TRADE AND INVASIVE SPECIES IN THE CARIBBEAN:

a Universe of Risk

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This report is made possible through the generous support of the USDA Forest Service International Programs office. Its purpose is to review the potential risk of introductions of invasive species through trade related pathways in the insular Caribbean, with a particular emphasis on larger islands and on the potential impacts of trade-related introductions of invasives on forests.

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Disclaimer

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Introduction

The New World's first documented environmental crises involved invasive species in the Caribbean (Harvard University 2005). Two ant plagues brought widespread crop destruction. The first was on the island of Hispaniola in 1518-19. The second, in the Lesser Antilles between 1760 and 1770, decimated Barbados' valuable sugar plantations. Professor E. O. Wilson and colleagues have concluded that the former was due a South American fire ant, and the latter an African ant invader. Because neither ant attacks crops, another species must also have been involved; Wilson believes that sap-sucking insects with symbiotic relationships with ants were involved. Today it is not possible to identify the mysterious symbiotic insect, but Wilson may have identified its pathway to introduction; plantains shipped to Caribbean plantations from the Canary Islands.

The Caribbean islands provided an early foothold for Old World colonists in the New World; they were defensible, and they were profitable, especially with forced labor from enslaved indigenous people and African captives. As Europeans colonized the New World, the Caribbean became the center of a global trade linking Spanish Pacific trade, European and African trade. It is not surprising then to know that biological invasions have played a role in shaping the Caribbean landscape for many hundred years. And these invasions continue today.

While the Caribbean isn't the strategic hub for global commerce that it was in the colonial era, it is the hub for the largest industry on the planet, the travel and tourism trade. Provision of amenities for tourism drives much of the commodity trade in the region.

Today, cheaper and more efficient shipping and improved communications technologies have led to a surge in global trade. During the past 50 years the growth in air travel passenger numbers increased approximately 9% per annum. Since 1993, global shipping traffic has increased by 27%. In addition, agricultural trade has increased in volume from USD$ 558 billion in 2001 to USD$ 674 billion in 2003, according to the WTO. This has been accompanied by demands to regularize governance of international trade through trade agreements. Trade agreements have become the subject of controversy for many reasons, including the perception that they require that social and environmental protection be reduced or eliminated as barriers to trade.

One clear risk of increased international trade is that of human-mediated biological invasion. Invasive species undermine human health and security and economic development either directly (e.g., through damage to economically important crop or forest species) or indirectly, through the disruption of ecosystem services. Their impacts pose significant risks to human well-being. Of the many pathways for the introduction of invasive species there is a subset[1] that is distinctly linked to trade, such as accidental introduction via ballast water, hull fouling, or contamination of cargo.

The expansion of air travel and seaborne trade overcomes geographic barriers to organisms, enabling them to move great distances in short periods of time. These organisms include agricultural pests and diseases, their vectors, and invasive species injurious to agriculture and human health to ecosystems and environmental services. They may be bacterial, viral, or mycological organisms as well as flora and fauna. They may be present not only in raw and processed commodities, but also in manufactured goods and in packing materials.

Such invasions constitute a "hidden cost" of international trade, and one that is a serious risk to economic, as well as ecological health, of all nations, developed and developing.

This report represents the preliminary steps in a "first cut" analysis of pathways to human-mediated introductions of invasive species in the Caribbean. Its objective is triage, the identification of pathways of high risk for purposes of discussing regional cooperation in capacity building. It is not intended to be a comprehensive study, and has significant gaps. For example, ballast water and hull fouling are not addressed in this report. Aquatic invasive species are almost certainly underrepresented in the available data. Microorganisms are also not addressed, although pathways for the introduction of diseases to plants, animals and humans are a critical component of any comprehensive biosecurity portfolio. Mechanisms for plant, animal, and human health have evolved separately from those for commerce and for environmental protection. Different data sets are used, and different ministries have the responsibility for their management. This is unfortunate because invasive species can be hosts for non-native microorganisms as well, some of which may be pathogens. Media for packing live plants and animals may also be vectors for invasives. Significant additional work is required before a

1 In this report, tourism is considered an aspect of trade, in the form of travel services.

comprehensive strategy for biosecurity can be put in place in any country, much more so a region.

The objective of this report is to suggest priority areas for international cooperation in the management of risk from invasive species introductions via trade-related pathways in the Caribbean; further work will be required to develop second cut analysis (detailed single pathway descriptions) and third-cut analysis (determination of scope and level of threat) (Kreish et al, 2007).





Definitions

Caribbean: For purposes of this report the Caribbean is comprised of the insular nations located within the chain of islands surrounding the Caribbean Sea, together with the Bahamas. Overseas territories and dependencies of France, the United States, the United Kingdom and the Netherlands are not addressed, nor is the wider Caribbean region incorporating the continental fringes of the Caribbean basin.

Invasive species: a non-native (alien) species that causes or has the potential to cause harm to the environment, economy, or human health (IUCN, 2000, US Executive Order 13112; Federal Register 1999).

Propagule pressure (also termed "introduction effort") is a composite measure of the number of individual organisms (and/or their reproductive units, e.g., seeds) released into an ecosystem to which they are not native. It incorporates estimates of the absolute number of individuals involved in any one release event (propagule size) and the number of discrete release events (propagule number). (Lockwood et al. 2005) (Reaser and Waugh, 2007)

Tourism: for purposes of this report, tourism is treated as an element of international trade, in the form of "travel services" which includes transportation, lodging, and amenities.

Trade: for purposes of this article, trade is the exchange of goods and services between sovereign states. A free trade agreement is a binding policy established between states (bilateral) or among states (multilateral) that enables an exchange of goods and services between parties unhindered by government restrictions, such as protective customs tariffs and non-tariff barriers such as quotas and restrictions. National measures to prevent the introduction of pests and invasive species may be interpreted as technical barriers to trade if they are not consistent with the World Trade Organization (WTO)'s Agreement on the Application of Sanitary and Phytosanitary Measures (SPS). SPS rules are controversial because they restrict the ability of States to prevent the introduction of species already known to occur within their boundaries, thus restricting efforts to control propagule pressure (q.v.).





Background

The antecedent of this report is a study by IUCN produced with the support of the US Environmental Protection Agency entitled Denying Entry: Opportunities to Build Capacity to Prevent the Introduction of Invasive Species and Improve Biosecurity at US Ports produced in 2007. That study addressed gaps in the US government's knowledge of the role that trade has played in the introduction of invasive species into the US. It concluded not only that there were significant gaps in the documentation of trade necessary to assess risk, but also that capacity was seriously impaired by a range of factors, not least of which was inadequate technical capacity at the ports, stemming in part from poor (or nonexistent) communication with other relevant authorities. This included poor communication within the inspection services, poor communication between the inspection services and other agencies with technical roles, and with other authorities in the chain of custody of people, goods and materiel entering US ports. These constraints hinder early detection and rapid response, and therefore interfere with the implementation of an effective biosecurity strategy. Experts agree that prevention measures are in principle[2] more effective than eradication measures, and that the prevention of invasive species introductions through ever-increasing international trade must become a public policy priority.

IUCN's report on assessing risk provided a series of recommendations to the US government to strengthen its capacity manage risk of invasive species introductions via trade-related pathways (Reaser and Waugh, 2007), including:

- Developing a comprehensive interagency biosecurity strategy, including early detection and rapid response, and a crosscut budget to support its implementation
- Developing a clearinghouse mechanism and learning network improve knowledge concerning invasive species and their pathways to introduction.

2 There is mounting concern that regulatory exclusion, the banning of organisms and regulation of common vectors through inspection and quarantine, has not been effective due to the gaps detailed here. In addition, it is impossible to exclude every potential invader; several organisms in recent years were not even known to science prior to introduction. Effective monitoring, early detection and rapid response must complement regulatory exclusion.

