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PLANTS FOR PLANTING INTERNATIONAL UPDATE

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Update of the international standard proposal for Plants for Planting.

This presentation introduces the current status of the International Plant Protection Convention (IPPC) standard for the international movement and trade for commodities known as Plants for Planting.

The IPPC expert working group has presented a proposal for an international standard intended to provide guidance to produce and export plants for planting with minimal plant pest introduction to importing countries. The standard will allow National Plant Protection Organizations (NPPO) to utilize phytosanitary requirements for a variety of processes to establish a "systems approach" that are integrated production measures to promote preventive pest risk management within defined parameters. A system approach requires the integration of different measures, at least two, which act independently and with a cumulative result. (ISPM14) The systems approach processes provide alternative or supplement options to single measures, particularly the port of entry import inspection. The production system approach can provide phytosanitary protection in situations where no single measure is either available or has been sufficient for phytosanitary protection to the importing country.

The standard will provide a foundation framework that will allow for the development of a process that is mutually accepted between countries with the purpose to minimize the export of regulated pests on plants for planting to an acceptable level by involving both import and export NPPOs, the plant producers and other entities at critical control points throughout the production and distribution process.

The proposed IPPC standard will be a guidance tool for plant producers to mitigate plant health risks in the country of origin and utilize uniform system approaches for plants for planting. The overall goal of this standard is to minimize the export of organisms on plants for planting. Often these plant associated organisms may not be viewed as plant pests in the country of origin, they may be organisms that are unknown to science or contaminating pests that are difficult to detect based on current import inspections. The net affect, substantially reduce the pest risk export of plants for planting with the least possible impact on trade within an international standard.

## **Exploring Patterns of Pest Interceptions on WPM**

### **Using USDA's Pest ID Database**

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“We cannot inspect our way out of the problem” is a current perception based on the recognition that over the past 8 years total imports (minus crude oil) increased 6.5 times faster than addition of inspectors at the 326 US Ports-of-Entry. Analysis of patterns in USDA's Pest Inspection Database (PestID) now provides APHIS and CBP managers with enhanced container surveillance and inspection algorithms.

Innovations include real-time email alerts, access to GIS maps and historical time-series of pest origin, points of interception, and final destination, automatic pest targeting, feedback on regulatory effectiveness, and improved detection surveys of escaped pests. APHIS is developing ways to predict the risk of outbreak for selected, especially high-threat species such as Medfly (worldwide), vineyard snail (Australia), and glassy-winged sharpshooter (California), among others. A global monitoring system is visualized that will track climate signals at four to five “epicenters” of frequent pests arriving on commodities from offshore.

In this “on-hands” workshop, we illustrate underlying concepts and demonstrate different toolkits under development that bring to decision makers at APHIS and CBP the kinds of information they most need in easily understandable, “finger-tip accessible” formats. We demonstrate how ISPM No. 15 has affected interception of the 8 target families at US ports-of-entry, and escapes beyond the ports. Since 2003, have WPM pests decreased as intended, or have they increased? Which groups have been the most responsive to the new regulation? What are the likely future trends? Where are the majority of the pests coming from, going to? What commodities are they associated with, and how do they change with the seasons?

## OCCURRENCE OF THE EMERALD ASH BORER, *AGRILUS PLANIPENNIS* IN RUSSIA AND ITS POTENTIAL IMPACT ON EUROPEAN FORESTRY

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The emerald ash borer (EAB), *Agrilus planipennis*, is a beetle native to East Asia where it causes little concern, attacking preferably weakened or dying ash trees. It was first discovered in North America in 2002 and, since then, it has become one of the most serious insect invaders, killing millions of healthy ash trees in urban and forested settings. Similar damage is now observed in the region of Moscow, Russia, which causes serious concern for Europe. We provide new information on EAB occurrence and biology in the region of Moscow and eastern Russia. In view of the new occurrence of this pest in European Russia, the following recommendations for research and management strategies in Europe can be made.

(1) The susceptibility of the European ash species, *Fraxinus excelsior*, *F. angustifolia* and *F. ornus* to EAB should be urgently assessed, since other measures in Europe will largely depend on the potential impact that the beetle may have on native trees. (2) A climate envelope should be calculated for EAB based on current pest distribution, and projected to Europe. (3) More surveys should be carried out in the region of Moscow and elsewhere in Russia to assess the present distribution of the beetle in the country, since recent tree mortality may have been unnoticed. Surveys should focus at least partly on *F. pennsylvanica* because it is widely planted in Russian cities and it has been shown to be particularly sensible to EAB attacks. The development of trapping systems for EAB in North America should be carefully followed and traps should be used as soon as possible to support the monitoring programmes. (4) Should the native European ash species appear to be susceptible to EAB, Europe should be proactive and develop research programmes aiming at better understanding the ecology of the beetle and developing detection and management methods, if possible in collaboration with North America and Asia.

# **FORAGPROTECT: AN INVASIVE EXOTIC SPECIES ASSESSMENT AND MANAGEMENT SYSTEM FOR FORESTS AND AGRICULTURAL LANDSCAPES**

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The primary goal of ForAgProtect is to produce an assessment and management tool for invasive exotic pest species that can be used by professionals in their forest and agricultural crop protection efforts. This tool uses GIS to integrate a broad range of geographic information with the important biological factors of individual exotic species. The main objective is to create an applied system complex enough to: assess risk of introduction, focus detection efforts, provide for rapid response and to help prioritize management actions and eventual restoration efforts.

Spatially-explicit data layers are being developed relative to potential pathways of introduction (ex: the location of nurseries, second homes, transportation routes, campgrounds, sawmills, scenic areas, etc.). Their physical (GPS) locations are being mapped and a data base is being created with specific contact information. To assess the potential for pest establishment and spread, specific host availability data layers (from aerial photos, FIA data, etc.) are being developed and will be integrated with layers reflecting the biological needs of the exotic pest (microclimate, elevation, aspect, soils, etc.). The assembly of these types of spatial data layers will be applicable to more than one pest and therefore will represent an institutional knowledge base that could be readily adapted to address the threat posed by a variety of different exotic pest species.

## **EARLY WARNING SYSTEM AGAINST INVASIVE ALIEN FUNGAL SPECIES ENTERING CANADA**

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The ISPM 15 international phytosanitary measure was developed to control pests on woody packaging material. Unfortunately it does not target live plant material of any kind shipped between trading countries. Many forest invasive alien fungal species responsible for diseases such as chestnut blight, Scleroderris canker, white pine blister rust, butternut canker and sudden oak death came to North America on live plant material. Many more will certainly arrive in the future.

In order to target this pathway of introduction that is not subjected to the ISPM 15 measure, we developed a new early warning system based on cloned fungal ribosomal DNA extracted from live plant material (leaves, stems, twigs and seeds). Annually, 400 randomly selected samples from major Canadian ports of entry will have their DNA extracted, PCR amplified for the ribosomal ITS region, then cloned and sequenced. Homologies with reference sequences from GenBank will provide information about the potential of foreign fungi found inside the live plant material to be invasive forest pests. The data will provide a 'radar image' of new fungal threats presently coming from abroad.

## FIREWOOD: ROLES, RESPONSIBILITIES, AND RISKS

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The USDA Emerald Ash Borer Program, in cooperation with state partners and other stakeholders, is diligently working to control and manage this non-native pest through survey, regulatory, and educational efforts. Through these efforts firewood has been identified as a pathway for the passive dispersal of emerald ash borer (*Agrilus planipennis*) Fairmaire. While focused on emerald ash borer control and management, the program has encountered other pest species that may also hitchhike on firewood.

Regulating firewood transport, sales, and use is a significant challenge for the program. Enterprises offering firewood for sale range from very small “Mom and Pop” operations to the large “big box” stores. The larger enterprises requiring regulation and education are readily identifiable. Even smaller regional businesses distributing firewood for sale are relatively easy to identify. The smallest firewood dealers, those of the home business type, are very difficult to identify since their business longevity may be fleeting or only identified by a small local newspaper ad or front yard sign.

Another firewood challenge is that of the vacationer. People have a long history of burning wood and this tradition continues as campers, vacation home owners/renters, hunters, etc. travel to their destination with firewood. Most unknowingly transport infested firewood to their journey’s endpoint and create a new point of infestation.

It is known through other pest studies that pests hitchhike on material transported great distances infesting new areas. With the expansion of global trade new arrivals of pests will require us to establish a new paradigm in our views of firewood.

## ʻOHĪʻA – BACKBONE OF HAWAII'S TERRESTRIAL ECOSYSTEMS AND CULTURE

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Hawai'i's dominant native forest tree, ʻohiʻa, (*Metrosideros polymorpha*), provides the backbone of Hawaii's terrestrial ecosystems and the fabric that harbors the rich remains of the archipelago's native fauna and flora. In addition to supporting a preponderance of Hawai'i's unique natural heritage, the ʻohiʻa tree itself has great cultural significance to Native Hawaiians. Forests dominated by ʻohiʻa are home to at least 22 extant species of native forest birds, the Hawaiian hoary bat, and many of Hawai'i's remaining native plants and invertebrates. Endemic Hawaiian honeycreepers, including 16 on the endangered species list, are dependant on these forests for critical habitat, as they have adapted to feed and nest in ʻohiʻa trees. Due to Hawai'i's isolation, organisms evolving here are often naïve to predators and diseases, and vulnerable to competition from invasive species that have escaped from the natural enemies of their home ranges and into Hawai'i's favorable climate. A recent report listed 13 insect species, 25 fungal or bacterial diseases, as well as a genus of nematodes that are potential pests of *Metrosideros* and other members of the Myrtle family (Myrtaceae). The fungal pathogen, *Puccinia psidii*, known as "ʻohiʻa rust" in Hawai'i, established and spread throughout the main Hawaiian Islands within months in 2005. Damage to ʻohiʻa has been minor so far, but should another strain of *P. psidii* or another pest cause total defoliation, as *P. psidii* has done to other Myrtaceae in Hawai'i, the ecological consequences could be catastrophic. Repeated destruction of the new growth of ʻohiʻa trees would result in low reproduction, dieback of the crown, and eventual death of the tree, and overstory changes could alter the composition, structure, and function of the forest. The Hawai'i Department of Agriculture has restricted the importation of plants in the Myrtle family from areas infested by this rust to prevent other, potentially more harmful strains of the rust from being introduced. This may also minimize importation of other pests of Myrtaceae, but only from those restricted areas. Given accelerated trade, a pathways approach to regulating the importation of plants in this family from the mainland and foreign countries is essential to maintaining Hawaii's unique and fragile ecosystems. For more information see:

[www.hear.org/species/puccinia\\_psidii/pdfs/ofr\\_2008\\_1008\\_loope\\_ohia\\_rust\\_assessment.pdf](http://www.hear.org/species/puccinia_psidii/pdfs/ofr_2008_1008_loope_ohia_rust_assessment.pdf)

## ARCHAEOPHYTOPATHOLOGY IN WESTERN SWITZERLAND: GENETIC CHARACTERIZATION OF *PHYTOPHTHORA* COLLECTIONS

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The genus *Phytophthora* accounts for numerous notorious plant pathogens. This work aimed at the molecular identification of isolates from two collections of *Phytophthora* spp. (Agroscope Changins-Wädenswil ACW and Swiss Federal Research Institute Forest Snow and Landscape WSL) established during surveys carried out between 1976 and 2006 in Switzerland. Species were identified by direct sequencing of the internal transcribed spacer (ITS) rDNA and for some of them by sequencing of nuclear genes such as 18S, 28S,  $\beta$ -tub, Ef1- $\alpha$  and mitochondrial genes such as cox I, NADH 1 and cox II. Species mostly associated with diseased plants included *P. cactorum*, *P. cryptogea*, *P. citricola*, *P. megasperma*, *P. gonapodyides*, *P. cambivora*. Interestingly molecular identification pointed at the not yet recorded presence of *Phytophthora* taxon "Raspberry", *Phytophthora* taxon "Pgchlamydo", *Phytophthora* taxon "Salixsoil" and the recently described species, *P. hedraiandra* and *P. inundata*, on the Swiss territory. Several additional isolates belonged to the genus *Pythium* and did not match known species. Numerous first reports and/or new host pathogen combinations are reported for the first time from several hosts. Results indicated that several *Phytophthora* species were more widespread in natural and managed ecosystems than previously thought. This consequently justifies the effort for conservation of phytopathological samples as a historical record of *Phytophthora* outbreaks.

