - Organism/pathway
        - Entry potential
        - Colonization potential
        - Spread potential
      - Consequences of establishment
        - Environmental impact potential
        - Economic impact potential
        - Perceived impact (social & political influences)
- **Risk Assessment Process**
  - Systematic
    - Standardized process
      - Evaluate risk of introducing alien species into new environment
      - Evaluate risk of certain pathways as vector of harmful invasive alien species
      - Evaluate vulnerability of ecosystems to invasion by alien species
    - Framework for review and synthesizing
      - Scientific information and data
      - Technical information and data
      - Other relevant data, including anecdotal data
    - Framework for documenting certainty and uncertainty (known vs. unknown)
  - Comprehensive, accurate, comprehensible and manageable
    - Quantitative and qualitative data
      - Identify data sources,
      - Indicate reliability (recognize that never capture all variables)
      - Identify uncertainties and data gaps
    - Consider and estimate cost of establishment

- Evaluate quality of own conclusions
- Accommodate full range of methodologies
- Prevent predetermined result(s)
  - Assessors and regulators remain independent
  - Extent possible conduct in atmosphere free of regulatory and political influences
  - Risk analysis not "policy-driven"
  - Risk analysis must be policy relevant
- Practical/Achievable
  - Reasonable estimation of overall risk
  - Evaluate risk in order to determine management action
  - Goal to prevent introduction of harmful invasive species
  - Based on best "information" available
  - Estimated risk utilized to determine whether the proposed activity involving a known or potential harmful invasive organism will be allowed and if so under what conditions
  - Recommendation(s) contain relative amount of uncertainty and where appropriate include mitigation measures
- Continuous, Open and Transparent
  - Stakeholder input
  - Integration of Risk Assessment process with Monitoring
  - Continuous updating
  - Clear, comprehensible explanation of rationale, including uncertainties in the process and the knowledge-base

❖ **Risk Assessment Limitations**

- Predictability – Must be recognized that
  - Virtually impossible to predict whether, when or how a particular organism will become established
  - Strive to achieve estimate of likelihood organism may be introduced and estimate its potential to do damage if becomes established under favorable host/environmental conditions
- Acceptable risk levels – Process cannot determine what is acceptable risk level
  - Risk levels are judgments characterized by variables beyond systematic evaluations of information
- Uncertainties of Assessment Process
  - Process – methodology
    - Assessment methodologies evolving and changing as technology and knowledge base of biology and ecology improves
    - Assessment process should not remain static or routine
    - Modified as new data and techniques available
  - Assessor(s) – human error
    - Mixture and quality of assessors
    - Balance
  - Organism – biological and environmental unknowns
    - Data quality
    - Data gaps
    - Biological and ecological uncertainties

- Pathways –
  - Identification of existing and potential pathways
  - Data gaps
- Ecosystems –
  - Identification of factors that have contributed to previous invasions
  - Data gaps

❖ **Precautionary Approach**

- Degree of biological uncertainty cannot be equated with degree of risk or non-risk
- Risk assessment cannot determine acceptable levels of risk
- Risk assessment cannot predict when, whether or how introduced organism will become established, harmful or invasive
- Risk assessment can estimate likelihood organism might be introduced and estimate its potential to damage under favorable conditions (host and environmental conditions)
- Risk assessment can provide estimation of risks that may be utilized in design and implementation of regulatory mechanisms to allow, restrict or prohibit high risk pathways or organisms with goal of preventing introduction of invasive alien species
- Risk assessment must be documented in sufficient detail and transparency to accommodate review and be challenged by qualified independent reviewers
- New introductions (first time imports) should be subjected to screening mechanism to ascertain whether a formal risk assessment is warranted. Assessment includes characteristics similar to those of introduced species that previously determined to be harmful invasive
- Risk assessment must be well-documented, comprehensive, up-to-date, relevant, rational, reliable, justifiable, and unbiased.

Appendix 2. Risk Analysis and Prevention: Current Activities

Risk Assessments

The U.S. government uses a number of risk assessment processes to evaluate the threat of invasive species (biological "contaminants") to the natural resources of the United States. Pest risk assessments are the foundation for risk management efforts to prevent or reduce the entry and spread of IS. The findings of example assessments follow, by two categories - list of known threats and lists of potential high risks.

