NATIONAL STRATEGY ON

INVASIVE SPECIES IN MEXICO

PREVENTION, CONTROL AND ERADICATION

MEXICO 2010

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Presentation

Native species are those naturally found in a region as a result of a long process of adaptation to the existing environmental conditions and the development of complex interactions with other species, but among them are the invasive alien species. These are organisms that have been transported either by natural means or by human activities and have become established outside their natural distribution area.

Although the basic principles that lead to the introduction of species to new environments are known, the magnitude of the damage that these can cause to ecosystems, environmental services and human, animal and plant health have not yet been fully studied. Therefore the environmental and social impacts caused by invasive species have not been evaluated in all their dimensions, nor the associated economic losses.

This problem, which is one of the main causes of biodiversity loss around the world, was ignored for a long time. Recently, the Mexican government took on the challenge and through the National Commission for the Knowledge and Use of Biodiversity (CONABIO), called upon distinguished members of over twenty academic and government institutions and representatives of organized civil society. This group assembled to form the National Advisory Committee on Invasive Species and developed the National Strategy on Invasive Species in Mexico, which was needed for our country.

The strategy describes the introduction, dispersion and establishment of invasive species as well as the harmful effects caused by this phenomenon. Not only does it offer a diagnosis, but it also identifies priority actions that need to be initiated to address the problem in a coordinated manner with the participation of every sector, from government to civil society. The strategy already has the political support needed for its implementation, so its success will depend, without a doubt, on the manner in which the different legal programs and instruments are harmonized,

on the continuous process of building knowledge and on the active participation of a well informed society. The Strategy proposes three large strategic objectives and five cross cutting actions that guide the participation and coordinate the work between key institutions and sectors of society. Such objectives will contribute at the same time to consolidate a culture that values the biological diversity of our country, promotes finding solutions to face invasive species and their harmful effects, and above all, to prevent the introduction of non-native species and the dispersion of those that are already established.

Today we are setting an important foundation upon which we can build by promoting cross cutting actions among different sectors. Only with this approach will we be able to consolidate the efforts to prevent, control and eradicate invasive species that threaten the vast, yet fragile, natural capital of Mexico. We must not forget that it is a privilege to have a country that hosts an exceptional richness in its biodiversity and that this entails, at the same time, the responsibility to conserve it.

Early attention to the problem of invasive species is needed now more than ever, especially when faced with the threat of other pressure factors such as climate change. We must strengthen the progress that we have already made. I invite all citizens of Mexico to be part of this effort.

Juan Rafael Elvira Quesada
Minister of Environment and Natural Resources

SUMMARY

In order to achieve the conservation and sustainable use of Mexico's natural heritage sustainably, it is necessary to reverse the tendencies of deterioration and reduce the pressure factors that threaten biodiversity. This includes preventing the introduction of exotic or non-native species that may become established causing serious ecological disturbances, as well as the management, control and eradication of those species that have already become invasive. The impacts that these species can cause include changes in the structure and composition of communities by displacing populations of wild species, reduction in the genetic diversity and spreading of diseases that affect human health and wildlife. They can even cause the extinction of native species and change ecosystem functions, leading to the subsequent degradation of ecological integrity. Besides the environmental implications, the introduction of these species also has economic, health and social impacts. This occurs in both terrestrial and aquatic environments, marine and freshwater alike.

Most invasive species are introduced through pathways directly related to human activities; however some are accidentally introduced by natural means (wind, hurricanes, storms, or marine currents, among others). Other pressure factors, such as climate change, exacerbate the dispersion and establishment of invasive alien species.

In response to the different challenges posed by the issue of invasive species and as a part of the commitments acquired by Mexico through the Convention of Biological Diversity (CBD) and the National Biodiversity Strategy, the Ministry of Environment and Natural Resources (SEMARNAT) identified the need to create the "National Strategy on Invasive Species in Mexico: Prevention, Control and Eradication". To comply with this task, an advisory committee formed by academic specialists, civil organizations and representatives of different areas of the federal government was established, the committee

provided knowledge and experience to consolidate this planning tool for Mexico, which was coordinated by CONABIO.

The focus of the strategy is to contribute to the conservation of the natural capital and human well being through actions directed towards the prevention, control and eradication of invasive species in Mexico, with the coordinated, pro-active and responsible participation of all stakeholders. The vision is that, by 2020, the country will have efficient prevention, detection and early response systems and instruments under an appropriate legal framework in accordance with the needs of prevention, mitigation, control and eradication of invasive species.

Based on this effort it will be necessary to develop cooperation plans at the international, regional, national, state and municipal levels and establish cross cutting strategies among the different sectors, with goals and success indicators. The cross cutting strategic actions, identified in the document, will allow the development of these topics within the legal framework, enhance capacity building, promote interinstitutional coordination, raise awareness and increase information to achieve the three strategic objectives: prevention and early detection, control and eradication, and environmental education and awareness.

CONTENTS

INTRODUCTION

One of the main causes of biodiversity loss around the world are invasive species (Naranjo and Dirzo 2009; Vié *et al*. 2009), which alter ecosystems and affect native species, causing severe damages to environmental services and public health, as well as economic losses. Many organisms from other countries or regions can survive in new environments during a long period of time, without causing harmful effects. However, some species can overcome environmental barriers, reproduce and establish new viable populations outside their natural distribution areas and, after several years, drastically modify their new surroundings. Once the damages caused by invasive species are perceptible, an invasion of great magnitude with serious consequences is already occurring. Invasive behavior is not restricted to exotic species, as native species can become invasive when they are introduced to a different ecological region within the same country (translocation), or even in their original distribution area when the ecological dynamics of the site are modified (CONABIO 2009).

The Convention on Biological Diversity (CBD), defines invasive species as "an alien species whose introduction and/or spread threaten biological diversity" (CDB 2009) and refers to them as "one of the main generators of environmental change in the world" (MA 2005; Sala *et al*. 2000).

Although biological invasions can be part of the natural process of dispersion and colonization of new habitats, human activities in the last few decades have increased the speed and dispersion distances of species of different taxonomic groups (Álvarez-León and Gutiérrez-Bonilla 2007; Hernández-Becerril *et al*. 2003). As a consequence natural geographical barriers that for millions of years have allowed for limited movements of species became less efficient with the increase of human migratory movements. To date, a large variety of species are still being transported and introduced to new areas to be used in productive activities. Over the last century both intentional and accidental spread of exotic species has reached unprecedented

levels as a consequence of the modernization of transport, increased means of communication and the opening of new commercial routes, (Burgiel *et al*. 2006; McNeely *et al*. 2001). At the same time, changes in land use, ecosystem alteration and climate change are increasing the vulnerability of many habitats to invasions, even in the most remote areas (Mooney and Hobbs 2000; Simberloff 2000).

Ecological impacts caused by invasive species can be dramatic and even cause the extinction of populations and native species (Wilcove *et al*. 1998), the degradation of aquatic and terrestrial environments (Carlton 2001; D´Antonio and Kark 2002), particularly island environments (Veitch and Clout 2002), the alteration of the processes and ecological functions and the modification of biogeochemical cycles (D´Antonio and Vitousek 1992).

Invasive species deteriorate natural resources and, in consequence, environmental services, they also affect food production and can be devastating for agricultural ecosystems (Pimentel *et al*. 2005). They can damage public infrastructure, degrade agricultural lands, increase vulnerability to commercial embargoes and affect the quality of land and landscapes with touristic value. For these reasons, their impacts can result in elevated costs related to direct damages as well as to indirect costs associated with resources invested in their control or eradication (Pimentel *et al*. 2000; Pimentel *et al*. 2001; Pimentel *et al*. 2005). In particular, aquatic environments have shown to be extremely sensitive; approximately 40% of species extinctions in these settings have been related to depredation, parasitism or direct competition by invasive species (Pimentel *et al*. 2001). It is estimated that the rate of extinction in aquatic environments, in particular freshwater, is five times greater than in land environments (Ricciardi and Rasmussen 1999).

Island biodiversity is especially vulnerable to introduced species, given that these habitats are home to a large proportion of endemic species that lack natural defense mechanisms against exotic species, with which they did not coevolve. This results in species extinctions in very short periods of time due to competition, depredation or pathogens (Primack 2002). For island birds in particular, the risk of extinction is 40 times higher than for continental species (Trevino *et al*. 2007). At a global level, 804 species have become extinct and 65 more are reported as extinct in the wild (Vié *et al*. 2009). The rate of island species extinctions in relation to area size is between 500 and 700% greater than in continental areas (Baillie *et al*. 2004) and invasive species are considered the first cause of loss of biodiversity in island territories (Aguirre-Muñoz *et al*. 2009), 62% of mammals, 88% of birds, 54% of amphibians, 86% of reptiles and 68% of mollusks re-

ported extinct are island species (Baillie *et al*. 2004). Many of the bird extinctions in islands have been the direct result of the introduction of exotic vertebrates (Butchart *et al*. 2006). In the islands of Mexico, 12% of endemic birds and 20% of endemic mammals have become extinct because of invasive species (Aguirre-Muñoz *et al*. 2009), for example feral cats have caused the extinction of at least 10 endemic rodents in islands of the northeast (Nogales *et al*. 2004).

Endangered native species face more than one threat at a time, making it complicated to tell apart the direct and indirect factors, and the degree in which these act in synergy to generate the situation observed at a given time. The interactions among those factors are complex and relatively little research has been done on the subject, making it difficult to evaluate their relative importance. Depending on the case, invasive species can be either the main cause, the variable that precipitates extinction, an element that marginally contributes to the problem or have no effect on the loss of biodiversity (Gurevitch and Padilla 2004).

In spite of the fact that not every non-native species becomes invasive immediately, potential effects of an exotic species are unpredictable and can be devastating, therefore prevention is the best defense, followed by early detection and rapid response (EDRR). The investment needed to put in place a system of prevention or EDRR widely compensates the losses caused by acting late. The ability to identify potential invasive species, besides contributing to establish regulatory measures to prevent their entry during imports, contributes to the efficient use of resources destined to deal with established exotic species, particularly those that are in the early stages of invasion (Kolar 2004).

Control and eradication of invasive species do not represent a conservation objective per se, but they are key instruments to achieve biodiversity conservation and maintain the ecological processes which support the goods and services needed for sustaining life. Therefore, it is essential for the country to act against this global threat bringing efforts together and establishing a national strategy that encompasses prevention, detection, rapid response, control and eradication of invasive species in order to address the threats to biodiversity and ecosystem health and, consequently, the social and economic well being of the country.

The problems related to invasive alien species are complex and wide. However, the biggest obstacle is that this issue is relatively unknown and thus underestimated (Espinosa-García 2009; Espinosa-García *et al*. 2009). In Mexico, as in other regions of the world, a number of exotic species have been introduced (IMTA *et al*. 2008). Their

impact on local biodiversity had gone almost unnoticed until a few years ago. Actions undertaken so far, important but isolated, have established a solid base to embark on this national strategy. The problems related to invasive species must be addressed by various sectors, given that they involve activities related to agriculture, forestry and fisheries, commerce, transport, tourism, health, border control and the conservation of biological diversity, among others. Therefore, it is essential to establish a national program of action and a cross cutting public policy for the coordination of all sectors.

In addition, cooperation with other countries within the region becomes essential, given that neither ecosystems nor species recognize geopolitical frontiers. We share ecosystems with several neighboring countries and this can contribute to the movement of invasive species across borders. Moreover, the growing commercial exchange promoted by international commercial treaties and the current globalization, has eased the movement of species from one country to another with the consequent risk of biological invasions, creating the need to share preventive and control measures. For this reason the United Nations, alongside other international organizations, has funded initiatives such as the Global Invasive Species Program (GISP), a worldwide program to study and provide advice on invasive species. In the same way, invasive species are a priority subject in the biodiversity work program of the Commission for Environmental Cooperation for North America, through which Canada, Mexico and the United States collaborate within the framework of the North American Free Trade Agreement (NAFTA).

Even when the impacts of exotic species have not been quantified at national level, the available data indicates that there are many affected ecosystems (Espinosa-García 2003; Espinosa-García *et al*. 2009). While there is a good estimate of the number of non-native plants at the national scale (Espinosa-García *et al*. 2009; Villaseñor and Espinosa-García 2004), the total number of invasive alien species from all taxonomic groups established in Mexico is still unknown, as well as their distribution or population sizes. Facing the disturbing news of "new discoveries" it is imperative to have a diagnosis of the situation in order to act decisively. The most intelligent and effective measure to avoid new introductions is, without a doubt, prevention, which includes educating the general public. Additionally, in order to establish the most suitable strategies, scientific research must be considered a priority. For these reasons it is crucial to create a collaboration network between scientists and government representatives to allow for the optimization of investments in research and establish a tangible compromise from all competent authorities. Due to the magnitude of the problem and its consequences, it is essential to involve all public and private entities (organized civil sector, firms, commercial associations) that, because of their activities, are related to this issue, as well as all citizens, who are often oblivious chief players in new introductions and are an essential part of the solution. In this sense, a proposal was made for an invasive weeds strategy (Espinosa-García and Vibrans 2009); some elements of this proposal were incorporated into this document.

