


EUROPEAN GUIDELINES ON PROTECTED AREAS AND INVASIVE ALIEN SPECIES

COUNCIL OF EUROPE
CONSEIL DE L'EUROPE

EUROPEAN GUIDELINES
ON PROTECTED AREAS
AND INVASIVE ALIEN SPECIES

Andrea Monaco,
Regional Parks Agency – Lazio Region (Italy)
and
Piero Genovesi,
Institute for Environmental Protection and Research (Italy)
and Chair IUCN SSC Invasive Species Specialist Group

Council of Europe

Recommended citation:
Monaco, A., Genovesi, P. (2014)
European Guidelines on Protected Areas and Invasive Alien Species,
Council of Europe, Strasbourg, Regional Parks Agency – Lazio Region, Rome

Cover: SPDP, Council of Europe
Layout: Jouve, Paris
Photo credits : Andrea Monaco, Archivio Fotografico Servizio Fitosanitario Regione Lazio, Massimo Bellavita, Marco Scalisi, Aurelio Perrone, Christian Angelici, Paolo Sposimo, Marco Giardini

Council of Europe, November 2014
Printed in Italy

CONTENTS

1. INTRODUCTION

Invasive alien species (IAS) have been pointed out as one the most important direct drivers of biodiversity loss and ecosystem service changes. Many international policy instruments, guidelines and technical tools have been developed to address the threat of IAS.

The Convention on Biological Diversity (CBD) at art. 8(h) calls for parties "as far as possible and as appropriate, (to) prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". In 2002 the CBD Conference of the Parties adopted the Guiding Principles on Invasive Alien Species (Decision VI/23) as a basic policy response. The first CBD guiding principle state that prevention is generally far more cost-effective and environmentally desirable than measure taken after IAS introductions.

Carpobrotus edulis

The Millennium Ecosystem Assessment (2005) highlighted the absence of an adequate regulation for several pathways of introductions and considered the adoption of measures to control major pathways as a fundamental goal to address the IAS threats to biodiversity (Goal 6).

A European Strategy on Invasive Alien Species was adopted in 2003 by the Bern Convention. The strategy identifies priorities and key actions in order to prevent or minimise adverse impact of IAS, and proposes measures required to recover species and natural habitats affected by IAS. Prevention measures are a priority of the strategy and one of the key actions is the pathways identification and management.

Europe, characterized by a territorial continuity, a high volume of trade, tourism and transport, and by a free trade regime, indeed requires a coordinated approach to IAS, also implemented at the supranational scale. Any European policy would require balancing regulatory and voluntary measures in order to address key pathways of IAS introduction into the region, such as pet trade, forestry, aquaculture, horticulture, etc. The European Commission is focusing on the regulatory aspects, and is drafting a dedicated EU legal instrument on IAS, but it is also crucial to encourage responsible behaviours also through agreed standards, best-practice guidelines, or codes of conduct.

Voluntary codes of conduct and best practices are in fact considered as fundamental flexible "implementation" tools which could be scaled up with support from public bodies, industry federations, user groups and/or NGOs as appropriate, with the aim of ensuring responsible, proactive policies, and applying these in a coherent manner across Europe (Shine et al. 2010). On the other hand, the principle of self-regulation is considered to be more successful and effective than any other legally binding scheme.

Myocastor coypus

For this reason the Bern Convention, with the technical support of the IUCN SSC Invasive Species Specialist Group, is developing a series of voluntary instruments (codes of conduct and guidelines) covering a number of industries, activities or contexts potentially responsible for the introduction of alien species (horticulture, hunting, pets industry, botanical gardens, zoological garden and aquaria, protected areas). The development of these instruments can play an important role in building awareness among key societal sectors, and is fully in line with Aichi Target 9 of the Strategic Plan for biodiversity 2011–2020 (CBD-COP, Nagoya, 2010, Decision X/38): "by 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment", and with Target 5 of the EU Biodiversity strategy to 2020, that strives to identify pathways of invasions for improving prevention, and to prioritize invasive alien species (IAS) for control.

Opuntia ficus-indica

Protected areas (PAs) preserve hotspots of biological diversity and ensure the maintenance of ecosystem services that are crucial to human livelihood; the impact of biological invasions can thus be particularly severe in these contexts, affecting species and human communities. A number of treaties, policies, legal instruments and position statements deal with: (1) the threats of invasive species to PAs and (2) the need for management of this threat in PAs to preserve biodiversity (e.g. CBD COP 10th in Nagoya (2010) Decision X/31, IUCN World Park Congress in Durban (2003)). Protected areas thus need to strengthen their efforts in terms of prevention, early detection and rapid response, eradication and management of invasions to address this threat.

1.1 Protected areas in Europe: an updated overview

In Europe, the term 'protected area' covers a wide variety of designations. Protected areas in this continent are characterized by quite different management regimes, from highly protected sites with limited access to visitors, to parks with a high numbers of visitors, and large areas with rather intense human presence, including dwellings and important economic activities within the borders of the PAs. Such intense human presence in some European PAs is reflected by the large extension of agro-ecosystems, accounting for over 28% of PAs (European Environment Agency 2006).

Europe has more than 120,000 nationally designated sites[i], of which 105,000 are located in the 39 member as well as collaborating countries associated with the European Environment Agency (EEA). European PAs represent 69% of the records in the World Database on Protected areas managed by UNEP-WCMC (European Environment Agency 2012). Protected areas in the EU cover 15.3% of the total surface (661,692 km^2), or even 25% (1,081,195 km^2) if sites implemented as part of the Natura 2000 scheme[ii] (Natura 2000 Networking Programme 2007; Gaston et al. 2008) are considered. In the 39 EEA member and collaborating countries the proportion of protected land is 13.7% (801,500 km^2), or 21% (1,228,576 km^2) if Natura 2000 sites are included.

Anoplophora chinensis

It must be stressed that the establishment of Natura 2000 network (but also its close relative, the Emerald Network[iii]) was a turning point in the history of European PAs which contributed to the considerable expansion of the existing system. Since 1995, the Natura 2000 network has grown to 26,400 sites with a total surface area of about 986,000 km^2, now accounting for nearly 768,000 km^2 of land, and 218,000 km^2 of sea (European Environment Agency 2012).

European PAs are, on average, very small in size compared to other regions of the world (Gaston et al. 2008). Most PAs in Europe (90%) are smaller than 1,000 ha and 65% range between 1 and 100 ha; the largest PA is the Jugyd Wa National Park in Russia which covers 1,891,700 ha.

1.2 Challenges and Opportunities for Protected Areas in addressing Invasive Alien Species

Invasive alien species are of one the most important direct drivers of biodiversity loss and ecosystem service change (Millennium Ecosystem Assessment 2005; Brunel et al. 2013), globally increasing at an unprecedented pace (Butchart et al. 2010). Furthermore, the challenges related to this threat are expected to grow, because of the strong links between invasions and other factors of change such as global warming, growing human populations, and habitat loss (Simberloff et al. 2014; Spear et al. 2014). In particular, the potential synergic effects of invasions and climate change appear alarming (Willis et al. 2010), because global warming can exacerbate the rate of invasions (Dudley et al. 2010). Additionally, efforts to reduce climate change impacts, if not carefully planned, may introduce further IAS (Ricciardi and Simberloff 2009; IUCN 2012).

Graptemys psudogeographica

The impact of biological invasions can even be worse in protected areas than elsewhere, because these areas preserve key elements of global biological diversity, ensuring the maintenance of essential services for the livelihood of many communities (Foxcroft et al. 2014).

Since the 80s a growing number of publications assessing the increasing threat of invasive alien species to biological diversity in protected areas have been published. In a 1980 report to the Congress in the USA, 300 national park service areas reported 602 perceived threats to natural resources involving alien plants and animals (Houston and Schreiner 1995). The SCOPE (Scientific Committee on Problems of the Environment) programme on biological invasions reported 1,874 alien invasive vascular plants from 24 case studies of nature reserves globally (Usher 1988). In a 1994 poll of U.S. National Park superintendents, 61 percent of 246 respondents indicated that invasions of nonnative plants alone were moderate or major problems in their parks (in Foxcroft et al. in press). A Global Invasive Species Report identified all over the world 487 protected area sites with invasive alien species recorded as an impact or threat and 106 countries with protected areas where IAS have been recorded as an impact (De Poorter et al. 2007). Invasive species were the most frequently cited threat in a 2009 summary of 974 Nature Conservancy projects around the world, listed by 60% of the projects (http://conpro.tnc.

org/reportThreatCount). In a recent (2012) survey in European PAs, 78% of respondent indicated IAS as one of the five most serious threats and 13% as the most important one (Monaco and Genovesi, Annexe 2 of this report).

Addressing this issue requires reconsidering general PA policies, as well as overall priorities, posing complex challenges to PAs, for example, to find ways to ensure understanding and support by PA visitors and even staff. It is therefore urgent that strategies for PAs are improved to address this, as well as other key threats, such as habitat loss and climate change.

Carpobrotus edulis

The impact of IAS on PAs has long been underestimated, and the concerns of scientists that this threat was going to increase (Usher 1988; Macdonald et al. 1989) was similarly ignored by many national and supranational institutions. The urgent need to address the threats being posed to PAs by biological invasions more effectively has been highlighted by several authors, who have tried to identify the obstacles that limit implementation (e.g. Laurance et al. 2012; Tu and Robison 2014). Based on a survey of PA managers, De Poorter et al. (2007) highlighted the main impediments to more effective IAS management as (i) the lack of capacity for mainstreaming IAS management into overall PA management, (ii) the limited capacity of staff at site level, (iii) the low level of awareness, (iv) the gaps in information on IAS available to PA managers, (v) the lack of funding, (vi) legal or institutional impediments, (vii) and the clashes of interests between stakeholders. The recent survey in European PAs (Annexe 2) largely confirmed the findings by De Poorter et al. (2007), highlighting the following main impediments to action in Europe: (i) limited resources indicated as the main problem, followed by (ii) the lack of capacity, (iii) lack of awareness, (iv) gaps in information, (v) little support by the public or stakeholders and (vi) the institutional and legal impediments to action. Apart from these constraints, the complexity of the issue and the need to implement measures that are specifically targeted at IAS, pose additional challenges to park mangers. For example, the interactions between IAS, which can show synergic patterns and cause

surprising cascade effects, require the responses to be very careful planned (Shaw 2014). Further, the measures usually adopted by PAs, such as enforcing a protection regime not necessarily coupled by active management, are clearly not enough to reduce the impact of IAS. For example, many islands are protected, but still highly impacted by invasions (Bergstrom and Chown 1999; Frenot et al. 2005; Kueffer et al. 2010; Baret et al. 2013). This is because of the inherent vulnerability of islands, as well as of all isolated ecosystems, to the impacts of IAS (Loope et al. 2014; Shaw 2014), and the need to implement measures specifically tailored to these situations. Also, the unintended effects of the establishment of PAs may facilitate the introduction of IAS, for example in the Mediterranean islands, which are characterised by high tourism pressure (Brundu 2014).

The urgent need to specifically address this threat in PAs is also linked to the "environmentalist's paradox" (Raudsepp-Hearne et al. 2010). Despite constant improvement of human wellbeing in many areas of the world, and the increase in PAs, the state of the environment often continues to worsen, and invasions are becoming epidemic in scale (Cox and Underwood 2011; McNeely 2014; Mora and Sale 2011), challenging the global community to improve the efficacy of conservation measures.

Ailanthus altissima

The ability to maintain the ecological integrity of PAs depends extensively on the efficacy of management outside their borders, and therefore PAs managers are also called to catalyse a more effective approach to IAS management beyond the PAs borders (Laurance et al. 2012; Spear et al. 2013). In this regard, PAs can have a key role in catalysing the participation of interest groups and communities, promoting more active support by society and of the measures needed to address invasions. Raising awareness on invasions at all levels is indeed one of the most important issues in which PAs can contribute to. Protected areas are generally highly regarded by society, and could therefore be particularly effective for communicating and educating visitors, local communities and the general public on invasions, an issue that is particularly difficult to approach (Boshoff et al. 2008).

The broad strategic approach needed to address IAS is indeed well known. Article 8(h) of the Convention on Biological Diversity calls parties "as far as possible and as appropriate, (to) prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". Further details were provided in 2002 at the Conference of the Parties of the Convention on Biological Diversity, with decision VI/23 providing guiding principles for invasive alien species management, based on a 'hierarchical approach'. This approach calls for prevention as the first line of defence, early detection and rapid response when prevention fails, eradication as the best option to manage established species, and permanent management when the other options are not applicable (Wittenberg and Cock 2001).