## **CURBING INTRODUCTIONS OF FOREST INSECTS AND DISEASES ON PLANTS FOR PLANTING**

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At least 18 devastating forest insects and diseases have been introduced to the United States since the early 1800s via the pathway of trade in living plants. Five of these introductions have been detected since 2000 – indicating rising rates of introduction.

Rates of introduction are rising due to increases in the number of plants in international trade and the geographic range of suppliers, coupled with more rapid transport which allows more pests to survive transit. At the same time, phytosanitary safeguards have been relaxed. Individual nations, regional bodies such the North American Plant Protection Organization, and the International Plant Protection Convention are studying new approaches to curtailing introductions via the plants for planting pathway.

To be effective, the proposed new approaches must overcome several problems, particularly the inability of pest risk analysis to identify and evaluate pests that are unknown to science. (At least six of the most damaging forest pathogens that entered the United States on imported plants were unknown to science when they were introduced.) In recognition of this dilemma, this Work Group of the International Union of Forest Research Organizations has called for adoption of an international standard (modeled after the international standard on wood packaging) that would allow clean stock programs to apply to the full range of pests, not just quarantine pests.

This proposal has great promise – but it is unlikely to be adopted and put into practice for several years. Protecting forests from invasions requires stringent measures to rein in movement of forest pests via this pathway *now*.

The Nature Conservancy has worked with stakeholders representing environmental, forestry, nursery, government and academic groups, to develop a set of consensus recommendations for curtailing such introductions in both the short and long term. We seek operation of a comprehensive program relying on a systems approach by 2015. In the short term, we advocate temporary measures focused on high-risk groups as determined by evaluating such factors as type (seed or tissue culture v. whole plants), geographic origin, or absence of either pest risk analysis or import history demonstrating a low risk. These high-risk plants would be subject to enhanced risk reduction efforts, which might include temporary prohibitions on importation; enhanced inspection at entry; enhanced post-entry quarantine; or mandatory disinfestation treatment.

## GENETIC CHARACTERIZATION OF OOMYCOTA ISOLATES RECOVERED FROM DECLINING FOREST IN POLAND

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Oomycetes account for numerous highly destructive plant pathogens with the genera *Pythium*, *Phytophthora* and *Peronospora*. Despite the ecological and agronomic importance of this group few studies have been dedicated to monitor their occurrence and diversity in natural ecosystems. This work aims to investigate oomycete diversity in declining *Alnus* and *Quercus* forests in Poland. Species were identified by direct sequencing of internal transcribed spacer (ITS) rDNA. Only a few oomycete species dominate highly diverse mycofloras associated with the studied ecosystems. *P. taxon salixsoil* as well as other *P. gonapodyides*-*P. megasperma* ITS clade 6 spp. have been mainly isolated. Numerous pathogenic spp. such as *P. alni*, *P. cambivora* and *P. quercina* have been isolated. *P. inflata* and *P. hedraiaandra* have been isolated for the first time from natural ecosystems in Europe and worldwide. *P. polonica*, previously reported as a new species, has been found in many occasions from these areas. The genera *Pythium* and *Saprolegnia* proved complex and numerous members are yet undescribed. However recently described *Pythium* species such as *P. sterilum* and *P. spiculum* were also found in these declining forest stands. This survey included riparian ecosystems where *P. taxon salixsoil* proved the only *Phytophthora* present in water with *Pythium* and *Saprolegnia* spp. Results indicated that several *Phytophthora* species were more widespread in natural ecosystems than previously thought, and that numerous species of *Pythium* and *Saprolegnia* have yet to be described.

## USDA Biological Control Research Programs and Overseas Opportunities

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Emergency control measures for invasive species often rely on use of pesticides and other destructive practices. Public concern about pesticide contamination of the ground water and the environment has led to increased restrictions on the use of pesticides for control of many destructive invasive species. Biological control often provides a cost effective, environmentally friendly and sustainable solution. Both the United States Department of Agriculture's Agricultural Research Service (ARS) and Forest Service (FS) have very active biological control programs to identify and expand the number of available biological control agents for key pests and weeds.

The ARS biological control program addresses agricultural and other pests of regional and national importance including *Aphis glycines* (soybean aphid), *Anoplophora glabripennis* (Asian longhorned beetle), *Euphorbia esula-virgata* (leafy spurge), *Cirsium arvense* (Canada thistle) and *Centaurea solstitialis* (yellow starthistle). ARS has several Overseas Biological Control Research Laboratories (OBCLs), with cooperators located in many countries around the world. Scientists at these laboratories search for biological control agents in the host's native range, study the basic biology and ecology of candidate agents, evaluate host specificity and ship the most promising agents to the U.S. ARS and collaborating scientists in the United States further evaluate these agents prior to their release. The OBCLs also facilitate international cooperation and collaboration on mutually beneficial high priority biological control research. Research at the OBCLs and at ARS laboratories in the United States led to the release of the *Melaleuca* weevil (*Oxyops vitiosa*) which caused massive reductions in *Melaleuca quinquenervia* in Florida. Natural enemies also were successfully released for gypsy moth, *Tamarix ramosissima* (tamarisk), *Arundo* (giant reed), *Lygodium microphyllum* (old world climbing fern) and numerous other pests.

The Forest Service invasive species biological control research focuses on priority pest species in forest and rangelands such as *Agilus planipennis* (emerald ash borer), *Adelges tsugae* (hemlock woolly adelgid), *Chondrilla juncea* (rush skeletonweed), *Centaurea masculosa* (spotted knapweed) and *Bromus tectorum* (cheatgrass). The program includes overseas evaluation and exploration as well as further development of mass rearing protocols prior to the natural enemy's release. The success of the biological control program is based on the scientists' close partnership with international, federal, state, university, tribal, state, local and nongovernmental organizations. Partnerships with Chinese scientists, APHIS, and state organizations have led to the field release of three parasites of the emerald ash borer and several hemlock woolly adelgid predators. Partnerships between Forest Service scientists and the OBCLs have led to the release of the release of many biological controls of invasive plants in the west.

## ASSESSING THE HAZARD OF *PHYTOPHTHORA ALNI* IN THE UNITED STATES

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*Phytophthora alni* subspecies *alni* (PAA), currently present throughout Europe, is a hybridized soil- and waterborne pathogen, which causes root and collar rot of species of the genus *Alnus* (alder). Once introduced, the pathogen quickly spreads naturally with streams, floods, and other drainage water. PAA can also be passively transported with the bare-root nursery stock, as it is able to adhere to fine roots of visually symptomless infected plants of alder and other tree species exposed to the pathogen.

Susceptibility Hazard products were developed for the Conterminous United States (CUS) in 1 square kilometer (km<sup>2</sup>) units by the U.S. Forest Service, Forest Health Technology Enterprise Team's (FHTET) Invasive Species Steering Committee. The product's intended use is to develop a detection strategy for PAA. Supporting information was taken from Exotic Forest Pest website URL: <http://spfnic.fs.fed.us/exfor/> and guidance from Dr. Thomas Jung (Phytophthora Research and Consultancy, Bavaria). The Susceptibility Potential Surface was produced by combining the Introduction and Establishment Potential Surfaces in a final equal-weighted overlay. It is estimated that 119,313,300 hectares of forest are susceptible to attack from PAA in the Conterminous US (CUS). An important assumption in modeling the PAA hazard in the US is that it is likely that the hazard will come from nurseries receiving infested plants and the delivery of infested plants to the general population, not from direct planting of alder in natural forests as is what commonly occurs in Europe.

The Introduction Potential Surface was developed using three primary variables in the analysis: 1) wholesale nurseries, 2) production nurseries, and 3) metropolitan areas. Each of the variables was used to depict potential locations where PAA could be released into the CUS. The Establishment Potential Surface was also developed using three variables for analysis: 1) alder host, 2) flood-prone areas, and 3) slopes less than 11 percent. These data were combined to depict the potential of PAA becoming established.

## **INCREASING GLOBAL TRADE AND CLIMATE CHANGE: CO-FACTORS INCREASING THE INTERNATIONAL MOVEMENT AND ESTABLISHMENT OF FOREST PESTS**

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Global trade, both in variety and quantities of goods moved, is increasing year by year. For example, WTO statistics indicate that between 2000 and 2005, global sea and air freight rose by around 20% with volumes now exceeding 7 billion tons per year. Trends in eco-climatic variables under different climate change scenarios also show marked differences in key drivers such as temperature, rainfall, soil moisture, etc. This juxtaposition of dramatically increased trade-driven international pest movement and more gradual shifts in climatic suitability in previously unsuitable regions of the world is providing new opportunities for plant pests to enter and establish in new locations.

Within the dramatically increased trade statistics, it is possible to determine which commodities are the high risk pathways for international movement of pests of phytosanitary concern. While wood, wood products and wood packaging have been recognised as key pathways and are subject to stringent phytosanitary controls, it is now becoming increasingly apparent that it is the 'plants for planting' pathway that poses the greatest current and future risk. Trade in live plants, often complete with root balls and associated soil, is increasing rapidly and globally. Full circumnavigation of the globe is now normality for live plants and, while there are phytosanitary rules in place, they tend only to reflect known pests. Those pests not on the lists of recognised organisms will consequently tend to be missed.

Transport along a pathway does not, of course, always result in successful establishment of pests in new locations. Previously, many organisms could not establish because of climatic unsuitability, reflecting the ecological and climatic barriers that determine distributions of pests in their natural ranges. The fact that distributions of pests in their native ranges is now changing and has been linked to climate change, indicates that climatic suitability for pests moving along trade pathways is also changing. Prediction of which pest will become damaging in new locations is not easy but lessons can be learnt from the ways in which pest organisms are adapting to climate shifts in their current locations. Overwinter temperatures, synchronicity of insect emergence with bud burst of hosts in the spring, reduced tree defences arising from climatic stress and warmer summers accelerating development are all aspects that provide insights into future pest adaptations to climate change. There is no doubt that the complex interactions between climate, pest and host tree will require detailed study to increase our understanding and allow development of pest management strategies for the future. However, it does seem inevitable that the increased opportunities for pests to encounter new and suitable eco-climatic zones for establishment will result in many new infestations and challenges in pest management.

**MODELING THE RISK OF ASIAN GYPSY MOTH, *LYMANTRIA DISPAR* (LINNAEUS), MOVEMENT ON SHIPS FROM ASIA TO THE UNITED STATES**

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The Asian strain of gypsy moth, *Lymantria dispar* (Linnaeus) (AGM), is considered a more threatening biotype than the European gypsy moth (EGM) that is in the United States. This is because AGM females are capable of flight and it has a larger host range than EGM. AGM has been intercepted and introduced at U.S. ports. These introductions have costs millions of dollars to eradicate.

We generated pest risk assessments, each comprised of three analyses, which characterized the risks to the United States associated with AGM on ships arriving at U.S. ports from Asia. We first geospatially characterized the risk of infestation at Asian maritime ports based on suitable habitat and U.S. bound ship volumes during the flight period. We then conducted a quantitative pathway analysis that estimated the approach rate of infested ships at U.S. ports coming from Asia. In the third analysis, we generated a pest risk assessment that characterized the risk to the United States if AGM were introduced from infested ships.

Our pest risk assessments can be used to inform regulatory policy and trade practices between Asia and the United States and help mitigate the likelihood of AGM introduction via the maritime ship pathway.