Assessment Findings for Known Threats

- United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) (http://www.plantprotection.org/rppc/) maintains databases identifying and providing information regarding non-indigenous arthropods that have been introduced into North America, and invasive species regulated by quarantine:
  - **Identified Plant Pests Regulated by APHIS (IPPRA)** database is comprised of insects, mites, nematodes, and plant pathogens regulated by APHIS.
  - **Federal Noxious Weeds (FNW)** database, lists species of plants regulated by APHIS. Since 1976, 88 individual species have been listed. Invasive plants documented for impacts to U.S. natural areas include:
    Range: Leafy Spurge, Cheatgrass, Squarrose Knapweek, Spotted Knapweed
    Forests: Mile-a-minute weed, Kudzu
    Arid lands: Saltcedar
    Hawaii: Banana poka (*Passiflora mollissima*), *Miconia calvescens*, Koster's curse (*Clidemia hirta*)
  - **North American Non-Indigenous Arthropod Database (NANIAD)** is focused on arthropods (insects, ticks, mites, spiders, etc.) not native to North America that have entered this region.
  -

Assessment Findings for Potential High Risk Threats

Potential high risk threats to the natural resources of the United States have been identified by focusing on dangerous alien organisms and high risk pathways:

- The **Exotic Forest Pest Information System for North America** (www.exoticforestpests.org) database, a collaborative effort of U.S., Canadian and Mexican regulatory and forest management agencies, ranks pest risk for alien insects, mites and pathogens that are likely to cause significant damage to North American forests based on ability to: maintain a free-living population, and to cause economic and environmental damage in its new range. The database also provides fact sheets of information on basic biology, dispersal and pathways for introduction.

  Dangerous alien Insect pests of high risk include:
  - Asian gypsy moth (*Lymantria dispar*),
  - Asian longhorned beetle (*Anoplophora glabripenis*),

- Black pine beetle (*Hylastes ater*),
- Brown tail moth and Nun moth (*Lymantria monacha*).

Dangerous alien pathogens identified by this risk assessment system include:
- European race of scleroderis canker (*Gremmeniella abietina*)
- Pine root disease caused by *Leptographium truncatum*
- Exotic strains of diplodia shoot blight (*Sphaeropsis sapinea*)

- **USDA FS Wood Import Pest Risk Assessment Team**, in collaboration with APHIS has identified potential risks associated with importation of un-manufactured wood in country-specific pest risk assessments (e.g., for log imports from Russia, New Zealand, Mexico and South America). In addition, APHIS is currently coordinating cooperating with the Forest Service on an assessment of risks associated with solid wood packaging materials imported into the U.S. from other countries. Both assessment processes consider probability of establishment (entry potential, colonization potential, spread potential) and probability of environmental and economic damage. The completed assessments indicated that importation of un-manufactured wood can present substantial risks to the forests and trees of the U.S. due to introduction of exotic organisms that have the potential to cause large-scale economic and environmental impacts. For example, the pest risk assessment for importation of logs from Russia demonstrated that the risk of significant impacts to North American forests is great. Detailed evaluations of six of the high risk pests (Asian gypsy moth, nun moth, spruce bark beetle, pine wood nematode, larch canker, and exotic strains of *Annosus* root disease) indicated that the possible economic impacts ranged from $24.9 million to $58 billion. The possible ecological impacts of these exotic pests and pathogens included tree species conversion, deforestation, wildlife habitat destruction, degradation of riparian communities, increased fire hazard, and loss of biological diversity. The pest risk assessments completed by the USDA Forest Service provided the scientific basis for universal and country-specific wood import regulations issued by APHIS to prevent the introduction of invasive forest pests (7CFR319).

- The U.S. participates on a North American Plant Protection Organization (NAPPO), that exchanges pest risk assessment and quarantine information among the member countries of Canada, Mexico, and the United States. NAPPO is evaluating the feasibility of conducting NAPPO pest risk assessments.

- APHIS has contracted with the Ecological Society of America, the Entomological Society of America and the American Phytopathological Society to formulate criteria for listing a top "twenty" invasive species threats to U.S. natural resources. No information on this effort is currently available.