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- Developing interoperable databases for use by the dozen or so federal agencies with a mandate to inspect trade pathways
- Conducting a thorough inter-agency needs assessment
- Establishing science and risk-based sampling protocols
- Enacting peer review processes

In 2007 The USDA Forest Service's International Programs Office asked IUCN to review the management of trade-related pathways for invasives introductions in the Caribbean. In the Caribbean, extreme weather events are likely to intensify as a result of global climate change; this is likely to lead to greater levels of disturbance and opportunities for colonization of disturbed sites, bringing greater challenges for the management of the remaining forests of the region. This report reflects the logical next step in the process of beginning to assess the capacities to address invasive species issues among trading partners, with a view to identifying potential synergies that would give trade a proactive role in biosecurity. It is a preliminary step in a much longer-term discussion on how trading partners can work together to mutually improve biosecurity and thereby take an important step towards the harmonization of international trade and sustainable development policy.

Biosecurity and Pathways to Introduction

Biosecurity is the condition of being free from biological harm. The practice of biosecurity consists of the measures and plans undertaken to protect human, animal, and environmental health against biological threats. Biological threats encompass health risks (e.g., pathogens and their vectors), economic risks (e.g., invasive, pest and weed species, plant and animal pathogens), and ecological risks (e.g., invasive species, injurious wildlife as defined under the Lacey Act). Biosecurity is the sum of risk management practices in defense against biological threats. (NASDA 2001, Reaser and Waugh 2007).

Biological threats are generally classified according to whether the impacts are ecological, medical, or economic in nature. Hence, in most countries, there will be a public health authority and plant and animal quarantine authorities responsible for sanitary and phytosanitary enforcement linked primarily to agricultural health. Sanitary/phytosanitary measures differ in emphasis from the ecological measures, e.g. those called for by the Convention on Biological Diversity (Young, 2006). None of the sovereign Caribbean states has comprehensive legislation to address invasive species (Kairo et al 2003). And the absence of a unifying national policy on biosecurity is universal in the region, and with only a few exceptions, is the case worldwide.

There are several reasons why biosecurity measures require a unified policy. The first is structural; organisms are often vectors of other organisms. Plants and animals may carry diseases; the medium they travel in can also be a vector. An example would be potting material. A second reason is managerial, and concerns the nature of pathways for introduction. Trade related pathways are the major avenues for accidental introductions of invasive species. A wide range of agencies may have some jurisdiction over trade pathways, including those concerned with food safety, counter-terrorism, customs and excise, and transportation. These agencies will compete for their share of the national budget. As competitors, and absent an overriding national policy, they will lack the incentive to share information, and are liable to duplicate efforts. And without a crosscutting national budget, agencies will be penalized the costs of collaboration, meaning that the mandate to coordinate in the implementation of a comprehensive biosecurity policy will come at the expense of their unique responsibilities.

Increasingly, governments are turning their attention to the ecological dimensions of biosecurity due to the mounting evidence of economic risks. Estimates of invasive species costs vary widely. The US Office of Technology Assessment (1993) estimated the cumulative costs of invasive species in the USA from 1906-1991 to be $US 131-185 billion dollars. Pimentel et al (2005) estimated the costs to be $US 120 billion per annum. Both of these estimates are anecdotal, and cover only direct costs; neither reflects impacts on ecosystem services. Neither was comprehensive in treatment of invasives. Nor do they account for potential benefits from invasive species.

The management and control of invasive species is a public good. To the extent that invasive species disrupt ecosystem functions or degrade biodiversity they impact upon the commons, and therefore require a cooperative public response. Although private benefits may be captured in market prices, markets generally fail to accommodate the risks posed by invasive species (Perrings 2002). A precautionary approach is therefore indicated where biological invasions are human-mediated, e.g., through transportation.

Biological invasion can be a function of several factors. There is for example the example of range extension induced by external factors such as climate. There is ample evidence of the role of multidecadal climate variability for example in structuring plant communities (see, e.g., Gray et al 2006), and across natural systems (Parmesan and Yohe 2003). Multidecadal change in climate does occur, and can result in displacement of species. One can debate whether displacement as a result of anthropogenic climate change is "natural." Notwithstanding the barriers posed by islands, such displacement has and will occur, and a case can be made this is a reflection of a stochastic character in biological communities and species life histories. Maintenance of stable, if not static, communities if a dynamic world may not be realistic, even if desirable.

In contrast to the distribution of species via natural forces is the human-mediated distribution of species, which is the subject of this paper. This distribution occurs through a variety of pathways, including intentional introduction for economic (e.g., aquaculture, agriculture, forestry) or aesthetic reasons (e.g. pets, sport, and horticulture), and unintentional introduction (e.g., "hitchhikers" on cargoes and conveyances).

Globalization is increasing the numbers and rate of exchange of invasive species (McNeely et al, 2001, Wittenberg and Cock 2001, Burgiel et al,

2006). Major pathways of biological invasion associated with globalization include ballast water, hull fouling, food supply, and aesthetics (e.g., ornamental plants and animals) (Ruiz and Carlton 2004). Stanaway et al (2001) found in a survey of 3001 empty sea cargo containers in Tasmania, over 30% contained living or dead insects, some of which were eligible for quarantine, including timber pests. Another important pathway is solid wood packing material. Fifty-two percent of maritime shipments to the USA include solid wood packing material; nine percent of the packing material in maritime shipments included bark. Solid wood packing material is generally associated with forest insects and pathogens with life histories involving tree-trunks (Cock, 2003).

Typically, regulatory exclusion targets individual species already known to be invasive or pathogenic. In trade, inspection is conducted to detect prohibited (black-listed) organisms, which when found, will be quarantined, and the vector will either be treated, destroyed, or rejected from admittance into a country (Reaser and Waugh, 2007) Another approach is to target pathways (e.g., to fumigate produce, or to require treatment of ballast water). This is deemed a more comprehensive approach than targeting individual species because it can be deployed strategically, and can address organisms not prohibited by regulation (Cock, 2003). Exclusion requires significantly more resources than are generally available to most inspection and quarantine authorities. Efficient use of resources requires a combination of regulatory exclusion methods plus early detection and rapid response measures at key points along a pathway, such as port facilities. Logically, early detection should involve communication along the pathway, following the chain of custody of both conveyance and cargo. International cooperation, including financial and technical assistance, to interdict invasive species would be in the self-interest of donor countries. “Because every nation is an exporter and importer of goods and services, every national is also a facilitator and victim….Wealthy nations therefore need to help raise the capacity of island nations and territories to minimize the spread and impact of IAS.” (Reaser et al 2007).

Invasive species are leading drivers of biodiversity loss and environmental change and they are impacting ecotourism and agritourism.

Invasive species are a factor in the deteriorating food security of the Caribbean. Since 1995 poverty levels have increased, while traditional exports have declined, and food imports have increased.

Source- Report of Facilitating Safer US -Caribbean Trade Invasive Species Issues Workshop, Caribbean Invasive Species Working Group, Trinidad, June 2004

Invasive Species in the Caribbean

Island ecosystems are geographically isolated and island species are therefore evolutionarily isolated. Islands therefore tend to have specialized, limited species assemblages featuring high numbers of endemics, if only limited diversity. They are particularly vulnerable to impacts of invasive species for a range of possible reasons (Kairo et al 2003). In the Caribbean, island ecosystems are characterized by resilience in the face of extreme weather events, including both droughts and hurricanes.

Islands have long been known to be under threat from invasives (Donlan et al 2003), and to have more invasives than comparable mainland sites (Lonsdale 1999). The United Nations Environment Programme (UNEP) estimates that invasive species represent a major factor in the potential extinction of 30% of threatened bird species, and 15% of threatened plant species. Invasive species are considered to be the greatest threat to biodiversity in geographically and evolutionarily isolated island ecosystems (Kairo et al 2003).

Human transportation of species onto islands breaches the ecological barrier provided by the sea (Clout and Veitch, 2002a). This has resulted in extinctions and dramatic alterations in ecological community structure and function, including to ecosystem services. Changes in climate and land use are rendering island habitats even more susceptible to biological invasion (Mooney and Hobbs 2000). Reaser et al (2007) argue that the proportionately greater impact that invasives can have on isolated island ecosystems makes them more vulnerable than equally susceptible continental land areas.

Factors influencing the spread of invasives onto Caribbean islands include dependency upon imported trade, especially in fresh food and living plants and animals, a high degree of exposure to extreme weather events, and the biological isolation of the islands that results in limited exposure to biological competition or predation (e.g., vulnerable bird and plant communities).