Impact of Rhynchophorus ferrugineus

All these measures need to be applied at the appropriate scale, from species-specific approaches to ecosystem management responses, and considering action at multiple scales, from local to regional and even global (Foxcroft et al. 2009; Seipel et al. 2012). Building on this concept, the problem of invasions should be addressed at the earliest possible stage of the planning of PAs, possibly starting from the design of any new protected area itself (Meyerson and Pyšek 2014). The landscape configuration of the geographic context in which a PA is established, and the natural corridors connecting the PA with surrounding areas, affects not only the interconnectivity which is vital for sustaining biodiversity, but also affects the permeability of the PA and is important in determining the future patterns of invasions (Foxcroft et al. 2011; Meiners and Pickett 2014). Ecological networks (in particular if poorly maintained or degraded) can provide pathways for the movement of IAS but there are strong arguments that resilient ecosystems are more resistant to IAS (Jones-Walters and Civic, 2011). Analogously, ecosystem restoration projects, often undertaken by or within the PAs, must take into account of the risk of causing or facilitating further IAS invasions (e.g. using of potential IAS in habitat restoration programs, etc.) and adopt risk assessment protocols and a precautionary approach when data relating to biosafety are lacking (IUCN, 2012).

Phoracanta recurva

A number of management actions have been undertaken to manage IAS (control or eradication above all) in European PAs. These efforts were often part of LIFE projects aimed at ecological restoration within Natura 2000 sites (Scalera and Zaghi 2004; Annexe 1). The acquired experience greatly improved knowledge and expertise among PA managers and has increased information about effective techniques and approaches to combat alien species.

Measures addressing IAS are not only important to reduce their impacts on biodiversity, but can also be beneficial for other aspects, for example by reducing patterns of erosion

Procambarus clarkii

or the risk of fires (Foxcroft et al. 2014), as well as for human safety. Several IAS have biological characteristics that pose a danger to the safety of park employees and visitors, as in the case of the lionfish (*Pterois volitans* and *P. miles*).

Invasions are also relevant to the perception of PAs by the public. The appeal of PAs is linked to the natural scenery and biodiversity of these areas. The reduction of native species or the extensive habitat alteration that IAS can cause, can affect the visitor's appreciation of PAs. Also, the implementation of management actions in several cases have raised concerns and criticisms by the PA's visitors that need to be carefully addressed (van Wilgen 2012). For example pine trees (*Pinus spp.*) in the Cape peninsula (South Africa), grown for plantation forestry since the 17th century, are particularly damaging to the endemic *fynbos* biome, but at the same time are regarded by people as attractive and ecologically beneficial (van Wilgen and Richardson 2012).

2. LEGAL AND POLICY CONTEXT

2.1 The International context

- ***Convention on Biological Diversity (CBD).***

The CBD recognises the importance of IAS impacts on biodiversity and calls on contracting parties to "*prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species*".

The CBD has identified IAS as a major cross-cutting theme and at the 6th CBD-COP in 2002 adopted the decision VI/23 (http://www.cbd.int/decision/cop/?id=7197) "Alien species that threaten ecosystems, habitats or species" and the "Guiding principles for the prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species".

Dryocosmus kuriphilus

A technical note (UNEP/CBD/SBSTTA/9/INF/32 5 November 2003, http://www.cbd.int/doc/meetings/sbstta/sbstta-09/information/sbstta-09-inf-32-en.pdf) was prepared by an Ad Hoc Technical Expert Group (AHTEG) pursuant to paragraph 9 of decision VI/23 which requested to identify and explore from a technical perspective specific gaps and inconsistencies in the international regulatory framework of the threats of invasive alien species to biological diversity. The technical note addresses protected areas in a specific section on restoration and invites Parties to actively promote "*positive measures*

to encourage the use of native plant species in landscaping, countryside management, revegetation, erosion control, protected area management and international assistance programmes".

The outcome of the AHTEG was adopted by CBD Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) at its 11th Meeting, in November 2005, as a Recommendation XI/12.

Lastly, at the 10th CBD-COP in Nagoya, 2010, the Decision X/31 "Protected areas" (http://www.cbd.int/decision/cop/?id=12297) highlights the management of IAS as an issue that need greater attention and *noting the role of invasive alien species as a key driver of biodiversity loss invites Parties to consider the role of invasive alien species management as a cost effective tool for the restoration and maintenance of protected areas and the ecosystem services they provide, and thus to include management of invasive alien species in the action plans for implementation of the programme of work on protected areas, taking into account decision X/38* (http://www.cbd.int/decision/cop/default.shtml?id=12304), *on invasive alien species.*

- ***The Ramsar Convention***

At the 10th COP of the Ramsar Convention in Korea, 2008, the Resolution X.1 (The Ramsar Strategic Plan 2009-2015, http://www.ramsar.org/cda/en/ramsar-documents-resol/main/ramsar/1-31-107_4000_0__) highlighted invasive alien species among "*challenges that still require urgent attention in order to achieve wetland wise use under the Convention* ". This statement was confirmed at 11th COP of the Ramsar Convention in Romania, 2012 (Resolution XI.3).

One of the strategies In order to achieve this goal involves IAS (Strategy 1.9):

Encourage Contracting Parties to develop a national inventory of invasive alien species that currently and/or potentially impact the ecological character of wetlands, especially Ramsar sites, and ensure mutual supportiveness between the national inventory and IUCN's Global Register on Invasive Species (GRIS); develop guidance and promote procedures and actions to prevent, control or eradicate such species in wetland systems.

Key Result Areas By 2015:

- All Parties to have a national inventory of invasive alien species that currently or potentially impact the ecological characters of wetlands, especially Ramsar sites.
- Parties to have identified more comprehensively the problems posed by invasive species in wetland ecosystems within their territories.
- National invasive species control and management policies or guidelines in place for wetlands.
- Comprehensive and up-to-date global guidance on invasive species, in cooperation with GISP, available to all stakeholders.
- Increased collaboration with the Convention on Biological Diversity on actions to address gaps in international regulations relating to invasive alien species.

Trachemys scripta

Previously other Resolutions have been adopted by the COP within the framework of the Ramsar Convention:

- Resolution VII.14: Invasive Species and Wetland (VIIth COOP, Costa Rica, 1999)
- Resolution VIII.18: Invasive Species and Wetland (VIIIth COOP, Spain, 2002)

- ***International Union for Conservation of Nature (IUCN)***

The Vth IUCN World Parks Congress, in Durban, South Africa, September 2003, considered the need to manage IAS as an "emerging issue", stating that "*management of invasive alien species is a priority issue and must be mainstreamed into all aspects of protected area management. The wider audience of protected area managers, stakeholders and governments needs urgently to be made aware of the serious implications for biodiversity, protected area conservation and livelihoods that result from lack of recognition of the IAS problem and failure to address it. Promoting awareness of solutions to the IAS problem and ensuring capacity to implement effective, ecosystem-based methods must be integrated into protected area management programmes. In addition to the consideration of benefits beyond boundaries, the impacts flowing into both marine and terrestrial protected areas from external sources must be addressed*" (http://www.iucn.org/about/work/programmes/pa/pa_event/wcpa_wpc/).

In 2012 the ISSG with the IUCN's Invasive Species Initiative (ISI) developed a policy brief on biological invasions and IAS, included in the IUCN documentation for "Rio+20 - United Nations Conference on Sustainable Development" (http://www.issg.org/pdf/RioPolicybrief.pdf). The policy brief identified some key areas of works for 2012-2020 and specific actions for PAs:

- Awareness raising: *to provide particular focus to the issues and management of IAS on islands and in protected areas.*

- Eradication: *to promote eradication campaigns in key areas such as on islands, protected areas, and key points of entry, such as ports.*
- Containment/Control: *to incorporate IAS and biosecurity policy imperatives in water and land-use planning at all scales from local to global, including islands, protected areas, river and lake basins, production landscapes and seascapes.*

The IUCN policy brief conclude stating that "*it is in particular urgent to immediately start working to meet the relevant aims of the CBD Strategic Plan 2011-2020, prioritizing and managing key pathways of invasions, and identifying and targeting the most harmful IAS. Furthermore, it is also crucial to enforce the relevant IAS aspects of the CBD program of work on islands as it concerns IAS, as well as to improve the management of IAS in protected areas as required by the CBD program of work on protected areas.*"

The IUCN adopted at the World Conservation Congress, in Jeju, Republic of Korea, September 2012, also the motion "*Implementing the provisions on invasive alien species of the Strategic Plan for Biodiversity 2011–2020*" (https://portals.iucn.org/docs/2012congress/motions/en/M-021-2012-EN.pdf). The motion calls on countries to identify invasive species for priority control, enforce stringent regulatory measures to prevent introduction of invasives, encourage voluntary measures, and promote eradication campaigns. Concerning PAs the motion:

Agave americana

Calls on all countries to:

- Promote eradication campaigns of priority invasive alien species, taking into account their potential or actual impact on biodiversity as well as on food security and human well-being, and giving priority to key areas such as islands, protected areas, and key points of entry, such as ports and airports.

- Incorporate invasive alien species and biosecurity policy imperatives in water and land-use planning at all scales from local to global, including islands protected areas, river and lake basins, production landscapes and seascapes.

Requests the Director General and IUCN Commissions to:

- Support collaboration between the IUCN Species Survival Commission (SSC) and IUCN World Commission on Protected Areas (WCPA) to promote the compilation and dissemination of best practice guidelines on invasive alien species management in protected areas, promote appropriate training to address this threat and enhance more effective management in protected areas.
- Strengthen support through the IUCN Secretariat and regional programmes to promote action and capacity building to address invasive alien species issues, especially through the protected areas, water, forests and drylands programmes.

Salvinia molesta

Calls on funding agencies, including in the public and private sectors and civil society to:

- Support prevention, eradication and control campaigns, especially on islands and in key biodiversity areas, protected areas and ecosystems threatened by invasive alien species.

2.2 The European context

- ***The Birds Directive***

Article 11 of the Directive 79/409/EEC (2009/147/EC) on the conservation of wild birds ("The Birds Directive") relates to the prevention of damage to local flora and fauna by the introduction of bird species which not occur naturally in the wild state in the European territory of the Member States.

- ***The Habitat Directive***

The Habitats Directive established the "Natura 2000 Network", the largest ecological network of special protected areas. It comprises special areas of conservation designated also includes special protection areas classified pursuant to the "Birds Directive". The Article 22.b of the Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora ("The Habitat Directive") ask to Member States to "*ensure that the deliberate introduction into the wild of any species which is not native to their territory is regulated so as not to prejudice natural habitats within their natural range or the wild native fauna and flora and, if they consider it necessary, prohibit such introduction*".

- ***The Water Framework Directive (WFD)***

The WFD Directive 2000/60/EC is the main policy document for the management of inland, transitional and coastal waters in the EU. The WFD institute a Register of Protected Areas. The protected areas are identified as those requiring special protection under existing national or European legislation, either to protect their surface water or groundwater, or to conserve habitats or species that directly depend on those waters.

The WFD states that water quality management be centered on river basins. Management of these basins will be achieved through management plans including the assessment of pressures and impacts caused by humans. The WFD does not explicitly require Member States to take account of alien species for the assessment of ecological status of their surface water bodies. Because of this a debate has arisen on the role of alien species in classification of area under the WFD.

- ***The Bern Convention***

Article 11.2.b of the Convention of Conservation of European Wildlife and Natural Habitats ("Bern convention", 1979) requires Parties to promote the reintroduction of native species and strictly control the introduction of non-native species.

Myocastor coypus

In 2003 the Bern Convention adopted a **European Strategy on Invasive Alien Species** (http://www.cbd.int/doc/external/cop-09/bern-01-en.pdf). The strategy identifies priorities and key actions in order to prevent or minimise adverse impact of IAS, and proposes measures required to recover species and natural habitats affected by IAS.

- ***The Barcelona Convention***

The Barcelona Convention (1976) has been updated with the adoption of the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (1995), which requires Parties to adopt measures aimed at promoting the reintroduction of native species and to strictly control the introduction of non-native species (Article 6.d). It also invites Parties to take all appropriate measures to regulate the intentional or accidental introduction of non-indigenous species (Article 13).

Several documents has been recently adopted within the framework of the Barcelona Convention:

- The Action Plan Concerning Species Introduction and Invasive Species in the Mediterranean Sea (2005) http://www.rac-spa.org/telechargement/PA/invasive.pdf
- Guide for Risk Analysis Assessing The impacts of the Introduction of non-indigenous species (2008) http://www.rac-spa.org/dl/LD_ANALYSE.pdf
- Guidelines for controlling the vectors of introduction into the Mediterranean of non-indigenous species and invasive marine species (2008) http://www.rac-spa.org/dl/LD_CONTOLE.pdf

- ***The EU Biodiversity Strategy***

In 2011, the European Commission adopted a new strategy that lays down the framework for EU action over the next ten years in order to meet the 2020 biodiversity headline target set by EU leaders in 2010 (http://ec.europa.eu/environment/nature/info/pubs/docs/factsheets/Biod%20Strategy%20FS.pdf).

