Invasive Plant Management Strategy

For Terrestrial Protected Areas in:

- **Fogo**
- **Santo Antão**
- **São Vicente**

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Executive Summary

Invasive Plants (IPs) can out-compete and displace native species, changing the ecological balance with consequences such as species endangerment and extinction, increased susceptibility to wildfires and reduced water availability. IPs have been identified as a major threat to Cape Verde's native biodiversity.

Many plant invasions can be reversed, halted or slowed, and in certain situations, even badly infested areas can be restored to healthy systems dominated by native species. In most instances this requires taking action to control and manage IPs, which is the subject of this management plan.

This plan is divided into three major sections: an overview and introduction in which the principles behind the plan are outlined; individual sections for protected areas in three islands: Fogo (Parque Natural do Fogo - PNF), Santo Antão (Planalto Leste – which covers the Moroços and Cova, Paúl and Ribeira da Torre Natural Parks), and São Vicente (Monte Verde Natural Park) in which specific recommended actions are outlined; and a series of annexes which provide supporting information, for example on major species of concern, possible control methods and environmental impact assessment guidelines for the use of herbicides.

The "ecosystem approach" - "a resource planning and management approach that recognises the connections between land, air, water and all living things, including people, their activities and institutions" has been translated into the following IP management principles that are the foundation of this plan:

Do not lose sight of your ultimate goals

- IP management is a means and not an end
- Do not only focus on a single target species
- Manage for multiple objectives
- The system took a long time to degrade. It is also likely to take a long time to restore

Stakeholder involvement is critical

- Work in close consultation with all relevant stakeholders
- Reconcile conflicts of interest
- Look for win-wins
- Prioritise and look for quick wins

Recognise the IAS management hierarchy within an integrated approach to IP management

- Prevention is better than cure
- Some areas cannot be easily restored so may need to be deprioritised
- Species of little concern now may become problems in the future
- Manage adaptively
- Initiate research projects to ask ecosystem-level questions

Manage risk

- Manage risks to minimise any negative impacts of IP management
- Restore incrementally as necessary

These principles are translated into recommended management actions for the PAs in each of the three islands. The recommended management actions are broadly generic but also involve some actions that are specific to each island. Recommended actions include zonation to prioritise area-wide management (prevention, early detection and rapid response, eradication, control/containment and active restoration), classification of IP species to prioritise species management actions, capacity building, awareness and communication, and monitoring, evaluation and review.

Zonation of the PAs to prioritise management actions is based upon: a) the extent of forest degradation (lowest degradation levels being the highest priority); b) accessibility (easy, medium, difficult and inaccessible); and c) landuse type (forestry, farming, ecosystem conservation). Vegetation grades are listed below:

- Grade 1 – almost entirely intact native vegetation (0-10% IP cover)
- Grade 2 (10% to 50% IP cover)
- Grade 3 (50-90% IP cover)
- Grade 4 (<10 % IP cover).

It is important to note that these percentages refer to percent of vegetation not percent of total ground cover, i.e. areas with no vegetation are not included in the figures.

Other things being equal, the less degraded an area the higher the management priority (greatest conservation benefits for least cost). However, some areas are very difficult if not practically impossible to access so must be deprioritised at least in the short term. Landuse can influence the IP management approach developed. For example, a plan to restore to 100% native species cover is unlikely to be implemented in areas designated for forestry or agriculture. However, it may be possible to restore a portion of lands designated in this way as a way of managing for multiple objectives.

This classification system gives rise to a wide range of combinations in PNF and Planalto Leste but only three in the Monte Verde (R1: Substantial restoration possible – remnants of native plant communities, not used for agriculture and accessible; R2: Mixed use restoration possible - remnants of native plant communities, used for agriculture and accessible; and R3: inaccessible – restoration not possible at present). Monte Verde covers a much smaller area than PNF and Planalto Leste and is more homogeneous in terms of landuse, topography and degree of degradation.

This zonation will be based upon the pre-existing mapping work undertaken for priority IPs in the three PAs. The zonation, in conjunction with IP control trials, will provide information needed to improve estimates of the extent to which native vegetation can be maintained in different sites in PNF.

IP species have been prioritised for management using the following categorisation: "widespread high impact species" (*Lantana camara* and *Furcraea foetida* in all three PAs and *Leucaena leucocephala* in Monte Verde); "localised high impact species" - other IPs that are locally abundant and likely to constitute threats to biodiversity and other ecosystem objectives (*Acacia mearnsii* in PNF and Planalto Leste, *Jacaranda mimosifolia* and *Cuscuta* species or dodder in PNF, *Bryophyllum pinnatum* in Planalto Leste and *Desmanthus virgatus* in Monte Verde) and "species of possible concern" - species that are not yet considered to be problematic but may become so in the future

No systematic IP management has been operationalised in Cape Verde's PAs to date but the extent of some priority invasive plant species has been mapped . This constitutes the baseline situation with regard to IP management in Cape Verde's terrestrial PAs. In order to address this situation, initial experimental work will be embarked upon to assess the efficiency and effectiveness of different management methods and the feasibility of upscaling these methods to larger areas of the park. This work will also help to build management capacity for key stakeholders. IP control trials will be undertaken in two phases: field trials on individual species and area-wide control and restoration in small plots.

Different manual and chemical control techniques will be tested to assess their effectiveness on *Lantana camara* and *F. foetida* (in all three PAs), *Acacia mearnsii* (in PNF and Planalto Leste), *Cuscuta* species (dodder) and *Jacaranda mimosifolia* in PNF only, and *Leucaena leucocephala* and *Desmanthus virgatus* in São Vicente only.

The results of this work will be used to inform control and restoration trials in small plots in which the efficiency and effectiveness of different control and restoration methods will be assessed.

In the long term biological control offers the possibility of large-scale sustainable management of some IP species. Under this plan the potential of biological control for IP management in Cape Verde will be investigated.

In addition to area and species management of IPs, species recovery work for the endangered endemic sedges *Carex antoniensis* and *Carex paniculata* ssp. *Hanseni*, both of which are threatened by the encroachment of papyrus sedge (*Cyperus papyrus*), will be undertaken in Planalto Leste.

Stakeholder participation is critical for successful implementation of this plan so community awareness and communication go hand in hand with IP management. Good examples of community restoration projects exist in Fogo and this work will be built upon. Considerable potential exists for native species restoration through the creation of native hedges close to arable areas to serve as windbreaks, to stabilise soil and to conserve water. The potential of such a "set-aside" scheme will be investigated as part of this plan. Industry can also be an important stakeholder and In Monte Verde the possibility of initiating a collaborative restoration project with CV Telecom using the land in and around the telecommunications installation will be investigated.

A comprehensive monitoring system will be developed through this management plan. Baseline vegetation maps will build upon the existing maps of *Lantana camara* and *Furcraea foetida* distributions in PNF and Planalto Leste and of *Lantana camara, Furcraea foetida* and *Leucaena leucocephala* in Monte Verde in order to document changes to in the extent of native versus IP cover. Methods to be used will include permanent transects and fixed point photographs.

IP management operations will be monitored to evaluate the efficiency of the methods used and used as a basis for estimating the cost of operations – essential information for future planning.

Monitoring information will be used to modify and refine management priorities, methods and plans (management plans will be modified annually in the light of monitoring results) so it is essential that the information acquired is analysed early and often and reviewed at least annually as an integral part of an adaptive management approach.

The implementation of this management plan will contribute towards the realisation of the following project indicator - **Rate of native/endemic species vegetative growth versus IAS cover in specific areas of target terrestrial PA sites for the project.** Initial provisional target values can be assigned in some cases (see table below) but in most cases these values can only be assigned once the zonation is completed and data from IP management field trials are analysed. The community outreach work is also important in this regard is as it will help to establish the extent to which the community will work with the park authorities to undertake restoration work. It will then be possible to produce "restoration scenarios" under "low, medium and high community participation levels" using the data from the vegetation mapping and the field trials.

Provisional indicators for the **end of project target** are:

- Native/endemic species vegetative cover maintained in accessible "Grade 1" vegetation (sites in which IPs comprise of 0-10% of vegetation cover) in P Fogo NP; Morroços NP; and Cova/Paúl/R da Torre.
- Target for rate of change of native versus IP cover established for all vegetation grades (from 0 -100% ground cover with IPs) in Fogo NP; Monte Verde NP; Morroços NP; and Cova/Paúl/R da Torre based on the results of: vegetation grade mapping: IP control trials; and community outreach work.

Table ES.1. The development of restoration indicators through the implementation of the IP management plan

Area	Indicator
Fogo NP	
Unvegetated areas (young ash slopes)	• Current extent of newly created native plantings documented • Target for extent of community restoration planting established
Fogo NP; Morroços NP; and Cova/Paúl/R da Torre	
Grade 1 (easy and medium access)	• Rate of change in extent of native versus IP cover documented • Current extent of native vegetation maintained
Grade 1 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented
Grade 2 (easy and medium access)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
Grade 2 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented
Grade 3 (easy and medium access)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
Grade 3 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented
Grade 4 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
Grade 4 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented
Monte Verde NP	
R1 (substantial restoration possible)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work
R2 (mixed use restoration possible)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
R3 (inaccessible – restoration not possible at present)	• Rate of change in extent of native versus IP cover documented

The management plan contains 11 annexes containing supportive information, in addition to references and sources of further information, terms of reference of the consultancy under which this management plan was produced and acronyms and abbreviations.

Annex 1 provides detail on the biology, distribution, economic uses, impacts and management of major plant invaders in protected areas in Fogo, Santo Antão and São Vicente.

Annex 2 gives an outline of the main approaches to invasive plant management (prevention, early detection and rapid response, eradication, control and impact mitigation). This is essential information for those needing a general overview of invasive species management.