The impact of invasive species on islands is high and is growing higher. The rate of biological invasions is at an all time high (Mack et al 2000), with potentially severe consequences for small-island developing states (UN 2003).

Ecological resilience, the ability of an ecosystem to withstand disturbance without losing its self-organizing capacity (Walker 2004) is at risk due to invasive species. In the Caribbean, ecosystems are adapted to extreme weather events, including periodic droughts and cyclonic storms. The loss of biodiversity in island ecosystems, which is due in large measure to invasive species (Clout and Veitch 2002b), erodes resilience, impacting ecosystem services. Because natural disasters are a defining feature of Caribbean life, the loss of resilience is significant.

Invasives can impact directly upon individual species within an ecosystem (e.g., through predation or competition). Invasives can also affect plant communities by reducing the abundance of a given species, changing the overall composition of species and vegetation structure, and altering the way those species interact within an assemblage (Reaser et al 2007). Disturbances facilitate biological invasions, and invasions can create disturbance feedback loops that further destabilize ecosystems. This can occur through poorly or differently adapted organisms, such as fire adapted or pyrophitic plants that introduce a new disturbance regime into an ecosystem, or through changes in land cover due to an invasive species that is vulnerable to extreme weather events such as floods, droughts or storms, leading to further disturbance (*Miconia calvescens*, for example, an aggressive forest invader in the central Pacific, has shallow roots and is prone to landslides when it colonizes the typically steep slopes of oceanic islands, creating further disturbance. Allelopathic *Casurina equisetifolia* have transformed coastlines around the world by suppressing native vegetation, resulting in increased susceptibility to coastal erosion and thence the risk further disturbance. Feedback loops can also occur through disturbance producing behaviors of animals, such as the rooting behavior of feral pigs, which exposes soil creating new opportunities for plant invasions.

The Caribbean region is a global biodiversity "hotspot" (Myers et al., 2000), supporting nearly 7000 species of endemic plants and 779 endemic vertebrates[3]. There is a long history of species extinctions in the Caribbean due directly or indirectly to human activity (67 out of 76 known land mammals have become extinct in the last 20000 years, 37 of which post-date human occupation).

There is also a long history of introductions in the Caribbean. The Indian Mongoose *Herpestes auropunctatus* is among the best known; it was

3 Further information on Caribbean biodiversity is available at: http://www.biodiversityhotspots.org/xp/Hotspots/caribbean/

first introduced in Jamaica in 1872 to control other introduced species (rats) living in sugar cane fields (yet another introduced species). The mongoose has been *implicated* in the extinctions of five endemic species.

Kairo et al (2003) identified a total of 552 alien species in the Caribbean region, including 390 species regarded by at least one authority as naturalized and/or invasive. Many of those identified are also recorded as invasive or naturalized on the North American mainland. Terrestrial species vastly outrank freshwater and marine species in the Kairo study, although the authors caution that there may be under-sampling of marine species. 281 plant species were reported as naturalized or invasive. 179 of these are trees. Some tree species have been identified as being naturalized or invasive in five or more countries, including:

Adenanthere pavonina

Albizia lebbeck

Casuarina equisetifolia

Tabebuia heterophylla

Ziziphus mauritania

Kairo et al stressed the limitations of Caribbean invasive species data. The authors created an invasive species database based upon an extensive effort to compile documentation and personal communications.

The present report also acknowledges data limitations for an assessment of invasive species and their pathways of introduction for the insular Caribbean. The records that exist for the region are incomplete. This report only reviews published sources of information on terrestrial and freshwater aquatic species known to be naturalized or invasive in the insular Caribbean drawn from the Global Invasive Species Database of the IUCN Invasive Species Specialist Group (available at http://www.issg.org), the IABIN I3N lists for the Dominican Republic, the National Biodiversity Strategy and Action Plan for Jamaica, and the Bahamas National Strategy. It is therefore necessarily limited in the conclusions it can draw on the extent of species introductions. Moreover, it is generally difficult to state with certainty the specific pathway of an established species, and often there is more than one plausible pathway. All statements about pathways must be understood to be conjectural, based upon known patterns of use and distribution of plants. The available

information is useful nevertheless, representing a body of knowledge about known invasive species in the Caribbean, and this report does draw some general conclusions.

66% of the plant species (38% of total species) of the 191 species reviewed are linked to horticulture as a probable pathway. Other prominent pathways include agriculture (23% of plant species), pet and aquarium trades (14.6% of all species), aquaculture (21% of animal species), biological controls (11% of all species) and accidental transshipment in trade (hitchhikers) (10% of all species).

Horticulture stands out in this incomplete survey as an important pathway for the introduction of alien species into the insular Caribbean. The point however is not to rank invasive species pathways but to understand them in the context of the environmental and socio-economic context of the region. Later sections will address trends in trade and tourism.

Threats to Caribbean Forests from Invasive Species

Forests of the insular Caribbean cover 5,974,000 hectares, and 26% of the land area[4]. The majority of the regions forests lie in the Greater Antilles nations of Cuba, the Dominican Republic, Jamaica, and the territory of Puerto Rico. The Bahamas and Trinidad and Tobago also have significant forest holdings (FAO 2005). None of the Caribbean states reported insect damage in the national reports for the 2005 Global Forest Assessment.

Significant changes have occurred to Jamaica's forests due to land use/land cover change associated with extractive industries (both forest products and minerals) and agriculture. The deforestation rate is high, ranging from 0.1 to 11.3% per annum. Forest cover is essential in maintaining watersheds, especially for the city of Kingston.

Invasive species impact native forests of the insular Caribbean through disturbance and direct competition. The Blue and John Crow Mountains National Park of Jamaica provides a good case for examining how invasive species affect native forests. According to the National Strategy and Action Plan on Biodiversity in Jamaica (2003), "there are increasing numbers of alien plant species spreading in Jamaica's forests and along riverbanks.

Species of particular concern include the Mock Orange (*Pittosporum undulatum*) and the Wynne Grass (*Melinis minutiflor*a) which are taking over large areas on the disturbed periphery of the Blue and John Crow Mountains National Park and spreading inwards. Wynne Grass prevents the regeneration of forests by competing with tree seedlings for space. Its propensity to ignite and burn increases the potential for bush fires, particularly in the drier months. The Mock Orange is a small, fast growing tree whose seeds are spread by birds. Control programs for these species are urgently needed" (Jamaica 2003).

4 Jamaica reported 31% forest cover to FAO in 2005. FAO reporting does not distinguish between closed forest and and partially forested areas; Jamaica reported to the UNCCD, for example, only 8% closed forest, 30% mixture of forest and cultivation, and 23% other forest.

Disturbance

Feral pigs were introduced throughout the Caribbean in the early years of European settlement, and are now common, for example, in the mountains of Jamaica (Goodland and Healey, 1996). The feeding habits of pigs, involving disturbing top layers of soil to expose food, has been cited as a major factor contributing to the introduction of invasive plants in Hawaii (Stone et al, 1992). Feral pigs may have contributed to the extinction of the ground nesting Black Capped Petrel in the Blue Mountains (Goodland and Healey, 1996).

Hurricanes and other extreme weather events may also be a factor in the introduction of invasive species. The US Global Climate Change Program Report states that "future disturbance impacts are likely to include…epidemic levels of insects and disease." Climate induced disturbances such as fires and drought are likely to create the conditions likely to create the conditions for the invasion and spread of introduced species. Insects and pathogens in particular, by virtue of their mobility and short reproductive cycles, can respond to climate change much more rapidly than trees. In Puerto Rico, possible increases in the frequency or intensity of hurricanes, floods, droughts, and fires could lead to new and greater stresses and drastic changes in forest structure and composition. A computer model run for the Luquillo reserve of Puerto Rico showed that stronger hurricanes could reduce the numbers and health of the trees, and favor the development of fast-growing, short-lived and weedy species, including invasive species. Source: US Global Climate Change Program (2001). Invasive species pose the largest potential risk to management objectives (Blundell et al 2003). Goodland and Healey document repeated mass flowerings of Cinchona abietifolia after hurricanes.

In Jamaica's Blue Mountains, disturbance in the form of plantations and trails created pathways and centers for invasive species colonization. *Pittosporum undulatum*, also known as wild coffee and mock orange, has spread from a naturalized population at the the Cinchona Botanic Gardens in 1883, where it was quickly established, and from other radiation points where it was planted as an ornamental tree species (Goodland and Healey, 1996).

