



Invasive species and the Global Strategy for Plant Conservation: how close has Brazil come to achieving Target 10?

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Abstract

Target 10 of the Global Strategy for Plant Conservation establishes that “Effective management plans are in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded” by 2020. The rationale for the target is that invasive alien species are a major threat to native plants, and thus should be excluded from areas reserved for the conservation of plant species, especially when endemic and/or threatened. In Brazil, although most management plans report the presence of invasive alien species and the need for management in federal protected areas, there are only a very limited number of management plans implemented. The national strategy on invasive alien species, published as CONABIO Resolution 05/2009, has not been implemented, so progress on policies and legislation focused on invasive alien species at the federal level has been slow. In order to reach an effective development of public policies in Brazil, federal environmental agencies must function as focal points and be in charge of coordinating actions aimed at (1) identifying priority areas for preventing and managing biological invasions, and (2) managing invasive alien species and reduce their impacts.

Keywords: biological invasion, control, invasive non-native plants, management, protected area.

Resumo

Na meta 10 da Estratégia Global para a Conservação de Plantas está estabelecido que, até 2020, planos de manejo efetivos serão implementados para impedir novas invasões biológicas e para manejar áreas importantes para a diversidade de plantas e que estejam invadidas. A justificativa para a meta é que espécies exóticas invasoras usualmente são uma grande ameaça de extinção a plantas nativas, e assim devem ser excluídas de áreas que são destinadas à conservação de espécies vegetais, especialmente aquelas que são endêmicas e/ou estejam ameaçadas de extinção. No Brasil, apesar da maior parte dos planos de manejo de unidades de conservação federais reportarem a presença de espécies exóticas invasoras nessas áreas, um número bem limitado de planos já foi implementado. A Resolução CONABIO 05/2009, que estabelece uma estratégia nacional sobre espécies exóticas invasoras, não foi colocada em prática, sendo lentos os avanços em políticas e legislação focadas em espécies exóticas invasoras em nível federal. Para que políticas efetivas sejam desenvolvidas no Brasil, órgãos federais da área ambiental devem funcionar como pontos focais e coordenar ações para (1) identificar áreas prioritárias para a prevenção e o manejo de invasões biológicas, e (2) para manejar espécies exóticas invasoras, reduzindo impactos pelas mesmas provocados.

Palavras-chave: invasão biológica, controle, exóticas invasoras, manejo, plantas unidade de conservação.

Introduction

Earth is currently undergoing its sixth mass extinction largely owing to human disruption of natural processes and ecosystems (Vitousek *et al.* 1997). Habitat transformation, especially due to deforestation, agricultural expansion and

urbanization; overexploitation of resources; and pollution are among the main drivers of contemporary extinction events (Millennium Ecosystem Assessment 2005; Vitousek *et al.* 1997). Today's drivers of extinction are often multiple as they may occur together, and their negative

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effects can be synergic, causing unprecedented consequences to biological diversity. Albeit global, the impacts of human expansion are more intense in the tropics, where much of Earth's biological diversity is sustained (Laurance *et al.* 2014). For instance, the Brazilian Cerrado has lost 46% (88 million ha) of native vegetation cover mostly due to agricultural expansion (Strassburg *et al.* 2017), and the Amazon biome has been reduced by ~ 67.3 million ha (Nogueira *et al.* 2017) to give way to anthropic areas. While anthropic habitats and landscapes are not deprived of life and do sustain some level of biological diversity (Laurance *et al.* 2014), the intensive management nature of these areas tends to favor some types of species over others. Generalist, fast-growing, and prolific species (r-strategist), for instance, tend to be favored in constantly disturbed habitats in comparison to specialist species (K-strategist). Many invasive alien species (IAS) tend to be r-strategists (van Kleunen *et al.* 2010). Consequently, the conversion of natural ecosystems into anthropic systems benefits invasive species and create opportunities for biological invasions.