Banco Chinchorro Island, Biosphere Reserve, renowned for its high biodiversity, is threatened mostly by rodents that affect populations of birds, crabs and reptiles. Photo: GECI

The Buff-tailed bumblebee (*Bombus terrestris*) is native to Europe, North of Africa and Asia. It has been introduced in other areas as a pollinator of commercial crops.
Photo: Miguel Sicilia/CONABIO

Dr. Salvador Contreras, biologist and specialist on invasive species, checking a specimen an Armored Catfish (Loricariidae) in the Infiernillo Dam in 2006.
Photo: Roberto Mendoza

Gecko (*Hemidactylus turcicus*) originally from the Middle East and the Mediterranean, it was introduced as a stowaway in ships and is currently established in the Gulf of Mexico and the Caribbean.
Photo: Julio Lemos Espinal/CONABIO

The American bullfrog (*Lithobates catesbeianus*) is native from Canada and the United States. It was introduced to Mexico through breeding farms for the pet and export market, but has escaped into the wild causing a decrease in other populations of amphibians and reptiles.
Photo: Héctor Ávila Villegas/CONABIO

A STRATEGY FOR MEXICO

To face the introduction, dispersion and establishment of invasive species, and their harmful effects, it is necessary to undertake coordinated actions by all sectors, which must be guided by a jointly developed strategy that identifies priority actions to address the issue. The *National Strategy on Invasive Species in Mexico* suggests a ten year vision, a period of time during which Mexico must consolidate its prevention, control and eradication systems —in such a way that the negative impacts of invasive species are significantly diminished— and guide the participation and coordinated efforts of institutions and key sectors of society to reach the proposed vision. We put forward three strategic objectives that group the priority results regarding prevention, control and eradication and distribution of information. In addition, the strategy establishes five cross-cutting strategic actions that will enable the process of implementation and monitoring of this strategy. For each strategic objective the main goals, priority actions and results, products or services that must be available in 2020 have been identified. This document includes some examples of topics related to the problem of invasive species, with the aim of showing the complexity of the issue however, there are many other examples in areas such as aquaculture, aquarium trade, horticulture and tourism that are not included.

This document is the result of the work of an advisory committee (see page 73) comprised by academic experts and representatives of civil society and of different sectors of the federal government who, for over two years, poured their knowledge and experience with the common goal of securing this planning tool for Mexico. The work plans for the implementation of the strategy must be developed by each institution according to their specific mandate. Progress in identifying a series of specific actions needed in the country has already been made through the work of the advisory committee, connected institutions and specialists involved in the issue; who have been working on the problem for the past three years. The strategy was further enhanced with the comments obtained during a public consultation that was carried out between January and April 2010, with the participation of over 230 people from federal and state governments, academia, civil organizations and the general public.

For the development of this strategy the advising group carried out an analysis of strengths, weakness, opportunities and threats (SWOT) on the subject of invasive species in the country (see Annex 1). The document identifies a series of premises that were considered important in order to attend to this matter.

The house sparrow (*Passer domesticus*) native to the Mediterranean region of the Middle East, was introduced to North America in 1850. It competes for food and nesting sites with other species, although it is found mostly in urban environments.
Photo: José Ignacio Granados Peón/CONABIO

PRINCIPLES

1. The introduction of exotic species can be an intentional or unintentional result of human activities, or occur by natural causes (winds, marine currents, among others).
2. Exotic species can become invasive and have adverse effects on biodiversity, environmental services, health and economic activities.
3. Frontiers or political limits do not prevent the entry and dispersion of invasive species.
4. The introduction and dispersion of invasive species result in the displacement of native species through direct competition, depredation, disease transmission or habitat modification.
5. Alterations in the structure and composition of wild populations and the degradation of the integrity of terrestrial and aquatic ecosystems generate conditions that are favorable to biological invasions.
6. Recognizing the threat represented by the synergy between climate change and invasive species, with effects that have been scarcely studied until now, both the precautionary principle and a long term vision must prevail.
7. In order to face the problems associated with invasive species, efficient prevention and early detection actions are needed to reduce the costs associated with eradicating, containing or mitigating their effects.
8. Prevention, control and eradication actions for invasive species should not only be undertaken in protected areas but also in every region of the country.
9. Species eradication requires monitoring and actions to restore the ecological integrity and prevent reintroductions.
10. Control and management of invasive species must be carried out using a comprehensive approach, considering that these species affect whole ecosystems and not just some of the elements within them.
11. Taking into consideration that invasive species have the capacity to quickly adapt to new environments, management strategies must be revised and adapted periodically.
12. Given that the problems inherent to invasive species affect the general population and not only the sectors directly involved with their introductions, authorities, civil organizations and the general public have a shared responsibility to prevent the entry and dispersion of invasive species into national territory and participate in their management and regulation.
13. To face the problem of invasive species, it is essential that decision makers have access to information based on the most recent scientific knowledge.
14. A well informed and aware society will have more and better capacities to participate in the solution to the problem.

STRATEGY: mission, vision and objectives

Mission

To contribute to the conservation of the natural capital and human well-being through a National strategy oriented towards prevention, control and eradication of invasive species in Mexico, providing guidance for the coordinated participation and the active and responsible cooperation of all stakeholders involved in the implementation of actions to monitor, detect, control and eradicate invasive species.

Vision

In order to attend to the issue of invasive species, in 2020 Mexico will have efficient prevention, alert and response systems in place, as well as appropriate tools within a coherent legal framework, to address the needs of prevention, mitigation, control and eradication of these species.

Mexico´s ecosystems, especially those that have been altered, and many of its native species could be threatened by the introduction and establishment of invasive species. Photo: Miguel Sicilia/CONABIO

Cross-cutting strategic actions

These actions are the driving forces that will enable the development and fulfillment of the objectives of the strategy and must be incorporated into any implementation activity:

1. **Legislation and regulation.** The legal and normative framework must be comprehensive and suitable to address the challenges, gaps, inconsistencies and weaknesses posed by the different aspects of the invasive species issue. Additionally it must promote the harmonization of legal instruments and the cooperation among different sectors, among federal entities and within different government levels.

2. **Capacity development.** Within the framework of this strategy, each of the activities undertaken must contribute to build scientific, technical, human and institutional capacities in order to strengthen the abilities of the country in terms of invasive species.

3. **Coordination.** It is fundamental to have the collaboration and consensus of a number of key stakeholders in order to carry out the necessary actions to attend the problems caused by invasive species in an efficient, transparent and harmonious way. In accordance to the latter, it will be necessary to define and establish protocols and agreements of coordination and cooperation among intergovernmental and inter-institutional entities and engage the participation of a well informed citizenship.

4. **Outreach and communication.** The success of the actions derived from this strategy depends not only on timely actions from authorities but on the support and cooperation of society. It is fundamental that such activities rely on updated and trustworthy information of easy access allowing the understanding of the context of the issue by the different users.

5. **Knowledge and information.** Decision making and implementation actions must be based on scientific information of the highest quality. Therefore it is necessary to strengthen the mechanisms to obtain, exchange, manage and access information at national level and fortify the scientific research that generates knowledge for a better understanding of biological invasions, their impacts and the restoration processes as well as to improve productive practices and promote the use of native specie.

CROSS-CUTTING STRATEGIC ACTIONS

STRATEGIC OBJECTIVE

1. Review, adapt and develop the legal and normative framework

2. Build scientific, technical, human and institutional capacities

3. Enhance coordination between the different government branches, sectors, institutions and the general public

4. Boost communication, education and awareness of Mexican society

5. Increase knowledge to support decision making.

1. Prevent, detect and reduce the risk of introduction, establishment and dispersal of invasive species.

2. Establish control and eradication programs for invasive species populations, which minimize or eliminate their negative impacts and favor ecosystem restoration and conservation.

3. Inform the public in an appropriate and efficient way to achieve a broad civil support and participation within their reach in actions to prevent, control and eradicate invasive species.

Strategic objective 1

Prevent, detect and reduce the risk of introduction, establishment and dispersal of invasive species.

2020 GOALS

1.1 National and international legal framework set up to regulate the introduction and management of invasive species, as well as those with invasive potential, in the country.

1.2 Relevant scientific and technical information is available in a timely manner, to generate capacities in different sectors to attend priorities related to invasive species.

1.3 Pathways for introduction and dispersion of high risk invasive species identified and monitored.

1.4 Standardized prevention mechanisms and protocols in operation, to decrease the risk of introduction, establishment and dispersal of invasive species.

1.5 Coordinated systems for the detection, risk management and early warning for entry and dispersal of invasive species.

1.6 Substitution of the most harmful invasive species of common use, by native species or species of lower risk.

1.7 Biosafety and sanitary measures permanently implemented regarding the introduction, handling and use of exotic invasive species.

2020 Goal	Priority actions	Expected results
1.1 National and international legal framework set up to regulate the introduction and management of invasive species as well as those with invasive potential in the country.	Based on the precautionary principle, review the national legal framework to detect gaps, inconsistencies and weaknesses.	Diagnosis of the legal framework in terms of invasive species.
	Modify, adapt and develop the pertinent legal instruments.	Legal framework appropriate to regulate the introduction and management of invasive species in the country.
	Establish harmonized protocols on the management of invasive species, taking into consideration the functions and authority of the different sectors.	Transparency within functions, authority and responsibilities in the matter, within each sector, for the coordinated attention of the problems caused by invasive species.
	Establish harmonized protocols regarding the functions, authority and responsibilities of the different government levels.	Transparency in the functions, authority and responsibilities in the matter, within each government level, for the coordinated attention of the problems caused by invasive species.
	Strengthen the application of international agreements regarding exotic species.	Reduction of intentional and non intentional introductions of exotic species.
	Promote regional and state action plans which will contribute to the implementation of the National strategy.	Attention to specific regional and state level issues and priorities.
	Promote bi-national prevention treaties with border countries.	Regional guidelines and protocols, as well as campaigns and action plans, to prevent the introduction and dispersal of invasive species.
	Review and harmonization of regional economic development policies in light of the problems related to invasive species.	Regional development policies incorporate the issue of invasive species and take into account measures to prevent their entry and dispersal.

2020 Goal	Priority actions	Expected results
1.2 Relevant scientific and technical information is available in a timely manner, to generate capacities in different sectors to attend priorities related to invasive species.	Establish a national and regional baseline on the situation of invasive species in Mexico.	Diagnosis to detect information gaps, identify priorities (national and regional) and establish specific action programs.
	Establish periodic revision protocols of the information on invasive species in data bases.	Updated, reliable and accessible information for all users through the National Invasive Species Information System.
	Develop knowledge regarding the biology of invasive species, their interactions with native species and their impacts on ecosystems.	Risk analysis based on updated scientific information. Appropriate restoration programs included in the activities implemented for the control and eradication of invasive species. Assessment of impacts caused by invasive species.
	Carry out cost/benefit analysis of long term effects of invasive species (economic, ecologic, health and social) in the different regions of the country.	Updated and relevant information available for decision making related to imports, use and management of invasive species, particularly the most harmful ones.
	Promote research for the accurate identification of invasive species.	Reliable identification of invasive species from every taxonomic group.
	Build up knowledge on the interactions and synergies of invasive species with other stressors of biodiversity such as climate change, change of land use, among others.	Management and planning of conservation measures based on scientific knowledge.
	Develop and establish agreements among diverse institutions and actors to build up new information.	Standards for the management of information on invasive species.
	Develop and establish tools and procedures to build up, manage and distribute information on invasive species throughout the country.	Consensus on how to manage information on invasive species. Access to invasive species information at different entry points by different types of users.
	Establish protocols and guidelines for the interconnection of databases.	Availability of information on invasive species through a network of internet portals from different institutions.
	Provide different types of information according to the different users (e.g. maps, information sheets, data bases, time or space series queries).	Access to information reflects the needs of different users.

2020 Goal	Priority actions	Expected results
1.3 Pathways of introduction and dispersion of high risk invasive species identified and monitored.	Identification and analysis of entry points and national and international transport and dispersion routes.	Baseline information on the main pathways of introduction and dispersion of invasive species related to human activities.
	Identification and analysis of high risk productive activities.	Baseline information on the risks linked to human activities.
	Development of predictive models for the natural dispersion of invasive species.	Baseline information on the main pathways of natural introduction and dispersion of invasive species.
	Establish protocols and guidelines to obtain statistics on imports, commercialization, transport, or movements of exotic species.	Statistical indicators are revised, approved and improved. Predictive models and pathway risk analysis developed and continuously updated.
	Prediction of dispersal and potential infestations considering land use changes, climate change among other factors.	Reduced risks related to new introductions and dispersion of introduced invasive species.
	Develop introduction and dispersal pathway risk analysis for invasive species.	Key control points for the introduction and spread identified; monitoring and surveillance activities are established.
	Evaluate the infrastructure, current capacities and gaps for the surveillance of pathways of introduction and dispersal.	Infrastructure and surveillance capacities for pathways of introduction and dispersal of invasive species are coordinated and appropriate to manage the problem.
	Strengthen surveillance actions (in customs, markets, aquariums, greenhouses, garden centers, among others).	Decrease of commercialization of enlisted species.

2020 Goal	Priority actions	Expected results
1.4 Standardized prevention mechanisms and protocols in operation, to decrease the risk of introduction, establishment and dispersal of invasive species.	Implement risk analysis procedures in activities related to the import, use, commerce or movement of exotic, invasive or translocated native species.	Decision making for the use, introduction, commerce or movement of exotic, invasive or translocated native species is based on scientific information and the precautionary principle.
	Conduct risk analysis for the most harmful invasive species.	Lists of species by risk categories.
	Establish systematic and standardized monitoring programs at high risk sites (e.g. protected areas, important agricultural areas, deep sea and coastal shipping ports, container transfer areas, main water bodies, dams and chanels, among others, see goal 1.3).	High risk areas of entry and dispersion of invasive species monitored and under surveillance.
	Implement mechanisms for rapid information access for surveillance personnel (see goal 1.2).	Rapid, reliable and timely identification of new introductions.

2020 Goal	Priority actions	Expected results
1.5 Coordinated systems for the detection, risk management and early warning for entry and dispersal of invasive species.	Establish protocols to prevent the entry of invasive species into Mexico.	An early detection and rapid response system for invasive species in Mexico.
	Identify responsibilities of different government entities regarding detection, risk management and early warning to identify and correct existing gaps.	Efficient and coordinated actions for rapid response.
	Develop contingency plans for the containment of new infestations.	A rapid response system for invasive species in Mexico useful at different scales.
	Establish specific detection programs for high risk species.	Specific prevention measures are in place for invasive species of higher risk for the country.
	Promote and follow up on mechanisms of social participation in surveillance activities.	Strengthening of monitoring and early detection actions and of actions related to the generation of information.