Anecdotal reports suggest that fire is a growing problem in the John Crow and Blue Mountain area, possibly due to drier weather conditions. Disturbances from drought, in addition to severe storms, could create additional opportunities for opportunistic invasions.

Competition

In the Blue and John Crow Mountains, some invasive plants compete with the native forest vegetation. At its area of maximum concentration, *P. undulatum* has a density of over 6000 stems per hectare twice the most dense native species (Goodland and Healey 1996). It advances slowly in undisturbed condition, but becomes dominant after extreme events such as hurricanes. Goodland and Healey found that the linear relationship between the dominance of *P. undulatum* and the density of native seedlings is so clear as to suggest that *P. undulatum* is contributing, if not causing, a major decline in the native seeding layer, reducing the recruitment of even shade-tolerant native species (Goodland and Healey, 1996). Mechanisms for its success as a competitor include shade and allelopathy. They also found that epiphytic plants, a critical element of the forest ecology of the Blue and John Crow Mountains, are much reduced in the crowns of *P. undulatum*.

P. undulatum is a threat to several vascular plant communities of the Blue and John Crow Mountains, including the Mor Ridge forest, an area of high plant endemism.

Hedychium gardneranum or wild ginger, is a shade tolerant rhizomatous herb also introduced through the Cinchona Botanic Gardens. *H. gardneranum* occurs as a dense continuous layer beneath secondary forests covering many hectares (Goodland and Healey, 1996). Because it is rhizomatous, it is almost impossible to eradicate.

Polygonum chinense, or redbush, a gap colonizer, can form dense mats in disturbed areas. The denseness and thickness of the mat it forms suppresses other species. It too was introduced to the Blue Mountains from Cinchona.

Melinis minutiflora (Wynne grass), introduced in Jamaica around 1925, is established by seed, especially in areas that have bur*ned. A pyrophytic species, M. minutiflora* has the potential to transform landscapes as fire becomes more common in the Blue and John Crow Mountains, by out-competing native plants and creating conditions for further fire disturbance. Fire has been proposed as an effective mechanism for the control and removal of *P. undulatum* (Goodland and Healey 1997). This approach should be considered with great caution in view of the risks of *M. Minutiflora* introduction.

Horticulture, Tourism and Invasive Species

The Caribbean hosted 21 million visitors in 2004, the most recent year for which there are complete statistics (CTO, 2008). This represents a 35% increase in a decade, and a staggering 519% increase since 1970. In addition, 19 million cruise ship passengers visited the Caribbean in 2004. Receipts in 2004 topped 21.6 billion dollars.

On average, the tourism industry accounts for seventy percent of gross domestic product per island in the Caribbean (absent Cuba). Fifty-five percent of the Caribbean labor force works in the tourism sector. Between 1992 and 2001, growth in arrivals and in per-capita expenditures have grown by four percent annually (USDA FAS, 2001)

Higher growth is expected to continue in the less expensive tourist destinations such as the Dominican Republic and Jamaica as tourists seek better value. The Dominican Republic's growth in agricultural imports grew 258% between 1990 and 2004 and Jamaica's grew 165% in the same period (source World Trade Organization).

An average of only 12.6% of the land is arable in the Caribbean (and in small islands, considerably less in some cases). Caribbean states find it to be more profitable to develop land for the tourism industry and purchase commodities from abroad. (USDA FAS, 2001) Caribbean states must also source materials for the construction and maintenance of tourism facilities. Imports from the USA, which dominates this market, have grown from 8.7 million dollars in 2001 to 19.45 million dollars in 2007, a 223% increase (USDA FAS BICO 2008).

By all measures, tourism is the dominant economic force in the insular Caribbean. It would be reasonable to expect that tourism would also be a major driver of trade-related introductions in the Caribbean region. The records bear this out, but with a surprising twist. Perhaps because agriculture is so small a part of most Caribbean economies, biosecurity at the borders is relatively lax in comparison with other island tourism destinations. The sheer volume would overwhelm even the best quarantine measures. Few records are available on port interceptions of invasive species, either in the Caribbean or elsewhere.

Examination of the documented invasive species introductions in the region show that there is a correlation with tourism but rather than the insects and plant diseases that would be expected via passengers, the most frequent pathway for introductions is via horticulture. There may be several factors behind the disproportionate number of invasives from horticulture, including under-sampling of non-plant species due to lack of capacity or emphasis and misattribution of pathways. Nevertheless, horticulture is clearly a significant driver of invasive species introductions, and the major consumer of imported horticultural products throughout the region is the tourism industry. Significant additional work will be required to quantify this through second and third cut pathway analysis.

The magnitude of the problem points to the need for early measures to protect Caribbean nature, through proactive engagement with the tourism industry - architects, landscape architects, contractors, landscapers, and nursery vendors, as well as with national inspection and quarantine services, to develop a plan to reduce the risk of introduction. This may involve improved inspection and quarantine practices, cultivation of native species, and reduction in inventory of species known to be highly invasive.

In the US, nurseries engaged in international trade in horticultural products must obtain an export certificate from the US Department of Agriculture's Animal and Plant Health Inspection Service (APHIS). They must also possess a valid USDA General Permit, and if exporting live plants, must obtain a phytosanitary permit from the importing country. (USDA FAS, 2003) In granting an export certificate, the USDA compares the proposed consignment to the importing country's certification and permit requirements. Plants and plan material covered under phytosanitary rules may be subject to sampling, inspecting and testing in advance of shipment

Phytosanitary rules are governed through the International Plant Protection Convention of 1952. The IPPC creates harmonized standards for international trade in plants and plant products and facilitates information exchange between the Parties to the Convention. National plant quarantine officials administer the IPPC at the national level. All the insular Caribbean members are parties to the IPPC.

In most Caribbean islands, live plants comprise the majority of nursery imports. Other common plant products include cuttings and slips, shrubs, trees, bulbs and tubers. Renovation after extreme weather events can cause spikes in demand. The US is the major source of nursery products for insular Caribbean landscaping, as inter-island transpor-

tation is often problematic. Local nurseries often obtain their products from brokers in Florida for resale; major developments, including resorts and golf courses, tend to import directly from the USA.

Table 1
Common Landscape Plants Imported to Anguilla

Species	Common name	Landscape use	Invasive character	Origin
Euphorbia milii	Crown-of-Thorns	ground cover, dwarf shrub	listed as naturalized and/or noxious in Australia	Madagascar
Bougainvillea spp	Dwarf Bougainvillea	shrub, ground cover on banks	not known to be invasive	South America
Nerium oleander	Dwarf Oleander	ornamental plant	invasive	Mediterranean, Southern Asia
Codiaeum variegatum	Petra Croton	shrub	listed as naturalized in Australia, invasive in Galapagos	South and SE Asia
Conocarpus erectus var. sericeus	Silver Buttonwood	small tree	low risk of invasiveness	coastal neotropics and tropical w. Africa
Murraya paniculata 'Lakeview'	Lakeview Jasmine	ornamental tree or hedge	cited as invasive on Florida Exotic Pest Plant Council's 2007 List of Invasive Plant Species	South and SE Asia
Hibiscus rosa-sinensis	Chinese Hibiscus	ornamental shrub	reported as invasive by Florida Exotic Pest Plant Council	East Asia
Lantana camara	Lantana	ground cover, flowering plant	highly invasive	neotropics (native to some Caribbean islands)
Ixora spp	West Indian Jasmine	hedge plant	moderate risk	South Asia
Schefflera actinophylla	Umbrella tree	shrub, tree	highly invasive, cited as invasive on Florida Exotic Pest Plant Council's 2007 List of Invasive Plant Species	Northern Australia and SE New Guinea
Plumbago auriculata	Blue Plumbago	shrub	moderate risk	South Africa
Roystonea spp	Royal Palm	tree	no risk	Caribbean
Wodyetia bifurcata	Foxtail Palm	tree	low risk	NE Australia
Phoenix roebelenii	Pygmy Date Palm	tree	low risk	SE Asia
Phoenix sylvestris	Silver Date Palm	tree	naturalized in Australia	South and SE Asia
Veitchia merrillii	Christmas Palm	tree	low risk	Philippines
Chrysalidocarpus lutescens	Yellow Butterfly Palm	tree	low risk, in Galapagos, Hawaii	Madagascar





Capacities in the Caribbean Region for Managing Risks from Invasive Species Introductions

Kairo et al (2003) reviewed existing plant and animal legislation in the insular Caribbean and concluded that existing law does not provide "the necessary instruments to prevent the introduction, spread, and management of invasive species". The study calls for urgent action to formulate legislation to prevent the introduction of invasive species that is consistent with international standards and conventions including the WTO's SPS Agreement.