## DETECTION OF PINE STANDS DAMAGED BY PINE WILT DISEASE USING IKONOS DATA

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Pine wilt disease, which damages pine stands and is caused by the pine wood nematode (*Bursaphelenchus xylophilus*), has spread throughout most of Japan. Finding disease damage at an early stage is important to stop the spread of the disease to other trees and prevent its expansion to other pine forests. However, current surveys of forest damage are conducted only by foresters. Such field surveys to find damaged stands and evaluate damage are time and labor intensive, and it is difficult to detect damaged stands located far from roads in mountainous areas. In this study, we used high-resolution satellite imagery to detect damage to pine stands caused by pine wilt disease.

The study was conducted in Japanese red pine (*Pinus densiflora*) stands on Mt. Tsukuba in Ibaraki Prefecture, Japan. A total of 66 plots (10 ×10 m each) were established in the study area, taking the damage ratio into consideration; all trees were tallied and examined for damage. The ratios of damaged pine trees, healthy pine trees, and hardwood trees were then calculated in terms of basal area. For satellite imagery, IKONOS “Geo” multi-spectral and panchromatic images taken in December 2000 were used. Pan-sharpened color imagery and multi-spectral imagery were analyzed, and normalized difference vegetation index (NDVI) values were calculated from the images. The relationship between the mean NDVI for pixels in each plot and the field-observed conditions in each plot was then examined.

The damage ratio and the ratio of hardwood trees tended to decrease and the ratio of healthy pine trees tended to increase as the NDVI increased for both imagery types. Moreover, to validate a prediction method, regression equations were derived from half of the plots and applied to the other half of the plots. The root mean square errors (RMSEs) for predicting the damage ratio and ratio of healthy pine trees from the NDVI were approximately 0.15 and 0.12, respectively, for the pan-sharpened imagery; the RMSEs for the same two ratios were approximately 0.17 for the multi-spectral imagery. The pan-sharpened color imagery effectively predicted the damage ratio in pine stands on a 10 ×10 m square basis. However, a mixture of deciduous hardwood trees in the study area increased the prediction error because the NDVI calculated from imagery in winter could not separate hardwood trees and damaged pine trees.

## UNINTENDED CONSEQUENCES FROM AN UNLIKELY PATHOGEN INTRODUCTION: DO WE REALLY KNOW WHAT WE THINK WE KNOW?

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The conifer root rotting pathogen *Heterobasidion annosum* (Fr.) Bref. *sensu lato* is one of the most significant pathogens of temperate zone conifer forests worldwide. In addition to being widely distributed, it was once regarded as a uniform monolithic species. During the past 30 years, study of this pathogen has resulted in significant discoveries regarding its population structure and genetics. These discoveries have led to definition of intersterility groups; two in North America and three in European populations. Other studies have shown degrees of ecological host specificity within intersterility groups. More recent studies involving DNA analyses have resulted in the European *Heterobasidion* intersterility groups being elevated to species, the F and S intersterility group are *H. parviporum* Niemela & Korhonen and *H. abietinum* Niemela & Korhonen, respectively. The P intersterility group in Europe is now referred to as *H. annosum sensu stricto*. The two North American S and P groups are currently undergoing similar taxonomic revision.

Threats from non-native invasive pathogens are on the rise due to increased international trade and overall globalization. These threats can adversely impact native ecosystems and ultimately affect human well being. In the case of *H. annosum sensu stricto*, a wood rotting Hymenomycete not normally associated with high risk as an intercontinental colonizer, recently discovered mortality events in Italian stone pine (*Pinus pinea* L.) has led to a startling research find. The region along the western Italian coastal range from Fregene in the north to San Felice Circeo in the south was demonstrated to have significant spore deposition quantities of the North American taxon of *Heterobasidion*. Observations of mortality patterns indicated the introduction site to be at or near Castelporziano. Based on mortality patterns from this putative initial infection focus, the introduction occurred during WWII and correlates with a United States Army infantry division. DNA analyses to date also indicate the origin of the initial isolate was somewhere in the southeastern USA and may be hybridizing with native *Heterobasidion*. This illustrates how human activity can bring together novel pathogen combinations that have been separated for millions of years, resulting in unpredictable outcomes in terms of impact on native ecosystems or pathogen evolutionary trajectories.

## TRANSPORT OF FUNGI ON WOOD CHIPS EXPORTED TO THE U.S. FROM CHILE

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International trade in unprocessed wood chips for the pulp and paper industry is a potential source for the introduction of non-native wood-inhabiting pests and pathogens that could pose a severe hazard to U.S. forestry resources. With permission from USDA-APHIS, 23 shipments of unprocessed *Pinus radiata* wood chips from Chile were shipped to an isolated processing plant on the pier at Bellingham, WA to evaluate the danger of introducing non-native fungal pathogens to the U.S. Fifteen samples were taken from each of 6 - 7 holds of the ship: five each from the top, middle, and bottom of the pile of chips, resulting in a sampling of over 2,000 bags of chips over 2 years. Three chips were removed from each bag, surface disinfested by flaming in alcohol, placed on malt extract agar (2% w/v), and incubated at 25°C. The resulting fungi were sub-cultured onto fresh medium and identified to taxon by examination with light microscopy.

Over 3400 cultures of fungi were identified to species, genus or higher taxon. Multiple fungi were often isolated from a single wood chip. Four fungal genera were particularly common and accounted for almost 75% of all isolations. They were: *Trichoderma*, *Geotrichum*, *Gliocladium* and *Phialophora* - all common mold fungi commonly associated with wood. Species of *Trichoderma* alone accounted for almost half of all isolations and were found exclusively when the wood chips were not surface disinfested. Other fungi were present in lower numbers, including the thermophilic basidiomycete *Phanerochaete chrysosporium*, a frequent inhabitant of wood chip piles, which was found in 19 of the shipments (3% of total isolations). Several potential pathogens were isolated in low numbers, including fungi in the genera *Graphium* (11 shipments, 2% of isolates), *Ophiostoma/Ceratocystis* (5 shipments, 0.7% of isolates), *Leptographium* (6 shipments, 1.8% of isolates), *Phoma* (3 shipments, 0.1% of isolates), *Fusarium* (4 shipments, 0.2% of isolations) and single isolations of *Moniliophthora*, *Phellinus* and *Verticillium*. No pathogenic genera were isolated when the wood chips were not surface sterilized.

Many different fungi can survive in unprocessed wood chips during extended ocean transport but fungi in the genera *Trichoderma*, *Geotrichum*, *Gliocladium* and *Phialophora* are more competitive and dominate. Species of *Trichoderma* are particularly successful at thoroughly colonizing the surface of wood chips under conditions in the ship holds and may act as biological control agents against pathogenic fungi. The introduction of non-native pathogenic fungi by international shipping of unprocessed wood chips is possible but unlikely due to rapid growth by ubiquitous saprophytic, imperfect fungi.

## USING SILVICULTURE AS A TOOL TO MINIMIZE IMPACTS OF INVASIVE SPECIES

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Once invasive species become established in new areas, they can have a wide variety of ecological and socio-economic effects on both forest ecosystems and people. After the initial invasion, many species proceed through the long process of naturalization. Numerous management tools can be used to minimize these effects during this transition period. One of the most cost-effective tools is silviculture, where commercial (and non-commercial) treatments can be used to either reduce the susceptibility and/or the vulnerability of forests to new invaders. Silvicultural tools have successfully reduced impacts of native insect outbreaks, in particular, bark beetles such as southern pine beetle (*Dendroctonus frontalis* Zimmermann), and mountain pine beetle (*D. ponderosae* Hopkins), and defoliators like spruce budworm (*Choristoneura fumiferana* Clements) and jack pine budworm (*C. pinus pinus* Freeman). They have also been used with invasive insects, most notably *Sirex noctilio* (F.) in New Zealand.

We will present research on the use of silvicultural treatments to minimize the effects of gypsy moth (*Lymantria dispar dispar* Linnaeus) on oak-dominated (*Quercus* sp.) forests both pre-invasion and post-invasion. Thinning to increase vigor of host trees prior to invasion significantly reduced mortality rates versus unthinned stands. New research efforts are investigating thinning as a tool for hemlock woolly adelgid (*Adelges tsugae* Annand) abatement. Reducing stand densities in overstocked hemlock (*Tsuga canadensis* (L.) Carr.) stands will enhance residual tree health and may decrease tree vulnerability to HWA infestation. Regeneration techniques for increasing the proportion of American beech (*Fagus grandifolia* Ehrh.) resistant to beech scale (*Cryptococcus fagisuga* Lindinger) in forest stands will also be discussed.

## HAZARD SITE SURVEILLANCE IN AUSTRALIA AND THE SOUTH PACIFIC - IT NEVER RAINS BUT IT POURS

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Australia has few serious exotic forest and timber pests, those that are established, e.g. *Sirex noctilio* Fabricius, do not threaten our forest and timber industries under current management practices. Trade globalisation and changes in trade barriers have increased the risk of exotic incursions and awareness of the threats to our environment, local economies and international markets.

Federal and State Government measures to address these issues include the listing of key exotic pests and diseases, including 37 forestry pests, and the development of national diagnostic protocols for all listed species. As well the Federal and State Governments are funding limited Hazard Site Surveillance programs in all States, with only Tasmania and Queensland sampling for forest and timber insect pests. In Queensland the Hazard Sites being sampled are mainly around Brisbane, and include the port, the airport, timber importers, warehouses, and Botanic Gardens. The objectives are to test the effectiveness of a range of traps, lures and methodologies, to provide an early warning system for new incursions and to obtain baseline data on the composition of local populations of target taxa. The targets include Asian Gypsy moth and other Lymantriids, Bostrichidae, Buprestidae, Cerambycidae, Platypodinae and Scolytinae. To date, in 24 months 36 collections were made, yielding 7295 specimens in 87 species and 5 families. No exotic incursions were detected.

A project to provide early warning of forest invasive species is being conducted in the South Pacific with funding from the Australian Centre for International Agricultural Research (ACIAR). The forest pest and disease situation in the South Pacific is of significance from two aspects. First, the importance to Australia of knowing what pests are present in neighboring countries, and to be aware of any immediate or potential threats; second, the importance of the forest and timber industries in the economies of several South Pacific nations, and the impact of pests and diseases on timber quality, value and export market access.

Until recently only Fiji had a limited forest health surveillance system and collections of forest pests. A project funded by ACIAR provided training and assistance to Forestry and Quarantine personnel in Fiji, Tonga, Samoa and Vanuatu in establishing forest health surveillance systems. A sampling program began and back-up for advice and identifications was provided. The current ACIAR project centres on Fiji and Vanuatu. A trapping program is in place at port, airport, nursery and plantation sites, with sentinel plantings at port sites. So far we have identified two serious pests not previously recorded as established in Fiji.

A new aid project in Vietnam, with similar objectives, will begin later this year.

## CURRENT STUDIES ON WOOD PACKING MATERIAL AND FIREWOOD

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In the past few years, we have (1) summarized USDA APHIS interception data for bark- and wood-infesting insects found in association with wood packing material (WPM) (Haack 2006), (2) shown that under ideal field conditions, bark- and wood-boring insects of quarantine significance readily infest and develop in barked logs and lumber after heat treatment, and (3) conducted surveys of WPM with the ISPM-15 logo at six US ports and found that about 9.4% of the WPM items inspected had residual bark, and of those WPM items with bark, about 1.2% had live insects of quarantine significance under the bark (Haack et al. 2007).

In fall 2007, we initiated another field study to examine insect colonization of barked WPM that had dried various lengths of time before initiation of spring flight by insects. We cut red pine (*Pinus resinosa*) trees and milled boards in November 2007, February 2008, and March 2008. Boards were of two thicknesses ( $\approx 2.5$  and 10 cm). All bark was retained on one face of each 2.5-cm-thick board. Two sizes of bark patches ( $\approx 50$  and 100 cm<sup>2</sup>), four of each size, were left on each 10-cm-thick board. Half the boards were heat treated (using ISPM-15 protocol at a commercial plant), and the others were used as untreated controls. We placed all boards in the field in late March to allow insect colonization. In early May, after initial bark-beetle flight began (e.g., species of *Hylastes*, *Ips*, *Orthotomicus*, *Tomicus*), we put the boards in rearing tubes. Bark and wood moisture content was also recorded. As available, data will be presented on wood moisture content and insect colonization patterns.