Annex 3 provides environmental impact assessment guidelines for the use of herbicides as part of an integrated approach to the management of major invasive plants in Cape Verde's PAs. Agrochemicals have not been used in PAs in Cape Verde to date. These guidelines provide those managing and coordinating the use of agrochemicals with a framework to assist the planning of all pesticide use, management and coordination activities in Cape Verde's PAs.

Annex 4 outlines the properties of glyphosate and triclopyr, two of the most commonly used herbicides in protected areas and those recommended for use on a trial basis in PAs in Cape Verde.

Annex 5 builds upon Annex 3 by providing detailed information on the steps to be undertaken to ensure that herbicide choice is based on a thorough consideration of the overall impacts of herbicide use on conservation targets, native species, and the ecosystem.

Annex 6 provides a brief summary of information available on the cost of invasive plant management. It emphasises the fact that initial weeding of large IP infestations is very labour-intensive and expensive. Management efforts should focus on less degraded areas unless there are overwhelming reasons for working in heavily invaded areas.

Annex 7 provides example monitoring data sheets and templates that can be adapted for use by those implementing this management plan.

Annex 8 provides the International Guidelines for the Export, Shipment, Import, and Release of Biological Control Agents and Other Beneficial Organisms (International Standard for Phytosanitary Measures No. 3). The process outlined in this document must be followed to ensure that any risks associated with the importation and release biological control are minimised.

Annex 9 outlines a possible structure for a national invasive species strategy for Cape Verde. Ideally this strategy will be formulated to ensure that the PA management plan outlined here is complemented by a wider effort that moves the country towards a comprehensive and cooperative approach to the management the invasive species that threaten the nation as a whole.

Annex 10 provides an outline of an invasive species database for Cape Verde which, if adopted, will facilitate rapid access to information on the presence, impact and management undertaken for particular species based on information that is available globally.

Annex 11 is the outline of a proposed course for the national project team that would improve their theoretical and practical knowledge of invasive plant management. It would also help to build their capacity to strengthen links with research and development institutions in the country. Together with practical sessions on the implementation of this plan, and post-course mentoring, this course represents the next essential step to ensure that the recommendations provided in this plan are translated into action on the ground.

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OVERVIEW AND INTRODUCTION

You do not need to read this document from cover to cover but we do recommend that you read this introduction in order to understand the plan's overall logic, structure and the principles that underpin it.

BACKGROUND

Invasive plants (IP) Impacts

Invasive alien species (IAS), defined as those non-native species that threaten ecosystems, habitats or species (CBD 2008), are widely considered to be the second greatest agent of species extinction after habitat destruction (Wilcove et al. 1998). IAS are also causing serious impacts on goods (e.g. fisheries, agricultural and forest products) and services (e.g. clean and plentiful drinking water, pollination, culture and recreation) that are fundamental to human well-being (Daily et al. 1997). Islands are especially vulnerable to IAS (Heywood 1995), with potentially severe consequences for the more than 50 million people living in small island developing states (SIDS; UN [United Nations] 2003).

Invasive Plants (IPs), probably the most prominent group of IAS, can out-compete and displace native species, changing the ecological balance with consequences such as species endangerment and extinction, increased susceptibility to wildfires and reduced water availability. IPs have been identified as a major threat to Cape Verde's native biodiversity (SEPA 1999).

Many plant invasions can be reversed, halted or slowed, and in certain situations, even badly infested areas can be restored to healthy systems dominated by native species. In most instances this requires taking action to control and manage those IPs, which is the subject of this management plan.

Invasive plants and protected areas in Cape Verde

Cape Verde is in the process of establishing a national system of Protected Areas (PAs) for both marine and terrestrial and ecosystems. A sustainably managed PA system is a vital instrument: (1) to safeguard Cape Verde's unique biodiversity; and (2) to engage communities surrounding PAs in a sustainable use of natural resources supported by environmental conservation.

The project "Consolidation of Cape Verde's Protected Areas System", funded through UNDP-GEF and executed by the General Directorate for the Environment, Ministry of Environment, Rural Development and Marine Resources (MADRRM), seeks to support the establishment and strengthening of PA management, and strengthen both community mobilisation and local capacity building for sustainable resource management within and surrounding PAs. This management plan is an output from the "PA Project".

The scope of this management plan

The overall objective of the PA Project is "to consolidate and strengthen Cape Verde's protected areas (PA) System through the establishment of new terrestrial and marine PA units and the promotion of participatory approaches to conservation". It seeks to achieve this objective by executing three project components that correspond to the following outcomes:

- Outcome 1: The governance framework for the expansion, consolidation and sustainability of the National PA system is strengthened;
- Outcome 2: Management effectiveness at selected terrestrial and coastal/marine PAs is enhanced;
- Outcome 3: The sustainability of PAs is strengthened through community mobilization, sectoral engagement and local capacity building for sustainable resource management within PAs/MPAs and adjacent areas.

This management plan will contribute to Outcomes 2 and 3 by elaborating a strategy for the management of IPs in the terrestrial PAs in Fogo (Parque Natural do Fogo), Santo Antão (Planalto Leste: Parque Natural de Cova/Paúl/Ribeira da Torre and Parque Natural de Moroços) and Sao Vicente (Monte Verde). This corresponds to Project Output 2.4 - *Exotic species are under management and IAS are under sustained control in target terrestrial PAs*. "While the Phase I Project had positive experiences with the fight against IAS in terrestrial PAs, this experience needs to be brought to another level (wider coverage) and a more varied set of methods needs to be tested, costed and evaluated. Also, collaboration with other government bodies, in particular the DGASP, as well as the pursuit for sustained funding for fighting IAS, will be necessary to achieve progress in this area." The implementation of this management plan will contribute towards the realisation of the following project indicator - **Rate of native/endemic species vegetative growth versus IAS cover in specific areas of target terrestrial PA sites for the project.** Initial target values can be assigned in some cases but in most cases these values can only be assigned once the plan is implemented and relevant information is analysed as part of the plan's adaptive management approach.

Specifically this work will involve mapping of the extent of IP cover versus native vegetation cover and field trials to establish the efficiency and effectiveness of different invasive plant management methods. Also important in this regard is community outreach work as it will help to establish the extent to which the community will work with the park authorities to undertake restoration work. It will then be possible to produce "restoration scenarios" under "low, medium and high community participation levels" using the data from the vegetation mapping, and the field trials.

Provisional indicators for the **end of project target** are:

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STRUCTURE OF THE PLAN - "DON'T READ IT ALL AT ONCE"

The plan is modular and divided into the following sections:

1. Overview and Introduction - an overview of the plan and the principles that are the foundation of this plan. We urge you to read this section at some point to familiarise yourself with some fundamental principles of the ecosystem approach as it applies to integrated IP management.
2. IP management plans for: a) Fogo; b) Santo Antão; c) São Vicente with details of area and species management options, monitoring recommendations and options for implementation of the plan and regular review as part of an adaptive management approach. The island plans are deliberately kept brief for ease of reading. Detailed supporting information can be found in the introduction and annexes.
3. Annexes with further relevant information, e.g. on the biology and management options for high priority species, the main IP management options, costs for IP management, the safe use of herbicides, etc. The annexes provide detailed information which will be helpful to those implementing the island management plans. Read these as necessary.

FUNDAMENTAL PRINCIPLES OF IP MANAGEMENT WITHIN THE ECOSYSTEM APPROACH

IP management must be compatible with an "ecosystem approach" - "A resource planning and management approach that recognizes the connections between land, air, water and all living things, including people, their activities and institutions"[1] seeks to balance the conservation of biodiversity, the sustainable use of its components, and equitable sharing of benefits derived from genetic resources. The ecosystem approach provides a conceptual framework that encompasses the fundamental principles behind this plan:

- IP management is only a means towards achieving our overall objectives and must be seen as part of a larger process.
- Ecosystem objectives are a matter of societal choice so it is essential that we work in close consultation with all relevant stakeholders. As people are the cause and solution to IAS problems, effective communication with all stakeholders is essential.
- Resources are always limited so a framework for prioritising actions is needed. Stakeholder involvement is essential in such a prioritisation process. This process is informed by the "IAS management hierarchy" that operationalises the familiar saying "prevention is better than cure".
- A plan needs to be a "living document" - part of the dynamic process of "adaptive management" through which we can improve practice by learning from our actions and the changing external environment.

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[1] www.mnr.gov.on.ca/en/Business/FW/2ColumnSubPage/STEL02_168425.html

[2] Adapted from the Objectives stated in the 2007 Management Plan for the Parque Natural do Fogo

- We never start with perfect knowledge, sufficient funding or unanimous support for our actions but “we have to start somewhere”. All actions, including doing nothing carry an element of risk. It is essential that we understand the risks involve and strive to manage to achieve our overall objectives while minimising the total negative impact over the short, medium and long term and at a variety of spatial scales.

The ecosystem approach can be translated into the complementary and interlinked principles to IP management as outlined below:

Do not lose sight of your ultimate goals

IP management is a means and not an end

IP management is a tool and must be considered as a part of the overall conservation programme for the respective islands. It is therefore essential to focus on the ecosystem we want (what do we want to replace the IP in question). Never lose site of the overall ecosystem goal – the reason why you are undertaking IP management in the first place.

The objectives of the terrestrial PAs in Fogo, Santo Antão and Sao Vicente are (broadly speaking) to conserve and enhance natural, architectural, human and landscape heritage values, with a view to preserving biodiversity, geodiversity and sustainable use of resources; controlling soil erosion to protect resources and geological landscape; supporting traditional human activities, boosting the economic development and welfare of populations living in harmony with nature conservation[2].