The Caribbean is dependent upon imports, and most countries have developed efficient means for handling incoming commodities. For most, customs duties are a key source of government revenues, and tariffs can be high. A few, mainly those with more land area and therefore more agriculture, have erected trade barriers to protect local producers (USDA FAS, 2001). In the main, the emphasis at ports of entry has not been the protection of the Caribbean environment from biological invasions until recent years.

The capacity to tackle invasive species varies considerably within the insular Caribbean, with most countries lacking the capacity to implement and enforce existing regulations (Kairo et al 2003). As the threats are regional in nature a regional response is indicated (Kairo 2000). Some experts are now calling for a precautionary approach to trade in live plants and animals unless or until complete inspections can be implemented to prevent the introduction of exotic species. Such an approach is potentially at loggerheads with the WTO's SPS Agreement, which places the burden of proof on importing countries to demonstrate risk. The SPS agreement also preempts efforts to ban organisms already known to be within the boundaries of the importing state, despite the fact that invasives species control and prevention science calls for the management of propagule pressure, including through reduction of introductions. Congruency of national biosecurity practices with the WTO SPS agreement is essential if national rules are not to be invalidated through WTO challenges.

The South Pacific Regional Environmental Programme (SPREP) provides the most developed model of a regional program (Sherley, 2000). SPREP has undertaken assessments and reviewed legislation. Based upon this work it developed a draft regional strategy in 2000 (Sherley 2000), recognizing key challenges in managing invasive species:

- Inadequate/inaccessible baseline information and information management tools for use in risk assessment and decision-making
- Inadequate mechanisms for regional coordination
- Inadequate attention to invasive species in existing laws, regulations, and policies
- Inadequate enforcement
- Shortage of technically trained personnel
- Inadequate inspection and quarantine infrastructure
- Insufficient funding

SPREP has been slow to implement its invasive species strategy, which remains in draft form at this time (February, 2008), possibly resulting in lost funding opportunities. Similar conditions apply to the insular Caribbean, as well (Kairo et al 2003).

The capacity to inspect and intercept potential invasive species has, with few exceptions, not been particularly strong anywhere, and it certainly has not kept up with the rate of growth in trade. Pimentel et al estimated a partial estimate of the annual cost to the economy from invasive species to exceed 120 billion dollars for the United States alone. The varroa mite (*Varroa destructor*), a serious pest in honeybee hives, has recently invaded New Zealand, expecting to have an economic cost of USD$ 267-602 million. A 1992 report of the Weed Science Society of America estimated that the total cost of invasive weeds was between USD$ 4.5 and USD$ 6.3 billion. In the South Africa Cape Floral Kingdom, the establishment of invasive tree species has decreased water supplies for nearby communities, increased fire hazards, and threaten native biodiversity, justifying government expenditures of USD$40 million per year for a control program (GISP, 2004).

Clearly, the value of global trade must be weighed in the balance between the full costs and benefits. But since the full costs may not be knowable in advance, prophylactic measures are in order to address some of the immediate and indisputable risks. Conspicuous among these are security measures, and significant resources are being invested in many places to ensure the safety of ports from acts of violence, illegal immigration, and contraband substances. Considerably less has been invested in ensuring the safety of ports from biological invasion, with most attention being paid to ballast water, through, for example, the

GEF/UNDP/IMO Global Ballast Water Management Programme.

Inspectors charged with the identification and quarantine of undesirable biological transients are hard-pressed to keep pace with the growing volume and shifting geographic patterns of trade. Even in cases where staffing is adequate, little is available to promote and develop collective knowledge of best practices in the interdiction of transient species.

Where capacity does exist, it tends to focus on phytosanitary issues (e.g. plant pests and diseases), overlooking that the plants being imported may themselves be pests.

Focus on Capacity: Jamaica

The Jamaica National Environment and Planning Agency (NEPA) is the lead government agency with responsibility for the management of biodiversity and natural resources in Jamaica. The responsibility for the protection of crops and livestock from pests and pathogens rests with the Ministry of Agriculture, through the Plant Quarantine Unit and the Veterinary Services Division. PQU and VSD are responsible for the issuance of permits for the import or export of living organisms. Both work collaboratively with NEPA to address quarantine issues involving invasive species. NEPA has convened an Alien Invasive Species Working Group, which consists of individuals with particular knowledge and/or responsibilities for invasive species, from government agencies and from academia.

Jamaica's capacity for regulatory exclusion is limited in two ways – lack of enabling legislation to permit exclusion, and limited capacities. Smaller ports, for example, do not have permanent inspection staff. While there is no dedicated biosecurity inspection undertaken at ports, Customs officials are trained to be aware of potentially banned organisms, and work with the Ministry of Agriculture to identify species found.

However, Jamaica does maximize its existing capacities through interagency cooperation. While there is no dedicated biosecurity inspection undertaken at ports, Customs officials are trained to be aware of potentially banned organisms, and work with the Ministry of Agriculture to identify species found. Both the VSD and PQU seek NEPA's assistance

as it regards importation of plants or animals, and NEPA also seeks technical contributions from VSD and PQU, including for species identification.

Current pathways of concern include smuggling of prohibited species of plants and animals by farmers, collectors, and pet dealers, and tourists. Cruise ships are not inspected for invasive species.

NEPA maintains a network of volunteer Game Wardens with responsibility to assist in the Wild Life Protection Act. In addition, private citizens throughout Jamaica knowledgeable about wildlife advise NEPA of sightings of non-native species. The Agency's enforcement officers also assist in reporting such species when they can be identified. NEPA also implements a Landscape Plan, which involves proactive engagement with developers and tourism facility managers to support and encourage the substitution of exotic species with native species. NEPA works with landscape architects and designers and reviews plant lists for problem species.

A major need is support for eradication of already established invasive species, including the mongoose *Herpestes auropunctatus* and the wild coffee *Pittisporum undulatum*. Achieving control of invasive species infestations will involve additional manpower and training, tools, and enabling legislation to authorize and where necessary enforce removals. The US Forest Service's International Program Office is providing support to the Jamaica Conservation and Development Trust, which co-manages the John Crow and Blue Mountains National Park in *Pittisporum* eradication efforts.

Another need is for improvements in risk assessment in order to better allocate scarce resources.

Jamaica does benefit from regional cooperation, for example through regional training in implementation of the International Plant Protection Convention by the UN Food and Agriculture Organization. Recently, a USDA APHIS team visited Kingston to conduct an in-depth pathway analysis, the results of which will be published later this year.

Focus on Capacity: The Dominican Republic

The Dominican Republic has the highest documented number of invasive species in the insular Caribbean. Unlike most of the insular Caribbean the DR is a exporter of agricultural products, with a growing organics industry. Strong biosecurity measures are considered as important to the economy. The DR also has a strong constituency for biodiversity conservation, including a very active NGO community.

The General Environment and Natural Resources Law of 2000 (64-00) establishes the legal and regulatory framework for environmental protection in the Dominican Republic. Article 144 prohibits the introduction of species that are harmful to natural ecosystems and endemic and native species that are pests, and that are harmful to humans. Article 142 empowers the Secretary of State for Environment and Natural Resources to withhold shipments of wildlife products not in compliance with the Act or with Dominican Republic's responsibilities under international law. Resolution 119/96 prohibits the importation of wild birds that are potential disease risks.

The institutions responsible for the inspection of incoming air and sea cargo for invasive species are la Secretaría de Estado de Medio Ambiente y Recursos Naturales for animals and la Secretaría de Estado de Agricultura for plants. Random inspections of cargo are undertaken, and inspections can also be undertaken upon the request of an importer or exporter. The quarantine laboratories of the respective agencies at the ports of entry maintain data records. The post common interceptions are linked to the pet trade, horticulture, and wood products.