Agave americana

The Target 5 of the EU Biodiversity strategy requires that "*by 2020 Invasive Alien Species (IAS) and their pathways are identified and prioritised, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new IAS*". Within the Action 16 of the Target 5 the EU has committed to develop a dedicated legislative instrument on the issue but, at this stage, the scope and coverage of the instrument are not yet clear.

3. AUDIENCE AND AIMS

Psittacula krameri

The aim of the Guidelines is to present key principles that should be adopted for PAs, in order to prevent and manage the threat of invasive species at local, national and supra-national scale. The Guidelines also provide concrete examples of best practices for prevention and management of invasive species in protected areas. They also illustrate the pivotal role that PAs may have for the IAS issue, both inside and outside the borders, by making best use of the specific knowledge about PAs and their sensitivity in awareness raising, surveillance and monitoring, and also for potential prompt reaction to invasions.

The Guidelines are aimed mainly at PA managers and staff, practitioners, decision makers at all levels (local to national) and local communities. The Guidelines are addressed to support PA managers and decision makers in the mainstreaming of the IAS issue into all aspects of protected area management. The Guidelines are also addressed to those (e.g. authorities, NGOs, politicians and funders) that can contribute to the enforcement of well planned and effective management programs. They also aim at raising awareness on the threat of IAS to biodiversity, and at improving the information on this issue.

The Guidelines takes account of existing initiatives and relevant obligations and principles of the Directive 92/43/EEC (the Habitat directive), the Directive 79/409/EEC (the Birds Directive), the Bern Convention, the Ramsar Convention and the Convention on Biological Diversity (CBD).

These European Guidelines on Protected Areas and IAS should be considered as an implementation of the European Strategy on Invasive Alien Species and aims to contribute to the ongoing development of the EU Strategy on IAS.

4. EUROPEAN GUIDELINES ON PROTECTED AREAS AND IAS

Sylvilagus floridanus

Biological invasions affect protected areas all over the world. The effects of this threat to the biodiversity of PAs are dramatic and are expected to grow in the future, especially as they increasingly interlink with other factors of change such as climate change, habitat loss and human pressure. It is therefore urgent that the management of IAS is improved in PAs, if PAs are to fully play a role as champions of the protection of the global diversity and of the ecosystem services we all rely upon for our very existence.

"Letting nature take its course" is not a strategy that can be used for IAS and active management of this issue is therefore fundamental. However, only evidence-based policy and management, developed through rigorous science, will allow an appropriate response in PAs to the growing environmental crisis at all scales.

Protected areas can and should play a major role in the struggle against invasions, not only by improving the efficacy of IAS management within their territories, but also monitoring the patterns of invasions, raising awareness at all levels, improving the capacity of practitioners to deal with invaders, implementing site-based prevention efforts, enforcing early detection and rapid response frameworks, and catalysing action also beyond the protected area boundaries.

Protected areas provide a valuable source of information on the effects of IAS on biodiversity and ecosystem functioning as well as the dynamics of invasions, as in general there is a much deeper knowledge base for protected areas than for the rest of the territory. Protected areas have also much greater applied knowledge through research, monitoring and management in PAs than in other areas (*e.g.* within the EU,

monitoring and surveillance of biodiversity in PAs is usually required to some extent and will be carried out at regular intervals). There exists a great potential for using PAs as a model for future research for developing a better understanding of impacts, restoration, monitoring and human dimensions of biological invasions in natural systems.

Protected areas cannot stop invasions, but can indeed be important in preventing and mitigating the global effects of this threat by being reservoirs of the heritage of native species and ecosystems. They can also be used as sentinels of incursions to speed up response at all levels, and champions for increasing information and awareness within the different sectors of the society, as well as catalysts for action at all scales.

4.1 Raise Awareness on Biological Invasions at all Levels

The limited awareness and concern of the public is a major constraint to the efforts to prevent and mitigate the impacts of IAS (Pyšek et al. 2014). A key role of PAs is to be used as a focal point for the diffusion of information and knowledge on biological invasions at all levels, from the PA staff and managers to the visitors, to local communities and the general public. Protected Areas can in fact play a pivotal role in this regard, because of the credibility that these institutions generally have and because of the greater interest toward these areas among scientists and the general public. More specifically, visitors have a direct contact with PAs and their staff, which provides an opportunity to inform them about the threat posed by IAS, while at the same time communicating the value of native biodiversity for the preservation of nature, and the ecosystem services we all rely upon. The awareness of IAS can also be raised through the involvement of the public in the different activities related to the monitoring and management of IAS.

Raising awareness on IAS


Eichhornia crassipes

There are very valuable examples of the involvement of scuba divers in the detection of seaweeds, as in the case of the seaweed *Caulerpa webbiana* in the marine PAs of Azores (Amat et al. 2008), for which a specific webpage has been created to report observations of this invasive seaweed (http://www.horta.uac.pt/caulerpa/httpdocs/english.html). In the Adirondack Park (New York State, USA) The Nature Conservancy involved volunteers in a monitoring campaign that delineated the distribution of 13 invasive alien plants along major roadways, allowing for prioritization of actions (Brown et al. 2001). These two examples highlight the potential of local communities' involvement for monitoring and detecting IAS. Also, and perhaps more importantly, to mainstream conservation and the need to combat IAS, thereby profoundly influencing the perception of the public to impacts of IAS, and the severe effects of biological invasions more generally. There are also several examples that show the efficacy of communities and volunteers for eradication and management of IAS. The "balsam blitzes" is an initiative aimed at controlling *Impatiens glandulifera* (Himalayan balsam), in the Pembrokeshire Coast National Park (Wales, UK), involving volunteers mostly from local NGOs. The on-going eradication of *Lysichiton americanus* (American skunk cabbage), in the Taunus Nature Park (Germany), is carried on with the involvement of over 100 volunteers (Pyšek et al. in press). With the "Quagga Mussel Blitz", in Glen Canyon National Park, the US National Park Service involves divers to assess the extent of *Dreissena rostriformis* in Lake Powell and to remove all existing mussels (http://www.nps.gov/glca/parknews/quagga-mussel-blitz.htm).


Eichhornia crassipes

Several successful campaigns aimed at raising awareness on the issue of invasive species in unprotected land can provide examples for PAs. The 'Weedbuster' (http://www.daff.qld.gov.au/4790_7012.htm) is an awareness and education programme launched in Australia in 1994 (thereafter also in New Zealand and South Africa) aimed at protecting the environment from weeds, by active initiatives such as the 'weedbuster weeks' or the 'weedbusters dirty weekends'. Gardeners are asked to identify any weedy ornamental species that might be growing on their properties and replace them with non-weedy alternatives from local garden centres. An example of the many human dimensions related to invasive species, and of the possible ways to address them, is the "Operation No Release" in Singapore (http://www.nparks.gov.sg/cms/docs/operation_no_release.pdf), aimed at discouraging the release of living animals done in the Vesak day (holy day), a Buddhist celebration where thousands of birds, insects and animals are released in a 'symbolic act to liberation' (Shiu and Stokes 2008). This successful programme is based on an active role of National Parks rangers, stationed at popular release sites and discouraging the public from releasing animals.

Raising awareness on IAS

Raising the awareness of the public requires effective communication strategies and sensitive arguments, such as the example of the direct danger to the safety of people posed by the lionfish. Lion fish, which have poisonous spines that can be hazardous to people snorkelling and scuba diving, have invaded many of the south-eastern ocean and coastal parks of the USA (McCreedy et al. 2012, Whitfield et al. 2002). Often the danger presented by invasive species is unexpected by park employees and visitors, and improving awareness of these dangers can help reduce further harm.

In some cases even the PA employees may not be aware of biological invasions, and require specific communication efforts. For example, the staff of the Kruger National Park (South Africa), in particular the longer-standing personnel, strongly opposed the parks efforts to clear well-known invasive ornamental plants that had been in their

gardens for a long time, and supported the programme only after specific education and communication efforts by the PA authorities (Foxcroft 2001).

4.2 Integrate Invasive Species and Protected Area Management

Addressing biological invasions raises serious technical challenges, often calling for complex solutions. PAs combating IAS requires coordinated measures ranging from prevention to control. Especially in the case of long, well-established species, the interactions among species (native and other alien species) and between species and ecosystem functions need to be taken into account. Furthermore, biological invasions interact in complex and non-additive ways with other drivers, such as climate change. This can alter the pathways of introduction and spread of IAS, influence the probability of establishment, modify the competitive and predatory impacts on native species, and also affect the prevention and control strategies (Rahel and Holden 2008).

Well planned, coordinated and effective strategies for PAs should be developed and enforced to address IAS, integrating all the elements from awareness raising and communication efforts, regulatory measures, prevention aspects, as well as eradication and management programmes into a single programme. There are indeed examples of coordinated and effective approaches to IAS in PAs. In North America, the National Park Service manages IAS on park lands at different scales, through an integrated approach of cooperation and collaboration, inventory and monitoring, prevention, early detection and rapid response, treatment and control, and restoration (http://www.nature.nps.gov/biology/invasivespecies/). Most USA parks have incorporated IAS management into long-term planning and routine PA management. For example, Curecanti and Glen Canyon National Recreation Areas have implemented "boat checks" to help visitors make sure their boats are free of zebra and quagga mussels (*Dreissena polimorpha* and *D. bugensis*) prior to entering the park (http://www.nps.gov/cure/planyourvisit/mussel_free_certification.htm).

Carpobrotus edulis

Unfortunately, in many cases the approaches adopted in PAs tend to be limited in focus. There is a tendency to concentrate efforts on the reaction to invasions, often neglecting more proactive approaches. For example, South African National Parks, which are acknowledged as being among the best managed in Africa, often focus more on the control of widespread of alien plants and of some mammals, but have to a large extent not focused sufficient attention to possible prevention, early warning and rapid response programmes (e.g. see Foxcroft and Freitag-Ronaldson 2007).

The dynamic basis of biological invasions also calls for an adaptive management approach, although there are many obstacles to adopting this method for IAS, including the lack of frameworks for decision making and feedback mechanisms, and the inadequacy of the governance structures (Foxcroft and McGeoch 2011). However, there are interesting examples where adaptive management approaches have been successfully applied, for example in the Kruger National Park (Foxcroft and McGeoch 2011). In particular, it would be important that activities on IAS in PAs are based on a priority setting exercise, in order to sustainably manage the available resources, and to direct them in the most effective way for minimizing the impacts of IAS (Randall 2011). An interesting example of the use of a prioritization approach in IAS concerns the black rat eradication on Italian islands (almost all within protected areas) to protect nesting shearwaters (Capizzi et al. 2010).

There are examples of tools to support objective priority setting, such as the Alien Plants Ranking System developed in the USA (APRS; http://www.npwrc.usgs.gov/resource/literatr/aprs/index.htm). The computer-based programme helps decision making by taking actual and potential impacts, as well as feasibility of control, into account.

4.3 Implementing Site-Based Prevention Actions as a Priority

Prevention includes screening and addressing pathways and vectors, intercepting movements at borders, and taking action based on risk assessment. These activities have been identified as a global priority by the Aichi Target 9 and adopted by the Convention on Biological Diversity, calling for the identification of key pathways of invasions and implementing measures to address them. Meeting this target requires action at multiple spatial scales, from global, to regional, and down to an individual PA or site-specific efforts, and linking the processes and responses operating at the different scales (Kueffer et al. in press). More than routine management of IAS in PAs could be done by encouraging responsible behaviour by private individuals and industries through for example, promoting the adoption of agreed standards, best-practice guidelines or codes of conduct. For instance the US National Park Service give to their visitors a number of general tips to ensure that they are not transporting invasive species into, around, or out of a park (http://www.nature.nps.gov/biology/invasivespecies/Prevention.cfm), or the Environment Agency of Wales (UK) that, while is eradicating the invasive fish *Pseudorasbora parva* from the Millennium Coastal Park, ask to the anglers to adopt biosafety measures to help prevent the spread of the species (http://www.environment-agency.gov.uk/news/143688.aspx).

Carpobrotus edulis

An example at the level of an individual PA, is the code of conduct implemented by the Kruger National Park, which includes a list of alien plants not to be planted, and to be immediately removed if observed (Foxcroft et al. 2008). Another example is the environmental code of conduct for terrestrial scientific field research in Antarctica (SCAR 2009). This includes provisions for all visitors, especially scientists, to the Antarctic and Sub-Antarctic to clean or sterilise equipment to remove propagules. At even larger scales, codes of conduct on IAS and horticulture, IAS and botanical gardens, IAS and zoological gardens and aquaria (Heywood and Brunel 2009; Heywood 2012; Scalera et al. 2012) could be supported and implemented in PAs.