Prevention Programs

Various programs have been implemented to prevent the introduction of new invasive species into the United States and to prevent or reduce the spread of established invasive species into new ecosystems. The following are a few examples of current and previous IS prevention programs that have successfully prevented or reduced impacts of IS. The final example is one that illustrates how letting down the guard on an IS can lead to disastrous consequences.

- **Verticillium wilt disease in alfalfa**.

Discovery: In 1982 an alert NY farmer noticed serious plant loss in his alfalfa fields.. He called his Cooperative extension agent, who checked fields , then called state plant pathologists and plant breeders at NYS College of Agriculture, Cornell. They checked fields, took samples to lab for analysis.

Identification: Laboratory tests identified the disease as Verticillium wilt, caused by a bacterium, and determined this could be a threat to NY alfalfa. The bacteria can easily move between farms, regions and states, so further spread seemed inevitable.

Rapid Response: Cornell extension plant breeders quickly organized a meeting in the field of seed company executives, Ag college researchers, and extension educators, with local farmers who were suffering losses. Plant losses were shown. This was followed immediately by a planning meeting to develop a response. Participants challenged researchers and extension to develop a rapid response plan. Industry representatives agreed to provide funds for extension and research activities. They also agreed to inform state legislators of the seriousness of the problem, and support a bill to provide funds to support appropriate research.

Risk Assessment. Biological risks were quantified by extension agents, who surveyed damage in affected fields. Added information was gathered from European contacts, who were familiar with the disease. It was determined that this disease had potential to cause serious alfalfa losses throughout the state, the Northeast, and ultimately the northern US. Economic risks were assessed. NY farmers grow about 1 million acres of alfalfa. Alfalfa serves as a major feed for NY's $2 billion dairy industry. Unchecked, this disease could raise the costs of producing milk, and boost its price to consumers.

Social risks were also considered. Loss of alfalfa fields would increase production costs and force some farmers out of business. Farm losses would hurt the economies of rural towns and industries that serve farmers. Ando consumers would face higher milk prices.

Action Plan: Short-term. Extension agents alerted near-by farmers to this threat and provided information on sanitation steps to slow spread of the disease.

Long-term: Cornell plant breeders initiated a "crash" program to develop alfalfa with genetic resistance to the disease. Within a year breeders had developed an alfalfa strain with strong resistance. Participating seed companies immediately increased seed of this new strain, and seed supplies were soon available to farmers. Other breeders used the new variety as a parent to develop over 200 resistant varieties that are now available to American farmers.

Success!: Verticillium wilt is no longer a threat to farmers in NY or the US. Nearly all alfalfa varieties being marketed in the US now contain strong resistance to this disease.

***Follow-up**. We continue to rate the resistance of new varieties before release. Plant pathologists and trained scouts continue to monitor alfalfa fields, to be sure new destructive biotypes of this or other diseases do not develop

Conclusions:
The components of most successful response programs include:
*An observant lay person who sees something unusual, and who reports it or seeks information.
This person may or may not have training or prior information about the invader.
*Prompt response from a local specialist, who knows which experts or agency to call.
*Prompt identification by knowledgeable scientists.
* Identification of lead agencies or person(s) to coordinate activities.
*A rapid assessment of the invader and its potential biological, economic and/or social impacts.
*Immediate involvement of public and private researchers, industry leaders and other stakeholders.
* A rapid response plan: With short and long-term components, involving stakeholders throughout.
Short-term: Information to threatened stakeholders to help them identify and limit spread.
Long-term: A 'crash" research program to identify and develop responses to the pest.
Action: Quickly implement research results, to eradicate, stop, or make harmless its invasion.
*Follow-up: By trained personnel, to:
Evaluate the success of the program
Determine whether additional steps are needed
Monitor against further break-outs or introductions of the pest.

- **Maize Dwarf Mosaic virus in Corn**.