[2] Adapted from the Objectives stated in the 2007 Management Plan for the Parque Natural do Fogo “To conserve and enhance natural, architectural, ethnographic and landscape values, through sound planning, according to the potential of each area, with a view to preserving biodiversity, geodiversity and sustainable use of resources; control soil erosion to protect resources and the geological landscape of the Pico de Fogo and its adventitious cones; supporting traditional human activities, boosting its economic development and the welfare of populations living in harmony with nature conservation.”

Figure 1. Conservation of native biodiversity – one of the ultimate objectives for undertaking invasive plant management control function must be replaced by an alternative means.

Controlling IPs ought to have a positive effect on native biodiversity and other desired ecosystem qualities in Cape Verde. However, this may not always the case. In some instances efforts to control one IP species results in another IP species taking over: net effect on biodiversity = 0. This can happen when intensive weeding is carried out in a highly degraded site in the absence of a subsequent programme of native species replanting. In other instances IPs may be removed from the edge of a steep slope resulting in an increase in soil erosion: a case of IP management inadvertently impoverishing an ecosystem.

It is, therefore, essential that we take action only when careful consideration indicates that leaving the IP unchecked will result in more long term damage than controlling it with available methods.

Figure 2. *Furcraea foetida* shown in this picture has been planted to combat soil erosion. If it is to be controlled this erosion control function must be replaced by an alternative means.

Do not only focus on a single target species

It is tempting to focus on what appear to be the priority IPs but single species approaches can often backfire. As outlined above the suppression of one IP might result in its replacement with another and not the desired ecosystem structure and function. In many cases a plant invasion is a symptom of an ecosystem level imbalance. For instance some potentially invasive plant species might be suppressed by a certain level of grazing. Removal of goats therefore might end up having unintended undesirable consequences. It is essential to monitor ecosystem level changes that result from management action so that we can modify management as needed (see section on adaptive management).

Figure 3. This ecosystem is invaded by *Lantana camara* and *Furcraea foetida* among other species so any invasive plant management undertaken must focus on multiple species

Manage for multiple objectives

PAs in Cape Verde are managed for multiple objectives. These include settlement, agricultural production, forest product production and watershed management. Not all objectives are necessarily compatible with restoration. For example, systems managed for forestry in Cape Verde are highly altered habitats that are in many cases very invaded and contain only small populations of native species. In such cases, restoration to native-dominated habitats is likely to be expensive, and may not be acceptable to local communities and other stakeholders. However, there are other areas which should be considered as priority for restoration as they contain threatened species or sizable populations of native species.

The system took a long time to degrade. It is also likely to take a long time to restore

Ecosystems typically become invaded over periods ranging from tens to hundreds of years and restoration ("invasion in reverse") is usually (though not always) a similarly slow process. However, projects typically work in timescales of 2-5 years. But managers need not despair as actions taken in the short term can be very significant e.g. containing the spread of an IP, an action which can safeguard relatively uninvaded landscapes, localised management of an invasion that threatens rare species, and development of techniques to optimise IP management. The fact that restoration is usually slow, funds are usually (always?) limited and incremental restoration is often ecologically optimal (as outlined below) can be a fortuitous coincidence.

Stakeholder involvement is critical

Work in close consultation with all relevant stakeholders

PAs in Cape Verde are a mosaic of landuse types that include settlement, agriculture and forestry. Community involvement, therefore, is essential if the PA's ultimate goals are to be achieved. The Cape Verdean PA system is in its early days so in most cases community involvement is at the buy-in stage. At the very minimum it is essential that any management undertaken is ethically acceptable to stakeholders in the area. In the medium to long term IP management within a restoration programme must move beyond community buy-in to community ownership and active involvement if it is to be sustainable. In addition, stakeholders may be able to teach us about invasions in their areas, and may already have species they think are a problem. Managing these species may open doors to acceptance of other actions

Reconcile conflicts of interest

Some local stakeholders are concerned about proposed IP management in cases where the IP species is perceived to serve a valuable function e.g. *Furcraea foetida* to combat erosion and *Acacia mearnsii* (molísima) as a source of fodder. Such conflicts of interest need to be managed to ensure that a balance is struck between multiple objectives e.g. *F. foetida* removed from the edges of roads and paths can be replaced with a less invasive species that can combat erosion and designated zones for *A. mearnsii* control (e.g. along the edge of infestations) and sustainable use (e.g. in heavily infested areas with few or any native plants) can be delimited. It is important to communicate that control of an IP does not have to mean elimination of the resource.

Look for win-wins

IP management can be very costly (Annex 6) so it is valuable to seek situations in which control costs can be recuperated to some extent ("win-wins"). For example harvesting the flowering stems of *Furcraea foetida* before it produces bulblets ensures that it will not reproduce (Annex 1). These stems are valued as poles so it ought to be possible for local people to cut the stems at no cost. Planting native species as hedges can help control erosion and serve as a wind break. Native hedge planting as part of a set-aside campaign might be a cost-effective method of native species conservation which is of direct economic benefit to farmers.

Prioritise

There are never enough resources for you to do everything you would like. Clearly then, is vital that you prioritise your action so that any actions undertaken are going to yield clear benefits.

Criteria to consider when prioritising your management options include the following:

- Technical feasibility
    - Can it be done and if so how?
    - What skills are available?
- Information
    - What information exists globally or locally & how accessible is this information?
- Support
    - What levels of agreement exist to support for the proposed work?
    - What degree of participation has there been – from communities, from government, from other stakeholders?
    - Is there a benefit to the community?
- Resources
    - What is the cost?
    - How long will the work take?
    - What is the cost-benefit?
- Net environmental impact
    - What are the potential environmental impacts of the proposed action?
    - How can these be mitigated?
- Implementation
    - Who does what?
        - At the strategic level
        - At the operational level
    - Where is the best place to start?
    - How often is management necessary?
- Timeliness: Can actions be undertaken as soon as possible using existing resources or are additional actions and resources required?

Look for quick wins

Quick wins or "low hanging fruits" refer to actions that can yield considerable benefit for relatively little effort. For example isolated very humid locations in Ribeira de Paul in Santo Antão are the only known locations for the Critically Endangered (sensu IUCN) endemic sedge *Carex antoniensis* (Leyens & Lobin, 1996). In some of these locations this unique species is threatened by the encroachment of *Cyperus papyrus* (papyrus sedge or paper reed). Regular careful hand weeding of papyrus for would be a very cost-effective contribution to saving *C. antoniensis* as part of a species recovery programme. IP management could be accompanied by awareness raising activities that would publicise the unique biodiversity of Ribeira de Paúl and the practical action being undertaken to conserve it.

Similar actions could be taken for another Critically Endangered endemic sedge *Carex paniculata* ssp. *Hanseni*, known only from the valleys of Cova/Paúl/Ribeira da Torre where it is also threatened by papyrus sedge. This species should also be considered for special attention like *C. antoniensis*.

Be realistic about what you can achieve

IP management is hard work and invariably takes time (The system took a long time to degrade. It is also likely to take a long time to restore). The temptation is to rush in and try to manage large areas but the long term gain in doing this might be minimal. A thorough planning process that involves stakeholders is likely to give rise to a system that can realistically manage IPs for ecosystem level benefits in a way that reconciles possible conflicts of interest while maximising the contribution from diverse sectors of society.

Recognise the IAS management hierarchy within an integrated approach to IP management

Prevention is better than cure

Management measures may be applied at various points in the process of invasion, starting from prevention, to early detection and rapid response, to eradication, containment and long-term control (see Annex 2 for details of the main approaches to invasive plant management). The further along in the process of invasion that the measure is applied, the more costly and less effective it is likely to be. In other words, although prevention measures may be costly, an analysis of the long-term costs and benefits (environmental, economic and social) will invariably show that they are less than the losses and costs which are incurred if the alien species are allowed to establish, and then require ongoing control. Any examination of benefits and costs should be done on a short, medium and long-term basis.

This is commonly known as the hierarchical approach to management as summarised below:

Prevention is better than
- Early detection & rapid response which is better than
  - Eradication which is better than
    - Long-term control and containment which is better than
      - Impact mitigation

Prevention is therefore the most cost-effective and environmentally desirable option, and should be given priority in any IAS management strategy. This does not, however, mean that an IP strategy should focus solely on prevention. Even for a single species, these management approaches are not mutually exclusive and it is likely that any integrated management approach chosen for an established biological invasion will involve some if not all of those measures listed above in different areas (see Figure 4 for an illustration of a hypothetical situation in which this is the case).