Other preventative actions at the scale of a PA could include the on-going assessment of site-specific activities and vectors responsible of IAS introductions, and developing measures to reduce the risk of further invasions. In this regard potential new invaders of PAs should be identified and forecasts made of what IAS are expected to be introduced, in order to intercept them when feasible. This approach has proved successful at larger scale contexts (see Simberloff et al. 2013 for examples), and should therefore also be adopted at site specific scales.

Although in general prevention is acknowledged by far as the most cost effective way to address invasions, management of IAS in PAs often tends to focus more on control and containment than on the sources of invasions, or on addressing new invasions in their early stages. Prevention of IAS in PAs should also include the eradication or control of newly arrived IAS, before they become widespread (discussed more in detail in guideline 4.5). There are however many examples of effective prevention efforts in PAs of all regions of the world. Some parks, such as the Galapagos National Park and Marine Reserve, regulate the number of visitors and the periods of access. Many PAs in the USA and New Zealand impose cleaning of shoes, clothes, vehicles or equipment

before entering, in some cases providing cleaning stations. The 'Check, clean, dry: didymo controls' programme of the Fiordland National Park (New Zealand) is aimed at preventing the establishment of the invasive freshwater algae *Didymosphenia geminata* (didymo) in the park, by encouraging visitors to check, clean and dry all gear before leaving the lake edge and moving into lake tributaries or other waterways (http://www.biosecurity.govt.nz/biosec/camp-acts/check-clean-dry). Prevention efforts could be based on voluntary approaches such as the codes of conduct mentioned above, but should consider regulatory approaches, for example addressing the activities carried on within the PA's borders, or in the surrounding areas, that could cause a risk of introductions (forestry, livestock breeding, horticulture, etc.).

Despite the positive examples reported above, it is evident that much more could be done in terms of information and education of visitors, as the behaviour of people is essential to increase biosecurity of PAs. Indeed a major limit for adopting a more comprehensive and effective strategy to address this threat is the scarcity of resources. However, this constraint highlights the importance of addressing the causes of invasions instead of the symptoms, calling for better planning, and for prioritising actions such as prevention, instead of concentrating the staff and funding in managing to the most visible IAS, often with limited effects in terms of impact mitigation.

Rattus rattus eradication

4.4 Develop Staff Capacity for all Aspects of Invasive Species Management

Invasive species management requires specialist knowledge and skills which can only be developed over time. The capacity and awareness of PA officials are crucial for

applying most of the guidelines presented. For example, PA managers have a key role in preventing further invasions, and streamlining employees' knowledge, experiences and skills, and would indeed significantly improve the ability of the PA to manage IAS (Tu and Robison 2014). In general the capacity of PA staff has been highlighted as essential for fulfilling the need for visitor's education on biological invasions and the value of biodiversity in PAs (Boshoff et al. 2008). One example of a programme aimed at improving skills and share experiences and ideas, is the Pacific Invasives Learning Network (Boudjelas, 2013), launched in an area of the world with particular problems of isolation and access to knowledge (Micronesia, Polynesia, Melanesia and Hawaii). The programme builds on multi-agency teams, and is aimed at empowering effective invasive species management through a participant-driven network rapidly sharing skills and resources, and providing links to technical expertise and information. The capacity of the staff, both in terms of technical skills and of general awareness on the problems, is particularly important for enabling the rapid detection of new incursions, and the prompt reaction to these (see also guideline 4.5).

One example in this regard are the SANParks 'honorary rangers', who volunteer to assist in a variety of activities in the organisation, as well as in the management of IAS. Improved public opinion is crucial to support PAs to be able to address the real causes of invasions, for example, by supporting the development of policies based on prevention, instead of only focusing on the 'symptoms' that affect their territories, such as widely established IAS.

Park rangers are often the foremost interface with the public. An informed staff can thus significantly help raising the awareness of the park visitors, and to ensure the public support to the control activities carried out in the PA. Once again an interesting example comes from the US National Park Service, where park officials are trained to communicate the implications of the lionfish invasion, thereby improving the understanding of the need for lionfish removal (McCreedy et al. 2012).

Managing Trachemys scripta in Protected areas

4.5 Set up Rapid Detection and Prompt Response Framework

Early warning and rapid response to new invasions is a key pillar of an effective strategy and PAs can indeed play a particularly important role in this respect, acting as 'miners' canaries' of incursions (Loope 2004). In this regard, the ability to rapidly enforce effective management of newly arrived IAS in PAs at the earliest possible stage after their introduction into the PA's territory needs to be improved. Prompt detection and rapid response can still be successful in eradication efforts that are likely to be challenging, such as for marine species (OCEANA, 2012). For example, in the case of the highly invasive Pacific alga, *Caulerpa taxifolia*, an incursion in California was quickly detected and successfully eradicated within six months of discovery, while procrastination in the Mediterranean allowed the species to invade thousands of hectares off the coasts of Spain, France, Monaco, Italy, Croatia, and Tunisia, making it ineradicable with current technologies (Simberloff et al. 2013). Prompt reaction is not only much more effective, but is also more economically viable. A review of successful or attempted plant eradication programmes carried out in New Zealand revealed that early removal of plants costs on average 40 times less than removal carried out after an invasive plant has widely established (Harris and Timmins 2009).

To enable more effective early detection and rapid response, a coordinated framework for surveillance and monitoring activities, species identification, risk assessment, information sharing, and selection and enforcement of appropriate responses (Genovesi et al. 2010) is required. Developing alarm lists of possible new invaders can also enable more rapid reaction. An effective large scale approach to early detection and rapid response is the California Weed Action Plan (Schoenig 2005), which although generally enforced at a large scale, can provide valuable suggestions for PAs. The action plan, which is supported by a budget of about US$ 2.5 million/year, is based on an official list of noxious weeds for which prompt action is mandatory. A network of biologists, and trained farmers and volunteers enable early detection of new incursions, and grants are provided to implement weed control activities. The action plan has allowed the successful removal of over 2000 infestations and the complete eradication of 17 weeds. The Californian example highlights the importance of coordinated and comprehensive frameworks for enabling prompt reaction to invasions. A questionnaire circulated to experts, decision makers, and practitioners in Europe identified the gaps for establishing an early warning and rapid response framework for IAS. These included (i) the limited funds available, (ii) the lack of early detection mechanisms, (iii) the absence of legal tools to regulate IAS introductions, (iv) the need for competent authorities to be able to carry out the appropriate responses, (v) the lack of legal tools to regulate possession of IAS, (vi) the limited ability to detect new invasions, (vii) the unclear assignment of roles and responsibilities, (viii) the technical constraints to management, and (ix) the legal obstacles to implementing control or eradication programmes (Genovesi et al. 2010). Many of these constraints also affect PAs and a coordinated approach needs to address all these aspects.

Additionally, priorities for rapid response to IAS in PAs need to be identified, based on a rigorous risk assessment process, These responses should make best use of resources, including the involvement of communities and volunteers (Pyšek et al. 2014), and enforcing effective responses once a new invader is detected (Simberloff 2014).

Eradication of Anoplophora chinensis

For the enforcement of early warning and rapid response systems to invasions it is essential to have adequate support from the public. Particular attention to the communication of the response priorities and plans should thus be given. It is also important to have methods in place to monitor the effects of the system in terms of outcomes, to allow improvement of the overall framework (Tu and Robison 2014). To improve the ability to respond promptly to new incursions in PAs, contingency plans, designed for species or broader taxonomic groups, as identified on the basis of an assessment of the most probable new invaders (see also guideline 4.3). Contingency plans should include training on management alternatives, and possibly the establishment of dedicated task forces, which could be created for an individual PA or at a larger scale (see also guideline 4.4). For example, the US National Park Service has developed an invasive plant management programme, creating 16 Exotic Plant Management Teams, which provide highly trained mobile assistance to parks throughout the National Park System (http://www.nature.nps.gov/biology/invasivespecies/EPMT_teams.cfm). The basic equipment needed for managing different taxonomic groups in PAs should be procured and maintained, thereby shortening the time taken to implement rapid response actions. The identification of contingency funding sources is crucially important to enable effective response to new invasions. For example, the successful eradication of *Caulerpa taxifolia* in California was made possible by the rapid procurement of substantial resources. On the other hand, the removal of the rabbit *Oryctolagus cuniculus* from a small island of the Canary (Spain) was suspended when it was almost completed, defeating the results obtained, because the project ran out of funds, thus defeating the results obtained (Genovesi, 2005).

Capture of Procambarus clarkii

4.6 Manage Invasive Species Beyond the Protected Area Boundaries

Land use outside PA boundaries provides propagules for colonization (Meiners and Pickett 2014), with features such as river networks facilitating the spread of IAS (Foxcroft et al. 2011; Vardien et al. 2013). This is also the case of weeds entering PAs through agricultural practices adopted outside their borders (Bazzaz 1986; Hulme et al. in press), and areas with high human population density (Spear et al. 2013). The invasive alien plants that are present in the adjacent areas are thus a key factor affecting the composition and number of individuals colonizing a PA (Rose and Hermanutz 2004; Dawson et al. 2011). This effect is particularly evident in the case of small PAs occurring in modified landscapes, where it is therefore particularly important to adopt a landscape perspective to planning (Meiners and Pickett 2014). It is also important to consider the establishment of buffer zones where promoting lower-impact land uses and involving local communities (Laurance et al. 2012). Cooperation with surroundings landowners and institutions is thus an important element for enhancing prevention. This can also be done at a much larger scale than the immediate surroundings of the PA, discussing and lobbying with the competent authorities at all levels the adoption of regulatory or voluntary measures to address activities potentially at risk of causing invasions, such as forestry, horticulture, hunting, or botanical gardens (see also guideline 4.3). Also the establishment of buffer zones of land managed not facilitate invasions can be an effective way to reduce risks of invasions in PAs (Foxcroft et al. 2011).

Barbus plebejus

4.7 Surveillance, Monitoring and Information Exchange Networks

The efficacy of any strategy to address IAS strictly depends on the available information, and on the sharing of data, knowledge and experience. For example, inventories of invasive species in PAs, based on rigorous scientific criteria, are an essential tool to prevent and control invasions in PAs (Pyšek et al. 2009). Furthermore, the effective management of IAS requires good quality data on the spread of invasive species, as well as access to information on the biological traits of the species, its impacts, and on the available management alternatives. In addition to the elements highlighted above (see also guidelines 4.3 and 4.5), early warning and rapid response requires effective surveillance to detect emerging incursions, and access to information to correctly identify the new invaders and to screen the associated risks to implement responses (Genovesi et al. 2010). Also, meta-analyses of the available data can permit prioritisation of pathways of introduction, as well as species, for example on the basis of the impacts they cause and the vulnerability to the control actions (Hulme et al. 2008).

Surveillance and monitoring schemes should be implemented for PAs, enabling the standardised collection of data on the distribution and abundance of IAS (Pyšek et al. 2014). Citizen science could significantly improve efficacy of surveillance and monitoring of IAS. Possible ways to involve visitors and volunteers in the collection of data in PAs should be explored (Gallo and Wait, 2011; see also guideline 4.1). Information in not only important for the effective management of IAS, but also – as already stressed - to raise awareness on the issue, by providing examples on the causes and consequences of invasions to the public, including in particular the impacts on biological diversity as well as on ecosystem services.

Monitoring should not be limited to IAS, but also address the efficacy of management actions, collecting information on the effects of control activities, on the costs of management, and on the public perceptions of the issue. All this information is essential to avoid waste of resources, especially in the case of permanent management, that should always be based on an assessment of the cost/benefits, and to an evaluation of the sustainability of the required actions in the medium-long term. The importance of increasing the sharing of information on IAS has also been stressed by the Convention on Biological Diversity, that with Decision X/38 started an initiative aimed at increasing the interoperability of databases on IAS. This decision has then led to the launch of the Global Invasive Alien Species Information Partnership (GIASIP; http://www.cbd.int/doc/meetings/sbstta/sbstta-15/information/sbstta-15-inf-14-en.pdf). The major existing global and regional information systems such as the Global Invasive Species Information Database of the IUCN SSC Invasive Species Specialist Group (http://www.issg.org/database/welcome/) and the Invasive Species Compendium of CABI (http://www.cabi.org/ISC/) have agreed to cooperate to improve the exchange of information within GIASIP (http://giasipartnership.myspecies.info).