2020 Goal	Priority actions	Expected results
1.6 Substitution of the most harmful invasive species of common use, by native species or species of lower risk.	Harmonize sector-based programs in relation to invasive species issues.	Programs from different sectors share a common vision regarding the problem of invasive species.
	Implement biosafety protocols, analysis of critical control points, among other actions, for exotic species most commonly used in productive activities.	Identification of high risk invasive species that are most commonly used in productive activities. Productive activities include measures to prevent dispersal.
	Identify and develop technological packages using native species suitable to replace productive exotic species of common use.	Reduction of use of exotic species with high risk potential.
	Revision of requirements for the import and use of exotic species.	The requirements are adequate to detect pathogens or other problems associated with the import of exotic species.
	Revision of the requirements of permits and guidelines for the handling of exotic species in the country in order to include biosafety requirements.	Integral management of invasive species incorporated into the decision making process related to the use of resources.

2020 Goal	Priority actions	Expected results
1.7 Biosafety and sanitary measures permanently implemented regarding the introduction, handling and use of exotic invasive species.	Develop risk reduction technologies for the use of exotic species (sterilization, generation of monosexual populations, closed systems of recirculation, radiation, among others).	Safer handling of exotic species. Confined handling of exotic species.
	Establish “best practice” guidelines, certifications and biosafety measures for the activities related to the import, use, commerce or movement of exotic, invasive or native translocated species.	The activities that include the use, introduction, commercialization or movement of exotic, invasive or native translocated species incorporate “best practice” measures, green certifications and biosafety measures that reduce the risk of entry, establishment and dispersion of invasive species.
	Establish economic incentives to promote the application of biosafety measures.	Appropriate biosafety measures are applied in a routinely manner in all procedures related to invasive species.

Strategic objective 2

Establish control and eradication programs for invasive species' populations, which minimize or eliminate their negative impacts and favor ecosystem restoration and conservation.

2020 GOALS

2.1 Agreed priorities for the control or eradication of invasive species.

2.2 Programs and action plans in operation for the eradication and management of the most harmful invasive species as well as for the mitigation of their impacts.

2.3 Mixed financing mechanisms for the prevention, control and eradication in contingency situations.

2.4 Mechanisms and initiatives to involve the public in prevention, control and eradication efforts in an organized manner.

2020 Goal	Priority actions	Expected results
2.1 Agreed priorities for the control or eradication of invasive species.	Develop protocols to determine priorities of attention and action based on scientific information (risk analysis).	Allocation of resources focused on country priorities regarding invasive species.
	Ensure that control and eradication programs for invasive species embrace (whenever possible) four objectives: biodiversity conservation, food security and agricultural productivity, maintenance of ecosystem services and improvement of quality of life.	Control and management programs for invasive species have a holistic approach.
	Development of specific mechanisms for the management and containment of established invasive species that cannot be eradicated.	Reduction of the risk of spread of established invasive species and mitigation of damages.
	Development of specific guidelines for the sustainable use of invasive species that are already established in the country.	Programs to replace the use of invasive alien species are encompassed within comprehensive recovery programs for native species and take into consideration economic well being of the population that participates in these programs. Control of the dispersal of invasive species, under a rigorous evaluation that does not generate negative secondary effects.
	Develop capacities to perform control and eradication actions, based on scientific information.	Mexico has the capacities to perform control and eradication actions of organisms belonging to different taxonomic groups in an effective and coordinated manner.

2020 Goal	Priority actions	Expected results
2.2 Programs and action plans in operation for the eradication and management of the most harmful invasive species as well as for the mitigation of their impacts.	Development of guidelines for the management, control, eradication and mitigation of the damages caused by invasive species of greatest concern (see objective 1).	Specific action guidelines and identification of stakeholders responsible for the effective management of invasive species, particularly those identified as the most harmful.
	Implementation of actions for species and areas identified by the baseline (see goal 1.2).	Control, management and eradication programs operating or completed for the areas and species identified as of greatest concern in the national diagnosis.
	Increase the capacity of response of authorities responsible for control and eradication activities.	Authorities are aware of the problems related to exotic invasive species and are capable to respond in an effective and timely manner.
	Establish monitoring actions for areas where control and eradication activities have been carried out.	Control and eradication actions are measured and assessed to improve and adapt management practices and to prevent new infestations or dispersals. The information allows for the update of the distributions and the detection of non desirable effects in a timely manner.
	Generate management, control and eradication plans wich consider ecological restoration measures of damaged areas.	Restoration of ecosystems and reduction of the risk of reestablishment of eradicated species or establishment of new invasive species.

2020 Goal	Priority actions	Expected results
2.3 Mixed financing mechanisms for the prevention, control and eradication in contingency situations.	Create a national fund for the control and eradication of invasive species.	Financial support for important projects and programs ensured.
	Establish economic incentives to promote the application of biosafety measures in the production and commercialization sectors.	Biosafety measures included in production and commercialization processes.
	Development of specific economic incentives appropriate to carry out specific eradication programs for invasive species through their use, within plans of integral attention.	Eradication programs, or those using invasive species for economic purposes, include economically viable alternatives that prevent their use as a permanent resource, thus contributing to their eradication.
	Establish a multisectorial fund to address contingencies caused by invasive species.	Transparent financial support for the immediate attention of emergencies related to invasive species is ensured and available.

2020 Goal	Priority actions	Expected results
2.4 Mechanisms and initiatives to involve the public in prevention, control and eradication efforts in an organized manner.	Develop mechanisms for the rapid identification and recording of invasive species of greater concern by all members of society.	Networks to exchange information and documentation of invasive species records. Increased monitoring and surveillance capacities. Agile and transparent procedure to report the introduction of invasive species.
	Establish and promote positive incentives to encourage public participation in the strategy.	Coordinated integration of certain sectors of the population to join the government's effort in fighting invasive species.
	Establish rapid, clear and efficient communication, reporting and response mechanisms.	Competent authority with capacities to attend to reports about new biological invasions.
	Include mechanisms for public participation in prevention and early detection campaigns of non established exotic species that are considered most harmful.	Citizens participate in the monitoring and early detection of new invasions.
	Set up voluntary teams to conduct environmental monitoring activities.	Increased identification and monitoring capacities.
	Carry out education campaigns (see goal 3.1).	Appropriate information available for the public to reduce the risk of introduction and dispersal of exotic species.

Strategic objective 3

Inform the public, in an appropriate and efficient way, to achieve a broad civil support and participation within their reach in actions to prevent, control and eradicate invasive species.

2020 GOALS

3.1 The population, key groups and authorities are aware of the threats and impacts that invasive species cause to biodiversity, ecosystem services, the economy and health; as well as the measures for their prevention and control.

3.2 Education plans and programs at different levels include the topic of invasive species.

3.3 Updated information and identification guides related to the main invasive species are available for staff associated with pathways of introduction and dispersal.

3.4 There are interinstitutional and interdisciplinary networks consolidated for the support and execution of education and awareness programs about invasive species.

2020 Goal	Priority actions	Expected results
3.1 The population, key groups and authorities are aware of the threats and impacts that invasive species cause to biodiversity, ecosystem services, the economy and health; as well as the measures for their prevention and control.	Develop awareness and education material on invasive species (see goal 1.2).	Information is distributed among the different sectors and levels in a clear and conclusive categorical manner and based on the best available scientific information.
	Train government staff (federal, state and municipal/local) in the different aspects of the problems caused by invasive species.	Greater understanding, support and enhanced participation in prevention, control and eradication actions.
	Train producers in the different aspects of prevention and biosafety involved in the handling of exotic species.	Handling, production and commercialization practices of exotic species comply with the requirements of biosafety and prevention.
	Promote capacity building workshops for staff that participate in control and eradication campaigns for invasive species.	More successful control and eradication programs for invasive species based upon scientific information and appropriate techniques.
	Design and carry out education campaigns at different levels.	Population, key groups and authorities, informed and attentive to the problem of invasive species, support the efforts of prevention, control and eradication.
	Inform in a continuous and timely manner about the situation of invasive species in the country and the activities of the different institutions regarding their control.	The population, key groups and authorities are aware of the measures and actions that are being carried out to prevent, control or eradicate invasive species in the country.
	To provide relevant information through internet portals of different institutions.	Transparent information sources for public consultation regarding the different actions related to invasive species, with emphasis on the most harmful ones.

2020 Goal	Priority actions	Expected results
3.2 Education plans and programs at different levels include the topic of invasive species.	Include the subject of invasive species in basic, middle and higher education programs.	Student population is sensitive about the subject, and supports and participates in prevention, control and eradication efforts.
	Develop education material on invasive species for school programs (see goal 1.2).	The information provided for different school levels is clear and based on the best scientific information available.

2020 Goal	Priority actions	Expected results
3.3 Updated information and identification guides related to the main invasive species are available for staff associated with pathways of introduction and dispersal.	Develop tools to look up information about invasive species tailored for different needs (posters, brochures, guides, internet, etc.).	Information about invasive species is easily accessible in different formats for different sectors.
	Development of tools for the rapid identification of invasive species.	Tools for the identification of invasive species of high risk in points of entry or dispersion.
	Capacity building workshops on how to use identification tools.	Staff involved in monitoring pathways of introduction and dispersal, as well as other surveillance activities is properly trained to identify and report the most harmful invasive species. The network of collaborators supports each other in the identification of invasive species.

2020 Goal	Priority actions	Expected results
3.4 There are interinstitutional and interdisciplinary networks consolidated for the support and implementation of education and awareness programs about invasive species.	Implement interinstitutional cooperation mechanisms that involve specialists in research, education and awareness activities related to invasive species.	The tasks of education and outreach related to invasive species are supported by scientific information developed by interdisciplinary groups of specialists in each subject.

IMPLEMENTATION OF THE STRATEGY

Progress regarding the different aspects of the invasive species problem in Mexico has been steadily achieved through the joint effort of governments, academia and civil society; these efforts have especially focused on species that are considered a risk for the natural capital of the country. Having the jointly developed objectives and lines of action established by this strategy, is a crucial step to systematize and harmonize actions that will allow the different sectors involved to act in a coordinated manner, without duplicating efforts and move jointly forward to prevent, reduce, mitigate and eliminate the harmful effects caused by these species. The lines of action of this strategy are ambitious however, the National Advisory Committee on Invasive Species considers that it is possible to fulfill the established goals by 2020. With the publication of this strategy, the different stakeholders must double their efforts to prevent and control high impact invasive species that are already in national territory or whose entry represents a high risk.

First meeting of the National Advisory Committee for the National Strategy of Invasive Species in May 2008. Photo: Juan Manuel Martínez/CONABIO

To adopt this strategy responsibly, there must be a strong political will and a concurrence of actions and resources. This requires establishing a coordinating organism and an action plan to identify stakeholders and assign specific responsibilities to execute, coordinate and follow up on short, medium and long term goals. Additionally there is a need to create a critical route to ensure the continuity of actions, define mechanisms to follow up on the implementation process and to evaluate compliance with the goals, as well as to establish a set of indicators to monitor progress, correct actions and respond with transparency. An important step has already been made by identifying selected actions and needs to attend to specific topics (see annex 2).

Lionfish (*Pterois volitans*) is a venomous species which is very popular in the aquarium trade. Its escape from aquariums was recorded in 2001 in the Atlantic coast of the United States and in 2009 it was detected in the Mexican Caribbean.
Photo: Mark Rosenstein

REGULATION ON INVASIVE SPECIES IN MEXICO

Mexico, as a signatory of international instruments regarding invasive species, must comply with the responsibilities inherent to the matter. Article 8h of the CBD establishes that contracting parties must "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species".

At a global level, the issue of invasive species has been incorporated into binding international agreements as well as into multilateral cooperation forums, whose agreements are of a voluntary nature. Mexico has acquired commitments to participate in both areas: international treaties and voluntary cooperation platforms. The Political Constitution of Mexico establishes that subscribed international treaties as well as those to be entered by the President of the Republic, approved by the Senate, are part of the Supreme Law of the Union.

At the regional level, Mexico is member of the North American Plant Protection Organization (NAPPO), which establishes regional phytosanitary standards applicable to plant export and import. In addition, Mexico has representation in the Aquatic Nuisance Species Task Force (ANSTF) panels, an organization in charge of preventing and controlling introductions of these species into the region. The Commission for Environmental Cooperation of North America (CEC) focuses on environmental issues of common interest, the prevention of possible environmental conflicts arising from commercial relationships, and the promotion of environmental legislation, complementing the environmental regulations of the North American Free Trade Agreement (NAFTA). Given that invasive species are one of the main threats that must be addressed in order to conserve the biodiversity of the region, the CEC in turn, collaborates with several institutions (CEC 2009). The agenda of the Security and Prosperity Partnership of North America (SPP) included "combat the spread of invasive species in both coastal and fresh waters" (SPP 2005).

In general, the international and regional framework establishes guidelines and standards that require national instrumentation and thus constitute a challenge for Mexico. In this sense, several forums have been held at both binational (among Mexico and the United States) and national levels, to define the agenda and institutional coordination needed to establish a baseline strategy, while the legal system attends to the issue through legal proposals.

Mexico has a well established framework for the management of plant and animal quarantine pests through phytosanitary and zoosanitary norms, all of them based upon the laws of plant and animal health respectively. The Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), through the National Service of Agro Alimentary Health, Safety and Quality (SENASICA), is in charge of applying these norms and, through the Ministry of Health (SS), establishes those that are necessary to fight pests related to human health; these norms can serve as a base for the implementation of others applicable to invasive species that do not necessarily represent a direct threat to agriculture or human health, but to the environment.

The Ministry of Environment and Natural Resources (SEMARNAT), through the Federal Attorney for Environmental Protection (PROFEPA) is responsible for ensuring compliance with regulations applicable to the management and use of wildlife. For this purpose, there is a program for the inspection of ports, international airports and border crossings. In addition, the National Environmental Policy for the sustainable Development of Oceans and Coasts of SEMARNAT proposes, in the ecosystems and biodiversity section, strategic and tactical objectives to control invasive species. This implies that there is a regulatory infrastructure which, once the policies and legal framework have been established, could be expanded to cover a wider concept of invasive species, putting into practice training, not only for officials and employees of PROFEPA, but also of SAGARPA, the Ministry of Economy (SE) and the Ministry of Communications and Transports (SCT), among other sectors.