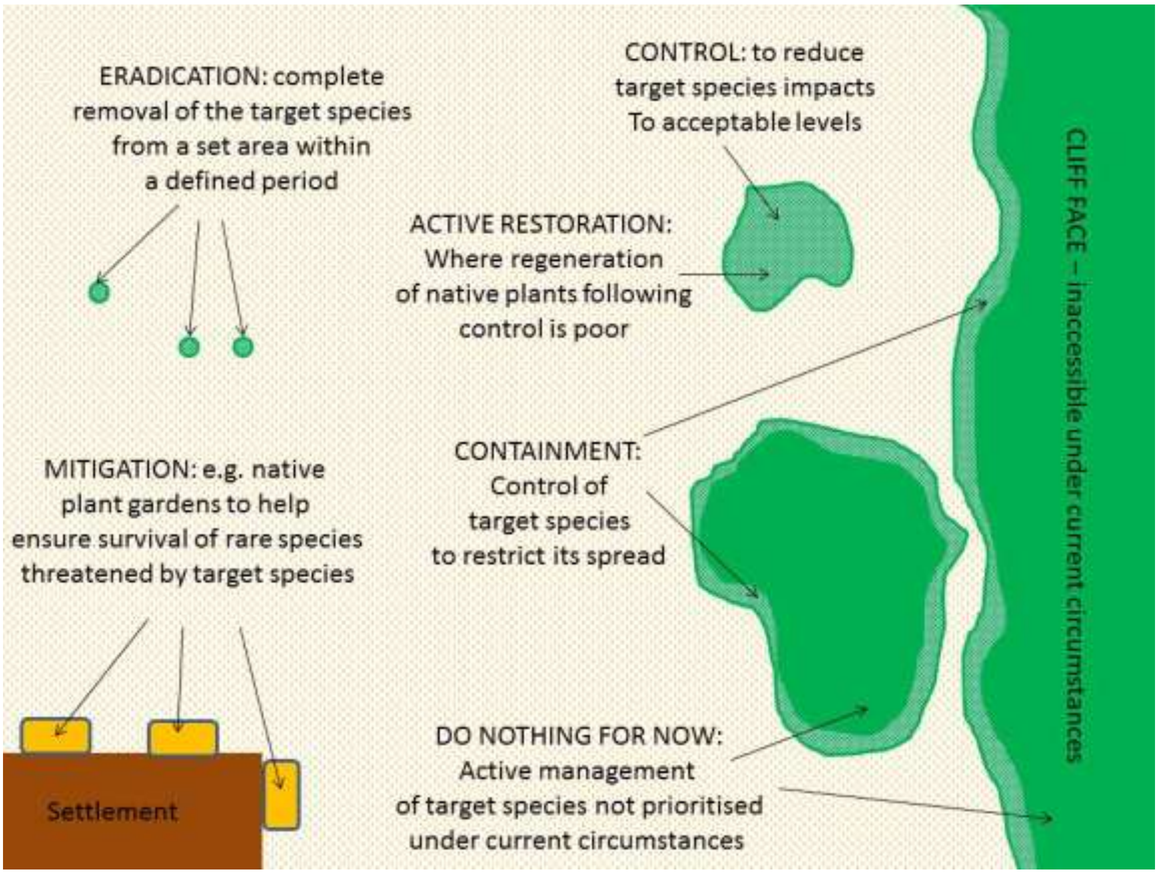

Figure 4. Schematic representation of management responses to a plant species invasion.

In the scenario depicted above a site has become invaded by a plant species (target species) that threatens rare native plants. The distribution of the target species has been mapped out with areas in which it is present shown in green. A management plan has been produced which recommends the following: Prevention in areas that the target species has not yet colonised, e.g. by restricting the movement of plant material and limiting the movement of livestock that could spread seeds of the target species; Early detection and rapid response through a system of surveillance and the implementation of Eradication or control measures for any new relatively small infestations; Control applied to larger infestations where eradication is currently not feasible but significant numbers of native plants remain; Active restoration, involving planting of native species among other measures in cases where the invasion is very dense and populations of native species are low (in such cases the regeneration of native plants following removal of the target species is likely to be poor); Containment, control at the edges of a larger infestation to restrict the spread of the target species, or control of flower and fruit production to limit spreading ; Impact mitigation (reducing the impacts of an IP on species or places that have high biodiversity, cultural or economic value), in this case by planting refuges or “safe havens” for the native species that are threatened by the target species; and No active management (“doing nothing for now”) is being applied – a) beyond the edges of a large infestation (in which control is not cost-effective under current circumstances) and b) on the infestation on the cliff face (which inaccessible under current circumstances) .

As noted below (manage adaptively) circumstances change and the plan must be regularly re-evaluated in the light of experience (e.g. planned eradication efforts were unsuccessful) and external circumstances (e.g. a new biological control agent has been successfully developed elsewhere which could make the management of the entire target population feasible once the necessary approval process has been undertaken).

Some areas cannot be easily restored so may need to be deprioritised

It is likely that it will be very difficult to restore some highly transformed landscapes in Cape Verde, at least in the immediate term. Planted forests are likely to come into this category so it would appear to be a better use of limited resources to focus on more “restorable (less transformed) communities” in the short term while developing management techniques that can work in more transformed areas.

Species of little concern now may become problems in the future

Invasive species are sometimes termed biological pollutants. In contrast to pollution incidences such as oil spills, which began dramatically and diminish with time (start with a bang and end in a whimper), biological invasions start small and expand over time (start with a whimper and end in a bang). A commonly observed phenomenon in biological invasions is the “lag-effect” - when a species begins to invade (cause problems) many years after being introduced during which time it has naturalised (reproduces in the wild but spreads only slowly and has little obvious impact).

Awareness of varying temporal scales and lag-effects alerts us to the fact that some species that are not causing significant problems now may become problems in the future. In this plan such species are referred to as “species of possible concern” – these are species that are known to be invasive elsewhere but are currently not considered to be problematic in Cape Verde. Examples include *Parkinsonia aculeata* in Fogo (appears to be spreading on the edge of the park, *Grevillea robusta* in Fogo and Santo Antão, known to be invasive elsewhere and commonly planted as an agroforestry tree – naturalised but not yet invasive in the three islands) and *Arundo donax* (invasive elsewhere and widely planted and regenerates naturally in the Cova/Ribeira de Paúl/Ribeira da Torre National Park - Santo Antão).

It has also been found many times in other islands that a large number of ornamental plants are species of possible concern.

It is important to monitor changes in the distribution of such species and take management action if it is deemed to be necessary. On a national scale it is likely that species that are not yet present in Cape Verde will become a problem in future if there is not a national level effort to minimise the negative impacts of IAS. This requires country level action in the shape of a national invasive species strategy and action plan (CBD Decision VI/23, 1999[3]). An outline for the structure of such a strategy is presented in Annex 9.

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[3] Decision VI/23. The decision on **Alien Species that Threaten Ecosystems, Habitats or Species** calls for the involvement of Indigenous Peoples and local communities in national invasive alien strategies and actions plans. Also a call was made for research and assessments on the socio-economic implications for Indigenous Peoples and local communities of invasive alien species, as well, on the use of traditional knowledge in the development and implementation of measures to deal with invasive alien species. When governments make a risk analysis of the impacts of invasive species and measures to control them, it is part of the definition that such risk analysis shall include socio-economic and cultural considerations.

Manage adaptively

This plan is part of an adaptive management strategy (Tu and Meyers-Rice 2001). Adaptive management is a form of "learning by doing" through which we can improve practice by learning from our actions and the changing external environment.

Adopt and adaptive management approach

Adaptive management in the context of IP management involves an iterative cycle of:

- Planning – Gauging the extent to which particular species are jeopardising our overall ecosystem management objectives and identifying and prioritising approaches to controlling these species or otherwise diminishing their impacts.
- Action – Implementing the plan and monitoring regularly to assess the efficiency our interventions (how well they control the target species, any unintended negative side-effects of the intervention, the cost and other resources used, etc.) and the effectiveness of our interventions (the contribution of our interventions to the overall management objectives).
- Reflection (or reviewing) and learning - Evaluate the effectiveness of our methods in the light of our objectives and the external environment (new techniques, funding support, stakeholder support, etc.).

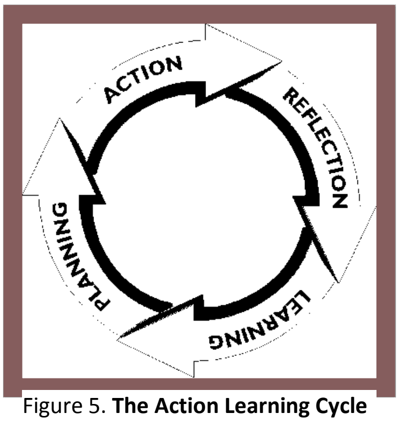

Figure 5. **The Action Learning Cycle**

This learning is fed into another iterative adaptive management cycle - re-planning to adapt and improve our control approaches priorities and plans, action, reflection and learning, as well as to incorporate emerging priorities.

This form of continuous learning by doing is known as the Action Learning Cycle.

It is important that adaptive management / action learning is adopted flexibly and not as a rigid sequence. For example, if you find a new location of a Critically Endangered endemic plant that is threatened by an IP you may decide to prioritise this area for management even if you are in not in the formal "reflection, learning and planning" phases. i.e. the implementation team must be receptive to "mini action learning cycles" within the larger formalised cycle.

The adaptive management approach relates to the formulation of **restoration indicators**. As outlined in the Project Documents logframe (strategic results framework), an indicator for the rate of native/endemic species vegetative cover versus IAS cover in specific areas of target terrestrial PA sites for the project will be determined through field studies carried out in connection with the project's ecological monitoring system. Some initial values are given in this document.

These provisional indicators for the end of project target (pp14-15) will be regularly revised and refined in the light of action and reflection as part of the action learning cycle.

The actions proposed in this plan will provide the information necessary to formulate more precise restoration indicators than is possible with the information as it currently stands.

The available information on percentage of park area covered by key IP species provides us with a basis for the zonation of the PAs to prioritise management actions based upon: a) the extent of forest degradation (lowest degradation levels being the highest priority); b) accessibility (easy, medium, difficult and inaccessible); and c) landuse type (forestry, farming, ecosystem conservation). Vegetation grades are listed below:

- Grade 1 – almost entirely intact native vegetation (0-10% IP cover)
- Grade 2 (10% to 50% IP cover)
- Grade 3 (50-90% IP cover)
- Grade 4 (<10 % IP cover).

A schematic version of such a zonation map is illustrated in the figure below.