The major needs identified by the authorities are reinforcement of regulatory exclusion mechanisms, increased technical capacities, and the establishment and maintenance of a national invasive species database.

The Dominican Republic is taking measures to address these requirements, including working with the Organization of American States (OAS) to create a national invasives inventory under the OAS/World Bank's InterAmerican Biodiversity Information Network (IABIN). The Direccíon Nacional de Vida Silvestre y Biodiversidad is the lead agency.

As a party to the CAFTA/DR Free Trade Agreement, the Dominican Republic hopes to benefit from capacity building efforts being initiated

by USDA APHIS to address environmental concerns expressed over the accord. As a pilot country for the Caribbean Regional Diagnostic Program of the CISSIP, the Dominican Republic Secretariat of Agriculture is working with the Universities of Florida and Mayaguez (Puerto Rico) to implement the Distance Diagnostic and Identification System, originally developed by the University of Florida for the Florida Plant Diagnostic Network, part of the National Plant Diagnostic Network system in the USA. The objective is to facilitate collaboration between diagnosticians, taxonomists, and management authorities to expedite the identification of potential invasive and pest species. If the program is successful in enhancing screening and monitoring in the Dominican Republic and Puerto Rico, it will be expanded to other nodes in the region.

Priorities Reflected in National Biodiversity Strategies and Action Plans in the Caribbean

The body of obligations under multilateral environment agreements (MEAs) concerning invasive species, plus the decisions of conferences of parties to these agreements, together amount to 432 separate, broadly applicable action items (Waugh, unpublished review). These can be grouped as creation of laws and policies, assessment of risk and status, management measures, economic instruments, outreach, international cooperation, and finance. The extent to which these recommendations are reflected in national law and policy is, of course, variable. Several tools have been developed to clarify priorities multilateral environmental agreements.

The UN Convention on Biological Diversity (CBD) is significant among MEAs as the primary source of guidance on invasive species. Article 8(h) stipulates that:

> "Each Contracting Party shall, as far as possible and as appropriate:
>
> (h) Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species" (UN, 1992).

CBD also stipulates in Article 6 that "each Contracting Party shall, in accordance with its particular conditions and capabilities:

> (a) Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, inter alia, the measures set out in this Convention relevant to the Contracting Party concerned; and
>
> (b) Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies" (UN 1992).

Eight Caribbean island states have produced draft or final National Biodiversity Strategies and Action Plans (NBSAPS). They are:

- Antigua and Barbuda (Antigua and Barbuda 2001)
- The Bahamas (Bahamas 2003)

- Barbados (Barbados 2002)
- Dominica (Dominica 2001)
- Grenada (Grenada 2000)
- Jamaica (Jamaica 2003)
- St. Lucia (St. Lucia 2000)
- Trinidad and Tobago (Trinidad and Tobago 2000)

Of these, seven have listed prevention and/or control of invasive (exotic, alien) species as a national priority, St. Lucia being the sole exception. Trinidad notes that invasive species is a major issue, but indicates that unlike other Caribbean nations invasives have not yet resulted in the extinction of native species.

The Bahamas NBSAP states "alien plants have been introduced with little control -- and a few by accident -- mainly by gardeners and horticulturists. Several are now recognized as serious threats to natural ecosystems and to biodiversity. Tree species, such as *Casuarina, Melaleuca* and *Schinus*, are aggressive invaders of forests, wetlands and disturbed or open sites, displacing native plant species.

Barbados notes, "There is anecdotal evidence … that some exotic plant species may be displacing local species in certain key habitats. In some forested areas, the cultivated Macarthur Palm (*Ptychosperma macarthuri*) seems to be displacing the indigenous Macaw Palm (*Aiphanes minima*) as the dominant understory species. In certain forested gullies, the characteristic shrub layer has been replaced by solid stands of Sweet Lime (*Triphasia trifiolia*) or Mother-in-law's tongue (*Savsevieria hyacinthoides*), both garden escapes."

Dominica indicates in its NBSAP that "storm-resistant" crops have been introduced due to the frequency of extreme weather, which has reduced agrobiodiversity. Jamaica noted a correlation between hurricanes and distribution of non-native species, citing the example of the spread of white-tailed deer (*Odocoileus virginianus*) released from enclosures into the wild during Hurricane Gilbert (1988). Elsewhere are records of *Pittisporum undulatum* dispersal after hurricanes (Goodland and Healey, 1996 and 1997). Dominica warns "an increase in pests and diseases is likely to result from changes in seasonal climate patterns."

Dominica's NBSAP argued that fire-adapted lemon-grass, or vetiver (*Vetiveria zizanioide*s), introduced as a soil conservation measure, quickly became dominant and resulted in "widespread destruction of the dry forest lands on the leeward side of the island." Trinidad and Tobago notes that fire adapted African grass species now dominate the western area of its Northern Range mountains.

Grenada and Jamaica stress the positive aspects of non-native species used in bio-control, or integrated pest management.

Jamaica notes national challenges to addressing invasive species include knowledge gaps, inadequate capacity and financial resources, and gaps in legislation. Antigua's strategy also calls for national legislation. Bahamas and Jamaica's NBSAPs call for risk analysis and contingency planning.

Barbados, Cuba and Jamaica call for improved quarantine measures to reduce the risks from invasive species in their NBSAPS. Cuba stresses improved enforcement.

Regional Cooperation

The diversity of political systems under which various small island states of the Caribbean are administered imparts a level of complexity to regional arrangements (Kairo et al 2003). Reflecting its history, the region includes three major language groupings (Spanish, English and French), and an admixture of national legal traditions based in varying degrees on either English common law or the Napoleonic code. The legal status of the islands varies as well, encompassing independent sovereign states and territories or provinces of France, the United Kingdom, the Netherlands, and the United States. There is also geographic diversity, with significant economic and ecological differences between the major islands of the Greater Antilles, the smaller islands of the Lesser Antilles and the continental extension of Trinidad. This diversity has limited regional cohesion, creating an overlapping matrix of regional economic, governance and technical cooperation arrangements (CARICOM, OECS, Caribbean Environment Programme etc). Regional trade tends to be less inter-island than between individual islands and major trading hubs in North and Central America, and so does not serve as a unifying factor in regional cooperation to the extent that it does in other parts of the world.

Notwithstanding the difficulties of regional engagement, there have

been some promising starts on international collaboration on invasive species in the Caribbean. Annex 3 summarizes existing regional arrangements.

The University of Florida has tracked a surge of invasive species into the state of Florida in the USA from the greater Caribbean region, and initiated technical contacts with counterparts throughout the region. In 1999 it convened an international workshop on mitigating the effects of exotic pests on trade and agriculture, followed in 2003 by a workshop in Grenada on challenges and opportunities in protecting the Caribbean, Latin America, and the United States from invasive species. This led to the formation, under the leadership of the Caribbean Agricultural Research and Development Institute (CARDI) of the Caribbean Invasive Species Working Group (CISWG) and the drafting, at a 2004 workshop in Trinidad and Tobago entitled "Facilitating Safer US-Caribbean Trade: Invasive Species Issues", of the Caribbean Invasive Species Intervention Strategy, CRISIS[5]. The aims of CRISIS are:

- Prevent the introduction of new invasive species
- Reduce the impact and spread of established invasive species
- Develop harmonized policies and regional cooperative frameworks
- Develop and maintain an information network
- Build management and research capacity

CRISIS would be implemented through the Caribbean Invasive Species Surveillance and Information Program (CISSIP) with the support of CARDI, the lead agency under CARICOM for research and development in the agricultural sector.

CISSIP is the first *tranche* of a Greater Caribbean Region surveillance and distance diagnostic surveillance system. Six countries will form the hubs of CISSIP, including in the insular Caribbean, Jamaica, the Dominican Republic, Martinique, and Trinidad and Tobago. Barbados, the Bahamas, and St. Lucia constitute the second phase.

5 CRISIS was approved by CARICOM's Council on Trade and Economic Development. A proposal for CISSIP was presented to a CARICOM donors' conference in June 2007, and considered by the InterAmerican Development Bank, but was not funded.