With Mexico´s adherence to the International Convention for the Control and Management of Ships' Ballast Water and adopted by the International Maritime Organization (IMO), the Ministry of Com-

[1] The agreement is of great importance to prevent, diminish and eliminate risks to the environment, human health, goods and resources, resulting from the transference of harmful aquatic organisms and pathogen agents, through the control and management of ballast water and ship sediments as well as prevent secondary effects caused by such control and promote the progress of related knowledge and technology. The government of our country has adopted this Convention, however, in spite of the fact that the Decree of Approval was published in the Official Newspaper of the Federation on December 18, 2007, it will not come into effect in the different countries, until twelve months after the date in which the combined merchant fleets of at least thirty States represent not less than 35% percent of the gross tonnage of the world's merchant marine, according to article 17 of this international order.

munications and Transports, through the General Direction of Merchant Marine, is in charge of undertaking different measures for the prevention, reduction and control of possible biological invasions (see Annex 3). By ratifying this legal international instrument, the Parties agree to make the resolutions of such Convention and its annex full and completely effective with the objective of preventing, reducing as much as possible, and eliminating the transference of harmful aquatic organisms and pathogens through the control and management of ballast water and ship sediments. Through this measure and with the purpose of preventing the entry of harmful aquatic organisms, naval inspectors appointed to the diverse Port Authorities of our coastlines carry out pertinent inspections according to Article 65 of the Law of Navigation and Maritime Trade (LNCM).

In addition, according to Article 76 of the LNCM on prevention and Control of Marine Pollution it is forbidden to discharge, spill, throw or any equivalent action, ballast, waste, wastewater or any element, in any state of matter or energy, that may cause damage to life, ecosystems and marine resources, to human health or to the legitimate use of navigable routes and high seas that surround Mexican marine zones as identified in the Federal Law of the Sea (SCT).

The Subsecretary of Promotion and Environmental Regulation of SEMARNAT through the General Direction of the Primary Sector and Natural Renewable Resources analyzed the applicable national legal

Maneuver in the vessel "Sonora" of the Mexican Navy during a project of eradication of invasive species in San Pedro Mártir Island, Gulf of California.
Photo: GECI

BOX 1. **REGULATORY FRAMEWORK FOR INVASIVE SPECIES**

1. International Legislation

International Treaties

- Convention on Biological Diversity (CBD)
- Ramsar Convention on Wetlands (Ramsar)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- United Nations Convention on the Law of the Sea (UNCLOS)
- International Convention for the Control and Management of Ships Ballast Water & Sediments
- The Cartagena Protocol on Biosafety
- International Plant Protection Convention (IPPC)
- North American Plant Protection Organization (NAPPO)
- International Maritime Organization (IMO)
- Commission for Environmental Cooperation (NAFTA/CEC)

Voluntary agreements

- Code of Conduct for responsible Fisheries (FAO)
- WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement)

2. National Legislation

Laws

- General Law of Ecological Equilibrium and Environmental Protection (LGEEPA) and its Regulation.
- General Law of Wildlife (LGVS) and its Regulation.
- General Law of sustainable Forest Development (LGDFS) and its Regulation
- Federal Law of Animal Health (LFSA) and its Regulation
- General Law of Sustainable Fisheries and Aquaculture (LGPAS)
- General Health Law (LGS)
- Law of Maritime Navigation and Trade
- Law of Harbors and its Regulation

Regulations

- Regulation on the Law of Fisheries

Norms

- Norms on plant and animal health
- Norms on environmental protection
- Norms on Sanitary regulations of fisheries
- Health norms

Environmental policies instruments

- National Fisheries Chart

From Cornett, V. and P. Álvarez, 2009.

framework concerning invasive species, as well as the distribution of institutional responsibilities, in order to find the regulatory gaps and develop, within the framework of this strategy, the actions for legal and regulatory improvements and updates. The National Strategy for Invasive Species will have to determine the actions related to inspection and law application and promote the adjustment and innovation of the legal framework, the regulations and norms necessary to be efficient and effective in the prevention, control and eradication of invasive species in Mexico.

In 2010 the Official Newspaper of the Federation published modifications to the General Law of Ecological Equilibrium and Environmental Protection (LGEEPA) and to the General Wildlife Law (LGVS) and its Regulation (DOF 2010). These modifications define the term "invasive alien species" and establish measures for their management and identification. This is an important first step, although it is still not enough. Therefore it is necessary to continue working to amend the legal instruments and fill voids and omissions.

Thus, there are general foundations, but there are still no specific instruments to regulate the problems caused by invasive species. Arriaga and collaborators (2004) and Espinosa-García (2009) indicate that the legal framework for the prevention and control of invasive species is incomplete or deficient. Faced with an issue that is beyond the capacities of any institution or sector, it is urgent to have a strategy on the subject to coordinate the necessary actions to face the problem.

The theme for the International Day on Biological Diversity (IDB) in 2009 was invasive alien species (IAS).

Cruise ship in the Gulf of California. Maritime transportation is a common route of introduction of invasive species. Photo: Isabel González/CONABIO

Machinery used in different places and the construction of new pathways of communication can result in the accidental transport of organisms.
Photo: Miguel Sicilia/CONABIO

Unintentional dispersion of invasive weeds, such as *Centaurea solstitialis*, due to terrestrial transportation.
Photo: Jerry Asher/USDI BLM/Bugwood.org

Carrier ship crossing the Panama Canal. Many invasive species have been accidentally transported in ballast water. Photo: Georgia Born-Schmidt/CONABIO

PATHWAYS AND MECHANISMS OF INTRODUCTION

The movement of organisms and the colonization of new sites is a process that has occurred naturally throughout time. However, the growth of population, its movements and activities, derived from the economic, social and cultural development, have increased the frequency, number and diversity of exotic organisms that are transported and can become established in new areas. These relocations have caused a number of negative ecological, economic and social impacts. The identification, analysis and management of these pathways of introduction are key elements to prevent the entry and dispersion of species in regions outside their natural historic distribution ranges.

Pathways are those processes through which a species is transferred from its native region to a new area that it would not have been able to reach through natural dispersion; vectors are mechanisms through which such species are transported (Lockwood *et al*. 2007). These vectors are the means, activities or products through which an exotic species can be intentionally or accidentally transported to new surroundings (Koike *et al*. 2006).

Natural pathways include winds, currents or other natural means, for which species have developed morphological or behavioral adaptations. *Artificial pathways* are those that open up or increase as

a direct consequence of human activities. These can be divided in two types: *intentional pathways*, when they are a result of transportation, trade, handling and intentional release of organisms or propagules, and *unintentional pathways*, which transport species indirectly, for example, activities associated to the construction of infrastructure and means of communication, ballast water, organisms stuck to the hulls of ships, soil for gardening or plant nurseries, food import or tourism (Kriesch 2007). Three general categories of pathways have been recognized: the first related to transport of people and goods; the second associated to the trade of live organisms and their products, and the third includes the consequences of other human activities and natural causes (Kriesch 2007).

The analysis and management of pathways requires identifying the different stages of the process from its start until its destination, the possible vectors, and the species that can be transported throughout this route in order to establish detection, prevention and monitoring actions. Some of the factors that must be considered are the speed of the vectors, frequency of travel, season of the year, amount of individuals, species susceptible to be transported and the similarity of the receiving area with the region of origin, among others.

Not all invasions show clear signs that allow the determination of the pathway, which hampers the implementation of the necessary measures needed to prevent the route´s permanence. Some exotic species can be present in an area without causing any harm during long periods of time and thus can pass unnoticed. For example some species of trees or shrubs introduced in an ecosystem in which they lack means to reproduce (for example, a specific pollinator). These species survive and do not show invasive behavior until the arrival, several years later, of the adequate pollinator, introduced accidentally or intentionally (Espinosa-García 2009). In these cases, because of the time that can elapse between these two events, it is impossible to trace back the steps that brought the original species to the new habitat. Monitoring the pathways of introduction and their vectors is one of the main tools that must be considered in the fight against invasive species.

BALLAST WATER

Ballast water is used to maintain the safety of ships. The purpose of taking it in, or discharging it, is to maintain the draft level and the stability of the ship, which are important for propulsion, and for the maneuvering and weight compensation needed to make up for the consumption of fuel. Because of the transport of ballast water, the amount of plankton and exotic invertebrates introduced in different regions has significantly increased; these invasions severely affect marine and estuarine ecosystems (Salles Vianna da Silva *et al*. 2004).

It is estimated that ten thousand million tons of ballast water are transferred on an annual basis, and that close to three thousand species of plants and animals are transported daily around the world this way (Carlton and Geller 1993). In Australia, studies have revealed that over 50 thousand species of zooplankton and 10 million phytoplaktonic organisms can be found in a cubic meter of water (Subba-Roa *et al*. 1994). Consequently from the decade of the 80s on, when it was discovered that the bloom of toxic dinoflagellates of exotic origin implied great economic costs and affectations to human health (Hallegraeff 1998), active research on ballast water began and a management strategy for marine invasive species was developed.

Many species of marine phytoplankton and other groups of marine invertebrates, as well as their geographic distribution, are still unknown. It is assumed that a large number of cosmopolitan species exist, but this fact can be connected to early transferences of species due to transoceanic ship transport (Carlton and Rukelshaus 1997).

The impacts caused by exotic species are generally irreversible; in the marine environment the problem is complex as practically all marine species have one or several planktonic stages, as part of their life cycle, that can be transported in ballast water or sediment.

For all these reasons, international agencies have been created to protect the marine environment. Among the most important ones are the International Council for the Exploration of the Sea (ICES), created in 1902; the International Maritime Organization (OMI), cre-

ated in 1948 through its Marine Environment Protection Committee (MEPC, of which Mexico is a member since 1954) and the Intergovernmental Oceanographic Commission (IOC, belonging to UNESCO), created in 1960, which have formed a group for the study of ballast water and sediments. In 2004, the International Convention for the Control and Management of Ships' Ballast Water of the IMO was adopted by our country. The decree of Approval appeared in the Official Newspaper of the Federation on December 18th 2007, waiting for it to enter into force at the international level. Until this happens, the Maritime Authority will develop an Official Mexican Norm (NOM) for its implementation (see annex 3).

Species introduced by ballast water can cause the following problems:

a) Health problems, such as cholera or different parasitic diseases, which affect humans, animals and plants, including organisms used in aquaculture. Examples of this are problems related to red tides and the increase of their frequency at a global level or the Paralytic Syndrome Phenomenon due to the consumption of mollusks (PSP) (Anderson 1989; Hallegraeff 1993; Smayda 1990).
b) Predation of native species and negative effects on the habitat.
c) Pollution, such as blockage of pipelines and increased clarification in water bodies associated with the propagation of exotic mollusks.

Some of the recommendations to reduce the risk of translocation of species due to ballast water are: each port should have a specific area assigned for this maneuver, avoid very shallow waters or very polluted (dredged) zones, or those where red tides are present; avoid whenever possible the discharge of ballast water and do so only when strictly necessary. In addition, multiple mechanical, physical, chemical (Salles Vianna da Silva *et al*. 2004) and biological treatments have been proposed to kill, diminish or sterilize organisms contained in ballast waters and sediments, as well as special antifouling paints with biocides to diminish the amount of organisms adhered to hulls (Ferreira *et al*. 2004).

The most effective way to reduce the impact of ballast water is the exchange at high seas (ocean floor depths greater than 500m), because the ocean environment is inhospitable for fresh water, estuarine and most coastal marine organisms. Although nor this one nor any of the ballast water treatments is 100% efficient, the exchange at high seas, combined with a system of control and revision, drastically lowers the risk of introduction of unwanted species (Salles Vianna da Silva *et al*. 2004).

BOX 2. **BALLAST WATER: A PATHWAY OF INTRODUCTION WITHOUT BORDERS**

Because of its antiquity and frequency, ballast water is the pathway that has transported the greatest volumes of organisms from one site to another. Among the main invasions caused by ballast water documented around the world we highlight the following:

a) Zebra mussel *Dreissena polymorpha*, originally from Europe, established itself in the Great lakes and has currently invaded 40% of American rivers, from the north to the south, in both coasts of the United States (Gauthier and Steel 1996). In 2008 its presence was detected in California and it is now found in the border zone with Mexico.

b) The ctenophora *Mnemiopsis leidyi*, endemic species of the North American Atlantic was found in Europe for the first time in 1982, in the Black Sea, from where it expanded to the Azov Sea in 1988, the Aegean Sea in 1990, the Marmara Sea in 1992 and reached the Mediterranean and Caspian Seas in 1999 (Shiganova *et al*. 2001; Swedish Environmental Protection Agency 2005). Decades later it has caused the extinction of several native ctenophores (GESAMP 1997).

The Zebra mussel (*Dreissena polymorpha*) is an invasive mollusk that has been recorded in California, United States near the border with Mexico. Photo: Randy Westbrooks, USGS, Bugwood.org

c) The Northern Pacific sea star *Asterias amurensis*, which is originally from Japan and was introduced in Australia, as well as the toxic dinoflagellates of the genera *Alexandrium* and *Gymnodinium*, have had severe negative effects on fisheries and agriculture (Hallegraeff y Bolch 1991).

d) A cholera epidemic caused by *Vibrio cholera* that began in 1962 in Indonesia and gained worldwide importance again in 1992, was caused by the introduction of the bacteria by cargo ships coming from South America (McCarthy and Khambaty 1994; Simanjuntak *et al*. 2001).

e) The macroalgae *Caulerpa taxifolia*, which reproduces by fragmentation, is native to the coasts and seas that surround Hawaii, where it presents no invasive tendencies. It was accidentally introduced in the Mediterranean Sea from where it was transported through domestic ships to parts of Europe. In 1987 a small population was found 3km from Monaco; in 1991 a surface of 30 ha was reported to be covered and in 1996 this area was close to 3000 ha. It currently covers millions of hectares in the coasts of France, Spain, Italy and the Adriatic Sea and has displaced native macroalgae, limiting the habitat for fish and invertebrate larvae (Meinesz and Hesse 1991; Meinesz *et al*. 1993).