Discovery: Several years ago a farmer in Southern Illinois noticed dwarfed and discolored plants in his corn fields.. He contacted his Cooperative extension agent, who called state plant pathologists and plant breeders at the University of Illinois. They checked fields, took plant samples to labs for analysis.
Identification: Laboratory tests identified the disease as Maize Dwarf Mosaic, caused by a virus. Scientists determined this could be a threat to Illinois corn. The virus is spread by common insect vectors and could easily move between farms, regions and states. Further spread seemed inevitable.
Rapid Response: U. of Illinois scientists quickly organized an emergency meeting of state, federal and seed company researcher to show and evaluate the threat. Participants challenged researchers and extension to develop a rapid response plan. Industry representatives agreed to provide funds for extension and research activities. They also agreed to inform state and federal legislators of the seriousness of the problem, and support legislation to provide funds to support appropriate research.
Risk Assessment. U. of Illinois scientists assessed biological risks by surveying damage and quantifying losses in affected fields. Scientists in near-by states were alerted, and affected fields were found in southern Indiana, Ohio and in Kentucky, in fields near the Ohio river. It was determined that this disease had potential to cause serious corn losses in the Ohio river valley, with potential to spread into the lower corn belt. Economic risks could be huge, as corn production in this area is valued at billions of dollars annually. Social risks were also

considered. Farm losses would hurt the economies of rural towns and industries that serve farmers. And consumers could face higher food prices.
Action Plan: Short-term. State and county extension agents alerted area farmers to this threat and provided information on sanitation steps to slow spread of the disease.
Long-term: Illinois and Ohio corn breeders surveyed available corn germplasm, and found several lines resistant to the disease. Seed company and USDA plant breeders initiated a "crash" program to use these to develop corn varieties with strong resistance to the disease. Within 2 years breeders had developed corn hybrids with strong resistance. Participating seed companies immediately increased seed of these new strains, and seed supplies were soon available to farmers. Within five years after discovery only resistant corn varieties were being sold in the infested area.
Success!: Maize Dwarf Mosaic virus is no longer a threat to grain growers in the Ohio valley, or elsewhere in the US . The virus can still be found in the area, but grain varieties all carry strong resistance.
***Follow-up**. Breeders continue to rate the resistance of new varieties before release. Plant pathologists and trained scouts continue to monitor corn fields, to be sure new destructive strains of this disease do not develop.

- **Invasive Plants in Pennsylvania**

Discovery: In 1997, a botanist with the Morris Arboretum of the University of Pennsylvania discovered *Galega officinalis* invading meadows while working on native and naturalized flora of Pennsylvania. This species was listed on the federal noxious weed list but was known only in the western U.S. as a range invader. Historical reviews of horticultural literature revealed that the plant had a long history of garden use.
Response: An adhoc committee was formed to survey the extent of infestation and host a workshop to discuss strategies for control and eradication with experts from the western U.S. Surveys indicated that only about 80 acres were infested, but the plant was growing in riparian habitat. A cooperative strategy for eradication was developed in partnership with State and federal agencies and adjacent private landowners. Within five months of identifying the problem, a long-term eradication plan was developed, funded, and put into action combining resources from the Arboretum, with state and federal funds to immediately contain and eventually eradicate Galega.
Conclusions: Any program designed to respond quickly needs more than an organization to coordinate response. It needs the committed collective eyes of thousands of people to identify new invaders and a convenient mechanism to alert those who need to know.

- **Saint Croix National Scenic Riverway and Zebra Mussel Prevention**

The Saint Croix National Scenic Riverway has a multi-faceted approach to prevention of zebra mussel that includes education, monitoring, management methods, and teamwork. Two hundred fifty river miles are protected - virtually the entire river. (Two states - Minnesota and Wisconsin - handle the lowermost 20 miles of the river.) The program began in 1992; initially, a line item provided $100,000 to $150,000 per year; this has since been institutionalized and is now in the park's base funding. Both states have enacted laws to protect the St. Croix River.

1. Education: brochures, media blitzes (television), presentations for user groups.

2 Monitoring: Contract divers check 36 sites on a monthly basis throughout the summer. Passive samplers were installed in 1993.

3. Management methods: for one season, checked boats and washed them down with hot water; now several marinas do this for a fee. Also have a check point on the river where boats are turned back if the operator cannot provide proof that the boat had been decontaminated or not been in zebra mussel infested water. This permit system has been well received.

4. Teamwork: The USF&WS, both state Departments of Natural Resources, and the NPS meet at least twice a year to review the program. Key players meet monthly.

5. Results: Thus far in CY 2000, only 24 zebra mussels have been detected, which are so few that the establishment of an infestation would be unlikely. The numbers detected have grown slightly over the years, but the program is considered a success, as it is located in an area that is at high risk for zebra mussel infestation.