In Michigan, hardwood firewood is either confiscated or dropped-off voluntarily by drivers at the Mackinac Bridge (8 km long), which connects the Lower and Upper Peninsulas of Michigan. This is done to slow human-assisted movement of emerald ash borer (EAB; *Agilus planipennis*) from Lower to Upper Michigan. In April 2008, we inspected 186 pieces of recently confiscated firewood that represented at least 11 tree species. Overall, 16% of the firewood pieces had live borers (mostly Cerambycidae and Scolytidae), 40% had evidence of past borer infestation, and 44% appeared uninfested. Of the 19 pieces of ash firewood inspected, 0 had live EAB, but 10 had EAB larval galleries. Additional surveys of confiscated firewood will be conducted in summer 2008.

Haack, R.A. 2006. Exotic bark- and wood-boring Coleoptera in the United States: recent establishments and interceptions. *Canadian Journal of Forest Research* 36: 269-288.

Haack, R.A., T.R. Petrice, P. Nzokou, and P. Kamdem. 2007. Do insects infest wood packing material with bark following heat-treatment? Pages 145-149 in *Alien Invasive Species and International Trade*. H. Evans and T. Oszako, eds. Forest Research Institute, Sêkocin Stary, Poland.

# **HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP) PLANNING: A 5-STEP APPROACH TO PREVENT UNINTENTIONAL INTRODUCTION OF NON-NATIVE INVASIVE SPECIES**

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The form and function of HACCP planning will be displayed and discussed in this poster. HACCP planning is used by many different organizations and industries to make use of critical control points for preventing and managing non-targets. The use of critical control points is recommended as an efficient approach to implement control measures. There may be several steps in a process where a control measure can be implemented, but identifying the one step or best steps to implement the control measure is a more efficient approach when considering resources (i.e., staff time and money). The form in which critical control points are used is the U.S. Fish and Wildlife Service's 5-step HACCP. The 5-step structure is being implemented for various projects in an attempt to prevent non-native invasive species (e.g., non-targets) from being introduced through activities involving the U.S. Fish and Wildlife Service.

The 5-steps are 1) Activity Description, 2) Potential Hazards, 3) Flow Diagram, 4) Hazard Analysis Worksheet, and 5) HACCP Plan Form. These 5-steps provide a structure, to lead a group of people familiar and responsible for conducting a specific project, to document threats, to implement corrective measures for addressing threats, and monitoring endpoints to determine efficacy of corrective measures. HACCP plans are developed for fish stocking projects, flora and fauna surveys, environmental monitoring, and restoration projects. Some of these specific plans are posted on the U.S. Fish and Wildlife Service's HACCP website (<http://www.haccp-nrm.org/>). This science-based approach to preventing and controlling non-native invasive species is available to anyone. The U.S. Fish and Wildlife Service provides training, HACCP support materials, and will review HACCP plans.

## MICROWAVE TREATMENT OF INSECT-INFESTED WOOD

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Microwave (MW) irradiation is a form of dielectric heating, generating waves that penetrate throughout the profile of wood, which heats the water in the wood and organisms in the wood simultaneously, in contrast to conventional heating which depends on radiant heating from the outside to the inside of the wood. For example, after approximately 3 minutes of MW exposure of red pine logs (*Pinus resinosa*), temperatures measured in the log with fiber optic probes was 62°C in the core, 60°C in the cambium, and 53°C at the surface, indicating that the core and the cambium heat up rapidly with dielectric heating. For several years, we have been testing microwave energy (MW) as an alternative method for destruction of wood-boring insects and pinewood nematode in wood used for international shipping as part of a formal NPPO submission of MW as an alternative method of phytosanitation.

MW kills 100% of adults, larvae, and pupae of a number of insect species and pinewood nematodes through short irradiation treatment times. To date we have shown that microwaves kill several species of cerambycids including *Anoplophora glabripennis*, pinewood nematode (*Bursaphelenchus xylophilus*), bark beetles (*Ips* spp.), and white pine weevil (*Pissodes nemorensis*) in wood of various species, sizes, and moisture contents. In red pine bolts naturally-infested with bark beetles, for example, all life stages were successfully eradicated at temperatures of 55° to 60° C measured in the cambium with exposure times of 2:40 ± 10 (min:sec). Also we examined the relationship between temperatures reached simultaneously at the bark surface vs. the cambium or the core. The temperature at the bark surface could be used to accurately predict the temperature in the cambium to ensure that lethal temperatures are met in all regions of the log. Interestingly, the cambium and the core are always hotter than the outer surface of the wood (due to convection cooling from the surface). This is important because it is more practical for operators to monitor surface temperature during treatment.

We are currently collaborating with USDA personnel on MW and radiofrequency testing of wood infested with emerald ash borer (*Agrilus planipennis*) and *Sirex noctilio*. Equipment that can operate by batch or pass-through (conveyance) processing are commercially available, but design types are currently limited. As cost-benefit analyses are conducted to demonstrate the efficacy and cost-effectiveness of dielectric methods compared with conventional heating, we anticipate a considerable effort by companies to produce the necessary equipment.

## INTEGRATING DNA BARCODING INTO DETECTION AND SURVEILLANCE PROGRAMS FOR INVASIVE SPECIES

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Non-indigenous species pose a serious threat to the ecological and economic sustainability of forests globally. The availability of taxonomic or diagnostic expertise often hampers the identification of species recovered in detection and surveillance programs for invasive species. DNA barcoding – the use of short, standardized DNA sequences for species identification – is a methodology which can be incorporated into arthropod surveillance programs to enhance the recognition of invasive arthropod species moving in international trade. We present an overview of DNA barcoding and outline the requirements for using barcoding as a diagnostic tool.

Projects are now underway exploring several target groups of major forest pests, and each are at varying levels of completion. Firstly, work on invasive bark and woodborers has concentrated on the development of protocols for specimen and DNA recovery and building DNA reference libraries. Our results suggest the dilution of trap solutions and chemical dehydration of specimens has little impact on COI barcode recovery. Secondly, a study on aphids, scales and adelgids has generated a large dataset for their rapid detection, and has identified amplification difficulties for scale insects using standard COI-5' primer sets. Lastly, a comprehensive survey of forest Lepidoptera in BC has been initiated. Significant progress has been made on collections in urban and natural forests, on sampling from museum specimens in regional collections, and the ongoing generation of a barcode library. Our results indicate very modest barcode variation in species spanning the continent, as well as clear demarcations of variation between species. In general, results on forest pests reinforce earlier work on other animal groups, and that the incorporation of barcoding into detection and surveillance systems will certainly be advantageous.

## PROACTIVE QUARANTINE-BASED RESEARCH ON NUN MOTH: PREVENTING INTRODUCTION AND ESTABLISHMENT IN NORTH AMERICA

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The nun moth, *Lymantria monacha* (L.), is closely related to gypsy moth and similar in appearance and behavior. Nun moth is not known to be established in North America, but is an Eurasian pest of conifers (spruce, fir, larch and pine) that poses an ever-present threat of being accidentally introduced because of its biology and behavior. Its establishment in North America would be disastrous because of its polyphagous feeding habits, ability to colonize new habitats, and capacity to be spread rapidly by vagile adults. Adults are readily attracted to artificial lights and have been observed in Russian Far East ports. Nun moth has a high potential to be transported via commerce because, although eggs are normally laid in tree bark crevices they also could be deposited in crevices on containers, pallets, ships, etc. Since 1996, quarantine-based research on this insect has been directed toward proactive development of tactics to prevent its introduction and establishment in North America and to provide eradication options should it be introduced.

No adequate artificial diet or rearing methods existed for nun moth; they have been developed, in collaboration with scientists in the Czech Republic, making further quarantine-based research possible. A guide for use in identifying all stages of nun moth and differentiating it from gypsy moth has been developed and is in use by regulatory officials. Other researchers have developed a nun moth specific pheromone trap for use in detection and monitoring surveys. An evaluation of the suitability of various North American tree species for nun moth survival and development indicated that not only are they able to utilize several spruce, fir, and some pine species, but also that nun moth do very well on typical gypsy moth preferred broadleaf hosts, such as oak and birch. The phenology of nun moth on both the artificial diet and white spruce has been determined and could be used to develop a life stage model. Nun moth has 4-6 instars on both the artificial diet and white spruce. Males tend to develop faster than females and begin emerging sooner. Nun moth was found to be not as susceptible to commercial *Bacillus thuringiensis* as the United States gypsy moth, but this still is a viable control option for use in an eradication effort. Nun moth eggs have lower chill requirements for hatch than gypsy moths from the United States and when bark cracks (their usual oviposition substrate) are not available, nun moths will lay their eggs in plastic, metal or wood cracks. This illustrates that the nun moth could establish and cause widespread problems if introduced into North America. Research is ongoing to determine if different biotypes of nun moth exist that could pose additional regulatory concerns.

**PREDICTION, DETECTION, AND MONITORING OF INVASIVE SPECIES  
IN FORESTS, RANGELAND, AND AQUATIC ECOSYSTEMS:  
A SYNTHESIS OF USDA FOREST SERVICE – ROCKY MOUNTAIN RESEARCH  
STATION RESEARCH FOR MARKETING, EDUCATION, AND OUTREACH**

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The USDA Forest Service – Rocky Mountain Research Station (RMRS) has scientific expertise in widely ranging disciplines, and conducts multidisciplinary research on invasive species issues with special emphasis on terrestrial and aquatic habitats throughout the Intermountain West and related areas. Although considerable research-based information on invasive species is available, no comprehensive and easily accessible source is currently available for land managers in the regions served by the RMRS and beyond. The RMRS has recognized research strengths in management, mitigation, restoration, and rehabilitation, and it is also making significant advancements in areas of *proactive* research on invasive species (e.g., prediction, prevention, detection, and rapid response). A multidisciplinary team across RMRS research program areas has been organized. This multidisciplinary team has developed synthesis papers that summarize current RMRS research activities on invasive species. The team also has established a website ([www.forest.moscowfs.wsu.edu/rmrsinvasivespeciesresearch.com](http://www.forest.moscowfs.wsu.edu/rmrsinvasivespeciesresearch.com)) that will serve as a source for research information and technology transfer. In addition, a quarterly “RMRS Invasive Species Newsletter” will be published to familiarize RMRS stakeholders and customers with RMRS activities on invasive species. A primary goal of this collaborative project is to develop tools for improved prediction and prevention of invasive species introductions and spread, with special emphasis on climate change. These approaches are aimed toward reducing invasive species impacts at local, regional, and international levels. This synthesized information will also be used to further develop collaborative approaches and networks for managing invasive species on regional, national, and international landscapes.

## **GROWTH OF NASCENT INVADING POPULATIONS: LESSONS FROM THE GYPSY MOTH AND EMERALD ASH BORER**

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Understanding the growth of newly-founded populations is crucial to the development of effective approaches to managing invasions (e.g., eradication). One trait that is common to invading populations of many different species is the existence of a time lag between the time of initial arrival and the ultimate growth and spread of the invaded area. This phenomenon has important implications both to the development of effective approaches to detecting new populations in a timely manner but also to the practicality of eradication. Here we explore the growth of newly-invaded populations using invading populations of the gypsy moth and the emerald ash borer in N. America as model systems. We use both analyses of historical data and spatially explicit models to document invasion lags and provide insight into their causes.

## CHANGING CLIMATE ASSOCIATED WITH INCREASING FOREST DAMAGE DUE TO INVASIVE PESTS IN MAINE, USA

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Studies on American beech (*Fagus grandifolia* Ehrh.), balsam fir (*Abies balsamae* (L.) Mill.), eastern hemlock (*Tsuga canadensis* (L.) Carr.) demonstrate how climate change is affecting exotic pests and their impacts in Maine.