The importance of data sharing for PAs is twofold. On the one hand, tools for identifying species, prioritising action, and enabling prompt reactions in PAs need to be accessed. This requires access to information on the management alternatives, as well as contacts of experts at the global scale. Access to information is particularly important in developing countries, or in remote areas such as oceanic islands, where local expertise is often limited (see the Pacific Invasive Learning Network in guideline 4.4). On the other hand, data and information from PAs can be provided and can guide action, including examples of best practises, which can enable improved management in other contexts. For this reason web-based information platforms are needed to enable reporting and sharing of information and data. National, regional and larger scale information services

Procambarus clarkii

should also be improved to enable the global sharing of information. Databases providing information about alien species are an important tool for building management capacity at a global level. One example of an effective information system for invasive species in PAs is the Marine Invasive Species Database (http://www.nature.nps.gov/water/marineinvasives/MISdatabase.cfm), compiled by the US National Park Service using reports of invasive species in National Parks from several agencies and NGOs. The list permitted to identify marine invasive species documented within each park boundary, as well as a list of potential marine invasive species that are present within the ecoregion, but not yet documented in a park. The Great Lakes Invasive Species Database (http://www.nature.nps.gov/water/marineinvasives/GLISdatabase.cfm), also implemented by the US National Park Service, includes data on invasive species for five Great Lakes National Park units, both covering species recorded for the parks, as well as invasive species established in the region but not yet reported for a national park, the latter aimed at enabling early detection of new incursions.

Eucaliptus forest

Eradication of Anoplophora chinensis

The implementation of data sharing platforms could also permit the involvement of the public for the monitoring and management of IAS, for example through the use of applications developed for mobile phones, tablets, etc. (e.g., "PlantTracker" http://planttracker.naturelocator.org/; "Aliens Among Us app" http://www.royalbcmuseum.bc.ca/TravellingExhibitions/default.aspx; "iAs_sess", http://ias-ess.org; "What'invasive!" http://whatsinvasive.com/). Trained volunteers can indeed support monitoring, but could be particularly helpful for detecting new incursions; the EEA initiative "Eye on earth" (http://www.eyeonearth.org/en-us/Pages/Home.aspx) provides an interesting example in this regard.

4.8 Lobby with Institutions and Decision-Makers to Support Stringent Policies

Addressing biological invasions requires action at all levels, from the local to the global level. Trade regulations, which that are important for preventing invasions, though for example horticulture, can only be enforced at the national, regional or even global scale. Furthermore, legal frameworks can facilitate, but also constraint the efficacy of action, as highlighted by the results of the survey carried on in Europe on the issue, which reported the inadequacy of legal systems among the key constraints for combating IAS (Genovesi et al. 2010). Therefore, as also stressed in guideline 4.6, PAs should cooperate with institutions and all competent authorities for adopting regulatory or voluntary measures to address key pathways such as forestry, horticulture, hunting, or botanical gardens (Hulme et al. 2008).

Another area where it is important to cooperate at a larger scale than that of PAs, is the identification of priorities in terms of management of IAS. In order to make best use of the available resources these priorities should in fact be identified at the national scale and across all protected areas, basing the decision on a rigorous assessment of risks.

Synergic actions involving protected areas, can promote the adoption of more stringent policies at the national as well as global scale, and to convince donors and funding agencies to secure budget and funding for IAS. Impacts and projected future effects of IAS can be documented in PAs, and information on the resources spent to address this threat can be provided. Coordination amongst relevant institutions and stakeholders can be catalysed for PAs, thus promoting more effective actions beyond their territories (Tu 2009). Regional or national networks working with PAs (e.g. IUCN World Commission on Protected Areas, Europarc for Europe, etc.) should encourage national and global institutions, such as the Convention on Biological Diversity, to adopt and enforce more effective policies, and to address the legal constraints to management of IAS, that in some cases have been shown to limit the effective response to invasions. Furthermore, interacting with relevant national or even supranational institutions can facilitate the access to available resources, as in the case of the European Union LIFE funding instrument.

An example of a regional attempt to develop coordination amongst relevant institutions, is the present European Guidelines on Protected Areas and IAS, which is promoted by the Council of Europe and supported by the IUCN SSC Invasive Species Specialist Group.

The guidelines are based on European legislation and international conventions on the mitigation of impacts caused by IAS to PAs, and the need for more effective management of this threat in PAs to preserve biodiversity. The guidelines take into account the best-practises in PAs throughout the world, and will provide non-binding recommendations to PAs to improve their ability to respond to this threat. Especially in the case of PAs, internal regulations – although often carrying less force than a law - can in fact be much more appropriate, effective and successful than any binding national legislation.

Myopsitta monachus

Table 1. *A summary of European Guidelines on Protected Areas and Invasive Species.*

Guideline	Rationale
Raise Awareness on Biological Invasions at all Levels	*Limited awareness and concern of the public is a major constraint to prevention and mitigation of impact of IAS, and priority to informing on this issue should be given in PAs. In some cases also PA employees are not fully aware of the issue.*
Integrate Invasive Species and Protected Area Management	*Addressing IAS requires strategic approaches, based on coordinated prevention as well as management measures. Dynamic nature of invasions calls for more proactive rather than reactive approaches to the issue, and to adaptive management.*
Implement Site-Based Prevention Actions as a Priority	*Prevention should be the first line of defence from invasions. More than routine management of IAS in PAs could be done by encouraging responsible behaviours by privates as well as enterprises, identifying most relevant vectors and pathways of invasion, or IAS expected to arrive to their territories, and developing focused measures to reduce risks. Prevention should also be linked to early warning and rapid response.*
Develop Staff Capacities for all Aspects of Invasive Species Management	*Capacity and awareness of PA officials and staff are crucial for applying most of the guidelines. Trained staff are key to effective management, and can contribute to communicate to the visitors as well as to the general public.*
Set up Rapid Detection and Prompt Response Framework	*Early warning and rapid response is a key element of any strategic approach to invasions, as it is much more effective and cost effective than controlling invaders once they have established. It requires a coordinated framework for surveillance and monitoring activities, identification of invading species, assessment of risks, sharing of information, development of alarm lists and selection and enforcement of appropriate responses. Support by the public, and contingency action and funding are also very important.*
Manage Invasive Species Beyond the Protected Area Boundaries	*The invasion of PAs often originates from the surrounding areas and this calls for a landscape perspective to planning. Establishment of buffer zones should be explored. To enhance prevention, cooperation among PAs and surroundings landowners and institutions should be established as well as a lobby with competent authorities for implementing regulatory or voluntary measures to address activities such as forestry, horticulture, hunting, or botanical gardens.*
Surveillance, Monitoring and Information Exchange Networks	*Effective prevention and response to invasions – but also awareness - largely depend on knowledge basis. Information on the spread of invasive species, biological traits of the species, impacts, and available management alternatives are essential. Early warning and rapid response require effective surveillance and access to information to identify new invaders and screen the associated risks. Collection, sharing and access to information, also exploring the involvement of visitors and volunteers in data collection, should be implemented for PAs*
Lobby with Institutions and Decision-Makers to Support Stringent Policy	*Addressing biological invasions requires action involving PAs at all levels, from the local to the global levels, including cooperation with institutions and all competent authorities for adopting regulatory or voluntary measures to address key pathways, and for identifying priorities. More stringent national and global policies are crucial also for preventing invasions in PAs, that should support their adoption, as well as influencing donors and funding agencies policies. Impacts can be documented in PAs and information on best practises can be provided. Coordination amongst relevant institutions and stakeholders can be catalysed for PAs.*

5. ACKNOWLEDGEMENTS

Many experts contributed to the present document with comments, suggestions and information on the drafts presented at the 9th and 10th meeting of the Bern Convention Group of Experts on Invasive Alien Species (2011: St. Julians - Malta; 2013: Alghero - Italy), at the 3rd meeting of the Bern Convention Group of Experts on Protected Areas and Ecological Networks, held in Strasbourg (France) on 19-20 September 2011 and at the Meeting of the Select Group of Experts on Invasive Alien Species, held in Rome (Italy) on 15-16 March 2012. A special thank to Melanie Joseffson for greatly improving a previous version of this document.

The survey on invasive species in European PAs, that provided key information for the guidelines, was made possible by the support of the Council of Europe, and by the help of many experts, protected areas staff, and organizations, including in particular Europarc, IUCN World Commission on Protected Areas, IUCN Regional Office for Europe, IUCN Med Office, the Group of Experts of the Bern Convention on Protected Areas and Ecological Networks. A special thank to Iva Obretenova and Federico Minozzi for their invaluable help to disseminate the survey.

Much information and many case studies reported in the present document are extracted from the book: "*Plant invasions in protected areas: patterns, problems and challenges*" (Springer 2014, Dordrecht; eds. Foxcroft, Pysek, Richardson and Genovesi). We sincerely thank Llewellyn Foxcroft, Dave Richardson and Petr Pysek for having compiled and assessed a huge amount of information on invasive species management in protected areas from all regions of the world, that indeed provided us with an essential basis of knowledge for developing the guidelines.

6. REFERENCES

Amat JN, Cardigos F, Santos RS (2008) The recent northern introduction of the seaweed *Caulerpa webbiana* (*Caulerpales, Chlorophyta*) in Faial, Azores Islands (North-Eastern Atlantic). Aquat Invas 3:417–422

Baret S, Baider C, Kueffer C et al (2014) Chapter 19: Threats to paradise? Plant invasion in protected areas of Western Indian Ocean islands. In: Foxcroft LC, Pyšek P, Richardson DM et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Bazzaz FA (1986) Life history of colonizing plants: some demographic, genetic, and physiological features. In: Mooney HA, Drake J (eds) Ecology of biological invasions of North America and Hawaii. Springer-Verlag, New York, NY, p 96–110

Bergstrom DM, Chown SL (1999) Life at the front: history, ecology and change on southern ocean islands. Trends Ecol Evol 14:472–477

Boshoff AF, Landman M, Kerley GIH, Bradfield M (2008). Visitors' views on alien animal species in national parks: a case study from South Africa. S. Afr. j. sci. 104:326-328

Boudjelas S (2013). Biodiversity Conservation Lessons Learned. Technical Series 17: Long Term Capacity for Invasive Species Management. Conservation International Pacific Islands Program

Brown WT, Krasny ME, Schoch N (2001) Volunteer monitoring of non-indigenous, invasive species. Nat Areas J 21:189–196

Brundu G (2014) Chapter 18: Invasive alien plants in protected areas in Mediterranean islands: knowledge gaps and main threats. In: Foxcroft LC, Pyšek P, Richardson DM et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Brunel S, Fernández-Galiano E, Genovesi P et al (2013) Invasive alien species: a growing but neglected threat? In: Late lessons from early warning: science, precaution, innovation. Lessons for preventing harm. EEA Report 1/2013, Copenhagen, p 518–540

Butchart SHM, Walpole M, Collen B et al (2010) Global biodiversity: indicators of recent declines. Science 328:1164–1168

Capizzi D, Baccetti N, Sposimo P (2010). Prioritizing rat eradication on islands by cost and effectiveness to protect nesting seabirds. Biological Conservation 143: 1716–1727.