One of the most prominent impacts of biological invasions is the homogenization of the biota on Earth. Invasions of natural habitats by alien species are one side of biotic homogenization, whereas extinctions of native and endemic species are the other one (Olden 2006; Rosenblad & Sax 2016). Through invasions and extinctions, biotic homogenization increases the similarity of biotas of different regions of the planet and decreases the world total biodiversity (Olden 2006). Virtually all ecosystems now have thriving alien species among its communities (van Kleunen *et al.* 2015). So much so that some regions of the planet now host more alien species than native species (van Kleunen *et al.* 2015; Dawson *et al.* 2017).

One of the main strategies adopted by countries to conserve their biodiversity is the establishment and maintenance of protected areas (*e.g.*, national and state parks, biological reserves, and other wilderness areas). Many protected areas are designed to protect biodiversity by providing *refugia* to native species from the spread of invasive alien species (Gallardo *et al.* 2017). Thus, alien species occurring in these areas must be controlled and/or excluded. These actions are necessary given the chance that certain alien species will become invasive and cause negative ecological impacts, and that some alien species can have negative effects on ecological processes even when they become

invasive (Wardle *et al.* 2011; Simberloff *et al.* 2012). Among the known impacts invasive alien plants have on native communities and ecosystems are reduction in native plant diversity, plant fitness, native animal abundance, increase in soil microbial activity, and increases in soil nutrient levels (Vilà *et al.* 2011; Pyšek *et al.* 2012).

In order to prevent and reduce the impacts of biological invasions on biological diversity, country governments which are signatories of the Convention on Biological Diversity (CBD) compromised to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species (CBD 2006 - Article 8h). Aiming at fulfill that commitment, several recommendations and requests are stated in CBD decisions. One of them requests countries to adhere to the Global Strategy for Plant Conservation (GSPC) that includes outcome-oriented global targets. This decision was originally set for the year 2010, and then renewed for 2020 (<<https://www.cbd.int/gspc/strategy.shtml>>, last accessed on 6 November, 2017). Target 10 of the GSPC for 2020 calls for “Effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded.” The rationale is that invasive alien plants are one of the major causes of extinction of native plants and must therefore be excluded from areas established for the conservation of native species, especially those which are endemic or endangered.

Invasive alien species have been linked to recent extinctions of different taxa and are currently considered a major threat for the conservation of native flora and fauna (Bellard *et al.* 2016; Spatz *et al.* 2017). Invasions by alien species are the fourth major cause of plant extinction, being associated with almost 30% of the total number of species that are categorized as extinct in the IUCN Red List (Bellard *et al.* 2016). Most plant extinctions were caused by herbivores such as goats (*Capra hircus*), sheep (*Ovis aries*) and European rabbits (*Oryctolagus cuniculus*), and alien plant invasions (Bellard *et al.* 2016). However, impacts of invasive alien plants on the extinction rates of native plants may have been underestimated for lack of consideration of changes caused by introduced plants on landscape structure that can compromise native plant persistence on the long-term (Gilbert & Levine 2013). As a consequence, deterministic extinction trajectories of native plants might be masked by short periods of time since invasion in different parts of the world, blurring our

comprehension of the full impact of plant invasions on native biodiversity (Gilbert & Levine 2013).

Many studies addressing the impacts of IAS on natural ecosystems are focused on highly relevant areas for biological diversity such as tropical islands and protected areas (Blackburn *et al.* 2004; Foxcroft *et al.* 2013; Doherty *et al.* 2016; Spatz *et al.* 2017). Biological invasions are the primary driver of vertebrate extinctions on islands (Blackburn *et al.* 2004; Doherty *et al.* 2016; Spatz *et al.* 2017), with catastrophic ecological consequences for entire ecosystems. For instance, the loss of island-inbreeding sea birds due to introduced predators can change plant and microbial ecological communities (Fukami *et al.* 2006), and the population decline of specialized pollinators limited the reproduction of endangered plant species in Hawaii (Aslan *et al.* 2013). In protected areas, some intentional introductions generate well known examples of impacts to the local flora. Invasive *Schinus terebinthifolius* has replaced native vegetation with monospecific stands in the Everglades National Park, Florida (Li & Norland 2001), and *Morella faya* has displaced the endemic *Metrosideros polymorpha* over large areas in Hawaii Volcanoes National Park (Loope *et al.* 2014).