- **Invasive Species Quarantine/Preventative Programs**

Every year, USDA APHIS makes approximately 50,000 interceptions of invasive species at United States ports of entry. Quarantine/Preventative action is taken whenever these species are intercepted. Many species are intercepted repeatedly; APHIS' list of intercepted invasive species (plant pests) includes approximately 7,500 taxa (some higher taxa are listed). Well over 99% of intercepted species have never been detected beyond the interception/action point and have therefore been prevented from becoming established in the United States. Although a few of these species have been introduced (entry and establishment) most significant, invasive species that are introduced become the target of management or eradication programs (e.g., Asian longhorned beetle, *Anoplophora galbripennis* (Motchulsky)).

The following are six specific examples of prevention and eradication efforts for various types of IS:

1. ***Caulerpa taxifolia***. In April, 1999, APHIS published a final rule adding the green alga *Caulerpa taxifolia* (Mediterranean clone) to the list of aquatic noxious weeds. This noxious weed is believed to be a genetic clone of a single plant, introduced into the Mediterranean by an aquarium release or escape. Since its discovery in 1984, *Caulerpa taxifolia* (Mediterranean clone) has been spreading rapidly throughout the Mediterranean Sea. Bright green mats of the plant dominate large expanses of sea floor that were previously rich in flora and fauna. If introduced into the United States, *C. taxifolia* (Mediterranean clone) could colonize large expanses of American coastal waters and cause negative impacts on natural ecosystems, given its significant negative effects on the regions in the Mediterranean where it is already established. Since listing, APHIS-PPQ

inspectors have intercepted undeclared *Caulerpa* plants (e.g., shipment from Sri Lanka) and prevented introduction of this invasive species.

2. Asian Longhorned Beetle (ALB), *Anoplophora galbripennis*.
Asian longhorned beetle (ALB) poses a serious threat to the United States (U.S.) forest resources. The first ALB infestations in the U.S. were discovered in Brooklyn and Long Island, NY in 1996. Another infestation was discovered in February 1999 in Queens. In the summer of 1998 three separate ALB infestations were found in the greater Chicago metropolitan area. Recently, infested trees have been found in Manhattan, New York.

Regulatory work by APHIS, State Departments of Agriculture of Illinois and New York, and local governments is focused on prevented spread, and further introductions. Spread has been prevented through establishment of a quarantine that restricts movement of host material out of the quarantine area. Further introductions have been prevented primarily through establishment of a new law (Interim Rule) published in the Federal Register. Within weeks of first detecting ALB in NY, APHIS completed a plant pest risk analysis and developed an initial plan to prevent further introductions. The analysis showed that the majority of interceptions of ALB and related beetles were on shipments with solid wood packing material from a single country, China. The beetle larvae were being transported within untreated, raw wood used to make pallets and other packing materials. APHIS established an Interim Rule restricting shipments from China with solid wood packing materials. And although additional interceptions have occurred, there is no evidence of further establishments since the Interim Rule was put into place.

Cooperative programs involving AHPIS, USDA Forest Service, States, and local governments to detect and remove infested trees in IL and NY are continuing. Several thousand infested trees have been removed. Programs to replant and re-green areas where infested trees have had to be removed are also underway. Public information programs have been implemented to assist in locating and identifying new infestations of ALB including printed materials, posters, and a website (http://willow.ncfes.umn.edu/asianbeetle/beetle.htm and http://www.aphis.usda.gov/oa/alb/alb.html). Training programs have targeted tree care workers with the hope that they can be on the lookout for new infestations.

3. **Pink Hibiscus Mealybug (PHMB), *Maconellicoccus hirsutus*.** APHIS recognized the risk presented by this invasive species at least a decade ago after it had spread to various locations in the Caribbean. At that time, PHMB had not yet found its way to the United States but it was considered only a matter of time until this invasive species spread to the United States through natural means such as hurricanes, or through trade or smuggling of agricultural items. Over the last decade, APHIS has been active in several countries where PHMB occurs conducting research on containment and control, especially biological control agents. In 1997 APHIS published New Pest Response Guidelines: Pink Hibiscus Mealybug, *Maconellicoccus hirsutus*. This document included biological and risk information, and information to form the basis of management programs. When this species recently found its way to a restricted area in California, APHIS was prepared; spread and impact have been minimized.