Cox R, Underwood C (2011) The importance of conserving biodiversity outside of protected areas in Mediterranean ecosystems. PLos One 6(1):e14508

Dawson W, Burslem DFRP, Hulme PE (2011) The comparative importance of species traits and introduction characteristics in tropical plant invasions. Diversity Distrib 17:1111–1121

De Poorter M, Pagad S, Ullah MI (2007) Invasive alien species and protected areas: a scoping report. Produced for the World Bank as a contribution to the Global Invasive Species Programme (GISP), ISSG IUCN

Dudley N, Stolton S, Belokurov A et al (2010) Natural solutions: protected areas helping people cope with climate change. WWF International, Gland

European Environment Agency (2006) CORINE land cover 2006. http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster

European Environment Agency (2012) Protected areas in Europe: an overview. EEA Report 5/2012, Copenaghen

Foxcroft LC (2001) A case study of human dimensions in invasion and control of alien plants in the personnel villages of Kruger National Park. In: McNeely JA (ed) The great reshuffling: human dimensions of invasive alien species. IUCN, Gland, Switzerland and Cambridge, UK, p 127–134

Foxcroft LC, Freitag-Ronaldson S (2007) Seven decades of institutional learning: managing alien plant invasions in the Kruger National Park, South Africa. Oryx 41:160–167

Foxcroft LC, McGeoch MA (2011) Implementing invasive species management in an adaptive management framework. Koedoe 53:111–121

Foxcroft LC, Richardson DM, Wilson JRU (2008) Ornamental plants as invasive aliens: problems and solutions in Kruger National Park, South Africa. Environ Manage 41:32–51

Foxcroft LC, Richardson DM, Rouget M et al (2009) Patterns of alien plant distribution at multiple spatial scales in a large national park: implications for ecology, management and monitoring. Diversity Distrib 15:367–378

Foxcroft LC, Jarošík V, Pyšek P et al (2011) Protected-area boundaries as filters of plant invasions. Cons Biol 25:400–405

Foxcroft LC, Pyšek P, Richardson DM et al (2014) Chapter 2: The bottom line: impacts of alien plant invasions in protected areas. In: Foxcroft LC, Pyšek P, Richardson DM et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Frenot Y, Chown SL, Whinam J et al (2005) Biological invasions in the Antarctic: extent, impacts and implications. Biol Rev 80:45–72

Gallo T, Wait D (2011) Creating a successful citizen science model to detect and report invasive species. BioScience 61:459–465

Gaston KJ, Jackson SF, Nagy A et al (2008) Protected areas in Europe. Ann NY Acad Sci 1134:97–119

Genovesi P (2005) Eradications of invasive alien species in Europe: a review. Biol Invasions 7:127–133

Genovesi P, Scalera R, Brunel S et al (2010) Towards an early warning and information system for invasive alien species (IAS) threatening biodiversity in Europe. EEA Technical Report n.5/2010. European Environment Agency, Copenhagen

Harris A, Timmins SM (2009) Estimating the benefit of early control of all newly naturalised plants. Science for Conservation N. 292. New Zealand Department of Conservation, Wellington

Heywood V (2012) European code of conduct for botanic gardens on invasive alien species. Council of Europe Document T-PVS/Inf (2012)1. Council of Europe, Strassbourg

Heywood V, Brunel S (2009) Code of conduct on horticulture and invasive alien plants. Nat Environ 155:1–35

Hulme PE, Bacher S, Kenis M et al (2008) Grasping at the routes of biological invasions: a framework for integrating pathways into policy. J Appl Ecol 45:403–414

Hulme PE, Burslem DFRP, Dawson W et al (2014) Chapter 8: Aliens in the arc: are invasive trees a threat to the montane forests of East Africa? In: Foxcroft LC, Richardson DM, Pyšek P et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Houston DB, Schreiner EG (1995) Alien species in National Parks - Drawing lines in space and time. Conservation Biology 9 (1):204-209

IUCN (2013) Guidelines for reintroductions and other conservation translocations. Adopted by SSC Steering Committee, 5th September 2012. IUCN SSC Reintroduction Specialist Group and Invasive Species Specialist Group

IUCN (2012) Biological invasions: a growing threat to biodiversity, human health and food security. Policy recommendations for the Rio+20 process. IUCN's Policy Brief 4 pp.

Kueffer C, Daehler CC, Torres-Santana CW et al (2010) A global comparison of plant invasions on oceanic islands. Persp Plant Ecol Evol Syst 12:145–161

Kueffer C, McDougall K, Alexander J et al (2014) Chapter 21: Plant invasions into mountain protected areas: assessment, prevention and control at multiple spatial scales. In: Foxcroft LC, Richardson DM, Pyšek P et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Jones-Walter L, Civic, C (2011) The future of ecological networks in Europe. A discussion paper. Council of Europe Document T-PVS/PA (2011) 9, Strassbourg

Laurance WF, Useche DC, Rendeiro J et al (2012) Averting biodiversity collapse in tropical forest protected areas. Nature 489:290–294

Loope L (2004) The challenge of effectively addressing the threat of invasive species to the National Park System. Park Science 22(2): 14-20

Macdonald IAW, Loope LL, Usher MB et al (1989) Wildlife conservation and the invasion of nature reserves by introduced species: a global perspective. In: Drake JA, Mooney HA, di Castri F et al (eds) Biological invasions: a global perspective. John Wiley, Chichester, p 215–255

MacDonald I AW, Graber DM, DeBenedetti S, Groves RH, Fuentes ER (1988) Introduced species in nature reserves in Mediterranean type climatic regions of the world. Biological Conservation 44: 37–66.

McCreedy C, Toline CA, McDonough V (2012) Lionfish response plan: a systematic approach to managing impacts from the lionfish, an invasive species, in units of the National Park System. Natural Resource Report NPS/NRSS/WRD/NRR—2012/497. National Park Service, Fort Collins, Colorado

McNeely J (2014) Chapter 6: Global efforts to address the wicked problem of invasive alien species. In: Foxcroft LC, Richardson DM, Pyšek P et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Meiners SJ, Pickett STA (2014) Chapter 3: Plant invasion in protected landscapes: exception or expectation? In: Foxcroft LC, Richardson DM, Pyšek P et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Meyerson LA, Pyšek P (2014) Chapter 21: Manipulating alien species propagule pressure as a prevention strategy in protected areas. In: Foxcroft LC, Richardson DM, Pyšek P et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Mora C, Sale P (2011) Ongoing global biodiversity loss and the need to move beyond protected areas: a review of the technical and practical shortcoming of protected areas on land and sea. Mar Ecol Progr Ser 434:251–266

Natura 2000 Networking Programme (2007) Natura 2000. http://www.natura.org.

OCEANA (2012) Guidance on Marine Biodiversity and Climate Change. Draft version. Council of Europe Document T-PVS/Inf (2012) 10, Strassbourg , 16 pp.

Pyšek P, Hulme PE, Nentwig W (2009) Glossary of the main technical terms used in the handbook. In: DAISIE (eds) Handbook of alien species in Europe. Springer, Berlin, p 375–379

Pyšek P, Genovesi P, Pergl J et al (2014) Chapter 11: Invasion of protected areas in Europe: an old continent facing new problems. In: Foxcroft LC, Richardson DM, Pyšek P et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Rahel FJ, Olden JD (2008) Assessing the effects of climate change on aquatic invasive species. Cons Biol 22:521–533

Randall J (2011) Protected areas. In: Simberloff D, Rejmánek M (eds) Encyclopedia of biological invasions. University of California Press, Berkeley and Los Angeles, p 563–567

Raudsepp-Hearne C, Peterson GD, Tengö M et al (2010) Untangling the environmentalist's paradox: why is human well-being increasing as ecosystem services degrade? BioScience 60:576–589

Ricciardi A, Simberloff D (2009) Assisted colonization is not a viable conservation strategy. Trends Ecol Evol 24:248–253

Rose M, Hermanutz L (2004) Are boreal ecosystems susceptible to alien plant invasion? Evidence from protected areas. Oecologia 139:467–477

Scalera R, Zaghi D (2004) LIFE Focus/Alien species and nature conservation in the EU: the role of the LIFE program. European Commission, Office for Official Publications of the European Communities, Luxembourg

Scalera R, Genovesi P, De Man D et al (2012) European code of conduct on zoological gardens and aquaria and invasive alien species. Council of Europe Document T-PVS/Inf (2011) 26 rev., Strassbourg

SCAR (2009) SCAR's environmental code of conduct for terrestrial scientific field research in Antarctica. In: Antarctic Treaty Consultative Meeting XXXII. Committee on Environmental Protection XII. Information Paper 004, 6–17 April 2009, Baltimore, US

Schoenig S (ed) (2005) California noxious and invasive weed action plan. California Department of Food and Agriculture (CDFA), California Invasive Weed Awareness Coalition (CALIWAC)

Seipel T, Kueffer C, Rew LJ et al (2012) Processes at multiple scales affect richness and similarity of non-native plant species in mountains around the world. Glob Ecol Biogeogr 21:236–246

Shaw J (2014) Chapter 19: Invasion of Southern Ocean Islands: implications for isolated protected areas. In: Foxcroft LC, Richardson DM, Pyšek P et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Shiu H, Stokes L (2008) Buddhist animal release practices: historic, environmental, public health and economic concerns. Contemporary Buddhism 9:181–196

Simberloff D (2014) Chapter 26: Eradication – pipe dream or real option? In: Foxcroft LC, Richardson DM, Pyšek P et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Simberloff D, Martin JL, Genovesi P et al (2013) Impacts of biological invasions: what's what and the way forward. Trends Ecol Evol 28:58–66

Spear D, Foxcroft LC, Bezuidenhout H et al (2013) Human population density explains alien species richness in protected areas. Biol Cons 159:137–147

Tu M (2009) Assessing and managing invasive species within protected areas. Protected Area Quick Guide Series. Editor, J. Ervin. Arlington, VA. The Nature Conservancy

Tu M, Robison MA (2014) Chapter 24: Overcoming barriers to the prevention and management of alien plant invasions in protected areas. In: Foxcroft LC, Richardson DM, Pyšek P et al (eds) Plant invasions in protected areas: patterns, problems and challenges. Springer, Dordrecht

Usher MB (1988) Invasions of nature reserves: a search for generalizations. Biol Cons 44:119–135

van Wilgen BW (2012) Evidence, perceptions, and trade-offs associated with invasive alien plant control in the Table Mountain National Park, South Africa. Ecol Soc 17:23

van Wilgen BW, Richardson DM (2012) Three centuries of managing introduced conifers in South Africa: benefits, impacts, changing perceptions and conflict resolution. J Environ Manage 106:56–68

Vardien W, Richardson DM, Foxcroft LC et al (2013) Management history determines gene flow in a prominent invader. Ecography 36:1–10

Whitfield PE, Gardner T, Vives SP et al (2002) Biological invasion of the Indo-Pacific lionfish *Pterois volitans* along the Atlantic Coast of North America. Mar Ecol Progr Ser 235:289–297

Willis CG, Ruhfel BR, Primack RB et al (2010) Favorable climate change response explains non-native species' success in Thoreau's Woods. PLoS One 5(1):e8878

Wittenberg R, Cock MJW (eds) (2001) Invasive alien species: a toolkit of best prevention and management practices. CAB International, Wallingford, Oxon, UK

ANNEXES

Annex 1: Selected LIFE projects aimed to control or eradicate IAS in protected areas

LIFE project no.	Name	Period	Country	Major target IAS	Habitat
LIFE94 NAT/P/1034	Conservation of the seabirds communities and habitats of Açores	1995–1997	Portugal	*Oyctolagus cuniculus, Rattus rattus*	Atlantic insular ecosystems
LIFE95 ENV/F/0782	Control of the *Caulerpa taxifolia* extention in the Mediterranean Sea	1996–1999	France	*Caulerpa taxifolia*	Posidonia beds
LIFE96 NAT/E/3180	Restoration and integrated management of the Island of Buda	1996–2000	Spain	*Phoenix* spp., *Washingtonia* spp.	Atlantic insular ecosystems
LIFE97 NAT/E/4147	Recovery Plan of *Puffinus p. mauretanicus* in SPA Balearic Islands	1997–2000	Spain	*Felis catus, Rattus sp.*	Atlantic insular ecosystems
LIFE97 NAT/UK/4244	Restoration of Atlantic Oakwoods	1997–2001	UK	*Rhododendron ponticum*, non-native conifers	Atlantic forest
LIFE97 NAT/UK/4242	Securing Natura 2000 objectives in the New Forest	1997–2001	UK	*Rhododendron ponticum*, non-native conifers	Heathland
LIFE97 NAT/P/4082	Management and conservation of the *Laurissilva* Forest of Madeira	1998–2000	Portugal	*Hedychium gardnerianum*	Laurel forest
LIFE97 NAT/IT/4134	Restoration of alluvial woods in the Ticino Park	1997–2000	Italy	*Prunus serotina, Robinia pseudacacia, Ailanthus altissima, Quercus rubra*	Wet woodlands
LIFE98 NAT/A/5418	Pannonian sand dunes	1998–2002	Austria	*Ailanthus altissima, Robinia pseudacacia*	Relict dunes
LIFE99 NAT/E/6392	Restoration of the islets and cliffs of Famara (Lanzarote Island)	1999–2002	Spain	*Nicotiana glauca, Oyctolagus cuniculus, Felis catus, Rattus sp.*	Atlantic insular ecosystems
LIFE00 NAT/UK/7073	Mink control to protect important birds in SPAs in the Western Isles	2001–2006	UK	*Mustela vison*	Atlantic insular ecosystems