For the 2010 goal, Brazil aimed at implementing management plans for at least 100 IAS that threaten plants, communities or habitats and associated ecosystems. To our knowledge, in 2010 there were no management plans for alien plants implemented by the federal government. There were exceptions at the state level. In Rio Grande do Sul, the State Law 13.187/2009 established a program to control the invasive alien grass *Eragrostis plana*. In 2005, the Paraná state environmental agency (Instituto Ambiental do Paraná) started to manage and remove invasive alien plants from state protected areas (Zenni *et al.* 2016).

The new Brazilian target for 2020 is to have effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded. According to a 2011 IUCN bulletin (IUCN 2011), the 2020 target is “a combination of prevention and management inside critical areas and a first step towards the development of management plans for all types of important biological invasions that threaten plants, plant communities and associated habitats and ecosystems. Invasive species may be plants, animals, or microorganisms, and management plans should be developed to rectify the damage

caused to plants and/or their communities and to restore ecosystem functions and services.”

Brazil did not have an appropriate legal framework in 2010 to achieve Target 10 of the GSPC, and still has not (for details, see text below and Zenni *et al.* 2016). However, between 2010 and 2020, some initiatives were set in motion, especially the design of National Action Plans for threatened species which often include actions against invasive alien species, indirectly covering Target 10 (ICMBio 2017). In order to quantify and understand if actions linked to GSPC Target 10 were being carried out in Brazil, we reviewed the most recent management plans of federal protected areas.

Methods

We systematically reviewed all management plans of protected areas available in the ICMBio (Brazilian Institute for Biodiversity Conservation - Instituto Chico Mendes de Conservação da Biodiversidade, in Portuguese) website (<<http://www.icmbio.gov.br/portal/planosmanejo>>) in July, 2017. For each of the management plans, we recorded (a) if invasive alien species were known to occur in the area, (b) if any management action was indicated for the area, and (c) which management action was indicated. We assessed protected areas registered in the National System of Protected Areas (Sistema Nacional de Unidades de Conservação, in Portuguese - Federal Law 9985/2000) because of the lack of a clear definition of which, exactly, are “important areas for plant diversity” referred to in the GSPC target.

Parallely to the revision management plans, we sent a questionnaire to managers of 313 federal protected areas in Brazil and 13 ICMBio Research Centers (Appendix 1, freely available on the following link: <<https://figshare.com/s/e935c7901996848da105>>, DOI: 10.6084/m9.figshare.5975425). We asked questions related to the occurrence of invasive alien plants in protected areas and their impacts: location of invasive plants, size of the area of occurrence, potential impacts on biodiversity, history of introduction, control actions taken and suggested, and source of the information provided.

Results

Out of the 324 federal protected areas, we found 248 management plans available on the ICMBio website. Eight plans were either not publically available or the files were corrupted.

was known for only 46% of the species. Thirty-two percent of the species were considered to be causing significant negative impacts to biodiversity, whereas 16% of them were considered to harm threatened species. Only 19% of the respondents described existing control actions, and 16% pointed out suggestions for management. Only 47% of the information about management was linked to a source (*i.e.*, bibliography or personal communication).

The respondents showed some confusion regarding the species identification and the correct categorization of alien species as invasive. Fifteen percent of the cited species were identified at the genus level and two species were identified by their vernacular names. While the questionnaire was explicitly about invasive alien species, cultivated non-invasive alien species were also cited, such as: *Carica papaya* (papaya), *Manihot esculenta* (manihot), *Musa paradisiaca* (banana), *Pyrus communis* (pear), *Prunus persica* (peach), and *Zea mays* (corn). The most frequently cited invasive alien species in the questionnaires, with occurrences registered in five of the 15 protected areas were: *Urochloa decumbens*, *Impatiens walleriana*, *Psidium guajava* and *Pinus* sp. At the Saint-Hilaire/Lange Wildlife Refuge (Refúgio da Vida Silvestre Saint Hilaire/Lange), the impact of *Urochloa decumbens* and *Impatiens walleriana* on the habitat of the threatened bird *Stymphalornis acutirostris* (Reinert & Bornschein 2008) was the most consistent impact described in the questionnaires.