**Beech Dieback** – A high amount of beech mortality was observed (21-72%) along with 68% average crown dieback in surviving trees in northern Maine. There are two types of stands. The first type involves stands affected in the 1930's by beech bark disease, where a scale insect (*Cryptococcus fagisuga* Lind.) weakens trees so that a *Neonectria* fungus can kill the mature stems. Regenerated beech is now reaching a size and age at which beech bark disease probably contributes to the observed increase in mortality, especially after the drought of 2001. The second type of stand involves those in northern Maine that show significant mortality but no previous symptoms of beech bark disease, i.e., no pocket cankers. The drought in 2001 and/or an outbreak of beech scale associated with warmer winters may have predisposed these trees to infection and mortality by a *Neonectria* fungus.

**Balsam Woolly Adelgid** - Three-year growth trends of fir affected by the balsam woolly adelgid (*Adelges piceae* (Ratzenburg)) (BWA) were compared with the less affected fir and nonhosts in a region not previously associated with BWA mortality. Beginning in 1998 and continuing through 2001 growth trends of the more affected fir were significantly less than nonhost trends region-wide. A chronology of rotholz occurrence suggests a buildup of adelgid populations from the late 1980's continuing through 2003. Lethal temperatures for BWA in the study area have been less frequent since the 1940's, and it appears there has not been sufficient cold to appreciably slow the increase of adelgid populations since this time. An additional stress, the drought of 2001, coincided with a spike in fir mortality. A continuation of current climate conditions will allow adelgid populations to build up in the stands in which they currently occur regardless of site and stand characteristics.

**Hemlock Woolly Adelgid** - Hemlock is experiencing decline and mortality throughout much of its range south of Maine due to the invasive insect *Adelges tsugae* (Homoptera:adelgidae), the hemlock woolly adelgid (HWA). The insect is now just entering Maine along the New Hampshire border. Current rates of spread for HWA are slower than expected in northern Massachusetts, New Hampshire, and Maine, and damage does not appear to be as severe. Cold temperature is thought to be the primary limitation for the spread of insects in temperate regions, but minimum temperatures in southern Maine are increasing during winter. Studies are in progress assessing how climate, HWA, and tree decline will interact.

## **Puccinia psidii AND OTHER PATHOGEN AND INSECT PESTS OF MYRTACEAE: ACUTE THREATS TO HAWAII'S BIODIVERSITY**

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*Puccinia psidii* Winter was given the name `ohi`a rust by Hawaii Department of Agriculture (HDOA) when first discovered in the state in April 2005 on `ohi`a (*Metrosideros polymorpha*, in the family Myrtaceae), the endemic tree species that overwhelmingly dominates Hawaii's native forests. Originally found on native guava (*Psidium guajava*) in Brazil in the 1880s, *P. psidii* has since been recognized as having a broad host range within the Myrtaceae. Generally recognized as the most serious threat to eucalyptus cultivation worldwide, it is also considered among the foremost of newly emerging tree diseases. Present in the USA in Florida since the 1970s, its establishment as an outlying population in Hawaii, bringing the rust to a hub of transportation 8,000 km nearer, stimulates much concern in Australasia, home to over 2000 Myrtaceae species.

In its first three years in Hawaii, no sexual stage of this rust has been detected, and preliminary DNA analysis has not yet detected genetic variation. The single strain in Hawaii has produced a major, landscape-level impact on non-native rose apple (*Syzygium jambos*) throughout the state but has had only limited effects on `ohi`a. The decimation of rose apple demonstrates the potential virulence of this rust species complex, which consists of numerous genetic strains, only superficially documented to date, defined by the suite of host plants they infect. Shipments to Hawaii by the flower/foilage industry in California are believed the source of the existing *P. psidii* strain in Hawaii and a likely threat for vectoring additional strains. In August 2007, after *P. psidii* had been repeatedly intercepted on Myrtaceae foliage from California, Hawaii's Board of Agriculture approved an interim rule empowering restriction of movement into the state of plants and plant products in the Myrtaceae from areas infested with *P. psidii*, to prevent arrival and establishment of new strains of the rust. Effort is currently underway to develop a long-term rule and strategy to prevent not only new strains of *P. psidii*, but also numerous other invasive pests -- both insects and fungi -- that attack Myrtaceae. Special measures must also be developed in collaboration with Hawaii's eucalyptus industry to reduce the risk of bringing in seeds and other forms of germ plasm. Little is known about this Neotropical rust in California, since it is not considered a significant agricultural or environmental pest there, nor is it recognized as a regulated or reportable pest by USDA. An especially troublesome issue for HDOA inspectors has been that of a large incoming volume of multitaxa bouquets that include potential hosts of the rust -- myrtle (*Myrtus communis*), waxflower (*Chamelaucium uncinatum*), and/or *Eucalyptus* spp.

## MONITORING AND EARLY DETECTION OF THE ASIAN LONGHORNED BEETLE

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The Asian Longhorned Beetle (ALB), *Anoplophora glabripennis* (Coleoptera: Cerambycidae), is a high risk, exotic species in the U.S. In 2002, two male-produced volatiles were isolated from ALB that stimulated antennae of both sexes of ALB. The components were synthesized and consisted of an aldehyde (4-(n-heptyloxy)butanal) and an alcohol (4-(n-heptyloxy) butan-1-ol).

Behavioral tests conducted in the laboratory in 2006 showed a significant attraction of virgin females ALB toward the alcohol ( $P < 0.05$ ). In July 2007, field trapping experiments using ALB male-produced pheromone performed in Ningxia province in China using IPM Intercept traps showed a significantly higher total trap catch in the pheromone blend-baited traps, followed by traps baited with the pheromone blend with plant volatiles ( $P_{(MPvs.MPPL)} = 0.04$ ). Alcohol-baited traps caught only females, supporting previous lab results. Coupling plant volatiles with the male pheromone appeared to increase the attractiveness of females to the traps. Laboratory experiments were then conducted in 2008 to test the attractiveness of various maple and poplar volatiles to adult ALB.

Results showed a significant attraction of both sexes to two plant volatiles. Interestingly, some plant volatiles were only attractive to either males or females ALB. Coupling the most attractive plant volatiles to the male-produced pheromone significantly increased attractiveness in the Y-olfactometer. Field trapping tests using the best combination of pheromone and plant volatiles will be conducted in China in July and August 2008.

## POTENTIAL INVASIVE ARTHROPODS AND MICROORGANISMS ASSOCIATED WITH INTERNATIONAL TRADE - A JAPANESE CASE STUDY-

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Since the opening of Japan to foreign countries in the 19th century, many organisms, including plants, arthropods, and vertebrates, have been introduced to Japan by overseas travelers and some of them have established populations through release or escape to the field. Also, many types of small organisms, which tend to be introduced accidentally, have become pests in Japan. For example, the pine-wilt nematode, *Bursaphelenchus xylophilus* (Nematoda: Aphelenchoididae), which probably migrated with pine logs from North America, has destroyed pine forests in southern and central Japan and in the process has established a new relationship with the endemic Japanese cerambycid beetle.

Recently, wood materials including logs, lumbers, and crating materials are suspected as important materials to introduce small exotic organisms into Japan. In one of our survey, we suspect that a predacious insect migrates with a wood decomposer insect both with crating materials all over the world. The Argentine ant has been suspectedly introduced into Japan together with logs and has been expanding its distribution. We also have conducted an isolation test with discolored imported woods, then, detected several saprophytic fungi including *Pacilomyces varioti*. So far, we have not collected serious forest pests although this is a preliminary study and a further critical research will be required. From the list of bark and ambrosia beetles from crating materials in Japan, fungal associations are highly predicted. Beetle-associated fungi, such as *Ophiostoma*, *Leptographium*, *Raffaelea* spp. are potential to invasive together with beetles with crating materials.

Another concern is invasive organisms unintentionally introduced into Japan with pets and commercial natural enemies of agricultural crops. In our new research project, we will develop a risk assessment method as a case study of intentionally introduced small organisms imported with targeted organisms and materials. We introduce and demonstrate the project and risk assessment methods to be improved.

## **ALIEN INVASIVE SPECIES ENTERING AFRICA IN THE PAST 25 YEARS, A THREAT TO AGRICULTURE, THE NATURAL ECOSYSTEMS AND INTERNATIONAL TRADE**

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Alien invaders constitute a growing threat to agricultural productivity and nature conservation, affecting many people's lives, especially the poor.

At the grassroots level, national plant quarantine officers have prevented unknown numbers of species to get a foothold in Africa. In many instances, however, their control failed. This paper presents arthropods (insects and mites), nematodes and pathogens that have invaded the African continent during the last 25 years. It explains why quarantines have failed in Africa and proposes an African bio-security framework that inter-links the work of quarantines to surveillance, rapid identification and a timely response; a bio-security framework that complies with voluntary border measures, the participation of public and private sector in surveillance and collaboration with those involved in pest management, those conserving our vast indigenous biological diversity-all need to contribute in the realization of this system. For best effect, quick and reliable identifications, rapid responses to incursions have to be harmonized and taught and a corresponding how-to-do guide together with easy to use identification keys are needed. The use of illustrated guides that warn of potential new invaders, i.e. species that have already shown their invasive destructive potential on other continents, but have not yet reached Africa, will further reduce the risks.

## EPPO APPROACH IN DEVELOPING REGIONAL PHYTOSANITARY STANDARDS FOR FOREST COMMODITIES

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The European and Mediterranean Plant Protection Organization (EPPO) is an intergovernmental organization created in 1951. It currently has 49 member countries. In terms of the IPPC, it is a Regional Plant Protection Organization. Its aim is the international cooperation in plant protection (plant quarantine and plant protection products).

The EPPO Project on Quarantine Pests for Forestry (Orlinski, 2006) was run from 1999 to 2005. It was mainly focused on the risks of forest pests from the non-European part of Russia and other former USSR countries for the European part of the EPPO region. 1365 species of pests have been considered under the Project, PRA have been conducted for 45 of them, 19 species have been included into the EPPO lists of pests recommended for regulation.

After the end of the Project, the EPPO Panel on Quarantine Pests for Forestry started to develop EPPO phytosanitary standards for forest commodities. It was decided that these standards should be genus-specific (genus of *Coniferae*, *Quercus* & *Castanea*, etc.) and cover following commodities: plants for planting (except seeds), cut branches, wood (non-squared, squared, particle, waste, WPM) and isolated bark. They should be based on Pest-Specific Phytosanitary Requirements (PSPRs) and results of Pest Risk Management (PRM) stage of PRA (Pest Risk Analysis). The Panel agreed to consider all untreated forest commodities except seeds, avoid prohibitions and use the option of “area freedom”, do not include occasional hosts and pathways, use where appropriate the option of “Heat Treatment” instead of “Kiln Drying”, do not include “debarking” as a general measure.

Development of these forest commodity standards includes following steps: selection of relevant pests from the EPPO lists (A1 – pests absent from the EPPO region and A2 – pests of limited distribution in the EPPO region); collection of PSPRs and PRMs, their check for consistency and updating; drafting the standard and discussion of the draft by the forest expert Panel; country consultation; update by using the comments of EPPO countries; approval by the EPPO Working Party on Phytosanitary Regulations; adoption by the EPPO Council.

Standard on *Coniferae* (*Abies*, *Chamaecyparis*, *Cryptomeria*, *Juniperus*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, *Taxus*, *Thuja* and *Tsuga*) was recognised as first priority. This standard is currently at the stage of country consultation. Standard on *Quercus* and *Castanea* was recognised as second priority: it is currently at the stage of drafting.

Reference: Orlinski A.D., 2006 Outcomes of the EPPO project on quarantine pests for forestry. *Bulletin OEPP/EPPO Bulletin*, 36, No 3, 497 – 511.

## NORTH AMERICAN PLANT PROTECTION ORGANIZATION PLANTS FOR PLANTING UPDATE

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This presentation provides an update on the work of the North American Plant Protection Organization (NAPPO) Plants for Planting Panel.