4. **Asian Gypsy Moth (AGM), *Lymantria dispar***. Asian Gypsy moth is a strain of *L. dispar* native to Russia. The Asian strain differs from the European strain (the strain currently established in the eastern United States) in several significant ways. Most notably, AGM has a much wider host range including conifers, and while females of the European strain are incapable of flight, females of the Asian strain can fly. The ability to fly significantly increases the likelihood and speed of spread because egg masses can be deposited over a greater range. After AGM was introduced to the northwestern United States in the early 1990s, APHIS conducted a variety of risk analyses, identified the primary pathways of introduction, and created new work plans to deal with this new threat. Although there is currently an infestation in Washington State, eradication is expected soon, the original infestations have been eradicated and introductions have decreased.

5. **Golden Nematode, *Globodera rostochiensis***. Golden Nematode is an important pest of potatoes that was introduced into NY sometime during the 1940s. During the early 1950s, USDA (APHIS per se did not exist at that time) established a quarantine to prevent movement of host material and potentially contaminated conveyances out of the two quarantine areas in NY. Over the last 40 years, Golden Nematode has not spread to locations outside the quarantine area. Perhaps the best indicator of success is that major potato growing areas outside NY have been spared the ravages of this invasive species and other countries, very concerned about introductions of Golden Nematode, continue to accept U.S. potatoes grown outside the quarantine area.

6. **European Spruce Bark Beetle, *Ips typographus* and associated plant pathogenic fungi.** The introduction of a bark beetle known as the pine shoot beetle, *Tomicus piniperda*, to the Great Lakes region in 1992 prompted a pathway analysis by APHIS-PPQ in 1992-1993. The purpose of the analysis was to identify other exotic bark beetles likely to successfully enter and establish in the US using the same or similar pathways and to target these species for exotic pest survey. The analysis identified six bark beetles for survey. The most serious pest and primary survey target in this group was *Ips typographus*, the European spruce bark beetle (ESBB). In its native range of Europe and Asia, it is one of the most serious pests of spruce. It carries several fungi pathogenic to conifers. The most serious of these is a blue stain fungus, *Ophiostoma polonica*, which is capable of killing healthy trees. After identifying the target pests, PPQ planned to develop a region-wide survey to be implemented in spring of 1994. PPQ implemented a pilot survey for the targeted bark beetles to test survey protocol at limited sites across the region in spring of 1993. In the 1st week of the 1993 pilot survey, 11 ESBB were trapped in Erie, PA. In 1994 during the first year of the formal survey, ESBB was trapped in Camden, NJ, near Philadelphia. In both cases, suspect sources of the pests, abandoned dunnage piles in the port environs, were located and destroyed. Follow up surveys indicated that ESBB was locally eradicated in both areas. The regional survey committee received a Group Award for Excellence from USDA for developing the successful bark beetle survey.

- **Hawaii IS Prevention Programs**

Although the invasive species problem is especially severe in Hawaii, Hawaii may lead the nation in cooperative action to begin to address the problem in a comprehensive fashion. The incentive has come from agency and public perception of immediate threats to Hawaii's biodiversity, economy, agriculture, health, and quality-of-life – involving species such as the Brown Treesnake, the Red Imported Fire Ant, Biting Sandflies, Lethal Yellowing Disease of Palms, etc.

CGAPS

Since 1995, a statewide coalition of government agencies and private interests, the Coordinating Group on Alien Pest Species (CGAPS), has been working together to identify and create the programs, legislation, funding, and public buy-in required to effectively reduce and mitigate the alien-species problem in the state. A successful early project involved a major public relations effort to inform the media and the public about the seriousness of Hawaii's alien pest crisis. CGAPS is currently in the process of producing a comprehensive review of capacity needs for invasive species prevention/ management.