The Northern Pacific or Japanese sea star (*Asterias amurensis*) is on the "One Hundred of the World's Worst Invasive Alien Species" list. It feeds of a great variety of prey and, once established, it is very difficult to eradicate because of the large size of its populations. Photo: Wikimedia

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PREVENTION OF INTRODUCTIONS

In order to face the harmful effects of invasive species, it is necessary to combine different approaches, considering that the actions to be undertaken depend on the specific situation of each biological invasion. Besides the procedures for prevention, control and eradication, there are other tools such as risk analysis, whose aim is to prevent the establishment of invasive agents or epidemics in the environment (Drake 2005). Risk analysis serve as technical support for decision making in situations of uncertainty (Suter II 2007).

The risk analysis process is divided into: *risk evaluation*, which estimates the possibility of an event occurring and its severity; and *risk management*, which identifies, evaluates, selects and implements actions to lower the risk (Andersen *et al*. 2004). Risk analysis for biodiversity, as a consequence of invasive species, requires the participation of an interdisciplinary team, as it involves topics such as ecology, economy and statistics. The discipline of ecology examines the characteristics of the species and the environmental conditions, to determine the invasive potential in a given ecosystem; the economic analysis reviews the transport conditions of these species and calculates the costs of prevention and control, and the statistical analysis provides tools that allow the thorough examination of probability values (Leung *et al*. 2002).

There are different methodologies of risk analysis; some are directed towards specific groups of organisms, others provide more general guidelines or are focused on the pathways. This is important as every case must be analyzed individually, considering that each scenario depends on the species, ecosystem, pathway, frequency of introduction, time of year, potential damage, potential benefits, among other factors.

As a general rule, risk analyses should be based on solid scientific data and on transparent processes that are open to public scrutiny for their evaluation. The assessment tools must address, in an independent manner, each of the steps of invasion, including trans-

Vehicle washing to prevent weed dispersion in the United States promoted by S-K Environmental
Photo: Georgia Born-Schmidt/ CONABIO

port, establishment, proliferation and impact. When carrying out the analysis it must be recognized that, depending on the circumstances of introduction, the species and the ecosystem can acquire different weight in the estimation, although it is possible to calculate, at a general level, the risk associated with taxonomic groups or types of ecosystems. The degree of uncertainty and the quality of the data must also be established as well as the reliability of its origin (Campbell and Kriesch 2003).

Risk analyses provide decision makers with the necessary information to determine which organisms can be introduced and their possible impact on native species and ecosystems. Such evaluations must be based on the best available scientific evidence, be complete and explicitly presented as part of the evaluation document (Griffin 2008). Considering that the definition of risk includes the probability of occurrence of adverse events and the magnitude of their consequences, the guidelines for evaluation must show results in both respects.

In the phytosanitary area, the Food and Agriculture Organization (FAO) of the United Nations, through the International Plant Protection Convention (IPPC), has established the International Standard for Phytosanitary Measures (ISPM) Number 11, titled: "Risk analysis of quarantine pests" (FAO 2004), which allows for the identification of the risk, its evaluation and identification of management options.

Based on the guidelines established by the FAO/IPPC, the methodology of pest risk analysis (PRA) has been formally applied in decision making for almost 18 years by the General Direction of Plant Health.

Bird predation by invasive mammals (rodents, feral cats and dogs), is one of the main problems caused by introduced species in the islands. Photo: David Mudge/Nga Manu (Many birds) images

Lionfish young (*Pterois volitans*) captured by members of the Punta Allen Community who participate in the eradication of the species in the Sian Ka'an Biosphere Reserve. The young have greater capacity to move to new territories than adult individuals.
Photo: Alma Álvarez Morales

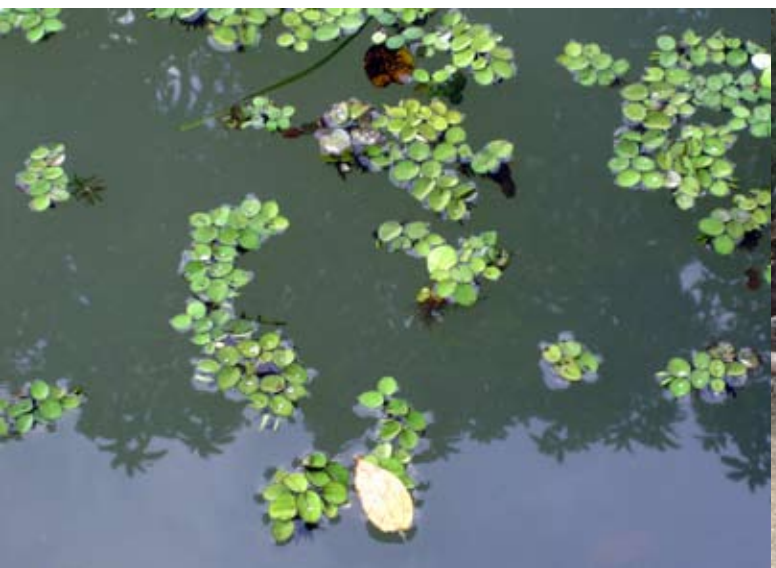
Our country regularly works with the regional plant protection organizations for agricultural health, OIRSA and NAPPO, which have established work panels for PRA, with the aim of reducing the differences or possible controversies that could arise through its use, in order to facilitate trade and avoid the implementation of unjustified measures such as barriers to trade (Elizalde 2001; SAGARPA 1996).

It is necessary to consider that a PRA regards as a *pest* any plant or animal species, race or biotype, or pathogen agent injurious to plants or plant products, and defines a *quarantine pest* as an organism of potential economic importance for Mexico, even when such pest is not yet present or, if it is, remains confined and under official control (FAO 2004).

The PRA should be thoroughly documented so, if a revision is needed or a controversy arises, the sources of information and the facts used to make the decisions can be clearly identified, either in relation to the established phytosanitary measures or those that will need to be adopted as a result of the PRA (FAO 2004). The General Direction of Plant Health holds over three thousand phytosanitary requirements that will contribute, based on the risk evaluations, to establish the appropriate phytosanitary measures needed to maintain an adequate level of protection. Risk analyses are essential for decision making since they lower the subjectivity and document the processes. These analyses require the cooperation of scientists, academics and the agricultural sector.

Salvinia molesta is a fast growing exotic plant that is dispersed by currents and, between water bodies, through contaminated equipment and ships.
Photo: Georgia Born-Schmidt/ CONABIO

The training course "Assessment, control and monitoring of invasive species in Mexican islands" was organized by GECI, CONANP, INE, and CONABIO and aimed at personnel from insular natural protected areas of Mexico, DGVS, SEMAR, PROFEPA and communities of fishermen in Baja California. It took place in Ensenada and Guadalupe Island on December 2008.
Photo: Isabel González / CONABIO



BOX 3. **PEST RISK ANALYSIS**

The requirements for a Pest Risk Analysis (PRA) are encompassed in three stages.

Stage 1: Initiation of the PRA process

There can be two different approaches to starting a PRA: 1. the identification of a pathway or 2. the identification of a pest.

During stage 1 a list of pests that has been identified (in case of initiation by a pathway) will be subject to a risk evaluation. Those pests are examined separately in order to determine, for each one, if they fulfill the criteria to be included among quarantine pests, which are defined as "those of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled" (FAO 2004; IPPC 2009).

Stage 2: Pest Risk Assessment

Considering all aspects of each pest, and especially the information on their known geographic distribution, biology and economic importance; the establishment potential, dispersion and economic importance for the area included in the PRA are evaluated. Lastly, the potential of introduction into the area is determined (FAO 2004).

Stage 3: Pest Risk Management

The management of the risks posed by pests is based on the information collected in stage 2. Phytosanitary measures should be applied across the minimum necessary surface required for the effective protection of the endangered area. A list of risk management options should be produced to determine the best way of lowering the risk to an acceptable level: these can include pathways of introduction and a revision of circumstances that allow the entry of commodities (FAO 2004).

Documentation of the PRA process

Upon finishing the PRA, the process should be documented enough so if a revision is needed or a controversy arises, the sources of information and the facts used to make the decisions can be clearly identified, either in relation to the established phytosanitary measures or those that will be adopted as a result of the PRA (FAO 2004).

The General Direction of Plant Health holds over 3000 requirements; these reflect the appropriate phytosanitary measures needed to maintain an adequate level of protection.

Conclusions

- The PRA is a necessary component to make phytosanitary decisions.
- The PRA reduces subjectivity and documents processes.
- The PRA requires the cooperation of scientists, the academic sector and the agricultural industry.

Alejandra Elizalde, SENASICA-SAGARPA

EARLY RESPONSE

The term *early response* refers to the immediate actions to be taken when prevention has failed and an invasive species is detected and treated before it becomes established and disperses. In order to carry out these actions in time, it is essential to have an infrastructure that allows executing quick measures to contain or eradicate these infestations.

Monitoring is a crucial component of rapid response and, although so far there are few situations regarding invasive species in which it has been implemented, there are examples for species, there are examples for species hazardous to human and animal health, such as the National Biological Information Infrastructure of the United States for avian influenza (NBII 2010).

Preparation of poison to be applied in the trunks of *Tamarix* sp. during the campaign to control tamarisk in Cerralvo Island in 2010.
Photo: Margarita García

BOX 4. **EARLY RESPONSE: ERADICATION OF THE CACTUS MOTH**

The Cactus moth (*Cactoblastis cactorum* Berg.), of South American origin, was widely used for biological control of cactus species (*Opuntia* sp.), considered exotic invasive plants in Australia, South Africa and the Caribbean. In 1989 it was found in the Florida peninsula and in several islands of the Caribbean and thus became a threat for North American deserts. Since 2000 government agencies together with civil organizations, recognized the importance of this threat, which has the potential of causing social, economic, and ecologic damages, especially to the *Opuntia* shrublands and production fields in Mexico. In response the authorities published the official Mexican norm NOM-EM-040-FITO-2003 with regulations to prevent the introduction, dissemination and establishment of the cactus moth in Mexico. In addition to this effort, with the collaboration of international organisms, a technical education campaign was directed towards the monitoring of cacti in high risk areas, in order to have an early detection system throughout the country.

On August 2006 the cactus moth was detected in Mujeres Island, Quintana Roo. Fortunately, a swift response resulted in the successful eradication of *C. cactorum* in both Mujeres Island and later in Contoy Island. The eradication campaign was carried out with the collaboration of national (SAGARPA and CONAFOR) and international organisms (OIEA, USDA and NAPPO), who prepared pheromone traps and provided the training required for the eradication. Since February 20th 2007 no male adult specimen has been collected in Mujeres Island and since March 5th of the same year not a single stick of eggs has been collected in the sentinel cacti or in the traps.

The eradication of the outbreak of the Cactus moth in Mexico is an unprecedented event that emphasizes the importance of prevention and early response for the eradication, with interinstitutional and international collaboration. The eradication of this plague represents the safekeeping of part of Mexico's biological, cultural and economic richness.

Jordan Golubov, UAM-Xochimilco, Aridamérica and Alejandra Elizalde, SENASICA-SAGARPA

Larvae of Cactus moth (*Cactoblastis cactorum*), a species that threatens the diversity of cacti, the arid and semi-arid ecosystems and the *Opuntia* shrublands and production fields of Mexico.
Photo: Ignacio Baez/USDA

ECONOMIC, SOCIAL AND ENVIRONMENTAL IMPACTS

Invasive species cause substantial economic losses, which reach thousands of dollars per year, adding to the intrinsic value of the loss of biodiversity as part of the natural capital of a national territory. There are tangible estimates of this economic impact on certain productive sectors, although more detailed studies are still needed, especially for Mexico. In the United States it is estimated that the impacts of the more than 50 thousand recorded invasive species sum up approximately 120 thousand million dollars in damage to crops, water supply and native ecosystems (Pimentel *et al*. 2001 & 2005). In Mexico, these types of evaluations are just being developed so there are no estimates of the costs derived from the presence of invasive species. There are however a few examples, such as the evaluation of costs associated to damages caused by the introduction of Loricariidae, or Armored catfishes to the Infiernillo Dam, at the border of the states of Michoacán and Guerrero; which were estimated at over 13 million dollars (Stabridis Arana *et al*. 2009). Another example is the amount invested in the campaign against the Cactus moth (*Cactoblastis cactorum*) between 2002 and 2009, which amounts to over 5 million dollars (SAGARPA-SENASICA 2009); this amount, although considerable, would be widely surpassed by the economic and social consequences that the establishment of the moth would mean for the country. To the direct costs for the management of invasive species, we must add those derived from the effects on the environment. The South African government, for example, invests 40 million dollars per year

Livestock in the Tuxtlas area. Changes in land use because of activities such as cattle farming, open opportunities for the introduction of exotic species.
Photo: Mari Carmen García/ CONABIO

on the control of three invasive plants that have not only affected the local biological diversity, but have also lowered the reserves of some aquifers and increased the risk of fire. By causing economic damage, invasive species contribute to social instability and consequently represent obstacles for the development and economic growth of the regions (Pimentel *et al*. 2001; Sala *et al*. 2000). In terms of public and human health, invasive species have direct consequences such as the exposure to new diseases and parasites, and indirect, like those derived from higher and more frequent exposures to pesticides and other chemicals that are needed to eradicate and control those species.