The University of Florida has developed the software for the Caribbean Regional Diagnostic Network, one of the key components of CISSIP. It has also provided a Spanish language version the Distance Diagnostic and Identification System to the University of Puerto Rico-Mayaguez and the Secretariat of Agriculture of the Dominican Republic. UF has used the DDIS since 1999 as a tool for diagnosticians to share information on plant diseases and other pest diagnostics. The system allows users to submit digital samples from the field for pest identification, allowing problems to be quickly identified and evaluated in near real time. It boasts a 60% success rate with plants, 80% with insects. UF and the University of Puerto Rico will train professionals in the Dominican Republic on distance diagnostics. UF is also working with USDA APHIS to introduce the DDIS in Haiti, with funding from USAID.

Elements of CISSIP are being implemented through the Caribbean Safeguarding Initiative, a program of the USDA APHIS. The process shows promise of becoming a model for regional cooperation for invasive species early detection and rapid response.

In 2009 APHIS produced a Caribbean regional pathways analysis on behalf of CISWG members, as a contribution to CRISIS (Meissner et al 2009). This report calls for regional coordination, public engagement, early warning and rapid response, and a unified pest information system. It also represents a major step towards a comprehensive approach addressing invasive species not only *from* the region to trading partners, but also *vice versa.* It is expected that pathway summaries including risk analysis will serve to catalyze further discussion on regional collaboration and advance the work of the CISWG.

Solutions

Trade-related impacts on biological diversity are an important aspect of the process of balancing economic growth and environmental protection, and one of the clear risks from trade is the introduction of alien species, including invasives, pests and pathogens, via trade-related pathways. There is no existing mechanism for the exchange of information and the formation of knowledge between inspection and quarantine authorities. An independent biosecurity learning network for the insular Caribbean would serve to build the capacity of and to support the inspection and quarantine staffs of participating countries through an interactive learning network. This effort would help to safeguard the

environment by addressing potential risks from international trade, and contribute to efforts to ensure that international trade provides net gains to society. It can also serve as a vehicle for integration across sectors.

Effective participation in international trade should be predicated upon the capacity to address the inherent risks of trade. Trade-related impacts on biological diversity are an important aspect of the process of balancing economic growth and environmental protection, and one of the clear risks from trade is the introduction of alien species, including invasives, pests and pathogens, via trade-related pathways.

Such mechanisms as exist for the exchange of information and the formation of knowledge between inspection and quarantine authorities is limited. Invasive species interventions are typically sectoral in nature, and do not address the full panoply of risks (agriculture, public health, forestry, infrastructure, aquatic systems). Moreover, they tend to be oriented toward the needs of the major economic powers in trade, rather than to the overall health of the system.

An independent learning network for the insular Caribbean would serve to build the capacity of and to support the inspection and quarantine staffs of participating countries through an interactive learning network. This learning process will strength as well the efforts on current existing scientific databases such as the ISSG (IUCN Invasive Species Specialist Group) Data Base and the IABIN - I3N (Inter American Biodiversity Information Network - Invasive Species Information Network).

The diversity of political systems under which various small island states of the Caribbean are administered imparts a level of complexity to regional arrangements (Kairo et al 2003). Reflecting its history, the region includes three major language groupings (Spanish, English and French), and an admixture of national legal traditions based in varying degrees on either English common law or the Napoleonic code. The legal status of the islands varies as well, with French, English, Dutch and American territories as well as fully enfranchised French Departments, and independent sovereign states. There is also geographic diversity, with significant economic and ecological differences between the major islands of the Greater Antilles and the smaller islands of the Lesser Antilles. This diversity has limited regional cohesion, creating an overlapping matrix of regional economic, governance and technical cooperation arrangements (CARICOM, OECS, Caribbean Environment Programme

etc). Regional trade tends to be less inter-island than between individual islands and major trading hubs in North and Central America, and so does not serve as a unifying factor in regional cooperation to the extent that it does in other parts of the world.

Proficiency in inspections for pests and invasive species generally requires a minimum of three years of professional practice in addition to formal education (Reaser and Waugh, 2007). There is therefore a considerable sunken cost in the development of a cadre of a professional inspection service. Relatively low-cost interventions to improve efficiency in information collection, exchange, and knowledge generation would enhance this investment.

Even after becoming fully proficient, inspectors are on a constant "learning curve" as they learn to adapt to emerging threats related to new commodities, new packaging, new shipping practices, and new ports of origin. Such learning is extremely valuable. Full advantage of the knowledge acquired by a professional inspector requires documentation and communication to others. But even greater benefits can be attained through interactive communication among inspectors within a port, within a country, and between trading partners. This includes the identification of species, the identification of pathways (e.g., a species found in a new type of packing material), and the identification of management measures (e.g., is fumigation an effective treatment).

An Internet based tool such as the Distance Diagnostic and Identification System could provide for access to reference materials such as documentation and images, experts such as taxonomists and control experts, web logs or bulletin boards for open discussion, and a help-desk function. An independent neutral clearinghouse for the Caribbean with a multilingual staff with inspection and quarantine experience would provide the help-desk function to support existing inspection and quarantine efforts. The help-desk could be initiated in the short term; additional resources such as on-line forums for open discussion could be developed on the basis of consultation with agencies and staff to ensure that the products are properly demand-driven. Important strides have already been made through the development of the CDRN and DDIS systems by the University of Florida for implementation through the CISSIP.

After the help-desk function is established a learning network for the inspection of cargoes and their containers. Elements of the learning network would include:

- Training courses, including continuing education through on line facilities
- Access to improved tools, such as taxonomic tools to support identification
- Early warning functions to alert the network to potential invasive species threats
- Formation of interagency rapid-response teams using shared resources to address outbreaks in and around ports of entry
- Forums for information collection and exchange.
- Development of region-specific protocols and tools to address specific problems, such as trade in live plants (horticulture)
- The learning network should produce the following results:
- An increase in innovation in the control of invasive species in trade-related pathways
- The development and dissemination of best practices, leading to a more professional approach to inspection and quarantine.
- International recognition for excellence, providing an incentive to implement best practices.
- Prevention of introductions of invasive species through early warning systems.
- More efficient response to invasives outbreaks through rapid response efforts.
- Professional pride, leading to greater retention of experienced inspectors.

Barriers to such an approach include real-time Internet access while engaged in inspection duties and languages. Both can be overcome if sufficient resources are committed. Significant effort must be given to ensuring that the products are demand-driven and user friendly, especially in field contexts. This will require face-to-face meetings for design input. The approach must also be supported with training, including, where required, in basic skills for inspection and quarantine (methods, taxonomy, legal requirements etc.), and in use of information resources and technologies.

A prototype to demonstrate the proof of concept will require external funding. When the approach is mainstreamed, the greater efficiency

and reduced risks that would convey to ports involved would be expected to produce savings sufficient to justify the costs, which could be borne by the port authorities and apportioned to shippers on the basis of a "polluter pays" approach. Ultimately, new trade agreements should incorporate participation in the process, including specifications for meeting the costs.

Recommendations

1. That standards for trade in and handling of horticultural species in the insular Caribbean be adopted, building upon Voluntary Codes of Conduct for the horticulture industry (Center for Plant Conservation, 2001 and as amended in 2002 at http://www.centerforplantconservation.org/invasives/codesN.html).

2. That the US government's Caribbean Safeguarding Initiative be modified to foster and encourage regional cooperation on invasive species issues in trade-related pathways.

3. That trade agreements should provide for cooperation between the parties to build the capacity to identify, intercept, and manage undesirable biological transient species such as potential pests and invasive species.

4. That sanitary/phytosanitary rules and regulations within the region be revised, consistent with WTO's SPS agreement, to strengthen protection against invasive species introductions, with particular attention to standards for the trade in and use of horticultural species.

5. That governments of the region work together and with other governments, to assure that trade rules are fully consistent with and supportive of Article 8 (h) of the Convention on Biological Diversity and with best practices to prevent the introduction of invasive species, and that standards for the prevention and control of invasive species be developed and agreed between countries sufficient to withstand challenges under the international trade regime.

6. That further studies be conducted to model disturbance resulting from extreme weather events and to analyze risk of invasive species introduction and spread associated with climate change

7. That governments, the private sector, academia, and civil society organizations work together to create a regional learning network on invasive species, to aid in identification, provide early warning (including notification of discovery), and share resources to rapidly respond to invasive species outbreaks to ensure eradication.