Island Invasive Species Committees (MISC & BIISC)

Island-specific invasive species committees have formed in the past few years on the islands of Maui (Maui Invasive Species Committee (MISC)) and Hawaii (Big Island Invasive Species Committee (BIISC)), providing leadership and capacity for control efforts centered on early detection, rapid eradication/containment, and public education geared toward changing relevant policy and personal habits. These committees are now closely coordinated with CGAPS, but their roots are in grassroots action starting in 1991 to address the invasion of the plant *Miconia calvescens*. Miconia was relatively well documented as one of most destructive invasive plant invaders in the world as a result of its history in Tahiti. (Unfortunately, the species had been introduced to Hawaii in the 1960s and was starting to get a firm foothold before public and agency awareness was raised.) In 1999-2000, these committees raised over $1 million in federal, state, county and private $$ to address *Miconia* and other pests. *Miconia* not only provides the poster child for these island committees, but still represents the #1 problem which they must address.

- **International Programs to reduce IS in source areas**

USDA APHIS and USDA Forest Service are cooperating with other countries to monitor and reduce outbreaks of alien pests that are potential IS of U.S. forests and trees:

- Russian Lymantriid Monitoring Program
  The Asian gypsy moth, *Lymantria dispar,* has traveled to ports in the U.S. and Canada aboard ships from the Russian Far East. In 1993 a cooperative program was initiated by Russia (Federal Forest Service of Russia and State Plant Quarantine Inspection Service of Russian Federation and the United States (USDA Forest Service and APHIS) to develop an early warning system to alert ports in the U.S. and other cooperating countries of increasing forest pest populations in Russia's Far East

and to reduce the risk of their introduction. The Lymantriid monitoring program was developed to determine population levels and flight periodicity of three Lymantriid species (Asian gypsy moth, *Lymantria dispar*; Nun moth, *L. monacha*; and the Rosy gypsy moth, *L. mathura* in Russian Far East ports. A variety of monitoring techniques have been used to track populations of these pests. The information has been used to develop a database to determine infestation levels and regulatory risk associated with ships and cargo transiting these ports. APHIS officials have also worked with their Russian counterparts to improve the ship and container inspection process.

- **Integrated Pest Management Program for *Sirex nocillio***
  Sirex noctillio is a forest pest that currently infests 200,000 hectares of pine plantations in southern Brazil resulting in millions of dead trees. This insect also causes serious damage to pines in Australia and New Zealand. The USDA Forest Service report "Pest Risk Assessment of the Import of *Pinus radiata* and Douglas-fir Logs from New Zealand" predicted that should Sirex be introduced into the U.S. forest damage could exceed 100 million dollars. Biological control has been successful in Australia and New Zealand. For biological control to be successful in Brazil, the location and severity of the outbreak must be determined. During 1997, the Forest Service entered into a Participating Agreement with government agencies in Brazil to assist in controlling Sirex. The goal of the project is to enhance remote sensing and aerial detection of Sirex activity which can be shared with foresters and pest management specialists in all South American countries experiencing Sirex activity. This will facilitate implementation of an integrated pest management program to reduce outbreaks of Sirex.

- **Reducing Spread and Impacts of Established IS of Forest Pests**

USDA Forest Service (FS) (http://www.fs.fed.us/foresthealth) is responsible for protecting the health of America's forests and grasslands by reducing the adverse effects of forest insects and diseases, including non-native invasive species, such as the gypsy moth and Port-Orford-cedar root disease fungus:

- **Slow-The-Spread of Gypsy Moth**
  Since its introduction into the United States in 1869, the gypsy moth has spread to all or part of 17 States and the District of Columbia. The area already infested by the gypsy moth represents only 25% of the total area that will be susceptible to outbreaks as the insect spreads. Gypsy moth defoliates trees, which makes them vulnerable to other killing agents; affects water quality; alters wildlife habitat; and hurts timber, tourism, and recreation. Damage from the gypsy moth often occurs in forested neighborhoods and urban parks where dead trees are a safety hazard and are expensive to remove. Gypsy moth affects commerce because commodities shipped to uninfested areas must be certified free of gypsy moth.

Gypsy moth is spreading at a faster rate than in the past and could infest much of the South and Midwest during the next 30 years. Slowing the spread would delay the damage and management costs associated with infestation of new areas. A recent pilot project demonstrated that the rate of gypsy moth spread could be slowed by at least 60% through application of the latest survey and management practices.