LIFE project no.	Name	Period	Country	Major target IAS	Habitat
LIFE00 NAT/UK/7074	Woodland habitat restoration: Core sites for a forest habitat network	2001–2005	UK	*Rhododendron ponticum, Fallopia japonica, Synphoricarpus alba*	Atlantic forest
LIFE00 NAT/E/7339	Dunas Albufera: Model of restoration of dunes habitats in 'L'Albufera de Valencia'	2001–2004	Spain	*Carpobrotus edulis*	Coastal dunes
LIFE00 NAT/E/7355	Conservation of areas with threatened flora on the Island of Minorca	2001–2004	Spain	*Carpobrotus edulis*	Mediterranean insular ecosystems
LIFE00 NAT/D/7057	Restoration of clear water lakes, mires and swamp forests of the Lake Stechlin	2001–2005	Germany	*Hyphthalmichthys molitrix, Tenopharyngodon idella, Cyprinus carpio Picea sp.*	Wetland and Wet woodlands
LIFE00 NAT/IT/7159	Conservation of *Austropotamobius pallipes* in two pSCIs of Lombardy	2001–2004	Italy	Procambarus clarkii	Watercourses and riparian ecosystems
LIFE02 NAT/FIN/8468	Management of urban Natura 2000 areas in SW Finland	2002–2006	Finland	*Mustela vison, Nyctereutes procyonoides*	Deciduous broad-leaved forests and others
LIFE03 NAT/IT/000139	RETICNET 5 SCI for the conservation of wetlands and main habitats	2003–2006	Italy	Unspecified	Alpine wetland
LIFE03 NAT/FIN/000039	Lintulahdet: Management of wetlands along the gulf of Finland migratory flyway	2003–2007	Finland	*Phragmites australis*	Wetland
LIFE04 NAT/ES/000044	Recovery of the littoral sand dunes with *Juniper* spp. in Valencia	2004–2007	Spain	*Carpobrotus edulis , Agave americana*	Mediterranean dunes
LIFE04 NAT/CY/000013	Conservation management in Natura 2000 sites of Cyprus	2004–2008	Cyprus	*Robinia pseudacacia, Eucalyptus regnans*	Mattoral
LIFE05 NAT/D/000051	Large herbivores for maintenance and conservation of coastal heaths	2005–2009	Germany	*Prunus serotina*	Heathland
LIFE05 NAT/IT/000037	DUNETOSCA: Conservation of ecosystems in northern Tuscany	2005–2009	Italy	*Yucca gloriosa, Amorpha fruticosa*	Mediterranean coastal ecosystems

LIFE project no.	Name	Period	Country	Major target IAS	Habitat
LIFE05 NAT/IRL/000182	Restoring priority woodland habitats in Ireland	2006–2009	Ireland	*Picea abies, Picea sitchensis, Larix decidua, Pinus radiata, Fagus sylvatica, Acer pseudoplatanus, Aesculus hippocastanum, Laurus nobilis, Fallopia japonica, Rhododendron ponticum*	Woodland
LIFE05 TCY/CRO/000111	IBM, Central Posavina: Wading toward integrated basin management	2006–2008	Croatia	*Amorpha fruticosa, Xanthium* spp.	Floodplain ecosystem
LIFE06 NAT/MT/000097	GARNIJA-MALTIJA - SPA Site and Sea Actions Saving *Puffinus yelkouan* in Malta	2006–2010	Malta	*Rattus rattus*	Coastal habitats
LIFE08 NAT/IT/000353	Montecristo 2010: eradication of invasive plant and animal aliens and conservation of species/habitats in the Tuscan Archipelago,Italy.	2010–2014	Italy	*Ailanthus altissima, Carpobrotus spp., Pinus halepensis, Acacia pycnantha Rattus rattus, Capra egagrus*	Mediterranean insular ecosystems
LIFE09 NAT/ES/000529	LIFE TRACHEMYS - Demonstration strategy and techniques for the eradication of invasive freshwater turtles	2011–2013	Spain	*Trachemys scripta*	Wetlands
LIFE09 NAT/IT/000095	EC-SQUARE - Eradication and control of grey squirrel: actions for preservation of biodiversity in forest ecosystems	2010–2014	Italy	*Sciurus carolinensis*	Woodlands
LIFE/10/NAT/IT/000239	RARITY: Eradicate Invasive Louisiana Red Swamp and Preserve Native White Clawed Crayfish in Friuli Venezia Giulia	2011–2014	Italy	*Procambarus clarkii*	Watercourses and riparian ecosystems
LIFE11 NAT/UK/000387	Scilly rat removal - Maintaining and enhancing the Isles of Scilly SPA through the removal of rats from two key islands	2012–2017	UK	*Rattus norvegicus*	Atlantic insular ecosystems

Annex 2: Invasive alien species and protected areas in Europe: a global picture from a web survey

Monaco Andrea and Piero Genovesi

To collect relevant information and opinions for developing the "European Guidelines on Protected Areas and Invasive Alien Species", within a joint Bern Convention and IUCN SSC Invasive Species Specialist Group, we developed a web survey. The survey was also supported by Europarc, IUCN World Commission on Protected Areas and both the Bern Convention Group of Experts on IAS and on Protected Areas and Ecological Networks, who contributed to its dissemination.

The survey, aimed at biologists, park managers, park rangers or other experts and practitioners (hereafter all cited as "PAs managers") working with European protected areas, yielded 138 responses from 21 European countries (Fig. 1) ranging from alpine to marine protected areas; 25 surveys from 11 extra-European nations were excluded from the analysis.

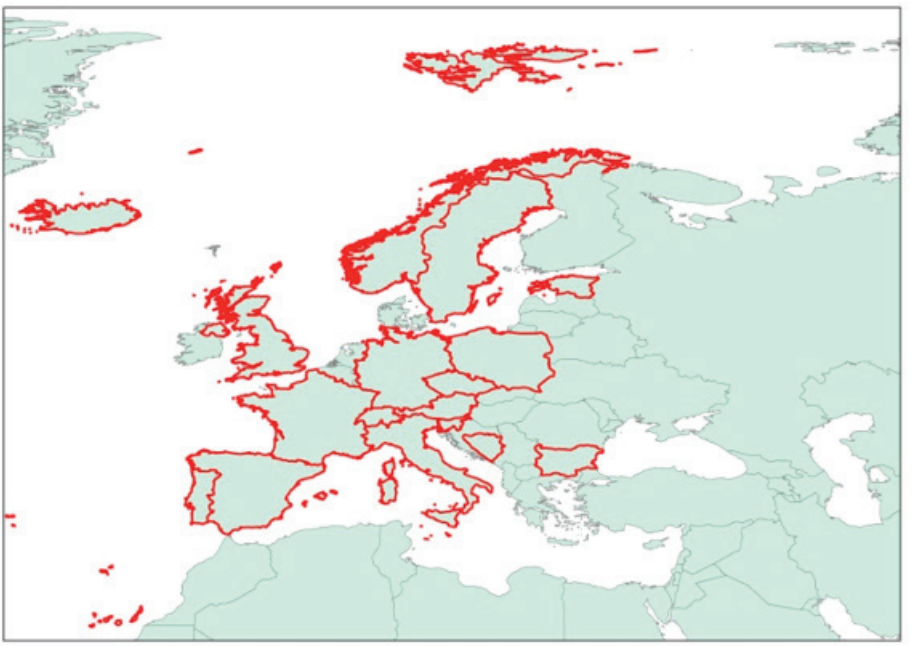

Figure 1. *European countries covered (in red) by the web survey on IAS and protected areas.*

It is important to note that the generally limited awareness of biological invasions by the general public does not extend to the managers of European PAs, who appear to have a generally high concern about the threats posed by IAS.

Responding to question "what in your opinion are the most important threats to your protected area?" PAs managers considered IAS as the second most serious threat, after habitat loss and fragmentation – and more important than tourism (Fig. 2). Recurrent examples of "other" threats are: human conflicts, climate change, lack of resources, ecological instability and lack of political support. This specific attention of European

PAs on biological invasions probably reflects the direct experience of managers with the impacts caused by IAS whose numbers are constantly and rapidly growing in all European environments and regions.

An insight into how impacts of invasive plant species are perceived by the PAs managers in Europe is provided by the answers to the question "what in your opinion are the worst impacts caused by invasive species in your protected area?", that highlighted a wide number of impacts. In general, if answers for both plants and animals are merged, the most serious impacts of invasive species in European PAs are considered to be: competition with native species and changes imposed to the habitats and ecosystem functioning (Fig. 3). Interestingly, the impacts that can be largely attributed to competition, i.e. those on richness, diversity and abundance of resident species, are most likely to be significant, and those affecting habitats, i.e. mainly on soil properties, come second.

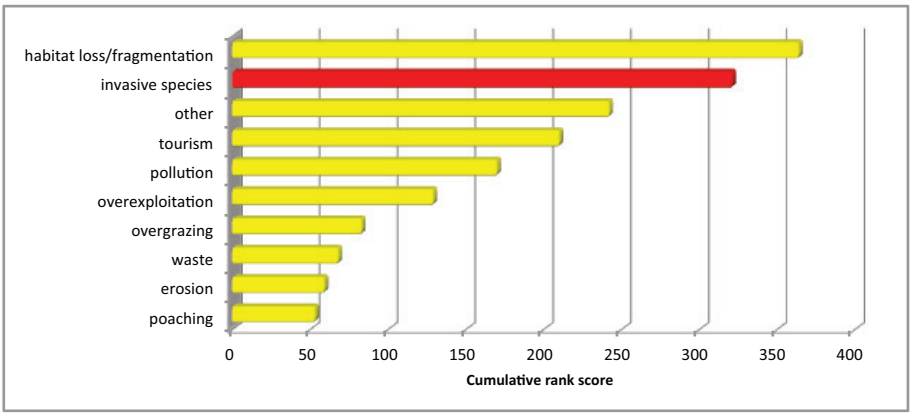

Figure 2. *Major threats to protected areas as perceived by European PAs managers.*

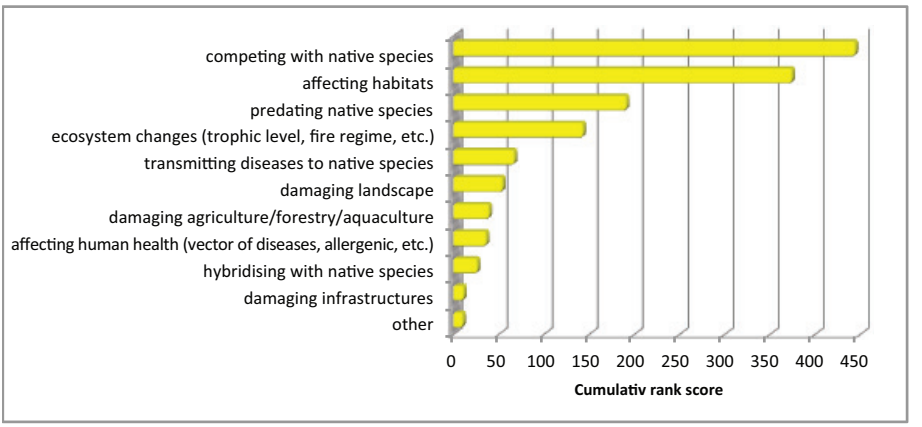

Figure 3. *Worst impacts caused by IAS to protected areas as perceived by European PAs managers.*

Management options that PAs managers in Europe consider to be most effective are closely linked with impacts (Fig. 4). The respondents to the survey perceive eradication and control to be the best approaches for dealing with invasive species. The fact that

European PAs managers consider these two measures more important than prevention, education or public involvement, probably reflects the approach often adopted in PAs that tend to focus more on responding to invasions than working on prevention, although prevention is increasingly viewed as the best management option.

When comparing the responses that are considered as the most effective, with the actions that are actually implemented, several interesting differences emerge. For example, the most frequently implemented action against alien species in PAs is monitoring, while active management options (eradication and control) are considered the best strategies to deal with this threat. The same applies to prevention, that is assumed to be the most effective and cost-effective measure, but scarcely applied in European PAs. Prevention is actually enforced in terms of education and public involvement, and in fact communication efforts towards the public is implemented by a large number of PAs. The more frequent implementation of control and eradication efforts for plants compared to animals, likely reflects the greater difficulty of undertaking active management actions for animals.