The revision of management plans and questionnaires seems to indicate that protected areas are far from having effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded. Although some adequate initiatives might exist, the general rule for protected areas seems to be the absence of adequate training and practical action. For animals, a recent review indicated that 87% (n=101) of the protected areas with invasive alien animal species had management recommendations in the management plan; 79% (n=81) of these had some control measures implemented (Guimarães & Schmidt 2017). However, the authors considered that most of the recommendations were generic, and none of the plans had specific IAS control programs (Guimarães & Schmidt 2017). For both animals and plants, we see a similar pattern: generic guidelines for invasive alien species, low level of knowledge and training, and a small number of control actions in place.

Discussion

Global and national responses to Target 10 of GSPC

A mid-term review of progress towards the Global Strategy for Plant Conservation (GSPC) was carried out in 2014. The review was published by the CBD Secretariat in collaboration with Botanic Gardens Conservation International (BGCI) as CBD Technical Series No 81 (Sharrock *et al.* 2014). According to this review, the evidence suggests that progress was insufficient to meet the target in nearly all countries, although some encouraging activities were on-going in managing areas already affected by biodiversity loss.

An important global result was the establishment of the International Plant Sentinel Network (IPSN) in order to facilitate collaboration between botanic gardens and arboreta, National Plant Protection Organizations (NPPOs) and plant health scientists. They are meant to provide botanic garden professionals with training and diagnostic support to better monitor and protect their collections; facilitate greater collaboration about invasive pests and pathogens among botanic gardens and with other organizations with improved databases and communication protocols; and enhance garden outreach efforts to educate their communities on the impact of high-consequence plant pests and pathogens and engage individuals as “First Detectors”. The IPSN currently includes 41 botanical gardens in 18 countries (<<http://www.plantsentinel.org/the-network/>>). None of the Brazilian botanic gardens participate in the initiative, but no country in the Americas is part of the initiative. On the other hand, the GSPC targets related to botanical garden collections are being thoroughly developed and are expected to be achieved by 2020 (Forzza *et al.* 2016).

In South Africa, the National Strategy for Plant Conservation (NSPC) was developed under the leadership of the South African Biodiversity Institute (SANBI), with support from the Botanical Society of South Africa and the collaboration of botanists from conservation agencies, non-governmental organizations and academic institutions. The NSPC includes 16 outcome-oriented targets, which are aligned with the outcomes and activities of the National Biodiversity Strategy and Action Plan (NBSAP) (South Africa’s Strategy for Plant Conservation 2015). In 2008 an Invasive Species Program was established at the SANBI, funded by the

Working for Water Programme, to specifically engage in the early detection of new invasive alien species, conduct risk assessments for post-border introductions and work on the eradication of invasive alien species that have just started to spread (SANBI 2008). In accordance with the NSPC, this program is actively monitoring 42 emerging invasive species (those that still have limited distribution), conducting research to understand the process of legal introductions and developing policy interventions to prevent them, conducting risk assessment for 174 plant species, and producing management plans for species requiring compulsory control to ensure eradication within a specified timeframe.

The Great Britain (GB) Invasive Non-Native Species Framework Strategy was published in 2008 and reviewed in 2013, with recommendations to advance the strategy published in 2014 (GBNNS 2015). The Strategy focuses on preventative measures and on preventing the establishment of new invasive species by ‘horizon scanning’ to identify emerging threats. “Horizon scanning is a systematic examination of information to identify potential threats, risks, emerging issues and opportunities allowing for better preparedness and the incorporation of mitigation and exploitation into the policy making process” (GBNNS 2015). Plantlife and the Freshwater Biological Association have undertaken horizon scanning for 599 alien freshwater and terrestrial plants. In the assessment, 92 plants were ranked as ‘critical’, requiring a full detailed risk assessment as a matter of priority. Other 55 species were ranked as ‘urgent’, for which a full risk assessment was recommended. Following detailed risk assessment of individual species, a key part of the GB Strategy is the production of Invasive Species Actions Plans (ISAP). These plans have been produced for water primrose (*Ludwigia grandiflora*) and a further four are in development. In addition, five invasive aquatic species are banned from sale in England since April 2014. The Invasive Alien Species Regulation was implemented in January 2015 with a list of invasive alien species being agreed to in 2016.