Feral cats (*Felis catus*) on Bird Island located in the Laguna Grande of Coyuca, Guerrero. Abandoned cats cause damage to native bird populations in many islands of the country. Photo: Michael Schmidt

Red-billed Tropicbird (*Phaethon aethereus*) in Farallón de San Ignacio Island, Gulf of California. After the eradication of the black rat in 2007, the reproductive success of these birds increased, as well as the number of nesting areas. Photo: J.A. Soriano/GECI

BOX 5. **IMPACTS OF AQUATIC WEEDS**

Freshwater systems in Mexico harbor several species that are not native to our country. Common water hyacinth (*Eichhornia crassipes*), hydrilla (*Hydrilla verticillata*), salvinia (*Salvinia* spp), saltcedar (*Tamarix ramosissima*) and giant reed (*Arundo donax*) pose a serious problem that has direct effects on the supply of water. Proliferation of these plants causes economic, ecologic and health impacts. Examples of the damages to the economy are loss of water due to evapotranspiration, premature accumulation of sediments in reservoirs, restrictions on fishing and recreational activities, obstruction of water canals and water inlets in hydroelectric installations and reduced efficiency of hydraulic installations (Gopal 1987). Aquatic weeds also have a direct effect on health by providing suitable habitat for the development of organisms that are vectors for serious and even mortal diseases such as dengue fever, helminthiasis, philiarasis, encephalitis, malaria and yellow fever, among others (Hernández and Pérez 1995). Among the ecological damages is the accumulation of large amounts of aquatic weeds causing water stagnation thus lowering the concentration of dissolved oxygen and killing aquatic species (Barrett 1989). Additionally, there are also changes in the physicochemical conditions of water bodies and the displacement of native aquatic plants. It was recently demonstrated that the presence of aquatic weeds is linked to the proliferation of cyanophytes (Wilde *et al*. 2008), it is important to be aware of these blooms, as some of these algae produce toxins that can cause the death of animals or humans drinking the water where these organisms proliferate.

Maricela Martínez Jiménez, IMTA

Common water hyacinth (*Eichhornia crassipes*) is an aquatic weed that grows very quickly covering large surfaces in dams, lagoons and irrigation channels, blocking the free flow of water or navigation; it also affects survival of native plants and animals. Photo: Hernando Cabral

Hydrilla (*Hydrilla verticillata*) is an invasive weed of fresh water bodies that covers the surface of the water blocking the sunlight. Photo: Chris Evans, River to River CWMA, Bugwood.org

Giant reed (*Arundo donax*) is an invasive aquatic plant that affects wetlands in the north of Mexico. Photo: Ignacio March

BOX 6. **CURRENT SITUATION OF AQUATIC RESOURCES IN TABASCO: ECONOMIC AND SOCIAL IMPACTS OF ARMORED CATFISHES (LORICARIIDS)**

Armored catfishes are a group encompassing over 680 known species of the Loricariidae family native to the Amazon basin in South America. Also known as armored catfishes, tank cleaners and in Mexico, devil fish, they have expanded their range in an alarming manner in only a few years. About twelve species of these fish are registered as established in the wild in several regions of the planet such as the United States, Taiwan, the Philippines, Japan, Singapore and Mexico, causing serious damage. In our country they were first spotted in 1995 in the Mezcala River, in the basin of the Balsas River. These fish have several particularities in their morphology, physiology and behavior that accentuate their invasive potential, and they can displace other species in different ways such as by incidental ingestion of eggs and competition for algae and detritus. They are also possible carriers of diseases and parasites. They have caused devastating damages in what used to be the most important freshwater fishery of Mexico (Mendoza *et al*. 2009).

In Tabasco, as a result of workshops carried out in 2007 with fishermen and other stakeholders in the municipalities of Balancán and Tenosique (Barba *et al*. 2007; Barba and Estrada 2007), it was concluded that the presence of the Armored catfishes, which were captured for the first time in this area in 2005, has had a negative effect on the fishing industry.

These fish have been captured in a variety of environments, in rivers, lagoons and in areas of both soft and shallow or rocky floors. They are captured with any type of fishing gear, mostly filament nets (64%) and during nocturnal capture periods (72%). The average number of fish captured per net is of 210 organisms with an average weight of 400 g. Of the people surveyed in these workshops, 45% are not aware of any use for the armored catfishes, while 55% indicated that they use them as bait for crayfish and other species.

According to the population census of 2007, a total of 12,887 people depend directly on fishing activities. The number of people affected (directly and indirectly) was of 51 548. The invasion of the armored catfishes requires immediate actions. Already several studies are being carried out for their use; however, it is necessary that the proposals for their economic use have a comprehensive vision, accompanied by applied research to substitute them by native species and to include preventive actions to avoid reintroductions.

Everardo Barba, ECOSUR*-Villahermosa*

Economic impacts of the armored catfishes include damages to river banks caused by their nesting habits and the collapse of important fisheries such as the case of the Infiernillo dam in the state of Michoacán.
Photo: Roberto Mendoza

USE OF EXOTIC SPECIES IN PRODUCTIVE ACTIVITIES

The use of exotic species in productive activities (agriculture, stockbreeding, aquaculture, forestry and production and sale of ornate plants) has been extensive for over a century. Recently, the production of plants for biofuels has also increased, as another factor to satisfy the ever increasing demand of services for the population. In many cases, these activities have had very high costs from the environmental point of view. Some of them direct, such as the loss of biodiversity and the introduction and propagation of parasites and diseases; and some indirect that have increased the negative effects of other pressure factors, such as the deforestation of rainforests and forests, the overgrazing of desert shrubland, the increasingly difficult access to water resources, soil erosion and agrochemical pollution, among others.

In the north of the country, 80% of the flora introductions for different purposes (food, landscaping, reforestation, research) are species that originate from Africa, Asia and Europe, as a consequence of the Spanish colonization and domination. The family Poaceae has the greatest number of introduced species registered in the country. Among the introduced grasses, Buffelgrass (*Pennisetum ciliare*), Gamba grass (*Andropogon gayanus*), Guinea grass (*Panicum maximum*) and Bermuda grass (*Cynodon dactylon*) stand out as a serious problem. These grasses were intentionally introduced because of the availability of technologies for their cultivation and have been used for erosion control, stabilization of highway and canal edges or as forage crops for cattle. In general these are easily adapted species with quick growth, resistance to drought and high biomass productivity. Their adaptation has been successful because of the similar-

Casuarina or Australian pine (*Casuarina equisetifolia*) alters soil chemistry and therefore the conditions in which native species develop. Photo: Forest & Kim Starr/ USGS/ Bugwood.org

ity in climatic conditions between the areas of introduction and their original distribution. Their dispersal across native ecosystems has occurred in relatively few years, during which time they have practically replaced the native vegetation cover and modified the fire regimes of the region (Arriaga *et al*. 2004; Villaseñor and Magaña 2006).

Aquatic exotic species were initially promoted by international organizations, such as FAO, and were included in the strategies implemented by governmental organisms, aimed to increase food supply and raw materials. These introductions frequently took place in natural water bodies, causing the establishment and propagation of invasive species and diseases in different areas of the national territory, with the corresponding impact to different native species, deterioration of terrestrial and aquatic environments and loss of ecosystem services and productivity. Examples of this are tilapias, carps, the American Bullfrog, Australian lobsters or the translocation of shrimp from the Pacific to the Gulf of Mexico.

The introduction of some exotic species for reforestation programs or for soil conservation, such as Casuarina (*Casuarina equisetifolia*) and Eucalyptus (*Eucalyptus globulus*), have impoverished the quality of native habitats, altered the availability of water resources and caused health problems in human beings. The common water hyacinth (*Eichhornia crassipes*), used mostly for ornamental purposes, has caused impacts on productive activities such as fisheries and navigation.

The introduction of exotic plants with invasive potential for the generation of biofuels represents a great risk. Many of these species are selected because they have traits that contribute to their naturalization and establishment in new areas, which is a characteristic of their invasive potential (Barney y DiTomaso 2008; Buddenhagen *et al*. 2009; GISP 2008); their production in the country must thus be avoided.

Tilapias have been introduced to a large number of water bodies in Mexico and have caused the extinction of populations of native fish.
Photo: Miguel Sicilia/ CONABIO

Plecos, also known as tank cleaners or Armored catfishes, have expanded their range alarmingly in only a few years; they represent one of the biggest threats for the biodiversity of freshwater ecosystems in Mexico.
Photo: Wikimedia

Processes such as livestock ranching in tropical forests, promoted by development policies, to expand the national farming border and solve the problems of agrarian distribution, opens opportunities for the introduction and establishment of exotic species. Although the warm-humid tropical zones of Mexico form the richest, most diverse and complex natural ecosystems known (Márquez-Cabrera 2010), the vegetation of the humid tropic of the country has been severely diminished in the last 50 years. Currently only 17% of tropical forests are preserved in primary condition (Challenger and Dirzo 2009).

The lack of consistency between environmental and productive policies, coupled with the fact that biodiversity loss is not valued and that no investments have been made to build technological packages using native species, has encouraged the use of exotic species. Public policies that promote the use of potentially invasive alien species in the long run, must consider their impacts in all surroundings: environmental, social and economic. Food production must be harmonized with the conservation of the natural sources of production, this means it must maintain the balance with the ecosystems and therefore with the environmental services they provide.

Many exotic species are widely used and important for food safety and the economy. The species that have not proved to be a threat are not the ones that should worry us, and this strategy does not focus on them. However, current biosafety measures must be assessed to ensure that the use of exotic species is made possible under conditions that prevent their dispersal and introduction into natural ecosystems.

The application of preventive measures constitutes the most appropriate control method for the management of invasive species. Therefore the use of tools such as risk analysis and other prevention mechanisms like the HACCP (Aguirre-Muñoz *et al*. 2009), must be mandatory in any production program involving the use of exotic species,

Bermuda grass (*Cynodon dactylon*) is an African grass with a wide distribution in diverse regions of Mexico.
Photo: Pedro Tenorio Lezama

Buffel grass (*Pennisetum ciliare*) from tropical Eurasia, was introduced as cattle feed in the north of the country. It has invaded shrub lands and tropical deciduous forests.
Photo: Pedro Tenorio Lezama

particularly next to protected areas (PAs). It must be understood that the introduction of exotic species must be strictly forbidden, or regulated under strict biosafety measures that ensure their total confinement, inside PAs and other strategically important ecosystems.

Regulation of potentially invasive alien species, within productive policies, might raise strong reactions from different sectors whose interests could be affected. However, Mexico must begin a harmonization process considering recent experiences that have demonstrated that invasive species not only cause serious damage to the natural environment, but can affect food production, damage public infrastructure, cause degradation of crop lands, increase the vulnerability of commercial embargoes, affect the quality of water and landscapes with historic and touristic value; their impacts can mean elevated costs, both because of the direct damage as well as the expenses required for their control and eradication (Aguirre-Muñoz *et al*. 2009).

The Monk Parakeet (*Myiopsitta monachus*) is native to Argentina and Uruguay and has been documented as a pest for crops, but can easily adapt to urban environments. It has a very high demand as a pet in Mexico. People, who are not aware of its potential of damage, release them and further contribute by feeding them like pigeons and house sparrows. Photo: Patricia Koleff/CONABIO

Common pigeons (*Columba livia*) are native to Europe and have been introduced around the world; they cause damage to buildings and can pass on diseases to other species. Photo: Isabel González/CONABIO

CONTROL AND ERRADICATION OF INVASIVE SPECIES

The importance of evaluating the possibility of controlling or eradicating invasive species, in terms of cost and available techniques, rests on the serious threat they pose to biodiversity, ecosystems and natural resources of high value for Mexico. Such is the case of exotic fish in continental water bodies that displace native species, the Cactus moth for arid and semiarid zones and cacti, aquatic weeds that considerably lower the water resource and mammals (cats, rats and goats, among others) introduced in islands that threaten the endemic species that inhabit them.

In terms of eradication of species introduced in islands, Mexico's work stands out at the international level. Over the last decade, forty populations of mammals that were introduced in 28 islands have been eradicated; this is a crucial step for the conservation of over one hundred endemic species and subspecies that inhabit the islands of the northeast of Mexico (Aguirre-Muñoz *et al*. 2008).

The outstanding result in the islands of the Gulf of California has been the product of the initiative of some individuals and civil organizations, supported by a scheme of inter-institutional collaboration and international cooperation. The restoration of all the islands in Mexico —there are just over thirty islands with introduced mammals— is a viable goal for 2025, and would represent a milestone of worldwide importance.

Eradication of *Arundo donax* is complicated because the growth of this plant is faster than that of many native species.
Photo: Ignacio March

Eradication of introduced plants in Isabel Island in Nayarit, to decrease the availability of one of the sources of food for the population of invasive rodents.
Photo: GECI

BOX 7. **RESTORATION ACTIONS ON GUADALUPE ISLAND**

Guadalupe Island is a volcano of 5,800 m in height. The emerged surface is of 1,298 m and it has a surface of approximately 250 km^2. It is an important center of endemism expressed in 34 plant species, including two genera (Moran 1996); eight terrestrial birds (Hubs and Jehl 1976); a seabird (Jehl and Everett 1985); eleven terrestrial snails (Pilsbry 1927) and at least 18 species of insects (González 1981). It is also an important breeding site for marine mammals such as the Guadalupe fur seal (*Arctocephalus townsendi*), the Northern elephant seal (*Mirounga angustirostris*) and a number of bird species, among them the Laysan albatross (*Phoebastria immutabilis*).

With the introduction of goats during the XIXth century, tree cover —pine, cypress, oak, palm and juniper— diminished dramatically; only 6% of the original cover has survived (Oberbauer 2005; Rodriguez-Malagón 2006). On the other hand, feral cats have caused the extinction of six species of birds and threaten the permanence of numerous populations of native birds.

To promote the environmental restoration of the island, the Island Conservation and Ecology Group C.A., in collaboration with government organizations (SEMARNAT and SEMAR) and academic institutions, implemented the project "Restoration and conservation of Guadalupe Island". The eradication of goats, which began in 2003, concluded successfully in 2006. Monitoring to confirm the results took place during 2007-2009. Thanks to this eradication, for the first time in over 150 years, recruits of tree species germinated and survived (over 130,000 in 2009), and six native species that were believed to be extinct or extirpated from the island were observed. The eradication of feral cats —which represents a worldwide challenge—, is in the planning phase. While the eradication of this damaging species becomes a reality, localized control actions have been carried out around the breeding areas of seabirds to mitigate the impacts of predation. The restoration project of Guadalupe Island together with advances in other islands of the region has national and worldwide relevance (Aguirre-Muñoz *et al*. 2005). The project is considered, to this date, a model on island conservation that places Mexico as an international leader in the conservation of ecosystems.