In 2005, the North American Plant Protection Organization (NAPPO) published RSPM No. 24, *Integrated Pest Risk Management Measures for the Importation of Plants for Planting into NAPPO Member Countries*. This Standard describes the essential elements required for integrated pest risk management measures associated with the importation of plants for planting by NAPPO member countries. It is based on applying systems approaches, or critical control points, to the production of plants in order to mitigate the risk of transmitting pests along this pathway.

The broad objectives of RSPM No. 24 are to prevent the introduction and spread of quarantine pests associated with plants for planting imported into NAPPO countries; significantly reduce the risk from other pests that may be associated with plants for planting imported into NAPPO countries; and facilitate equitable and orderly trade into and within the NAPPO region, utilizing to the extent possible, best production and best management practices. Canada, the United States and Mexico, the three NAPPO member countries, have all committed to implementing RSPM No.24.

The assignments for the Plants for Planting Panel in 2007-2008 include: (1) identifying constraints and recommending solutions for the implementation of RSPM 24, (2) collaborating in the development of guidelines for the authorization of Auditors; (3) reviewing RSPM 24 for consistency with International Standards for Phytosanitary Measures; (4) participating in IPPC activities related to the international standard on Plants for Planting; and (5) providing support to other NAPPO panels which intend to incorporate elements of the Plants for Planting Standard into other NAPPO guidelines.

## SUSCEPTIBILITY OF CONIFEROUS FORESTS TO PINE WOOD NEMATODE

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The pine wood nematode (PWN), *Bursaphelenchus xylophilus* is native to North America, is destructive pest of the pine forests of Japan and China. The nematode has also been introduced into Taiwan, South Korea and Portugal. As in Northern Hemisphere, the major forests are composed of pines, the PWN could become one of the most serious threats to forests for apparently 'disease free' regions and countries. The PWN was first recovered from dead Japanese black pine (*Pinus thunbergii*) and later on from Japanese red pine (*P. desiflora*, *P. luchuensis*), which are the predominant species in Japan. The PWN is naturally found in blue spruce and white spruce (*Picea* sp.), Eastern larch and European larch (*Larix* spp.), Douglas fir (*Pseudotsuga* spp.), balsam fir (*Abies* spp.) and Atlas cedar and deodara cedar (*Cedrus* spp.) in North America. The disease appears occasionally in Austran (*Pinus nigra*), jack (*P. banksiana*), mungo (*P. mugo*) and red (*P. resinosa*) pines and rarely in white pine (*P. strobes*). Surveys carried out in North Carolina, have found the nematode in pond pine (*P. serotina*), *Picea glauca* (spruce), *Cedrus deodara* and *C. atlantica*. The most serious damage is to Japanese black pine (*P. thunbergii*). In the Midwest, however, more than 90 percent of the trees killed by pine wilt have been Scots pine. The PWN is causing damage in China, on Japanese black pine (*Pinus thunbergii*) and southern red pine (*P. massoniana*); in Taiwan on *P. luchuensis* and Japanese red pine; and in Korea again on Japanese black pine and Japanese red pine. The nematode was found in Portugal on dead maritime pine (*P. pinaster*). A closely related wood nematode *Bursaphelenchus mucronatus* is frequently declining pine trees in Japan, China, Korea, Russia, France, Austria, Italy, Finland Sweden, Norway and Canada. In addition to *Pinus* spp. *Abies* sp., *Cedrus* sp., *Larix* sp. and *Pseudotsuga* sp. are its hosts in the US. The *B. mucronatus* is distributed over a geographically wider area than *B. xylophilus*.

The data on susceptibility reveals that the nematode has great potential to become a major threat in European countries, because the Scotch pine (*P. sylvestris*) and maritime pine (*P. pinaster*) are very susceptible species to the disease. Similarly in Taiwan, tree species at risk include the fir species (*Abies kawakamii*), Taiwan spruce (*Picea morrisonicola*), Douglas fir species (*Pseudotsuga wilsoniana*), the Chinese hemlock (*Tsuga chinensis*) and the Taiwan keteleeria (*Keteleeria davidiana* var. *formosana*). Fate of natural forests in Northern India of mainly of *Pinus longifolia roxburghii*, *Pinus gerardiana*, *Pinus wallichiana*, *Picea smithiana*, *Abies spectabilis*, *Abies pindrow* *Taxus baccata* and *Cedrus deodara* from lower altitudes, in warm south of Kashmir are yet not predictable.

Some conifer species which are rarely colonized by the pinewood nematode may become susceptible against the nematode due to environmental changes, such as increasingly warm and unusual weather conditions, which are expected soon due to global warming. These species include Douglas-fir (*Pseudotsuga menziesii*), redwood (*Sequoia sempervirens*), white fir (*Abies concolor*), western redcedar (*Thuja plicata*), eastern hemlock (*Tsuga canadensis*) and western hemlock (*T. heterophylla*).

## PINE WOOD NEMATODE, MICROBIAL POPULATION, PHYTOTOXINS IN THE RESIN DUCTS AND PINE WILT DISEASE

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Pine wood nematode (PWN), *Bursaphelenchus xylophilus* is reported mainly from *Pinus* spp. Apparently dead wood of all species of *Pinus* can act as a substrate for the multiplication of *B. xylophilus*. However only a limited number of species are susceptible to attack as living trees; and show typical wilting symptoms. *P. nigra*, *P. sylvestris* and *P. pinaster* are the only species known to be killed by pine wilt disease as mature trees in the forests. Other conifers (*Larix*, *Abies* and *Picea*) can also act as hosts but reports of damage are rare. There is no example of drastic death of adult trees because of any other nematode species.

Whole shoot hydraulic conductance is reduced in the trees by both low water and infection. Experimental findings have time and again created doubts about the actual pathogen (s) for the pine wilt disease. *B. xylophilus* may feed on plant cells (phytophagous) but is primarily a fungal feeding nematode (mycophagous) on *Ceratocystis* spp., *Ophiostoma minus* (blue stain fungus), *botrytis cinerea* (grey mould), *Ceratostomella ips* (blue stain fungus), *Colletotrichum* sp., *Fusarium* spp., *Macrophoma* sp., *Monochaetia* sp., *Nigrospora* sp., *Pestalotia* spp., *Rhizophthora* spp., *Sordaria* sp. and *Trichoderma* sp. The nematodes may live on fungi resident within the tree tissues and therefore not all trees or all tree species infested with PWN go on to develop symptoms of wilting. Such trees can act as reservoirs for the nematode. Some fungi (*Ophiostoma minus* and *Trichoderma* sp.) are also known to affect host trees. Simultaneous inoculation of *P. thunbergii* with *Ceratostis* like fungus and PWN resulted in higher and faster mortality than when inoculated independently.

There is another belief that the real pathogen of the wilt disease is a phenylacetic acid-producing bacteria. Experiments proved that the acid was not the product of the nematode but that of the symbiotic bacteria. The aseptic pine seedlings inoculated under aseptic conditions did not wilt. An examination by scanning electron microscopy revealed, bacteria on the surface of PWN. Infection of bacteria, *Xylella fastidiosa* occurs due to reduced hydraulic conductance caused by clogging of the vessels. Thus the symbiotic bacteria and PWN collaboratively invade and kill the host tree. Further studies are needed to evaluate the chemical nature of the substances that PWN and its associates, fungi and bacteria provide to each other. Thorough study only, would elucidate the wilting mechanism; processes involved, susceptibility of hosts, pathogenicity, and suggest the appropriate control measures.

## MANAGEMENT OF INVASIVE FOREST PATHOGENS IN SWITZERLAND

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Several tree pathogens have been introduced into Switzerland and have caused considerably damage to urban and forest tree species as well as ornamental woody plants. Main pathogens include *Cryphonectria parasitica* (causing chestnut blight), *Ophiostoma ulmi* and *O. novo-ulmi* (Dutch elm disease), *Phytophthora cinnamomi* (ink disease of chestnut), *Ceratocystis fimbriata* sp. *platani* (canker stain of plane), *Mycosphaerella pini* (red band needle blight on pine), *Mycosphaerella dearnessii* (brown-spot needle blight of pines) and most recently *Phytophthora ramorum* (dieback of viburnum or sudden oak death).

Management of the diseases in affected areas have ranged from complete neglect to intensive control programs and quarantine measures. Little efforts have been made to prevent spread of Dutch elm disease, mainly because of lack of appropriate management options. As a result, the number of elm trees in Swiss forests decreased by about 30% within ten years. An example, where suitable control options have been available is chestnut blight. This disease is naturally controlled by virus-induced hypovirulence in southern Switzerland. Factors found to contribute to the success of hypovirulence include (1) efficient dissemination of hypovirus-infected propagules; (2) low vegetative incompatibility barriers for virus transmission between fungal individuals; (3) the presence of dead chestnut wood that can act as a reservoir of hypovirulent inoculum; and (4) the relatively high ecological fitness of the natural biological control agent. In spite of quarantine measures, chestnut blight spread into most of the chestnut stands north of the Swiss Alps. Since natural hypovirulence did not appear in these stands, we applied hypovirulence by treating chestnut blight cankers with hypovirus-infected *C. parasitica* isolates. First evaluations of the biological control treatments showed that the hypovirus persisted in the treated cankers and, with some variations among stands, successfully spread to untreated cankers.

*Phytophthora ramorum* was first detected in Switzerland in 2003 on *Viburnum bodnantense* in a nursery. Up to date, *P. ramorum* has been found in 11 out of 119 nurseries inspected once a year in course of the European plant passporting system. In addition, the pathogen was detected in two private gardens and one garden centre. *P. ramorum* has so far only been recovered from *Viburnum* sp. and *Rhododendron* sp. mostly on recently imported plants. Eradication measures appeared to be successful in most cases, however, there is concern about a few nurseries with repeated occurrence of the disease.

# THE PAN- EUROPEAN INVENTORY OF ALIEN SPECIES ESTABLISHED ON TREES AND SHRUBS, A TOOL FOR PREDICTING TAXA AND ECOSYSTEMS AT RISK- FINAL RESULTS OF THE DAISIE PROJECT

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The 2005-2008 European project DAISIE (Delivering Alien Invasive Species Inventory in Europe) aimed at delivering the first continental inventory of the alien species of animals and plants already established in Europe. Among the 1541 alien species of terrestrial invertebrates which were noticed, a total of 443 species affect trees and/or shrubs (2 nematodes, 49 mites, 391 insects). The rate of establishment of these species significantly increased during the second half of the 20<sup>th</sup> century, the mean number of species arriving per year during the period 2000-2007 being twice as large as the one observed in the period 1950-1975, with a contribution becoming prevalent of Asia compared to North America.

The trade of ornamental plants, in all its forms (e.g., plants for planting, cut flowers, seeds, bonsais) was also observed to be the dominant way of arrival of the alien species related to trees and shrubs whereas trade of forestry products has only a limited contribution. For the moment, the major part of the invaders have a rather limited distribution, restricted to 1-2 European countries, and stay in habitats related to human activities in urban and semi-urban areas, especially in parks, gardens and hedges along the roads, rather than in forests. However, it cannot be excluded that the present situation only correspond to the time lag necessary for the invader populations to build up before invading natural habitats. In addition, near half of the species only attack exotic trees planted in Europe, usually their original host. Broad-leaved trees, fruit trees and conifers are the most colonized groups but an unexpected large representation of tropical trees, especially palms, eucalyptus, and acacias, was noticed. It is expected that global warming will trigger this process.

A comparison of the relative representation of the families within the established alien fauna with that observed in the interceptions by quarantine services revealed large discrepancies. Hemipterans, followed by coleopterans, largely dominate the invaders. Aphididae and Diaspididae are the families with the most important number of invaders related to trees and shrubs but species of these two families were very little intercepted, only few of them having been included in the quarantine lists in Europe. Another comparison of the relative representation of the insect orders in the native and alien entomofauna in Europe also indicated a significant over-representation of the hemipterans in the alien entomofauna whilst hymenopterans and lepidopterans appeared under-represented. As a result, the invader guilds mainly consist of sucking insects, their number being roughly equal to the total number of xylophagous species, external defoliators, leaf-miners and seed insects. A deeper analysis including a comparison of the biological traits susceptible to facilitate the establishment of these alien species is under process.