Public policies, strategies and action plans in Brazil

In 2001 the Ministry of Environment, EMBRAPA (the Brazilian Agricultural Research Agency) and the Global Invasive Species Programme (GISP) organized a meeting for representatives of South American countries in

Brasilia with the intention of forging international cooperation on invasive alien species prevention and management (Ziller *et al.* 2005). In 2004, the Ministry of Environment issued a call for proposals for the first national inventory of invasive alien species in terrestrial, freshwater and marine habitats as well as species that impact health and production systems. The inventory was funded by a GEF (Global Environment Fund) project entitled “Conservation and sustainable use of Brazilian biodiversity - Probio”. The compilation of data led the Ministry of Environment and partner institutions to organize the first National Symposium on Invasive Alien Species, held in Brasilia in December 2005. The symposium was a national milestone for invasive alien species, as a significant increase in technical, legal and scientific references has been observed since then (Zenni *et al.* 2016).

In August 2006, CONABIO Deliberation 49 established a permanent working group for invasive alien species issues, which included representatives from several Ministries and other institutions. The working group developed a national strategy for invasive alien species that was published in 2009 as CONABIO Resolution No. 9. Once the National Strategy was promulgated, the working group stopped meeting and the strategy was not implemented, and is currently under review to include an objective action plan, to be completed in 2018.

Also in 2009, the Ministry of Environment published a report on invasive alien marine species (Lopes 2009), as a result of the surveys conducted between 2004 and 2005. Only in 2016 the report on invasive alien freshwater species was published (Latini 2016). The report on terrestrial species has not been published to date.

In 2014, the National Program for the Conservation of Species Threatened with Extinction (called Pro-Species for short) was instituted by the Ministry of Environment. A new proposal was developed for the GEF to address the goals of this program, and granted approval in 2016. This project includes actions against the main threats to biological diversity, including a component on invasive alien species. Implementation should start in 2018 and address some of the concerns described in this article.

In 2016, the Ministry of Environment started working on National Action Plans for three invasive alien species of national concern: the wild boar (*Sus scrofa*), the golden mussel (*Limnoperma fortunei*) and sun corals (*Tubastraea* spp.). The Wild Boar

National Action Plan was formally approved in 2017 through joint regulations of the Ministry of Environment (Ministério do Meio Ambiente, in Portuguese) and the Ministry of Agriculture, Livestock and Supply (Ministério da Agricultura, Pecuária e Abastecimento, in Portuguese) (Portaria Interministerial 232/2017). The other plans are expected to be completed in 2018. As these plans are directed at animal species, two of which are aquatic, they do not effectively contribute with the achievement of Target 10.

A complementary effort led by the Ministry of Environment since 2004 is the development of national action plans for species threatened with extinction. Given the role IAS play as a threat to endangered species, many of the plans include control actions. The National Action Plan for the conservation of the endemic flora of Rio de Janeiro threatened with extinction includes actions to support the implementation of a State Program for Invasive Alien Species, with capacity building, replacement of invasive ornamental plants in cities and restoration efforts (Pougy *et al.* 2017).