The accumulated practical experience, together with the development of new technologies in other latitudes and the support of society and government, will allow for the formulation of an integral program for the eradication of introduced fauna for the islands of the country. Quick advances in the legal and financial aspects —currently nonexistent— are needed towards a scheme that favors island restoration in Mexico. With these elements, the successful implementation of restoration actions for species and ecological functions will be viable.

Luciana Luna and Alfonso Aguirre, GECI

Black rat monitoring in San Pedro Mártir Island, Gulf of California, an essential activity to evaluate the success of the program and an early detection tool. Photo: GECI

PROTECTED AREAS

Protected areas (PA) are the most consolidated conservation instrument in Mexico. Their mission is to conserve the natural heritage of Mexico and its ecological processes; therefore it is essential to maintain them free of invasive species. Until now, most of the efforts to control and eradicate invasive species have focused on the insular PA of the North Pacific and the Gulf of California because of the fragility of these ecosystems, which host a number of endemic species.

In Mexico, the registered number of invasive exotic flora greatly exceeds that of introduced fauna. The PAs of the northern regions identified by the National Commission of Natural Protected Areas (CONANP) (the Sierra Madre Occidental range, the Northeast region and the High Gulf of California) (DOF 2007) cover a large part of the deserts of North America. In these areas, a considerable number of exotic grasses and plants from arid and semiarid environments have become established (Bogdan 1997; Desert Museum 2008; Science Daily 2002). An example of this is Buffelgrass, a widely cultivated invasive species because of its use in stockbreeding, which in turn increases its opportunities of establishment and dispersal (Chambers and Hawkins 2004).

Prevention, control and eradication of invasive species must be considered in the management of PAs, as places of conservation, sustainable development and research. That is why it is essential that each PA has an adequate prevention program that includes continuous surveillance and moni-

The Laysan albatross, (*Phoebastria immutabilis*) inhabits several insular protected areas of the Pacific. In Guadalupe Island its population is very vulnerable to cats, rats and introduced mice. Photo: Isabel González/ CONABIO

toring actions with the objective of decreasing the number of introductions of exotic species and detecting, at an early stage, the species that are potentially invasive (De Poorter *et al*. 2007).

Since 2008, CONANP has carried out different actions aimed at gathering information on exotic, feral and invasive species, and their distribution in federal PAs, in order to have a diagnosis and establish the priorities of action throughout the country (CONANP 2009b). The results indicate that PAs are vulnerable to damage caused by invasive species. Without management to prevent and combat these species, the value of the protected area, including the ecosystem services and the biological diversity will be inevitably affected. However, this threat has also allowed the creation of capacities to effectively combat invasive species.

Biological invasions are a cross cutting issue which has an ecological, socioeconomic and even ethical dimension. Control or eradication actions are frequently costly and difficult to develop, and the alternatives of prevention, detection and early response, even if they are of high priority, require knowing the behavior of those species in other areas where they have also been introduced. Therefore, the generation of knowledge regarding management and control experiences and the cooperation and the exchange of information constitute the maximum strengths to work out these ecological problems (Schüttler and Karez 2008).

Different tilapia species were introduced to Mexico in the 60s and 70s. Currently Mexico is one of the main global producers; however many native species have disappeared or are endangered as a consequence.

The red-eared Slider (*Trachemys scripta elegans*) is very popular as a pet, but when released into natural ecosystems, outside its natural range (USA and North of Mexico), it competes and hybridize with native species. Photos: Miguel Sicilia/CONABIO

BOX 8. **INVASIVE SPECIES OF HIGHEST IMPACT REGISTERED IN PROTECTED AREAS**

Group	Exotic invasive species	Common name	Original distribution[1,2]	Number of PAs where they have been reported[3]
Plants	*Arundo donax*	Giant reed or giant cane	East Europe and Asia	6
	Pennisetum ciliare	Buffelgrass	Africa	13
	Cynodon dactylon	Bermuda grass	Europe, North of Africa and tropical Asia	17
	Dactyloctenium aegyptium	Crowfoot grass	Africa (Nigeria)	16
	Eichhornia crassipes	Common water hyacinth	South America	8
	Casuarina equisetifolia	Australian pine, Beach she-oak	Australia and part of the Indo Pacific	15
	Tamarix ramosissima	Tamarisk, Salt cedar	East Europe and Asia	12
Fish	*Cyprinus carpio*	Common carp	Europe and East and South of Asia	15
	Oreochromis niloticus	Nile tilapia	África	19
	Oreochromis mossambicus	Mozambique tilapia	África	14
	Pterois volitans y *P. miles*	Red lionfish and Red firefish	West Pacific and Oceania	8
Amphibians	*Rhinella marina*	Cane toad	Northeast of Mexico to Brazil (translocated)	25
Reptiles	*Trachemys scripta elegans*	Red-eared slider	USA	2
Birds	*Bubulcus ibis*	Cattle egret	Iberian Peninsula, Middle East and Africa	13
	Columba livia	Rock dove, Common pigeon	Europe, North of Africa and Middle East	7
	Passer domesticus	House sparrow	Middle East and the Mediterranean	10
Mammals	*Rattus rattus*	Black rat	India	15
	Felis catus	Feral house cat	Iberian Peninsula, North of Africa, Asia	29

[1] Álvarez-Romero *et al.* 2008.
[2] CONABIO. 2009.
[3] CONANP. 2009a.

Fernando Gavito and Margarita García, CONANP


Loteristas Marías

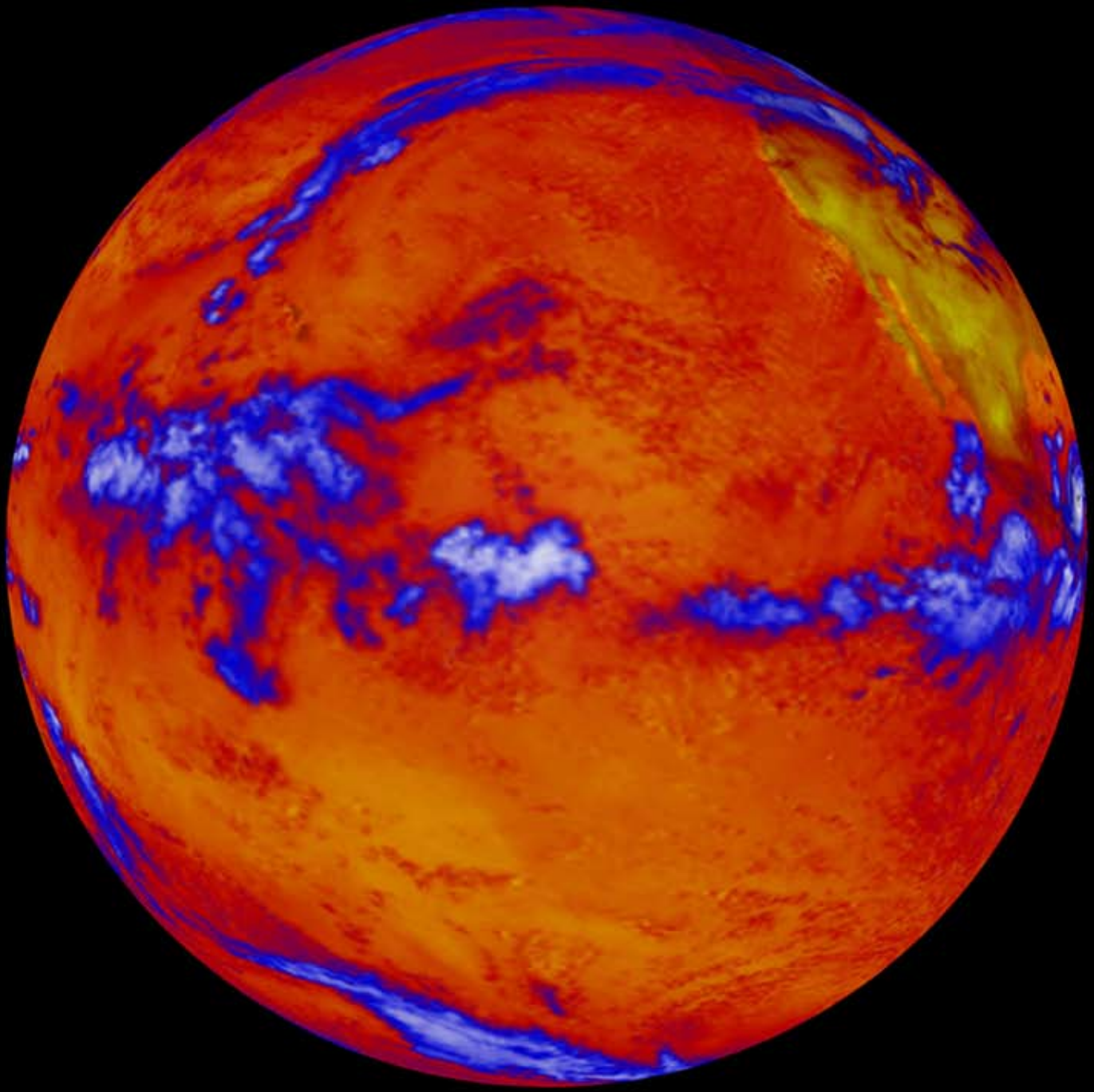
ENVIRONMENTAL EDUCATION AND OUTREACH

It is of uppermost importance to address the growing impact of invasive alien species from an educational perspective, as their introduction and dispersion is often a result of human activities; with effects encompassing not only ecosystems, wildlife and human health but also the productive activities on which the economy and social well being are dependent. The knowledge regarding invasive species and their effects is still not enough. It is necessary to make an educational effort that fully responds to the dimension of the problem to inform, sensitize and create consciousness in the different actors who are directly and indirectly involved.

This requires a specific educational design focused on the particular conditions of each of the social sectors at which it is directed; this effort requires interinstitutional cooperation in the formation of working groups, timely participation of the media and, above all, the involvement of the different sectors and civil organizations. Environmental education programs contribute to prevent early introduction and detection of exotic species, which is less costly than setting in motion control and eradication programs.

These needs require that society is properly and promptly informed so it is knowledgeable about the ecological, economic and social impacts generated by these species. One answer is to make information available to the general public in a timely manner, providing high quality facts that are significant, complete and appropriate for the social groups towards which the material is directed. The content needs to be geared towards a preventive approach while promoting the replacement of invasive species by native species. In particular, specific guidance and information efforts must be directed towards importers and consumers that introduce exotic species with commercial purposes for agriculture, livestock, landscaping, pet trade or cosmetic production, among others. In some cases, such as the import of species from the wild, there are international protocols that must be followed, as in the case of the species listed in the appendices of CITES.

Opposite page: Children with educational toys about the Marías Islands. Environmental education programs are essential to sustain the efforts for the prevention of introduction of invasive species and for early detection of exotic species.
Photo: J.A. Soriano/GECI



EFFECTS OF CLIMATE CHANGE

Invasive species and climate change are two of the major threats to the structure, function and integrity of ecosystems and the services they provide; their synergic effects, although of greater concern, are relatively unknown (Barnard *et al*. 2005)

It is expected that, in combination with the impacts of climate change, problems caused by invasive species will increase, particularly, the replacement of native species which are more vulnerable in the presence of the new climate conditions (Low 2008). Several studies suggest that climate change could trigger the expansion of invasive species to new regions. For example in the coast of the Mediterranean, climate change has added to other pressure factors such as pollution, habitat destruction and fragmentation and has caused the decrease of native species. It is possible that climate change is the cause of the dominance of eurithermal invasive species (which can withstand great oscillations of temperature) (Galil 2008).

In spite of these findings, the issue of invasive species has not received the recognition it deserves in the different forums where climate change impacts are being discussed. In Australia, priority actions have been identified, these include removal of weeds from peripheral populations, improvement in the management of grasslands susceptible to fire, a better preparation towards extreme events such as cyclones, strict legislative control in crops used for biofuels and the debate of conservation goals faced with a future of continual changes (Low 2008).

Although it is practically impossible to completely stop the effects of climate change or eradicate all invasive species, it is possible to lessen other threats, such as pollution, salinization, overgrazing, and overexploitation, among others. It is essential to carry out these actions to maintain healthy ecosystems as this has been recognized as one of the best practices to resist biological invasions (MA 2005).

Opposite page: Climate change and biological invasions are key processes that affect global biodiversity; their effects must be analyzed as a whole.
Photo: NASA-MSFC

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DEFINITIONS OF KEY TERMS

Alien species. A species, subspecies, or lower taxon occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes any part, gametes or propagule of such species that might survive and subsequently reproduce (CDB 2009, IUCN 2000). This term can also apply to upper taxonomic levels such as genus or family (IUCN 2000; Lever 1985).

Control. Maintaining a determined population within certain levels or under a threshold (in terms of the number of individuals in the population and its area of distribution), in which the negative impact on the natural resources or, in particular, on native species is practically eliminated, or considered tolerable or acceptable (Parkes 1993).

Eradication. The permanent removal of the entire population of a species within a specific time and area (Parkes 1993).

Introduction. Transference, by humans, of live specimens to a new region outside the natural distribution area of the species or taxa (historic or current). It can occur within the same country or among different countries or continents (IUCN 2000; Lever 1985). The process of introduction can occur inadvertently or deliberately as a consequence of specific human activities (IUCN 2000; McNeely *et al*. 2001).

Invasive species. An alien species which becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity. (CBD 2009, IUCN 1999).

Invasive alien species. A species of population which is not native, is found outside its natural range of distribution, is able to survive, reproduce and establish in natural habitats and ecosystems and is a threat to native biodiversity, the economy and public health (DOF 2010).