## PEST RISK ANALYSIS & CHALLENGES IN PLANTS FOR PLANTING PATHWAY

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The import and export of plant material is very important to New Zealand, but there are also significant risks to New Zealand's economy and environment from importing plants for planting. The entry of plants for planting into New Zealand requires an import health standard (IHS) in accordance with the Biosecurity Act 1993. Risk analysis underpinning the development of IHS is used as a decision making tool to effectively manage the biosecurity risk associated with the entry of plants for planting into New Zealand.

Pest risk analysis for plants for planting pathway is a complex task due to the uncertainties in available scientific information on biology of hazardous organisms, potential hosts, potential impact, and efficacy of risk management measures.

Many risk management measures used in plants for planting pathway are designed for pest management and using these for quarantine purposes is a significant challenge. The interception of *Fusarium circinatum* on imported Scion of Douglas Fir in a Quarantine facility in New Zealand demonstrated that the declaration of area freedom for certain diseases could be less reliable when there are symptomless hosts.

Interception data are widely used as an indication for efficacy of risk management measures for pathways such as fresh produce. However they may not always draw a true picture of the management of associated risk of plants for planting pathway as many viruses, fungi and bacteria can be difficult to detect visually and some could be latent for several years.

The presentation discusses the lessons learned from recent risk analyses conducted by MAF Biosecurity New Zealand and analysis of interception data on plants for planting pathway.

## **A PILOT SYSTEM TO SHARE INVASIVE SPECIES CHECKLIST INFORMATION GLOBALLY THROUGH THE GLOBAL INVASIVE SPECIES INFORMATION NETWORK**

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The sharing of standardized invasive alien species (IAS) information is vital to enable the coordination of efforts to control invasions. The Global Invasive Species Information Network (GISIN) is a collaboration of like-minded invasive species information managers interested in sharing data globally. A working group was formed in 2004 to create a system to share invasive species checklist information among diverse types of online information systems. To help reach its goals internationally, the GISIN has developed partnerships with the Global Biodiversity Information Facility (GBIF), the Secretariat for the Convention on Biological Diversity (CBD), the Group on Earth Observations (GEO), the US National Biological Information Infrastructure (NBII), the Invasive Species Specialist Group (ISSG), the US National Aeronautics and Space Administration (NASA), the Invasives Information Network of the Inter-American Biodiversity Information Network (I3N), Biodiversity Information Standards (TDWG), CAB International, BioNET-INTERNATIONAL, the Global Invasive Species Programme (GISP), The Polistes Foundation (Discover Life), and other global organizations working with the invasive species issue. The GISIN Steering Committee consists of 11 members from 10 countries: Argentina, Australia, China, Denmark, Germany, Great Britain, Malaysia, Morocco, New Zealand, and the United States.

To facilitate communication among its members and with the interested public, the GISIN has a list serve and a Web site hosted by the NBII at <http://www.gisinetwork.org>, and a Wiki for collaborative discussion and standards development hosted by TDWG at <http://wiki.tdwg.org/twiki/bin/view/InvasiveSpecies/WebHome>. The technical documents concerning the pilot system to share invasive species information is hosted by the National Institute of Invasive Species Science at <http://www.niiss.org/gisin>

GISIN is going to produce:

A central directory for data providers to register their services and consumers to discover what services are available

A Web service protocol for the exchange of standardized data on invasive species, their known locations, their current impacts, etc.

An example of a portal that allows browsing of registered providers

Toolkits to make it easy for most providers to make their data available to the GISIN

A technical web site with documentation, toolkits, and test tools for providers

GISIN members are planning to provide additional value-added products based on GISIN data:

Interactive maps based on data available through GISIN

Predictive models of invasive species distributions

Early response/notification services for new or threatened invasions

A universal register of the names of known IAS with annotations

Global and regional distribution records for some of the worst IAS

## **CERATOCYSTIS PLATANI: AN INVASIVE FUNGAL PATHOGEN THREATENING NATURAL POPULATIONS OF ORIENTAL PLANE IN GREECE**

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Canker stain disease, caused by the fungus *Ceratocystis platani* (Walter) Engelbrecht et Harrington comb. et stat. nov., was first observed in Greece on indigenous oriental plane (*Platanus orientalis* L.) in the fall of 2003. The pathogen is of American origin and was introduced into Europe during WWII. Oriental plane appears to be very susceptible to the disease. The pathogen is spreading in natural stands along streams and rivers of south-western Peloponnese, where thousands of dead and dying infected trees have been observed. Preventive phytosanitary measures have not been applied so far in Greece and the disease is disseminated into new localities by human activities, mainly by terracing machinery and cutting tools. *C. platani* is spreading through a combination of root connections between neighbouring trees, spore transmission in river water and possibly via insect vectors.

At present, however, there is limited knowledge of factors contributing to natural dispersal of *C. platani*. Work currently underway is investigating potential transmission through insect vectors and water pathways. The insect community associated with *P. orientalis* was investigated to determine if any species can act as active or passive vectors of the pathogen. Emphasis was placed on the order Coleoptera. Insects collected during summer 2007 were examined for the presence of the pathogen; *Platypus cylindrus* F. (*Platypodidae*) adults and frass were found to carry *C. platani*. Members of other major Coleoptera families (e.g. *Mycetophagidae*, *Monotomidae*, *Cucujidae*, *Silvanidae*, *Tenebrionidae*, *Nitidulidae*, *Scolytidae*, *Curculionidae*) were also examined as potential vectors.

Enhancing our understanding of the mechanisms of disease transmission in natural stands is of great importance in order to develop effective mitigation strategies. If no action is taken, huge losses are expected in populations of this important and currently abundant riparian tree species, with consequent depletion of biodiversity associated with *P. orientalis* throughout the natural range of the species.

## INVASIVE PATHOGENS, ALTERED FOREST MANAGEMENT REGIMES, AND GLOBAL TRADE: A KNOWLEDGE AND VIGILANCE IMPERATIVE

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Since the advent of anthropogenic influences upon the global forest landscape, many new disturbance regimes including altered fire regimes, global movement of agricultural products, and climate change, have accelerated the evolution and hybridization of forest disease causing organisms. The introduction of non-native fungal species to forest ecosystems can accelerate their spread and therefore increase the probability of hybridization with native pathogens and pose a major risk for negative to international forested resources. The phenomenon that native fungi can hybridize with newly introduced species creating potentially more destructive or adaptive species is being observed more frequently. Global economies, international trade, and efficient transportation have unleashed new issues regarding the movement of pathogens around the world. In many cases, our lack of detailed knowledge about non-native invasive pathogen ecology can become a potential liability. In addition, land management practices such as the exclusion of fire, have inadvertently encouraged the deterioration of forest health. A case in point regarding the global economy and movement of destructive plant pathogens is illustrated by the introduction and spread in the United States of Sudden Oak Death (SOD) caused by *Phytophthora ramorum* Werres, De Cock & Man in't Veld. Once thought of as a relatively unimportant fungus, it has now killed trees in Europe and the western United States, and launched major monitoring programs on several continents. Our research indicated that according to temperature and humidity parameters necessary for SOD infection to occur, the disease could become established in microcosms along the east coast where it has not yet occurred. This potential was not indicated by landscape scale risk maps currently in use. In other cases, diseases, even native ones, can be made worse or can have accelerated spread rates through management practices such as fire reintroduction after long periods of fire exclusion, a noteworthy problem in some fire-dependent ecosystems. Our research found that in fire-dependent longleaf pine ecosystems, for example, fire exclusion caused the build up of organic matter to such a degree that when accidental fire or prescribed fire did occur, pathological problems from opportunistic fungal root pathogen infections vectored by insects occurred.

## **IMPLEMENTATION OF RSPM NO. 24: INTEGRATED PEST RISK MANAGEMENT MEASURES FOR THE IMPORTATION OF PLANTS FOR PLANTING INTO NAPPO COUNTRIES.**

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The Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) Program have undertaken a major revision of Code of Federal Regulation 319.37 that outlines the quarantine requirements that must be met for the importation of plants for planting into the United States. Implementation of a proposal to establish the “Not Authorized Pending Pest Risk Assessment” (NAPPRA) category will eventually result in many more plants for planting not being authorized for importation. We expect to receive many requests to approve new imports which, under the regulations prior to NAPPRA, would have been admissible with no additional analysis or administrative procedures.

International Standards for Phytosanitary Measures no. 14: The Use of Integrated Measures in Systems Approach for Pest Risk Management provides the basis for establishing measures to mitigate the pest risk. A systems approach requires two or more independent measures, and it may also include one or more dependent measures. Systems approaches are advantageous to use because they address variability and uncertainty. APHIS frequently requires the application of systems approaches to manage the pest risk associated with importation of plants and plant products.

In order to manage risk effectively for this new set of anticipated import requests, among other things, APHIS will propose that the exporting country apply a “Regulatory Systems Approach Protocol” (RSAP) as a requirement of entry. An RSAP can be comprised of general and specific requirements, and would be conditional on agreements between the PPQ, the National Plant Protection Organizations (NPPO) of the United States and our trading partners NPPO to address regulated pest risk associated with the plants for planting importation pathway. The RSAP general requirements will be based on the requirements outlined in the North American Plant Protection Organization Regional Standards for Phytosanitary Measures (RSPM) no. 24: Integrated Pest Risk Measures for the Importation of Plants for Planting into NAPPO Member Countries. APHIS anticipates publishing the proposed rule for implementation of this standard in 2009.

General RSAP requirements would stipulate (1) responsibilities of the place of production including the implementation and maintenance of standard operating practices, documentation and record keeping, training, traceability of plant material, internal audits of program; (2) the responsibilities of the exporting NPPO, including administration, oversight and enforcement, and auditing of program; and (3) the responsibilities of PPQ (as the importing NPPO) including auditing, communicating requirements, specifying actions for non-compliance, and notifying the exporting NPPO of non-compliant shipments. Additional pest-specific requirements could be included in an RSAP such as inspection,

treatment, or a combination of measures designed to address risks. For example, pest-specific RSAP measures could include (1) regulated pest-free nuclear mother stock; (2) pesticides and other measures to avoid, exclude or eliminate pests of concern; (3) procedures for pest identification and survey; and (4) good agronomic practices. Although APHIS only establishes mandatory requirements to address the risk associated with regulated pests that may present a risk to American agriculture and the environment, a well-designed systems approach will also manage the risk associated with some pests that are not yet known. APHIS continues to work with international standard-setting bodies to help ensure that standards are developed to enable trading partners to more effectively manage the risk associated with the international movement of plants for planting.

## RECENT RECOGNITION OF *SAWADAEA* POWDERY MILDEW PATHOGENS OF MAPLES AS INVADERS OF NORTH AMERICA

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Powdery mildew pathogens of the genus *Sawadaea* are long-known from East Asia and Europe, but only relatively recently have been recognized in North America. Hosts of *Sawadaea* species are mainly maples (species of *Acer* L.). Likely modes of entry of *Sawadaea* powdery mildew pathogens include both seed and actively growing or dormant trees of European or Asian maple species, which have been repeatedly imported into North America. Introduction might also occur by means of importation of other untreated dead plant material (e.g., logs) that could bear chasmothecia. Chasmothecia of *Sawadaea* species bear simple or dichotomously or trichotomously branched appendages with uncinata to circinate tips. Conidia contain fibrosin bodies, are borne in chains, and both macro- and microconidia are produced. The first published North American report of *S. bicornis* (identified on the basis of morphology) noted its presence on Norway maples (*A. platanoides* L.) in the area of the Idaho-Washington, USA border in 2002. Presence of *S. bicornis* on the native North American tree box elder (*A. negundo* L.) in Wisconsin, USA in 2007 was supported on the basis of nuclear rDNA ITS sequence comparison. Occurrence of the very similar species *S. tulasnei* was reported in 2005, based on results of ITS sequence comparisons made in a taxonomic study including specimens from unidentified *Acer* sp. or *A. platanoides* collected in New York and Ohio, USA and Montreal, Canada. *Sawadaea tulasnei* also has been noted in disease reports (with identification supported by ITS data) of specimens from *A. platanoides* collected in New York in 2003 and 2005 and specimens collected in Wisconsin in 2007. An unidentified *Sawadaea* species also has been reported from California, USA. The currently known geographic ranges of *S. bicornis* and *S. tulasnei* in North America are discontinuous and quite limited. These known ranges are likely to expand greatly, however, as recognition of these fungi increases and as they continue to spread naturally or through movement of plant material. The discoveries of *S. bicornis* and *S. tulasnei* on this continent should prompt investigation of their North American host range and their potential to cause severe damage.