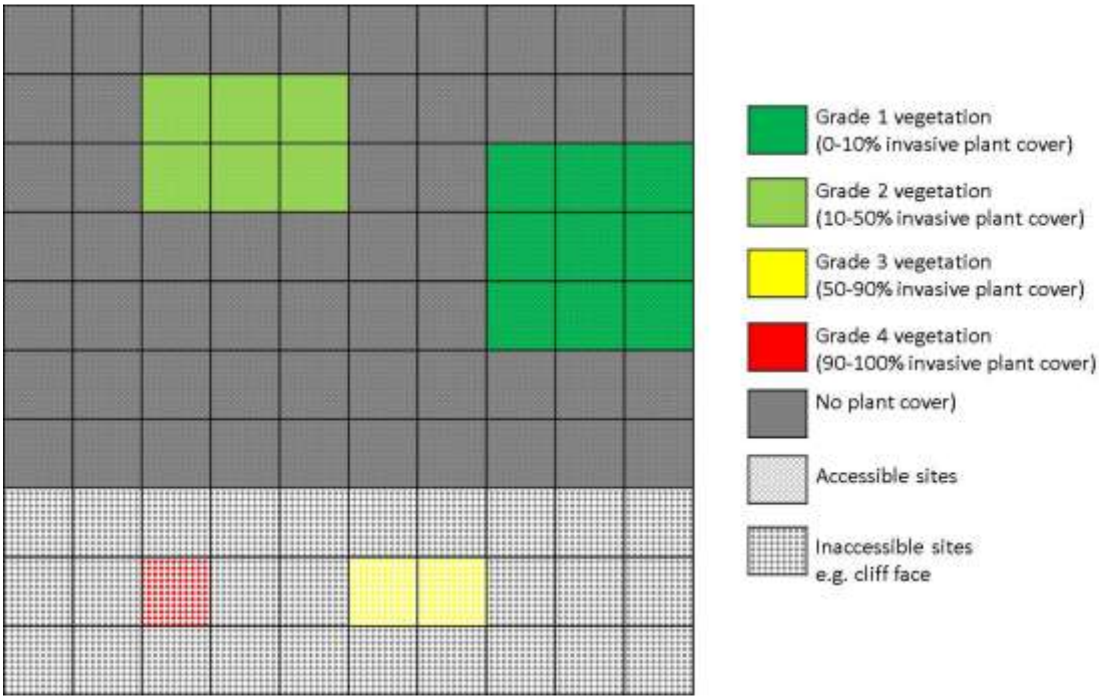

Figure 6. Schematic representation of vegetation grade map to inform restoration priorities.

In the area represented by the above map it is assumed that all landuse is for ecosystem conservation so there are no landuse conflicts (all land is in theory available for restoration).

The mapped areas translate into the following information:

- The vegetated area = 15% of the total area
- Accessible sites = 30% of the total area
- Grade 1 = 9% of the area, 60% of accessible vegetation or 50% of total vegetative cover
- Grade 2 = 6% of the area, 40% of accessible vegetation or 33% of total vegetative cover
- Grade 3 = 2% of the area, 0% of accessible vegetation or 11% of total vegetative cover
- Grade 4 = 1% of the area, 0% of accessible vegetation or 6% of total vegetative cover

Invasive plant cover = approximately 25.6% of the vegetated area or 4.6% of total area (calculated by approximating invasive plant cover by using the median values for each vegetation grade e.g. Grade 1 = 5% invasive plant cover, Grade 2 = 30% invasive plant cover, etc.).

This information provides essential information for restoration indicators.

Indicator 1. Native/endemic species vegetative cover maintained in accessible "Grade 1" vegetation (sites in which IPs comprise of 0-10% of vegetation cover) in P Fogo NP; Morroços NP; and Cova/Paúl/R da Torre: Under the above scenario we will aim to maintain native/endemic species vegetative cover in 60% of accessible vegetation (which represents the accessible area covered by Grade 1 vegetation).

Indicator 2. Target for rate of change of native versus IP cover established for all vegetation grades (from 0 -100% ground cover with IPs) in Fogo NP; Monte Verde NP; Morroços NP; and Cova/Paúl/R da Torre based on the results of: vegetation grade mapping: IP control trials; and community outreach work. Indicator 2 cannot yet be precisely defined using the information from this scenario. However, we can establish rate of spread in unmanaged sites using recommended monitoring approaches - see sections on monitoring, evaluation and review & associated annexes. This will be used together with data from the IP control trials and the results of community outreach work to give a target rate of change which will be: Rate of change without management minus the rate of restoration through management.

Initiate research projects to ask ecosystem-level questions

We never have perfect knowledge about the ecosystem we are managing. This is one reason why it is essential to have a well-designed monitoring system in place and to act upon analysed monitoring data as part of the process of adaptive management. In addition we may need to initiate trials to test out management approaches about which we lack information. This work can be supplemented by research on ecosystem function. For example, one area of research that could be valuable for Cape Verde is the quantification of the effect of invasive and alien planted species on water conservation. Research carried out in South Africa indicates that woody alien plants may be using as much as 9.95% of the utilisable surface runoff in South Africa (Versfeld et al. 1998; Le Maitre et al. 2000) and that matters would get worse if no action was taken. In South Africa this information was the used to justify IP management as a good investment to prevent water loss (van Wilgen et al. 1997; Hosking and du Preez 1999). We cannot simply take the work in South Africa and extrapolate to Cape Verde but we can adapt the South African research methods to investigate catchment level effects of invasions on water availability in Cape Verde as a basis for a cost-benefit analysis.

Manage risk

Manage risks to minimise any negative impacts of IP management

All management options, including doing nothing have advantages and disadvantages (on the ecosystem in question and on adjacent and other ecosystems) in terms of effects against the target IP(s), impacts to non-targeted plants and animals, risks to human health and safety, and costs in the short, medium and long term. It is important to consider the balance between the short, medium and long term costs and the benefit of any actions. Risks cannot be eliminated but there are approaches which help to minimise risk. For example herbicides have become an essential tool in the IP manager's toolkit and they are used in PAs throughout the world (Clout and Williams 2009). However, every effort must be made to ensure herbicides are used in a manner that minimises the risk of negative health and environmental impacts e.g. suitable products and application protocols must be used to ensure that herbicides do not leach into water bodies (see Annex 5 for guidelines for the safe use of herbicides).

Similar considerations apply to any proposed biological control releases. Biological control offers the promise of a low cost and sustainable method of IP management. However, there are risks that the released agents may feed on non-target species. Protocols have been developed to minimise these risks e.g. through host-specificity testing and quarantine procedures for imported agents (see Annex 8 for the International Plant Protection Convention Code of Conduct for the Import and Release of Exotic biological control agents (ISPM - International Standards for Phytosanitary Measures no 3, 1996). RA does not always have to be a complex process. An organised and documented discussion with a group of informed stakeholders on the pros and cons of an intervention can constitute a risk assessment process when the proposed actions are relatively straightforward. A more formal RA is likely to be needed for proposed actions that are more complex, potentially controversial or novel.

Restore incrementally as necessary

Ecological restoration is an ecosystem change which can have negative consequences in the short term. Management must seek to minimise such undesirable effects. For example, as previously outlined removing an invasive plant in some situations might increase the risk of soil erosion. In such instances management techniques need to be adopted that minimise this risk. For example invasive plants on slopes can be cleared incrementally in strips and these strips planted with non-invasive soil stabilising plants. This can provide time for desirable plants to establish and can protect the soil before the next phase of clearance and replanting.

PARQUE NATURAL DO FOGO – INVASIVE PLANT MANAGEMENT PLAN

SUMMARY

This IP management plan is a contribution to the overall Fogo management plan (2007) that seeks to enhance natural, architectural, human and landscape heritage values, with a view to preserving biodiversity, geodiversity and sustainable use of resources. This plan comprises of the following elements:

Management principles that operationalise IP management within the ecosystem approach.
Zonation of the park to prioritise management actions and establish verifiable restoration indicators: Building upon the mapping work undertaken to date, the park will be zoned according to the degree to which native communities are invaded by IPs ("native habitat quality"):

- Grade 1 – almost entirely intact native vegetation (0-10% IP cover)
- Grade 2 (10% to 50% IP cover)
- Grade 3 (50-90% IP cover)
- Grade 4 (<10 % IP cover).

Other parameters used to zone the park will be landuse - forestry, farming, ecosystem conservation; and accessibility – easy, medium, difficult and inaccessible.

The highest priority for cost-effective IP management (mainly prevention, early detection and rapid response) will be those areas of Grade 1 vegetation that are easy to access and have no landuse conflicts. The mapping to be undertaken, in conjunction with IP control trials, will provide information needed to improve estimates of the extent to which native vegetation can be maintained in different sites in PNF.

Prioritisation of invasive plant species for management: IP Species that threaten ecosystem management goals have been classified into the following categories:

- Widespread high impact species – species that threaten management goals across extensive areas of the park: - *Lantana camara* and *Furcraea foetida*
- Localised high impact species – species that threaten management goals across in smaller areas of the park relative to those above: - *Jacaranda mimosifolia*, *Acacia mearnsii* (molísima) and *Cuscuta* spp. (Dodder)
- Species of possible concern – species which do not appear to threaten management goals at present but may do so in the future, e.g. *Acacia holosericea* and *Grevillea robusta*.

Invasive plant control plans are outlined for each of these groups. Recommended actions range from no treatment to prevention, early detection and rapid response to intensive control in high priority areas to experimental control and restoration efforts in representative samples of different habitat types. No systematic IP control has been undertaken in Cape Verde's PAs to date so initial experimental work will be undertaken to assess the efficiency and effectiveness of different control methods and the feasibility of upscaling these methods to larger areas of the park.

Capacity building, awareness raising and communications. Park staff and other stakeholders will require capacity building in order to effectively facilitate IP management. For this management to be sustainable it is essential that local communities and other stakeholders understand, support and participate in IP management. Capacity building, and communications and awareness raising activities are outlined in this plan.

Monitoring evaluation and review Monitoring will include: periodic assessments of plant distribution and abundance, and habitat quality to document overall landscape changes and the effectiveness of our management actions (baseline and outcomes monitoring); monitoring of IP management operations will help us to evaluate the efficiency of our methods (activity and results monitoring) and documentation of herbicide application will help to minimise risks to non-targeted plants and animals, and human health and safety.

Monitoring information will be used to modify and improve management priorities, methods and plans.

Finally an implementation schedule for IP management actions, together with provisional restoration indicators, is outlined.