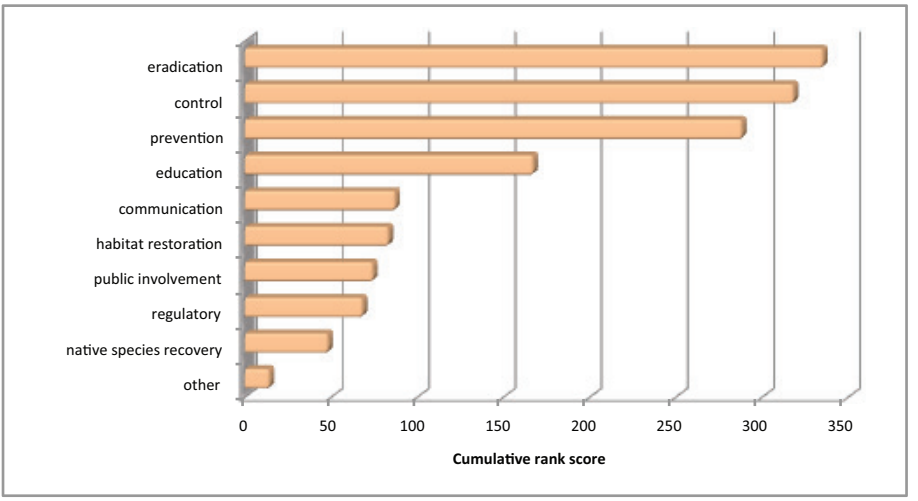

Figure 4. *Most effective management options to deal with IAS as indicated by European PAs managers.*

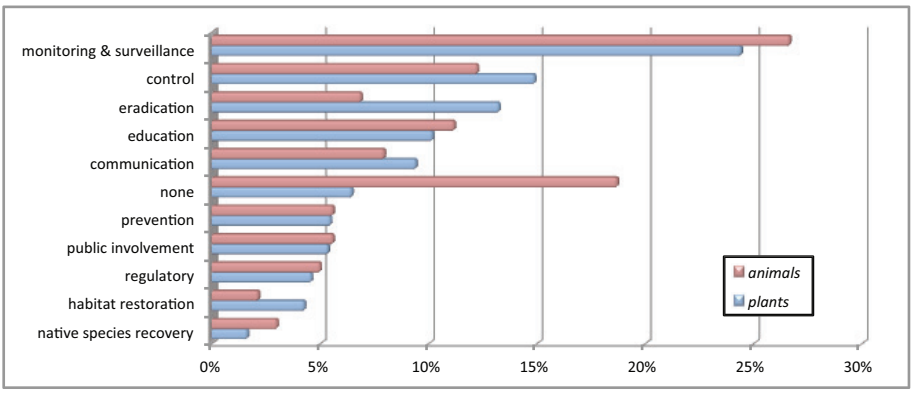

Figure 5. *Management activities implemented on IAS as indicated by European PAs managers.*

Responses to a general question on the key impediments to more effective IAS management in European PAs, highlight some key challenges (Fig. 6). The factors that constraint effective and science-based responses to this threat in European PAs include limited support from the rest of the society (including decision makers), the inadequate legal framework, the lack of early warning rapid response frameworks, the lack of specific financial mechanisms, including those for contingency actions, and – last but not least – the lack of data on invasive species in PAs. Recurrent examples of "other" key impediments are: lack of management tools, slow response after detection of a new IAS, impossibility to control natural processes, commodification (allowing a market to establish in the sale of an IAS as food).

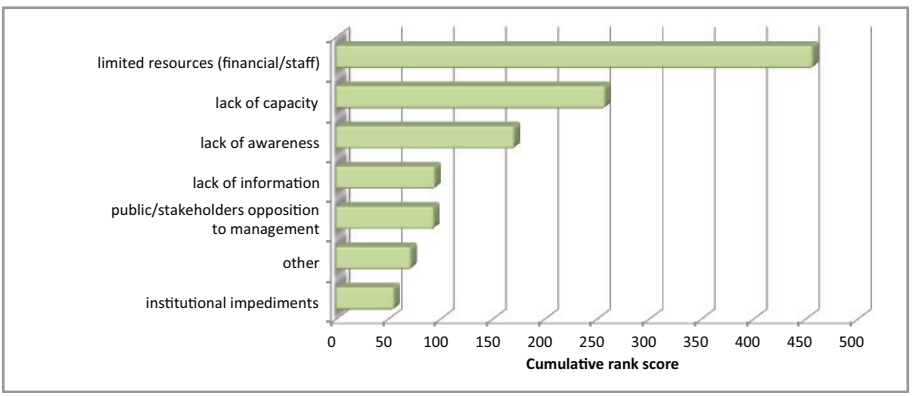

***Figure 6**. Key impediments to dealing with the spread of IAS as indicated by European PAs managers.*

Regarding the lack of data on IAS, the answers to the question "is there a check list of alien animals (or plants) in your protected area?" highlighted a general gap of information and stress the urgent need for inventories of invasive species in PAs, using standard scientific criteria, to support European PAs in their efforts to prevent and control invasions (Fig. 7). For what concerns plants, of the total received responses, 95 (79 %) indicated that some list of alien plant species is available, but the vast majority of lists include only a few invasive plant species of particular concern. The situation seems even worse for animals, where only 71 (58 %) protected areas have a complete or partial list of alien animal species available.

Information on invasions in European PAs resulted scarce (and mostly scattered in unpublished reports and grey literature), and invasions appear quite understudied; this is rather surprising considering the generally high level of science and monitoring in Europe.

A general picture of the major invasive species in European PAs can be inferred from the last section of the web survey, in which managers reported species ("top invasive" animals and plants) they consider most harmful in the PAs where they work (Table 1 and 2). Excluding species indicated as the top invaders only once, 36 taxa of animals and 52 of plants were recorded. While many invasive aliens occur only in a few responses, 15 animals and 16 plants were recorded in at least five PAs and the top three species were indicated by at least 12 % (animals) or 21% (plants) of the PAs.

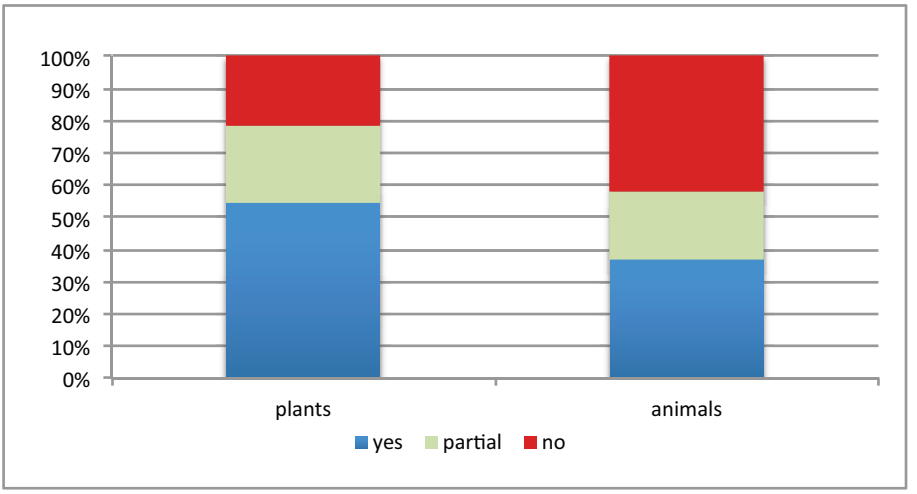

***Figure 7**. Availability of check-list of alien species as indicated by European PAs managers.*

Among the 215 taxa listed at least once (89 animals and 125 plants), the top invasive plants are *Fallopia japonica* (Japanese knotweed), which most likely includes other European taxa of this genus, *Impatiens glandulifera* (Himalayan balsam), *Robinia pseudoacacia* (black locust), *Ailanthus altissima* (tree of heaven), *Heracleum mantegazzianum* (giant hogweed) and *Ambrosia artemisiifolia* (common ragweed); the top invasive animals are *Neovison vison* (American mink), *Myocastor coypus* (coypu), *Procambarus clarkii* (louisiana crayfish), *Trachemys scripta* (red-eared slider), *Orconectes limosus* (spiny-cheek crayfish) and *Sciurus carolinsensis* (grey squirrel).

***Table 1**. Top invasive animals (most harmful) as indicated by European PAs managers. Only species present in at least 2 protected areas are reported. The "worst ten" are indicated in bold.*

Taxon	number of PAs
Neovison vison	**27**
Myocastor coypus	**18**
Procambarus clarkii	**15**
Trachemys scripta	**11**
Orconectes limosus	**10**
Sciurus carolinsensis	**10**
Nyctereutes procyonoides	**9**
Rattus norvegicus et sp.	**8**
Pacifastacus leniusculus	**9**
Ondatra zibethicus	**7**
Harmonia axyridis	**6**
Lepomis gibbosus	**6**
Arion lusitanicus	5

Taxon	number of PAs
Carassius gibelio	5
Oncorhynchus mykiss	5
Ameiurus melas	4
Branta canadensis	4
Felis catus	4
Sus scrofa	4
Crepidula fornicata	3
Dama dama	3
Micropterus salmoides	3
Muntiacus reevesi	3
Ovis aries	3
Procyon lotor	3
Carassius auratus	2
Centrachidae spp.	2
Crassostrea gigas	2
Cyprinus carpio	2
Ficopomatus enigmaticus	2
Leptoglossus occidentalis	2
Mus musculus	2
Oryctolagus cuniculus	2
Pseudorasbora parva	2
Salvelinus fontinalis	2
Sander lucioperca	2

Table 2. *Top invasive plants (most harmful) as indicated by European PAs manager. Only species present in at least 2 protected areas are reported. The "worst ten" are indicated in bold.*

Taxon	number of PAs
Fallopia japonica et sp.	**48**
Impatiens glandulifera	**29**
Robinia pseudoacacia	**26**
Ailanthus altissima	**16**
Heracleum mantegazzianum	**11**
Ambrosia artemisifolia	**10**
Solidago canadensis	**9**
Crassula helmsii	**8**
Solidago gigantea	**8**
Buddleja davidii	**7**
Acer negundo	6
Amorpha fruticosa	6

Taxon	number of PAs
Azolla filiculoides	6
Elodea canadensis	6
Impatiens parviflora	5
Prunus serotina	5
Baccharis halimifolia	4
Carpobrotus edulis	4
Echinocystis lobata	4
Ficus sycomorus	4
Heracleum sosnowskyi	4
Lupinus polyphyllus	4
Phytolacca americana	4
Rhododendron ponticum	4
Asclepias syriaca	3
Aster lanceolatus	3
Caulerpa racemosa	3
Datura stramonium	3
Opuntia ficus-indica	3
Rhododendron spp.	3
Senecio inaequidens	3
Xanthium italicum	3
Acacia spp.	2
Acer pseudoplatanus	2
Agave americana	2
Arundo donax	2
Aster spp.	2
Bidens frondosa	2
Campylopus introflexus	2
Cornus sericea	2
Cortaderia selloana	2
Crocosmia spp.	2
Erigeron annuus	2
Hedera spp.	2
Helianthus tuberosus	2
Ludwigia grandiflora	2
Ludwigia peploides	2
Opuntia maxima	2
Picea sitchensis	2
Pittosporum undulatum	2
Solidago serotina	2
Telekia speciosa	2

NOTES

[i] A given area can be designated under several designations, often with different boundaries. By 'site' we mean each individual record of a given area under a specific designation type.

[ii] The Natura 2000 network is formed by the Special Protected Areas (SPAs), classified under the Birds Directive, and the Special Areas of Conservation (SACs) designated under the Habitats Directive.

[iii] The Emerald Network, now under development as part of the Bern Convention, is conceptually similar to the Natura 2000 network, but it incorporates more countries. As the European Union is also a signatory to the Bern Convention, the Natura 2000 network can be considered as the contribution of the EU to the Emerald Network. The Emerald Network works as an extension to non-EU countries of Natura 2000. At present, non-EU countries engaged in the constitution of the Emerald Network are Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Croatia, Georgia, Iceland, Moldova, Montenegro, Norway, the Russian Federation, Serbia, Switzerland, Turkey, Ukraine, the former Yugoslav Republic of Macedonia (European Environment Agency 2012).

Invasive alien species (IAS) have been identified as one of the most important direct drivers of biodiversity loss and ecosystem service changes. Many international policy instruments, guidelines and technical tools have been developed to address this threat. However, European policies require supplementary regulatory and voluntary measures to address key pathways of IAS introduction into the region. For this reason, the Bern Convention, with the technical support of the IUCN SSC Invasive Species Specialist Group, is developing a series of voluntary instruments (codes of conduct and guidelines) covering a number of industries, activities or contexts potentially responsible for the introduction of alien species. The development of these instruments can play an important role in building awareness among key sectors of society.

Wild flora and fauna play an essential role in maintaining biological balance and providing ecosystem services which contribute to human welfare. However, loss of biodiversity is already undermining efforts to improve economic, social and environmental well-being in Europe and worldwide, with visible consequences on people's quality of life. The Bern Convention, Europe's treaty on nature conservation, works for the preservation of most of our natural heritage and promotes participation and representation in the environmental debate. More information is available at **www.coe.int/bernconvention**.

ISSG Invasive Species Specialist Group

Species Survival Commission

REGIONE LAZIO

PREMS 155114

ENG

www.coe.int

The Council of Europe is the continent's leading human rights organisation. It comprises 47 member states, 28 of which are members of the European Union. All Council of Europe member states have signed up to the European Convention on Human Rights, a treaty designed to protect human rights, democracy and the rule of law. The European Court of Human Rights oversees the implementation of the Convention in the member states.

COUNCIL OF EUROPE

CONSEIL DE L'EUROPE