Beginning in 1999, the USDA Forest Service, State partners and other USDA agencies implemented the Slow the Spread project (http://www.ento.vt.edu/STS/), with the goal of implementing a novel integrated pest management approach to reduce the spread of the gypsy moth across the 1,200 mile gypsy moth frontier from Wisconsin to North Carolina. Implementation of Slow the Spread is expected to…

-Decrease the new territory invaded by the gypsy moth each year from 15,600 square miles to 6,000 square miles.
-Protect forests, forest-based industries, urban and rural parks, and private property.
-Avoid at least $22 million per year in damage and management costs.

- **Reducing the Spread of Port-Orford-cedar Root Disease**
  Port-Orford-cedar (POC) root disease (caused by the fungus *Phytophthora lateralis*) has killed thousands of POC in Washington, Oregon and California. The origin of the fungus is not known, but the high level of susceptibility of POC and the resistance of Asiatic cedars indicate that the fungus probably originated in Asia. The disease was first reported on ornamental POC in Seattle in 1923 and subsequently spread to Oregon by 1942 and was found in the native range of POC by 1956. The fungus spreads via waterborne spores and through movement of infested soil. The USDA Forest Service, USDI Bureau of Land Management, Oregon Department of Forestry, and Oregon State University have cooperated in developing and implementing coordinated strategies to reduce the spread of the disease via road management and sanitation. Efforts are also underway to develop POC resistant to the disease.

- **Washdowns of Military Equipment**

The Department of Defense utilizes operational washdowns to ensure that foreign agricultural and public health threats do not enter the United States on military equipment re-deploying back to the Continental United States. Washdowns have been used for equipment returning from overseas since the Vietnam War. More recently, washdowns of equipment occurred in the aftermath of Desert Storm at ports in Saudi Arabia, Israel, and Spain. Operational washdowns apply to all military land vehicles and the aircraft and ships that transport contaminated equipment. Trapped soil and grass on the undersides of vehicles allows seeds from weed species, nematodes, insect eggs, plant and animal pathogens, fungal and bacterial pathogens to be transported into the continental United States. One example of how successful operational washdowns have been occurred when equipment was being re-deployed to the United States following the Gulf War. Following the Gulf War over 49,000 (Marine and Army) vehicles went through operational washdowns. Another example involves the operational washdown of equipment re-deploying from Italy, Spain, and Turkey,

regions known for Mediterranean land snails. Operational washdowns help to ensure that this undesirable species does not entire into the United States on military equipment. Once equipment has been cleaned it is placed in a dry, sheltered location, sometimes with salt barriers around the equipment, to ensure that cleaned equipment is not re-exposed to land snails. All of the efforts of the Department of Defense are designed to help ensure that the military does not introduce an exotic species into the Continental United States. To date, operational washdowns have helped ensured that no permanent introduction of an exotic pest species has been introduced into the Continental United States.

- **Continued vigilance is needed with IAS, even those where control or containment is achieved!**

Illustration: the alfalfa snout beetle!

A cutback in funds has allowed the alfalfa snout beetle to spread in northern NY. Larvae of this pest are large grubs that feed on alfalfa roots. Their attacks can destroy the economic value of a field in one year. A European pest, this insect probably came to upstate NY on packing straw from Germany unloaded at the port of Oswego, NY, on Lake Ontario, probably around the turn of the century.

The snout beetle was identified as well established about 1930, on alfalfa growing on farms near Oswego. Cornell scientists cooperated with the NYS Department of Agriculture and local farmers. Hay and straw from the area were quarantined to prevent spread, and control practices were initiated. State funds were developed to support quarantine activities and controls. Since the area was small, the annual state investment was small. These steps worked reasonably well for over 40 years.

But containment began to break down after 1980, when state support was eliminated, ending quarantine and control efforts. During the past decade the snout beetle spread has accelerated through the 10 counties in northern New York, and serious losses are occurring. Hay and straw from this area move into the rest of NY and into New England. Beetles also cling to machinery, even campers. Its spread into other alfalfa growing areas of the US is just a question of time.

So a minor, contained annoyance has grown into a large, uncontrolled disaster. This invasive species is still largely unknown and ignored outside of NY. However it presents a serious threat to alfalfa production throughout the US. Cutting the small annual cost of containment has proven to have been a disaster, the size of which will become apparent in future decades.