INTRODUCTION

The plans for the individual PAs have been kept brief to make them easy to read and understand. However, for a fuller understanding, it is recommended that the reader also looks at the overview and introduction which details the principles that are the foundation of this plan. The annexes can be consulted to provide additional details as required.

Site description (derived from the UNDP GEF Project document)

Chã das Caldeiras Natural Park or the Parque Natural do Fogo - PNF (Gazetted area: 8,469 ha) circles the crater of the Pico do Fogo Volcano. Native flora includes 31 endemic species (84% of the island endemics), with five found almost exclusively in the Bordeira and in the crater area (*Echium vulcanorum*, *Erysimum caboverdeanum*, *Tornabenea tenuissima*, *Verbascum cystolithicum* and *Diplotaxis hirta*). Native fauna is represented by *Falco tinnunculus*, *Apus alexandri*, *Pterodroma feae*, *Corvus ruficollis*, *Passer hispaniolensis*, *Sylvia atricapilla* and *Mabuya fogoensis fogoensis*). 48% of these species are listed in the Cape Verde Red list. Chã das Calderiras is at high altitude and receives frost during the winter months. There are approximately 3000 people living within and around the PA. The native vegetation, soil and water quality of the area are threatened by and fuel wood gathering, overexploitation of the natural springs and invasive plants.

Objectives for the protected area

The objective of the Parque Natural do Fogo, is to conserve and enhance natural, architectural, human and landscape heritage values, with a view to preserving biodiversity, geodiversity and sustainable use of resources; controlling soil erosion to protect resources and geological landscape; supporting traditional human activities, boosting the economic development and welfare of populations living in harmony with nature conservation (PNF management plan, 2007).

Invasive plants as a threat to protected area objectives

Invasive plants pose a threat to native plant species in the Parque Natural do Fogo which they can out-compete, driving them to rarity and possibly eventual extinction. Other ecosystem impacts of IPs in PNF could include habitat degradation for native vertebrates and invertebrates, increased susceptibility to wildfires and reduced water availability. If no action is taken it is certain that IPs will spread in PNF causing increased impacts, even though existing impacts are already very serious. The most widespread IP species are *Lantana camara* (freira) and *Furcraea foetida* (carrapat). Locally abundant IP species include *Acacia mearnsii*, *Jacaranda mimosifolia* and *Cuscuta* species (dodder). Detailed profiles for the above species can be found in Annex 1.

This plan examines management options for these species within a prioritisation framework for different sites classified according to: degree plant invasion, accessibility and landuse.

Indicators for the rate of change of native versus IP cover based on available information are provided in this document. These indicators will be refined using the information provided by the implementation of this IP management plan.

Principles of IP management within the ecosystem approach

The "ecosystem approach" - "A resource planning and management approach that recognizes the connections between land, air, water and all living things, including people, their activities and institutions"[4] can be translated into the IP management principles that are the foundation of this plan. These "fundamental principles of IP management within the ecosystem approach" are elaborated in detail in the overview and introduction.

ZONATION OF THE PARK TO PRIORITISE MANAGEMENT ACTIONS AND ESTABLISH VERIFIABLE RESTORATION INDICATORS

IP management is costly, especially in highly invaded areas (Annex 6). It is not possible or practical to control all IP species in all areas of the park at once. It is, therefore, vital to prioritise to help ensure that IP management is cost-effective. The IAS management hierarchy reminds us that for cost-effective IAS management our first priority is prevention; if this is not possible we can detect infestations early and eradicate or contain the infestation; where infestations are larger we may be able to sustainably control, actively restore, mitigate or in some cases do nothing.

To make informed decisions on management interventions it is necessary to have information on the baseline status of the landscape in question. To date species distribution maps have been produced for *Lantana camara* and *Furcraea foetida*. These maps outline areas heavily infested with either or both species. It is estimated that these areas cover 105 ha or 1.24%of the park area. Much of the park area is unvegetated so the figure for the *percentage of vegetation infested by IPs* will be much higher.

Vegetation quality

Building upon this work, it is recommended that the distribution of different categories of vegetation quality in the park is mapped to establish IP management priorities. Other things

[4] www.mnr.gov.on.ca/en/Business/FW/2ColumnSubPage/STEL02_168425.html

being equal the less degraded an area the higher the management priority (greatest conservation benefits for least cost).

The following vegetation quality categories are proposed:

- Grade 1 – almost entirely intact native vegetation (0-10% IP cover)
- Grade 2 (10% to 50% IP cover)
- Grade 3 (50-90% IP cover)
- Grade 4 (<10 % IP cover).

Figure 7. Vegetation quality: Clockwise from: Grade 1, Grade 2, Grade 3 and Grade 4

Ease of access

Some areas cannot be easily restored so may need to be deprioritised at least in the short term. This is true of areas that are very difficult to reach. Accessibility is a big issue in PNF. Some areas are accessible but very far from roads so it may be difficult for IP management teams to reach them easily. Many areas are on steep slopes or cliffs and are, for IP management purposes (other than for biological control), impossible to access. It is therefore recommended that PNF is mapped in terms of accessibility using the following categories:

- Easy access – access by IP teams in less than half an hour - round trip of less than one hour (e.g. close to tracks and/or settlements);
- Medium access – access by IP teams in half an hour to one hour (e.g. close to tracks but not near to habitation or close to habitation but not near tracks);
- Difficult access - access by IP teams in one hour or more (e.g. accessible but only accessible after a long car journey or a long walk or in challenging terrain);

- Inaccessible - not possible to access by practical means (on, or accessible only via, steep and dangerous slopes and cliffs).

Principal landuse types

Landuse can influence the IP management approach developed. For example, a plan to restore to 100% native species cover is unlikely to be implemented in areas designated for forestry or agriculture. However, it may be possible to restore a portion of lands designated in this way as a way of managing for multiple objectives.

The following principal landuse types will be mapped:

- Forestry and forest products (including cutting for fodder);
- Arable farming;
- Ecosystem conservation (i.e. no significant direct human landuse).

The above categories of vegetation quality (4 types), ease of access (4 types) and principal landuse (3 types) theoretically results in 48 separate combinations. However, some combinations will never arise e.g. inaccessible arable farming systems and grade 1 vegetation under forestry! The actual number of combinations is 34 (see Table 1).

Figure 8. Landuse types (from left to right): Forestry and forest products; arable farming; and ecosystem conservation.

For a consideration of how the zonation information will be used to provide information to strengthen restoration indicators see the section on adaptive management.

Table 1. Possible classifications combinations for IP management zonation based on the criteria of vegetation quality, ease of access and landuse type

Vegetation quality	Ease of access	Landuse Type
Grade 1	Easy access	Ecosystem conservation
Grade 1	Medium access	Ecosystem conservation
Grade 1	Difficult access	Ecosystem conservation
Grade 1	Inaccessible	Ecosystem conservation
Grade 2	Easy access	Forestry and forest products
Grade 2	Easy access	Arable farming
Grade 2	Easy access	Ecosystem conservation
Grade 2	Medium access	Forestry and forest products
Grade 2	Medium access	Arable farming
Grade 2	Medium access	Ecosystem conservation
Grade 2	Difficult access	Forestry and forest products
Grade 2	Difficult access	Arable farming
Grade 2	Difficult access	Ecosystem conservation
Grade 2	Inaccessible	Ecosystem conservation
Grade 3	Easy access	Forestry and forest products
Grade 3	Easy access	Arable farming
Grade 3	Easy access	Ecosystem conservation
Grade 3	Medium access	Forestry and forest products
Grade 3	Medium access	Arable farming
Grade 3	Medium access	Ecosystem conservation
Grade 3	Difficult access	Forestry and forest products
Grade 3	Difficult access	Arable farming
Grade 3	Difficult access	Ecosystem conservation
Grade 3	Inaccessible	Ecosystem conservation
Grade 4	Easy access	Forestry and forest products
Grade 4	Easy access	Arable farming
Grade 4	Easy access	Ecosystem conservation
Grade 4	Medium access	Forestry and forest products
Grade 4	Medium access	Arable farming
Grade 4	Medium access	Ecosystem conservation
Grade 4	Difficult access	Forestry and forest products
Grade 4	Difficult access	Arable farming
Grade 4	Difficult access	Ecosystem conservation
Grade 4	Inaccessible	Ecosystem conservation

In addition to the above areas, there are young lava flows that are currently unvegetated but have potential for restoration.

Data acquisition

In some cases the information is already largely available from the maps produced for *L. camara* and *F. foetida* distribution, e.g. heavily infested areas will be Grade 4 vegetation and landuse and accessibility are known to a greater or lesser extent. Other information will need to be collected. It is very difficult to estimate resource requirements but an estimate based on the time taken for the previous mapping work is that this will constitute eight week's work for one individual over a six month period.

Recommended actions

Produce a zonation map for PNF as a basis for prioritising IP management actions. Review the map annually and modify as appropriate. However, a repeat of the comprehensive process whereby the initial map was produced should not be necessary.

<u>Restoration in unvegetated areas</u>

Several UNDP Small Grants Programme (SGP) projects have been implemented in Cape Verde in which native plants have been introduced on young ash slopes as a means of biodiversity conservation, erosion control and catchment management. These projects also serve to increase the sense of community and pride in the uniqueness of the country's biodiversity heritage. Because the restoration work is being undertaken without the need for IP clearance it may well represent a cost-effective way of conserving biodiversity in a volcanic area such as PNF. This approach will be promoted as part of this plan.

A possible win-win situation may be to create native hedges close to arable areas to serve as windbreaks, to stabilise soil and to conserve water. The potential of such a "set-aside" scheme will be investigated as part of this plan.