The agencies IBAMA (Instituto Brasileiro do Meio Ambiente e de Recursos Naturais Renováveis, in Portuguese; Brazilian Institute for the Environment and Renewable Natural Resources) and ICMBio work closely with the Ministry of Environment. IBAMA is responsible for controlling the introduction of alien invasive species that may threaten ecosystems, habitats or native species (Complementary Federal Law 140/2011), as well as regulating species imports. The agency is also in charge of issuing regulations on breeding and use of non-native animal species and biological control agents. From 2017, the Department for the Sustainable Use of Biodiversity and Forests (DBFLO) is attributed with the coordination, supervision, proposal of regulations and measures and with implementing control actions for invasive alien species through the Coordination for Management, Destination and Management of Biodiversity (COBIO). The new responsibilities of the Department also include the proposition of criteria and measures for the prevention, early detection, risk assessment, assessment of pathways and vectors of spread of invasive alien species, as well as the issue of permits for invasive alien species management throughout the country (Portaria IBAMA 14/2017).

ICMBio is responsible for national protected areas. Although the presence of many invasive alien species in many protected areas throughout

the country has been widely recorded (Sampaio & Schmidt 2013; Ziller & Dechoum 2013; Guimarães & Schmidt 2017), ICMBio does not have a department in charge of practical management. Practical actions therefore are difficult to implement even by those willing to act due to the current institutional framework of the organization.

At the state level, progress has been made in the south of Brazil where the states of Paraná, Santa Catarina and Rio Grande do Sul published official lists of invasive alien species and complementary regulations. Control actions are in place in many state protected areas, and state committees managing state programs on invasive alien species have been established in Paraná and Santa Catarina.

Recommendations for a post-2020 Target

Achievement of targets related to biological invasions for the conservation of biodiversity must begin with the implementation of the Brazilian National Strategy for Invasive Alien Species. Secondly, Brazil national focal points, focal institutions or a working group of organizations must be established and acknowledged to take charge of linking existing actions and programs and create demands specifically related to the target. Currently, all the work on biological invasions in Brazil is done independently by several groups without a coordinated agenda (Zenni *et al.* 2016). The Ministry of Environment, along with IBAMA and ICMBio, have formed a working group with focal points of each institution to oversee the development of national action plans for three invasive species of national significance, review the national strategy and develop a proposal for the GEF focused on threatened species and causes of threat, which include invasive alien species.

A fund must be established in order to guarantee the implementation of a permanent program for invasive alien species in areas of relevance to the conservation of biodiversity. This fund could be sustained with financial resources provided by environmental compensation and/or payment for environmental services. ICMBio currently coordinates a management system in which *Eucalyptus* and *Pinus* plantations, established decades ago for experimental purposes, are being harvested in federal protected areas in exchange for the implementation of invasive alien species control and habitat restoration.

A post-2020 target must follow on the footsteps of actions already in progress and already

required by existing legislation. For example, the removal of alien species from protected areas in the category of strict protection (unidades de conservação de proteção integral, in Portuguese) is already required (Federal Law 9985/2000). However, as we have shown here, few managers and areas have the required technical knowledge, infrastructure and human resources to fulfill that requirement. Thus, instead of “making plans,” a more realistic and objective target would be to provide managers, researchers and stakeholders the necessary skills and means to implement effective management plans to prevent biological invasions and manage important areas for plant diversity that are invaded.

A post-2020 target should also include a way to prioritize areas for restoration from biological invasions, because this is a phenomenon in which timing is key for the success of management actions. The challenge is to identify species that pose significant threats to biodiversity, to determine the nature of the response, and then concert actions to alleviate problems on-the-ground. Management plans should specify the appropriate techniques to prevent, eradicate or control invasive alien species so that ecosystems can be effectively conserved. The need to set priorities in terms of species and areas is covered in the National Strategy and is widely acknowledged by technical staff in governmental agencies and by researchers. In addition, Target 10 suggests that priorities should be set at the national level, but actions must also be coordinated internationally. Successful prevention requires increased efforts in control and regulatory frameworks for invasive plants and pathogens due to international trade and international agreements.

Supplementary data: Occurrence of invasive non-native species in federal protected areas based on management plans and on a questionnaire sent to managers are freely available on the following link: <<https://figshare.com/s/e935c7901996848da105>> (DOI: 10.6084/m9.figshare.5975425). The data of the questionnaires were already published by Sampaio & Schmidt 2013. The questionnaire sent to managers of 313 federal protected areas in Brazil and 13 ICMBio Research Centers is also available on the same link.

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