## LEAPING BORDERS AND CROSSING COUNTY LINES: EXPLANATIONS FOR INVASION AND SPREAD OF *SIROCOCCUS CONIGENUS* IN NORTH AMERICAN FORESTS

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The fungus *Sirococcus conigenus* (DC.) P. F. Cannon & Minter causes shoot blight of pines, spruces, and some other conifers in both Europe and North America. This fungus abundantly sporulates on shoots it has colonized and killed and on cones. It can be seedborne, can be transmitted from seed coats to infect emerging seedlings, and can persist on or in asymptomatic shoots. Although widespread in North America, its known distribution there is discontinuous and likely incomplete. Discovery of the pathogen in North America occurred long after its recognition in Europe, and analyses of molecular markers do not allow differentiation of strains based on continent of origin. Nurseries are among likely points of introduction of *S. conigenus* into North America. First reported in the USA in 1914, the fungus was identified on diseased Norway spruce (*Picea abies* (L.) H. Karst) seedlings from the Biltmore Nursery in North Carolina, where other European hosts of this pathogen also were grown. Its discovery in the northcentral USA where native red pine (*Pinus resinosa* Aiton) can be severely damaged was in the northern Wisconsin county where that state's first forest tree nursery (to which seeds of European conifer hosts were imported) was located. In addition to subsequent distribution on nursery stock, current and proposed forest management practices in the north central region favor the increase in geographic distribution of this fungus and may increase incidence and severity of *Sirococcus* shoot blight damage. In the past, red pine has typically been artificially regenerated by planting seedlings following clearcut harvesting. Current and proposed practices, however, include retention of residual trees in harvested areas and development of all-aged or multicohort red pine stands. These practices provide overstory trees that can be a source of inoculum for subsequent disease development, and may be at least in part responsible for recent expansion of the known geographic range of this fungus in Wisconsin. Thus, unknowing introduction by our predecessors and present day provision of conditions that enhance pathogen dissemination and disease development may help explain the emergence of *S. conigenus* as a conifer pathogen in North America.

# **THE ROLE OF GHANA'S NATIONAL PLANT PROTECTION ORGANIZATION IN MANAGING INVASIVE ALIEN SPECIES IN INTERNATIONAL TRADE**

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Invasive alien species pose a serious threat to agriculture, forestry and water bodies in Ghana. Many of these species are plant pests and the prevention of their introduction and spread in international trade is the mandate of the National Plant Protection Service. However, it is recognized that the Convention on Biological Diversity (CBD), which was adopted in 1992, incorporates provisions on alien species which threaten ecosystems, habitats and species. This paper explains the crucial role that the Plant Protection and Regulatory Services Directorate (PPRSD) plays within existing legislative and regulatory frameworks in managing invasive alien species in international trade whilst avoiding any conflicts with the CBD. In addition, the paper describes which legislative and regulatory frameworks require updating in order to harmonize them with international agreements.

## **EXPLOITING ALLEE DYNAMICS IN THE MANAGEMENT OF BIOLOGICAL INVASIONS**

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In many low-density populations, survival and reproduction are limited by the lack of conspecifics, resulting in population decline. Certain processes could lead to decreasing net population growth with decreasing density, and thus, there often exists a threshold below which low-density populations are driven toward extinction. This phenomenon is known as the Allee effect, which has been critical in our understanding of extinction in low-density populations of rare and endangered species and therefore, is highly relevant in conservation efforts. However, because of their role in low-density populations, Allee effects have been recognized to be important during the establishment of invasive species since most founder populations of introduced species are generally also at low densities. Moreover, in established species, range expansion occurs when new colonies are introduced outside of the organism's current range, and also can be at low densities and thus subject to Allee dynamics.

Given the importance of Allee dynamics during the establishment and spread of non-native invasive species, Allee effects could be manipulated to manage biological invasions. Specifically, by strengthening Allee effects, low-density populations of invaders could be driven to extinction without further management intervention, defying the notion that eradication can only be achieved by killing all individuals. In this paper, we will review the role of Allee effects specifically in biological invasions; outline management techniques, such as mating disruption from the context of its manipulation of the Allee threshold to manage invasions; suggest other approaches for the manipulation of Allee effects that could be used to manage invading species, such as through the chemical enhancement of host plant defense or natural enemy enrichment that could render species establishment less likely; and argue that risk assessments and the management of invasion pathways should consider Allee effects (i.e., arriving species beset by strong Allee effects are less likely to become established). Exploiting species-specific characteristics that influence the strength of the Allee effect could facilitate the development of improved management strategies and risk assessments.

## **PROVING THAT A PEST IS/ISN'T ERADICATED OR CAN/CAN'T SPREAD OUT OF THE WOOD**

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Governments around the world are putting significant efforts in to preventing the export, import and establishment of alien invasive species. New treatments, alternative to ISPM No 15 registered treatments, are being actively sought. However, these efforts are hampered by the absence of international guidelines on the type and quality of data required to support the acceptance of alternative phytosanitary treatment methods. Generated data need to address the concerns of regulating bodies, yet at the same time not be so onerous that they will unjustifiably impede trade. It is important that these discussions are done on the international level so that the experimental approach and generated data are accepted worldwide. A clear and timely guide on these issues is essential and urgently needed for researchers that are currently developing or planning to develop these data. This paper encourages any further discussion and input that might help this process.

There are several unresolved questions on the type of data required to support alternative phytosanitary treatments for wood products. These include pest selection, replication required for statistical reliability, and the appropriate use of lab vs. field test data. This paper gives a historical background on treatment efficacy, in particular using an example of the development of the 56/30 heat treatment schedule to eradicate Pine Wood Nematode and its vectors. It will discuss current trends and approaches that have been discussed at recent IFQRG meetings and addressed through work of IPPC's Technical Panels on Phytosanitary Treatments (TPPT) and Forest Quarantine (TPFQ) that have been setting the criteria for testing alternative treatments.

## IDENTIFICATION OF MECHANISMS AND GENETIC MARKERS OF ASH RESISTANCE TO THE EMERALD ASH BORER

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The ultimate goal of our research on ash / EAB interactions is to develop ash trees that are resistant to EAB and that can be used to replant urban and natural forests in Ohio and elsewhere. In support of this goal, the central objective of our investigations is to identify specific mechanisms and genes that are responsible for resistance and develop them as genetic markers for targeted and accelerated breeding and selection programs. Our working hypothesis is that Manchurian ash is resistant because of specific, constitutive (static) and inducible (active) defenses selected over its co-evolutionary history with EAB. To test this hypothesis, we are attempting to (1) identify genes associated with constitutive resistance to EAB and (2) characterize secondary metabolic and defense protein induced responses in resistant and susceptible ash.

We are pursuing the first objective by using a proteomics approach to identify genes that are constitutively over-expressed in Manchurian ash (a known resistant species), or that are present in Manchurian ash but not in susceptible North American (NA) ashes.

The second objective is predicated on the assumption that soluble phloem phenolics and defense proteins are involved, at least partially, in resistance to EAB. This objective will be achieved by using MeJA (a phytohormone known to have a central role in mediation of host defense responses by insect attack) as a tool to induce and study host defense responses, specifically accumulation of bioactive phenolics and defense proteins in Manchurian and NA ashes. Any phenolics and defense proteins that are inducible by MeJA will likely have an effect on resistance of ash to EAB.

Identification of resistance genes and mechanisms, and subsequent development of genetic markers, will facilitate screening, selection, and/or breeding of resistant trees. Resistant genotypes will be critical for long-term reforestation and preservation of ash in forests, woodlots, and cities, if the eradication efforts are ultimately unsuccessful.

## **SPATIAL STOCHASTIC MODELING TO MAP INTRODUCTION AND SPREAD RISKS FOR INVASIVE SPECIES: CONCEPTS AND DATA NEEDS**

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Risk assessments associated with non-native invasive species are considered an important supporting component for decisions about control and mitigation policies and in developing regulatory actions aimed to contain the spread of the invasive organisms. Though broadly recognized, the risks and uncertainties associated with the introduction and spread of pests are difficult to quantify as they involve interactions between numerous biophysical and economic factors such as entry with tradable goods, establishment and spread across North-American landscapes. These interactions occur across a range of spatial and temporal scales, further complicating the calculation of risk and uncertainty estimates.

By way of a forestry example using *Sirex noctilio* Fabricius, we present the concept of using integrated stochastic simulation models to map the potential hazards and uncertainties associated with the potential introduction of invasive species at major ports of entry, and their spread through North American landscapes. The model simulates three basic stochastic processes: new entries based on recent data on marine shipments from countries where invading organisms are native, as well as the longer-term dynamics of foreign marine imports. The second process recreates the establishment of invading organism based on the geographical distribution of host species, their susceptibility and the infestation potential; and the third simulates the spread and movement of invading organism across North American landscapes.

Through Monte-Carlo replications, the approach provides a spatial representation of risks and uncertainties as a single mapped product. The integrated nature of the stochastic model also allows for testing the importance of key assumptions about invading organism via sensitivity analyses. Our effort has the advantage of accounting for existing and projected flows and geographical patterns of tradable goods and hence could help with prioritizing future inspection and mitigation efforts.

## USING BIOECONOMIC MODELLING TOOLS TO ASSESS THE IMPACT OF INVASIVE SPECIES ON FOREST'S WOOD SUPPLY: A *SIREX NOCTILIO* CASE STUDY IN EASTERN CANADA

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Invasive species are widely recognized as having potentially far reaching consequences on forest industry and forestry-oriented communities. Though easily acknowledged, these impacts are hard to quantify as they arise from interactions between the spread of invasion, impacts on standing trees, ongoing forest management activities and will follow large and small-scale mitigation efforts.

Our study presents an integrated modelling framework for impact assessment of a new alien species on wood supply and harvests. We evaluate the impact of *Sirex noctilio* Fabricius on pine wood supply and harvest activities in eastern Canada. We integrate the introduction potential and spread of *S. noctilio* with a forest biomass growth and heuristic harvest allocation model to generate the estimates of spread and impact on pine resources and harvests. We use this stochastic model to estimate the potential impacts of invasion on regional wood supply and also explore the idea of using infringements on the annual allowable cut (AAC; the annual harvest target specified by Provincial land management agencies) for assessments of the threat of *S. noctilio* to Canada's forest sector.

The net present value projections of total harvest losses after 28 years of outbreak could be between \$B 0.7 and \$B2.1 depending on the assumptions about *S. noctilio* behaviour in Canadian landscapes. The results also identify the minimum area of infestation that may trigger wood supply failures (approximately 12.5-14 M ha of pine forests in Ontario and Quebec). Beyond that point, the area of "harvest failure" grows rapidly. The period between the first detection of *S. noctilio* in a given forest management region and the beginning of harvest shortages is estimated to be between 8 and 15 years and largely depends on the detection accuracy of new *Sirex noctilio* infestations.

This approach should be appealing to forestry decision makers as it provide an integrated overview of the potential impacts and helps better understand the implications of large-scale changes caused by invasions by giving some indication of when and where it might occur. Regulatory agencies may also use the information to design more effective regulatory policies. Future efforts will aim to improve the relevant data and apply the approach to other alien species problems.

should be appealing to policymakers, especially since it begins to account for existing and projected flows of tradable commodities and could help with prioritizing future inspection and mitigation efforts.