Figure 9. Restoration plantings on a lava flow undertaken as part of a UNDP Small Grants Programme project

PRIORITISATION OF INVASIVE PLANT SPECIES FOR MANAGEMENT

As outlined, *Lantana camara* and *Furcraea foetida* distributions in PNF have already been mapped (Figure 9). The next stage for both these "widespread high impact species" species is management. There are other IPs that are locally abundant and likely to constitute threats to biodiversity and other ecosystem objectives – "localised high impact species". In addition there are species that are not yet considered to be problematic but may become so in the future – "species of possible concern". Recommended management approaches for species in each of these three categories are outlined below.

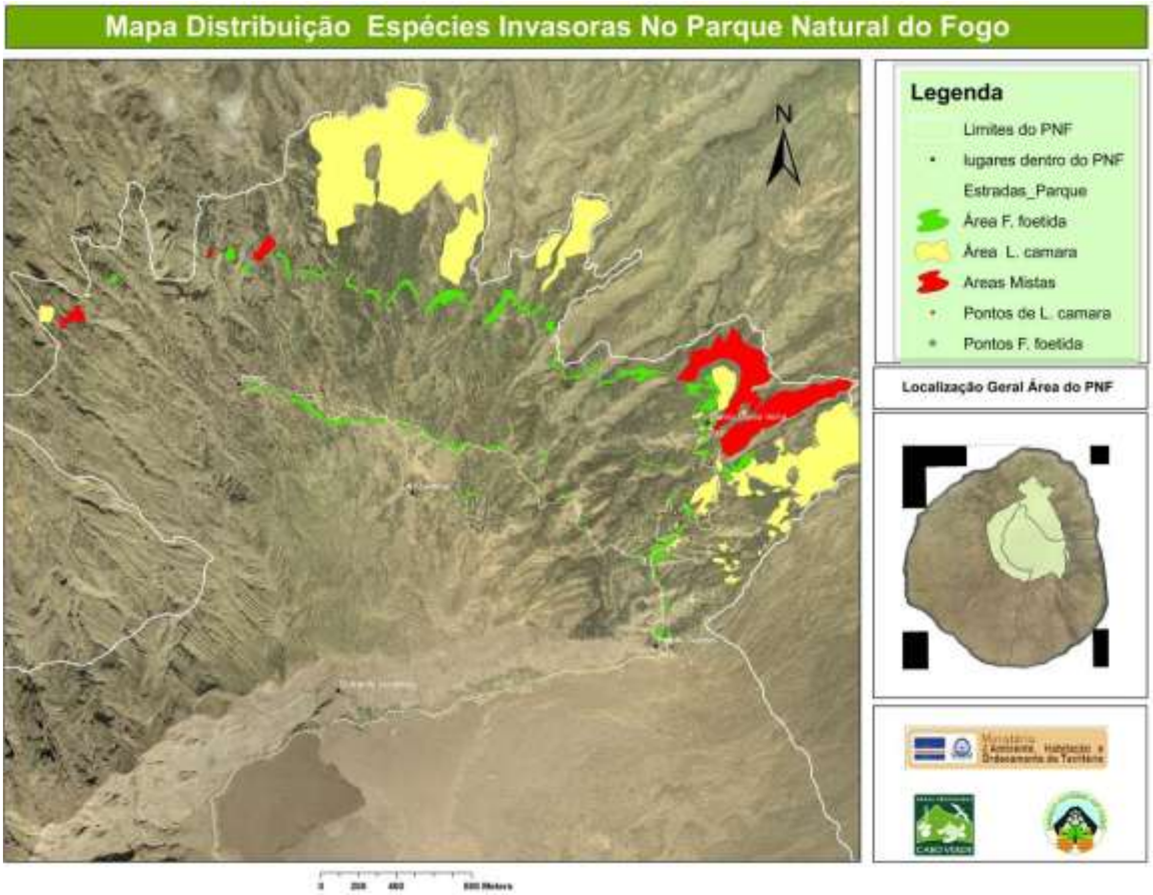

Figure 10. Map of *Lantana camara* and *Furcraea foetida* distributions in PNF.

Widespread high impact species

Lantana camara

Lantana camara is widely considered to be one of the world's most serious invasive plant species (see Annex 1 for a detailed species profile). It is very widespread in PNF where it competes with native species and introduced species of economic importance.

Figure 11. *Lantana camara* has taken over the understory of this planted forest area (inset: *Lantana* flower).

Management recommendations for *L. camara* in PNF are as follows:

Prevention

As part of the park's awareness raising programme the technical team should raise awareness of the importance of not planting *L. camara*, e.g. as an ornamental or as a hedge.

Early detection and rapid response

Initiate a programme of surveillance for *L. camara* in PNF with local stakeholders, as part of a park-wide surveillance programme for targeted IP species. Small individual plants seen along the edges of paths can be pulled up by hand as they are encountered. Such actions do not need to be individually documented. Park staff should prioritise their efforts in areas of high quality vegetation. People should report the sighting of isolated adult plants of *L. camara* (that cannot be easily and quickly pulled out by hand) in otherwise uninfested areas. The parks authorities will need to respond as follows:

1. Attempt eradication of relatively small infestations in accessible areas that are not close to existing larger infestations:

- Complete an invasive plant report form (as in the example in Annex 7)
- Control the *L. camara* plant(s). Depending upon considerations such as the terrain, size of infestation and presence of desired species the plant(s) should be removed

by hand or treated using herbicide[5] (triclopyr ester – Garlon 4® - as a cut stump or basal bark application or glyphosate as a foliar spray). Plants removed by hand can be utilised, burnt in a controlled burn or stacked in situ and left to decompose - being careful to minimise contact between the roots and the soil.

- Return to the eradication site at regular intervals to remove any *L. camara* regrowth by hand or the application of glyphosate as a foliar spray as appropriate.
- Continue this process until no plant has been seen for three years by which time the infestation can be declared eradicated.

This protocol assumes that plants will not recolonise via long-distance seed dispersal (e.g. by birds or people) and that the seedbank does not persist for more than three years. Observation of the area allocated for eradication will indicate whether these assumptions hold true.

2. Attempt containment when the infestation is relatively large and not close to existing larger infestations:

- Control plants at the edge of the infestation as outlined above to minimise their spread.
- Control any small "satellite" infestations close to the main infestation as outlined above.

3. Do not actively manage if the infestation is large and close to larger existing infestations unless the plant threatens a particularly significant population of rare plants or severely impacts some other priority objective.

Control

With limited funding *Lantana camara* control will have to be on a small scale for the foreseeable future pending the refinement of techniques, the initiation of cost-recovery mechanisms or successful biological control efforts. Recommended control measures are outlined as follows:

Initiation of field trials to optimise control techniques for *L. camara* among other priority IPs

1) Control trials using different methods on individual *L. camara* plants.

This would be PART ONE of a project to optimise restoration methods. The initial treatments are based on practices that have been used successfully elsewhere. Undertaking this work under Cape Verdean conditions will help the implementation teams understand what methods/combination of methods works best under local conditions and help the teams gain practical experience of IP management methods.

Individual plants would be used as replicates with up to 10 replicates per treatment.

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[5] In all cases decisions to use herbicides as well as or instead of other methods should be based on the conservation targets and management goals for the site. In addition, the health and safety of applicators and others in the vicinity must be considered BEFORE pesticides are applied (see Annex 4 for more detailed information about these chemicals and Annex 5 for guidelines for the safe use of herbicides).

Control methods will be trailed for the following IP species in Fogo *L. camara*, *Furcraea foetida*, *Acacia mearnsii*. *Jacaranda mimosifolia* and dodder (*Cuscuta* species).

Lantana camara

Manual control:

1. Cutting only
2. Cutting and uprooting

Chemical control:

3. Foliar spray of glyphosate – 2 % solution in water (2% of herbicide diluted with 98% of water)
4. Basal bark application of Garlon 4® (triclopyr ester) – 20% solution in diesel (20% of herbicide diluted with 80% of diesel)
5. Cut stump application of triclopyr ester – 20% solution in diesel

Furcraea foetida

Manual control:

1. Cutting and uprooting plants in vegetative state
2. Cutting and uprooting flowering stems

Chemical control:

3. Cut a well in the centre of the whorl and fill with triclopyr ester – 20% solution in diesel
4. Foliar application of triclopyr ester – 20% solution in diesel

Acacia mearnsii

Manual control:

1. "Saplings" (plants below 2.5 cm basal diameter) debarking to the ground
2. "Saplings" (plants below 2.5 cm basal diameter) Cutting and uprooting

Chemical control:

3. "Saplings" (plants below 2.5 cm basal diameter) cut stump application of triclopyr ester – 20% solution in diesel
4. "Young trees" (plants below 5 cm dbh) cut stump application of triclopyr ester – 20% solution in diesel
5. "Young trees" (plants below 5 cm dbh) basal bark application of triclopyr ester – 20% solution in diesel
6. "Older trees" (plants above 5 cm dbh) hack and squirt (600g/L in diesel) – 20% solution in diesel
7. "Older trees" (plants above 5 cm dbh) stem injection – "drill and fill" using triclopyr ester – 20% solution in diesel

Jacaranda mimosifolia

Manual control:

1. "Saplings" (plants below 2.5 cm basal diameter) Cutting and uprooting

Chemical control:

2. "Saplings" (plants below 2.5 cm basal diameter) cut stump application of triclopyr ester – 20% solution in diesel
3. "Young trees" (plants below 5 cm dbh) cut stump application of triclopyr ester – 20% solution in diesel
4. "Young trees" (plants below 5 cm dbh) basal bark application of triclopyr ester – 20% solution in diesel
5. "Older trees" (plants above 5 cm dbh) hack and squirt (600g/L in diesel) – 20% solution in diesel
8. "Older trees" (plants above 5 cm dbh) stem injection – using triclopyr ester – 20% solution in diesel

Dodder (*Cuscuta* spp.)