Naturalization. Process of establishment of an exotic species in its area of introduction. This establishment is associated to an area or place that, because of its characteristics (environmental similarity to the original distribution area or adequate conditions), allows the establishment of self sufficient free-living populations. The process of naturalization of a species requires overcoming some biotic and abiotic barriers for the species to survive and reproduce regularly in the new environment (Lever 1985; Richardson *et al*. 2000).

Negative impact. Adverse effects that invasive species can have on native flora and fauna, ecosystems, economy, society or health, according to their intrinsic biological characteristics, such as their life strategy and their feeding habits. Such effects are generated through competition, predation, herbivory, hybridization or disease transmission and they include vulnerability factors present in the areas into which it has been introduced (Álvarez-Romero *et al*. 2008). The impacts can be real or potential.

Pathway. Process through which a species is moved from its native region into a new area, which it would not reach through natural dispersion; vectors are mechanisms via which such species is transported (Lockwood *et al*. 2007). These vectors are the means, activities or products by which an exotic species can be transported to a new environment, whether intentionally or accidentally (Koike *et al*. 2006).

Pest: Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products (FAO, 2004; IPPC 2009). Quarantine pest: A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2004; IPPC 2009).

Sanitary and phytosanitary measures: Any measure applied to protect human, animal or plant health in an area or region of introduction, establishment or spread or pests, diseases or vectors. These measures try to prevent or limit the damages caused by pathogens through protocols and procedures established for the prevention, contention and rapid response (IUCN 2000; McNeely *et al*. 2001).

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ACCRONYMS AND ABBREVIATIONS

CBD	Convention on Biological Diversity
CEC	Commission for Environmental Cooperation of North America
CECADESU	Center for Education and Training for Sustainable Development, SEMARNAT
CEDES	Ecology and Sustainable Development Commission of the State of Sonora
CIECO	Center on Ecosystem Research, UNAM (Centro de Investigaciones en Ecosistemas)
COLPOS	Postgraduates College (Colegio de Posgraduados)
CONABIO	National Commission for the Knowledge and Use of Biodiversity
CONAFOR	National Forestry Commission, SEMARNAT
CONANP	National Commission of Protected Areas, SEMARNAT
CONAPESCA	National Commission of Aquaculture and Fisheries, SAGARPA
DGGFS	Department of Forestry and Soil Management, SEMARNAT
DGPAIRS	Department of Environmental Politics and Regional and Sectorial, Integration, SEMARNAT
DGSPRNR	Department of the Primary Sector and Natural Renewable Resources SEMARNAT
DGVS	Department of Wildlife, SEMARNAT
ECOSUR	South Border College (El Colegio de la Frontera Sur)
FAO	Food and Agriculture Organization of the United Nations
FCB	Faculty of Biological Sciences, UANL
GECI	Island Conservation and Ecology, C.A. (Grupo de Ecología y Conservación de Islas, A.C.)
GISP	Global Invasive Species Program
ICES	International Council for the Exploration of the Sea
IE	Institute of Ecology, UNAM
IINSO	Institute of Social Research, UANL (Instituto de Investigaciones Sociales)
IMO	International Maritime Organization
IMTA	Mexican Institute of Water Technology, SEMARNAT (Instituto Mexicano de Tecnología del Agua)
INAPESCA	National Fisheries Institute, SAGARPA
INE	National Ecology Institute, SEMARNAT

IPCC	International Plant Protection Convention
IUCN	International Union for Conservation of Nature
NAPPO	North American Plant Protection Organization
OIRSA	Regional Plant Protection Organization of Agricultural Health
PA	Protected Area
PRA	Pest Risk Analyses
PROFEPA	Federal Attorney for Environmental Protection, SEMARNAT
SAGARPA	Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food
SCT	Ministry of Communications and Transport
SE	Ministry of Economy
SEMARNAT	Ministry of Environment and Natural Resources
SENASICA	National Service of Agro Alimentary Health, Safety, and Quality, SAGARPA
SNICS	National Service of Seed Inspection and Certification, SAGARPA
SPP	Security and Prosperity Partnership of North America
SS	Ministry of Health
TLCAN	North American Free Trade Agreement
TNC	The Nature Conservancy- Mexico Program
UAM	Metropolitan Autonomous University
UANL	Autonomous University of Nuevo León
UNAM	National Autonomous University of Mexico

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ANNEX 1. SWOT ANALYSIS

	Internal scope	External scope
STRENGTHS / OPPORTUNITIES	1. Invasive species (IS) experts willing to collaborate. 2. Resources for research (in several institutions). 3. General legal framework. 4. Institutional capacity for sanitary management. 5. Emergency response mechanisms in operation in civil, health and phytosanitary protection, which can be adapted for the management of IS. 6. Successful national experiences (ie. islands). 7. IS lists available. 8. Documentation of environmental and economic impacts for some IS. 9. Some IS introduction routes have been identified and evaluated. 10. Risk analysis protocols for certain IS groups. 11. Some IS research projects have been carried out. 12. Mexico has signed international agreements on the matter of IS. 13. Beginning of interinstitutional coordination.	1. Some cases on the impacts of IS have been evaluated in relation to public interest. 2. Interest of commercial sectors in participating. 3. Interest from the media. 4. Available information technologies for communication. 5. Solid spirit of international cooperation regarding the issue of IS. 6. Operative potential for the management of IS. 7. There is already a lot of information for many IS of shared interest. 8. Will of integration and coordination between the region countries (North America, South America and the Caribbean).
WEAKNESSES / THREATS	1. Lack of knowledge on the ecology and impacts of IS. 2. Lack of coordination and follow up among institutions. 3. No monitoring or early detection systems. 4. Gaps and inconsistencies in the legal framework. 5. Lack or deficiency of measures for the control of entry and expansion of IS. 6. Lack of educational plans that include the issue of IS. 7. Laws, regulations or norms are not applied in an adequate manner. 8. Lack of integration with other countries to work on the issue. 9. Prevailing model in the use and management of resources, the short term gain prevails. 10. Antagonistic policies among institutions. 11. Lack of long term vision from individuals, organizations and governments. 12. Lack of qualified personnel. 13. Lack of political will to institutionalize the issue.	1. Increase in the introduction and dispersion of IS, especially in the presence of climate change. 2. Increase of severe ecological damage (i.e. habitat fragmentation and destruction, land use changes). 3. Increase in introduction and use of IS because of economic and social pressures. 4. Greater potential for ecological and economic damage due to the dissemination of IS. 5. Conversion of IS with productive uses in perverse incentives that perpetuate and spread them. 6. Increase in commercial movements and transit of people. 7. Insufficient information to the different sectors on the problem caused by IS. 8. Lack of uncertainty in the budget of environmental agencies and personnel exercising regulations. 9. Deeply rooted uses of some IS in local and national economies. 10. Uncertainty regarding the effects of climate change. 11. Increase in biological invasions in neighboring countries. 12. Presence of IS with populations in the latent phase.

ANNEX 2. SPECIFIC PROPOSALS FOR THE ATTENTION OF ISSUES RELATED TO INVASIVE SPECIES IN MEXICO

The following proposals summarize the main suggested actions that were received during the public consultation process.

1. Coordination (institutional, national and international)

- Establish joint priorities among academics and different institutions.
- Coordinate programs to carry out academic campaigns and consolidate research groups with specific and local knowledge in the main ports and their maritime zones.

2. Laws and regulations

- Promote strict revisions of imported woods in borders.
- Develop compulsory regulatory mechanisms on invasive species through norms, with emphasis in avoiding that incorrectly identified species could enter the country.
- Increase the observance of national and international legislation.
- Apply sanctions to those who introduce or release invasive alien species.
- Regulate ballast water control actions through administrative and legal mechanisms, to monitor water from vessels.
- Improve the regulation of exotic species programs, both in management units for the conservation of wildlife and in the traffic and trade of species.
- Generate appropriate instruments and carry out actions to attend to problems caused by invasive species.
- Identify and attend to the gaps in monitoring and surveillance duties of the different agencies to ensure that each situation is treated in an efficient manner.
- Revise regional economic development policies and projects in order to harmonize them with the vision of prevention of introduction of invasive species and the eradication of established invasive species.
- Promote sanitary measures from the shipping point in the countries of origin in the case of specimen trade.

3. Environmental education and communication

- Generate basic information at a local scale.
- Interact with main stakeholders in the areas involved and with affected inhabitants.
- Share information regarding the attributions and functions of the different agencies that attend to the issue.
- Inform the general population through different means, of the importance of eradication, study and control of invasive species.

4. Capacity creation

- Develop production systems for the use of native Ichthyofauna. Fish farming is important as part of the cultural and biological heritage of each region, as sources of food and consumption, as promoters of productive growth, jobs and income, particularly if they are developed in the context of a market and profitability in such a way that they can satisfy the existing regional demand and the growing market opportunities.

5. Research to generate information

- Increase economic resources for research programs and projects that generate knowledge about invasive species.
- Evaluate the potential of exotic species for pathogen introduction.
- Evaluate the effects of removing invasive species that are deeply rooted in the ecosystem and develop restoration mechanisms.

6. Prevention and monitoring

• Share information among the different sectors, for example, exotic species traders can supply data on amounts of specimens, species and buyers to have an updated record of sales.
• Request market studies before granting permissions for the culture of exotic species, in order to prevent possible releases into the wild and their consequences.
• Carry out preventive activities in aquaculture through the monitoring or capture of invasive species or through the use of traps to prevent their release into water bodies (lakes, rivers or canals).
• Create monitoring and incentive instruments to incorporate monitoring actions into the different sectors (for example, fish producers that monitor the area to detect escapes and give them some kind of compensation, such as tax reduction, among others).
• Develop standardized sampling mechanisms of natural populations.
• Develop sampling and analysis protocols for samples of exotic species that are subject to international trade.
• Promote the development of monitoring techniques with second generation genetic sequencing.

7. Control, management and eradication

• Adapt eradication techniques according to the characteristics and life history of each species of interest.

8. Specific cases for which action is urgent

Several invasive species were mentioned as a priority: the American bullfrog (*Lithobates catesbeianus*), the Common house gecko (*Hemidactylus frenatus*) and the Swordtail (*Xiphophorus hellerii*), although no concrete actions were identified. In the case of the Red lionfish (*Pterois volitans*), it was recommended to investigate the possible movement of eggs and spawn by cruise ships. Regarding invasive plants, the following were highlighted as priority targets: grasses in general (Poaceae) and in particular, the Guinea-fowl grass or Itchgrass (*Rottboellia cochinchinensis*), Star grass (*Cynodon plectostachyus*), and the Castor-Oil Plant (*Ricinus communis*) of the Euphorbiaceae family. It was stressed that for *Polygonum convolvulus*, Wild buckwheat, it is necessary to carry out an evaluation for its use as biodiesel.
Regarding water weeds, the need to carry out a diagnosis for common water hyacinth *(Eichhornia crassipes*), in the irrigation districts close to the Bravo River (known in the United States as the Rio Grande) and the Colorado River in Baja California was suggested, given that these are two points of introduction for this exotic water weed. For *Salvinia* it was advised to establish containment and barrier actions to prevent additional propagation. These same actions are proposed to prevent *Hydrilla* species to enter the country from Guatemala.

9. Implementation

• Evaluate the availability of resources, taking into account that many of the invasive alien species already have economic importance.
• Establish actions that are practical, direct, measurable and tied to available resources.
• Establish an intersecretarial commission to attend to the topic and coordinate everyone's efforts in the long term.
• Establish mechanisms to administrate efficiently the assigned resources.
• Promote the issue as a national priority and assign personnel and budget.
• Establish mechanisms that ensure the permanent continuity of these actions so that they are not subject to six-year programs.
• Attend to this problem as a national security issue.
• Establish a mechanism to evaluate results and to maintain society permanently informed of the actions undertaken.
• Define mechanisms to follow up and corroborate compliance of the goals of this strategy and any action plans that derive from it.

ANNEX 3. ACTIVITIES OF THE GENERAL DIRECTION OF MERCHANT MARINE, SCT IN RELATION TO THE INTERNATIONAL CONVENTION FOR THE CONTROL AND MANAGEMENT OF SHIPS' BALLAST WATER

It is important to emphasize that, even when the International Convention for the Control and Management of Ships' Ballast Water of the IMO is not yet in effect, the General Direction of Merchant Marine of the Ministry of Communications and Transport (SCT) is looking to implement the following measures, in addition of developing an Official Mexican Norm (NOM) in the matter. This is in order to comply with the resolutions established within the Convention that apply at the national level, while this international instrument enters into effect.

• Analyze and compare the strategies and measures adopted by other countries regarding this problem and evaluate their viability in the national maritime scope, with support and participation of the related institutions.
• The creation of an interinstitutional workgroup that promotes and attends to the constant problematic of invasive species that arrive in ballast water in ships, identifying and observing ports with ecosystems that are sensitive or prone to invasions. The work group must include legal and technical personnel in such a way that preventive measures are harmonically implemented, taking into account the technical dispositions within the corresponding legal framework.
• Celebrate meetings and agreements with similar national and foreign institutions regarding the issue of invasions that could have been a result of ballast water, in order to align preventive actions in the maritime field that can serve as reference for sensitive zones and species or for invasive species.
• Gather information regarding movements and maneuvers of ships with ballast water tanks in Mexican ports of greatest activity (especially vessels of more than 400 mts length). In due time and, according to rule E-1 of the International Convention for the Control and Management of Ships' Ballast Water, the corresponding inspection procedures will be applied by the Port Authorities.
• Train personnel in charge of verifying and applying temporary measures, based on information collected and researched, regarding the environment and invasive species, applicable technology to the control of organisms in the tanks of ballast water, management systems, technical specifications for the systems, verification instruments and procedures of approval and certifications. For this purpose, the trust for the Formation and Training for Personnel of the Merchant Marine (FIDENA) is making changes to include this topic in the study plans of the degrees of Pilot and Naval Machinist that are taught in the three Nautical Merchant Schools of the country. In addition, there are conferences planned for the personnel of the National Merchant Marine.

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