8. That each government in the Caribbean region be supported to develop a comprehensive biosecurity strategy, integrating disaster risk management, food security, anti-terrorism, sanitary/phytosanitary and ecosystem management responsibilities.

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Annex 1:
Selected Voluntary Codes Of Conduct From the St. Louis Declaration[6]

VOLUNTARY CODE OF CONDUCT FOR GOVERNMENTS

- Require risk assessment for government-led or financed plant introductions to ensure that no new harmful plant species are introduced, intentionally or unintentionally.
- Do not distribute existing holdings of invasive plant species to areas where they can potentially do harm; eliminate these holdings or maintain new or existing holdings using appropriate safeguards.
- Coordinate and facilitate collaboration in databases, early warning systems, monitoring, and other means of preventing invasive plant species problems.
- Lead and fund (subject to budgetary considerations) the development of environmentally sound methods to control harmful invasive plant species, seek control of such species on public lands and promote their control on adjacent private lands.
- Develop and promote the use of non-invasive plant species within all government units and to the public.
- Facilitate, lead, coordinate and evaluate public outreach and education on harmful invasive plant species.
- Encourage that employees and management participate in ongoing training programs on invasive plant species.
- Foster international cooperation to minimize the risk of the import and export of potentially invasive plant species.
- Develop partnerships and incentive programs to lessen the impact of invasive plant species and provide non-invasive restoration materials.
- Provide a forum for regular evaluation of the effectiveness of these voluntary codes of conduct towards preventing the invasive plant species problem.
- Enforce invasive plant species legislation at all levels.

6 http://www.centerforplantconservation.org/invasives/home.html

VOLUNTARY CODE OF CONDUCT FOR NURSERY PROFESSIONALS

- Ensure that invasive potential is assessed prior to introducing and marketing plant species new to North America. Invasive potential should be assessed by the introducer or qualified experts using emerging risk assessment methods that consider plant characteristics and prior observations or experience with the plant elsewhere in the world. Additional insights may be gained through extensive monitoring on the nursery site prior to further distribution.

- Work with regional experts and stakeholders to determine which species in your region are either currently invasive or will become invasive. Identify plants that could be suitable alternatives in your region.

- Develop and promote alternative plant material through plant selection and breeding.

- Where agreement has been reached among nursery associations, government, academia and ecology and conservation organizations, phase-out existing stocks of those specific invasive species in regions where they are considered to be a threat.

- Follow all laws on importation and quarantine of plant materials across political boundaries.

- Encourage customers to use, and garden writers to promote, non-invasive plants.

VOLUNTARY CODE OF CONDUCT FOR LANDSCAPE ARCHITECTS

- Seek out education and information on invasive species issues.
- Work with local plant ecologists, horticulturists, nurseries, botanic gardens, conservation organizations and others to determine what species in your region either are currently highly invasive or show aggressive potential. Investigate species under consideration that may present a threat.
- Increase interaction with other professionals and non-professionals to identify alternative plant material and other solutions to problems caused by harmful invasive plants.
- Take advantage of continuing education opportunities to learn more about invasive species issue
- Identify and specify non-invasive species that are aesthetically and horticulturally suitable alternatives to invasive species in your region.
- Eliminate specification of species that are invasive in your region.
- Be aware of potential environmental impacts beyond the designed and managed area of the landscape plan (e.g. plants may spread to adjacent natural area or cropland).
- Encourage nurseries and other suppliers to provide landscape contractors and the public with non-invasive plants.
- Collaborate with other local experts and agencies in the development and revision of local landscape ordinances. Promote inclusion of invasive species issues in these ordinances.

Annex 2: Regional Initiatives

CABI Caribbean and Latin America (Trinidad and Tobago). Established in 1946 as the West Indian Station of the former International Institute of Biological Control, CABI CLA supports activities throughout Latin America and the Caribbean in the prevention and management of invasive species, and in biological controls. CABI CLA is presently involved in the implementation of a pilot project on data management for invasive species in the Caribbean in six countries, funded by the Global Environment Facility.

Caribbean Invasive Species Surveillance and Information Program (CISSIP). A project under development for CARICOM through the Caribbean Invasive Species Working Group (q.v., below). CISSIP is the first element of a Greater Caribbean Region surveillance and distance diagnostic surveillance system. CISSIP will implement the Caribbean Region Invasive Species Intervention Strategy (CRISIS), which has been accepted as a region-wide strategy by CARICOM and the governments of the USA (through USDA/APHIS), France, and the Dominican Republic. CRISIS seeks to establish collective security to protect agriculture, natural resources and health in the region. It is also seen as a major step towards the removal of a major constraint to agriculture in the region by addressing inefficient and uncoordinated sanitary and phytosanitary systems. CISSIP will have four major components:

- Caribbean Regional Diagnostic Network (CRDN). Decision support to pest detection agencies for early detection and response.
- Pest Survey and Inspection Program
- Invasive Species Information System
- Public Education Program

CARICOM also proposes a "biologically-based area wide pest management system for horticultural crops in the Caribbean.

Caribbean Agricultural Research and Development Institute (CARDI), based in Trinidad and Tobago, is a unit of CARICOM that provides technical assistance in production systems, integrated pest management, and regional research coordination. CARDI is a member and current chair of the Caribbean Invasive Species Working Group.

Caribbean Invasive Species Working Group (CISWG). Formed at the Caribbean Food Crops Society annual meeting in 2003. Members include CARDI (as Chair), the Food and Agriculture Organization of the UN, the CARICOM Secretariat, CAB International, CIRAD, the University of Florida, IICA, the Pan American Health Organization (PAHO), the University of the West Indies, and the US Department of Agriculture's Animal and Plant Health Service (USDA/APHIS). Other participants include the Caribbean Development Bank, the University of Puerto Rico, Florida A & M University, and ministries of agriculture within the region). The CISWS goals are to develop strategies to safeguard the Caribbean from invasive species, and to prevent the introduction of invasive species. The focus is on agriculture and trade in agricultural products. CISWG organized the workshop in Trinidad and Tobago in June 2004 that produced the CRISIS manifesto.

Florida Plant Diagnostic Network (http://ddis.ifas.ufl.edu/) Developed Distance Diagnostic and Identification System (DDIS). Since 1999 has provided a tool for diagnosticians to share information on plant diseases and other pest diagnostics. The system allows users to submit digital samples from the field for pest identification, allowing problems to be quickly identified and evaluated in near real time. 60% success rate with plants, 80% with insects.

Interamerican Biodiversity Information Network (IABIN) (www.iabin.net). An intergovernmental biodiversity data initiative under the Organization of American States, IABIN includes five thematic focal areas, including invasive species. Through its invasive species node, led by the US Geological Survey's National Biological Infrastructure Initiative, IABIN has issued data digitization grants, developed standards and protocols for data exchange among countries, and conducted training in data digitization and management. IABIN has developed invasive species databases with and for Jamaica and the Dominican Republic, and conducted training in the Bahamas, Suriname, Jamaica, and the Dominican Republic. IABIN is presently developing a second generation of projects and is contemplating initiating an invasive species learning network in selected Caribbean countries in partnership with other regional programs.

National Plant Data Networks (USA). Funded by the US Department of Agriculture's CREES/APHIS, the NPDN is made up of regional nodes. The network provides conference calls, video conferences, email lists, and regional meetings to facilitate communication between experts

working on invasive species identification. The concept was conceived in 2001 to harness the existing resources of land-grant universities in a crop disease detection system, using the agricultural extension systems at the county level throughout the US.

USDA APHIS is providing training to member states under the Central America-Dominican Republic Free Trade Agreement, which is facilitating the adoption of the DDIS and CRDN. It has also initiated a Caribbean Safeguarding Initiative and is conducting a pathway analysis under the auspices of the CISWG. The Caribbean Safeguarding Initiative of USDA APHIS is an effort to target and reduce the risk of plant pests becoming established in the USA through the Florida pathway. Proposed efforts include a risk notification system, a threat advisory group, and pest detection efforts, including through on-line resources. APHIS will work with partner countries to develop chemical and biological control mechanisms for high risk pests.

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