Manual control:

1. Hand pulling and cutting the host plant below the point at which the dodder is attached and removing the dodder.

Flaming:

2. Flame cultivation using a small hand-held propane powered weed torch.

Before this work is initiated implementing personnel will need to be trained in invasive plant management for ecosystem restoration (Annex 11).

2) Field trials to be undertaken in small plots (up to 4 m x 4 m) to test the efficiency and effectiveness of different control methods. This would be PART TWO of a project to optimise restoration methods. It will be conducted one year after PART ONE is initiated. This should give enough time to monitor and utilise the results of part one in order to choose an integrated management approach.

Methods used should include hand weeding and herbicide use – a combination of methods (informed by the results of the field trials on individual species), i.e. an integrated management approach that uses the most appropriate combination of techniques for the circumstances to balance costs and benefits. Each treatment should be replicated at least four times. Parameters to be monitored will include time and cost of operations and native and invasive plant regeneration. See Annex 7 for examples of monitoring data sheets and templates which can be used to assess such parameters. These field trials will be undertaken in areas infested with Lantana camara only. This information gained regarding the effectiveness of techniques can be used to inform restoration work in areas invaded by other species. Of course there is not perfect correspondence between *Lantana*-infested areas and, for example areas infested by *F. foetida* or more than one species, but expanding this trial work for every invasion situation would be highly resource-intensive.

Figure 12. Illustration of some weed control techniques: 1) Manual removal of foliage; 2) Manual uprooting; 3) Foliar spraying; 4) Foliar spray application to regrowth; 5) Basal bark application; 6) Cut stump application (all photographs courtesy of the Charles Darwin Foundation, Ecuador)

Initiation of a biological control programme for *Lantana camara*

Biological control offers the possibility of sustainable management of *L. camara* over large areas including those that are inaccessible. It is recommended that the following actions are initiated:

- Find out what species (if any) have been introduced to Cape Verde for biological control of *L. camara*
- Collect the insects that are currently feeding on *L. camara* leaves, rear them out as necessary and identify them to species
- Contact the teams working on IP biocontrol in South Africa to initiate a programme for biocontrol on IP in Cape Verde including *L. camara*.

These efforts should constitute part of a national effort to access biological control organisms that have been successfully developed elsewhere. These actions can be conducted at national level by the most appropriate authority and must comply with international guidelines for the export, shipment, import, and release of biological control agents and other beneficial organisms (Annex 8).

Active restoration

All IP management actions can be classified as restoration. The term “active restoration” is used here to refer to a system in which planting is undertaken as well as IP control in order to hasten the recovery of the system to its desired state. Active restoration, like intensive weeding is expensive and the following recommended actions are restricted to an experimental scale for the moment:

Field trials to be undertaken in small plots (up to 4 m x 4 m) to test the efficiency and effectiveness of different restoration methods. Methods used should comprise of weeding only (no active restoration), weeding followed by planting of a fast-growing cover crop to suppress weed regeneration followed by planting of native species, and weeding followed by planning of native species but not cover crops.

The same plots used in part 2 of the field trials to optimise control techniques can be used as control plots for these restoration field trials.

The results should help land managers develop cost-effective restoration techniques for degraded areas. Each treatment should be replicated at least four times. Parameters to be monitored will include time and cost of operations and native and invasive plant regeneration. See Annex 7 for examples of monitoring data sheets and templates which can be used to assess such parameters. Before this work is initiated implementing personnel will need to be trained in invasive plant management for ecosystem restoration (Annex 11).

Furcraea foetida

Furcraea foetida is invasive in several countries (see Annex 1 for a detailed species profile). It is very widespread in PNF where it competes with native species and introduced species of economic importance. *F. foetida* has been widely planted in Cape Verde for erosion control on steep slopes and on the side of roads and tracks. It has also been promoted as a fibre crop but it is not as appreciated as sisal which is easier to work and produces better quality products than *F. foetida*. The woody flowering stems of *F. foetida* are used as poles.

Figure 13. *Furcraea foetida* colonising the forest understory.

Management recommendations for *F. foetida* in PNF are as follows:

Prevention

As part of the park's awareness raising programme the technical team should raise awareness of the importance of not planting *F. foetida*, for erosion control. It is not advisable to promote sisal (*Agave sisalana*) as an alternative as it can become invasive in the same habitats as *F. foetida*. Alternative species for erosion control could be promoted such as native grasses or other native species with wide-spreading root systems.

Early detection and rapid response

F. foetida will be included in the park-wide programme of surveillance. Responses to new *F. foetida* infestations will be as outlined above for *Lantana* camara. Opportunistic control of small *F. foetida* plants can be particularly useful – they are easy to pull out by hand and they often colonise edges of trails that are excellent habitat for many native plant species. The uprooted plants should be bagged (and left in the bag to rot) or if left in situ placed with the roots upwards to ensure that the plant does not re-establish. For adult plants an effective management method is based on the fact that this plant blooms only once in its lifetime and then dies. Cutting the flowering stem helps prevent a new colonisation by its bulblets in nearby areas. Provided that management is perfectly synchronised with the flowering period, this method allows for a reduction or at least control of the invasion. This provides a method of opportunistically controlling *F. foetida*. The stems are valued as poles so it ought to be possible for local people to cut the stems at no cost, a perfect example of a win-win. This type of action can be encouraged as part of the awareness-raising and communications efforts to be implemented as part of this plan.

Control

F. foetida will be one of the target species in the project to optimise control methods for the individual IP species. Other methods apart from manual weeding will be investigated.

Restoration

Because removal of *F. foetida* from a slope edge increases the risk of soil erosion, it has been suggested that any large plants removed should be replaced by a soil stabilising species. Trial replanting using non-invasive species will be undertaken.

Localised high impact species

Jacaranda mimosifolia

Figure 14. *Jacaranda mimosifolia*

Jacaranda mimosifolia has been planted as an ornamental tree and has become invasive in some of the forested parts of PNF. Its current distribution is relatively restricted but it appears to be suppressing native plant regeneration and is spreading. *J. mimosifolia* is invasive in several parts of the world (see Annex 1 for a detailed species profile).

Recommended management actions

Prevention

As part of the park's awareness raising programme, awareness will be raised on the importance of not planting *J. mimosifolia*, e.g. as an ornamental plant.

Early detection and rapid response

J. mimosifolia will be included in the park-wide programme of surveillance. Responses to new *J. mimosifolia* infestations will be as outlined above for *Lantana* camara.

Control

J. mimosifolia will be one of the target species in the project to optimise control methods for the individual IP species.

Biological control prospects for *J. mimosifolia* will be investigated as outlined for *L. camara*.

Acacia mearnsii

Figure 15. *Acacia mearnsii* (known locally as molísima)

Acacia mearnsii (often known in Cape Verde by the synonym *Acacia mollisima*) has been planted as an agroforestry tree and is used for its wood and its leaves are used as fodder for livestock. It is invasive in many parts of the world and has become invasive in PNF (see Annex 1 for a detailed species profile).

Recommended management actions

Prevention

As part of the park's awareness raising programme awareness will be raised on the importance of not spreading *A. mearnsii* to new areas but maintaining it in delimited zones demarcated for sustainable use.

Early detection and rapid response

A. mearnsii will be included in the park-wide programme of surveillance. Responses to new *A. mearnsii* infestations will be as outlined above for *Lantana* camara.

Control

A. mearnsii will be one of the target species in the project to optimise control methods for the individual IP species.

Biological control prospects for *A. mearnsii* will be investigated as outlined for *L. camara*.

Cuscuta spp. (Dodder)

Figure 16. *Cuscuta* species parasitising the native tortolho (*Euphorbia tuckeyana*)

Dodder is not widely distributed in PNF but individual infestations can have very serious impacts on native species. Dodder is also an agricultural weed and has no major uses in Cape Verde. A number of species of dodder are serious weeds in many parts of the world (see Annex 1 for a detailed species profile).

Recommended management actions

An early action should be to ascertain the correct species identity of dodder. Knowing which species or groups of species are represented in PNF will help when it comes to accessing management information.

Prevention

As part of the park's awareness raising programme, awareness will be raised on the importance of not spreading dodder to new areas. This may be done through moving infested plants and dirty agricultural tools or by people (especially children) who carry dodder plant fragments and then carelessly dispose of them.

Early detection and rapid response

Dodder will be included in the park-wide programme of surveillance. Responses to new dodder infestations will be as outlined above for *Lantana camara* although the precise management methods will to be different. Possible control measures to use for dodder are outlined in Annex 1 and will be investigated in detail in individual species control trials.

Control

Dodder, once identified to species, will be one of the target species in the project to optimise control methods for the individual IP species. Methods to be trialled are likely to include spot burning and manual control.

Species of possible concern

Species that come into this category include those that appear to be spreading in PNF and in neighbouring locations and those that are known to be invasive elsewhere although they do not appear to be having major impacts in PNF at present. A species that comes into the former category is *Acacia holosericea* that appears to be spreading, notably in the Bordeira area, since the removal of goats. A species that comes into the latter category is *Grevillea robusta* which is widely planted as an agroforestry tree in PNF.

Recommended management actions

An inventory of introduced species in PNF should be made and the information entered in a database (see Annex 10). Distribution changes can be noted and management actions recommended if necessary. For example if *A. holosericea* continues to spread so that it poses a threat to biodiversity and/or other park management objectives it may be possible to reintroduce goat herbivory in a controlled manner that does not endanger native biodiversity, e.g. tethered grazing.

Figure 17. *Acacia holosericea* (left) and *Grevillea robusta* (right)

CAPACITY BUILDING, AWARENESS RAISING AND COMMUNICATIONS

Park staff and other stakeholders will require capacity building in order to effectively facilitate IP management. A format for a training course in IP management for ecosystem restoration is outlined in Annex 11. Intensive courses such as this, together with expert help in operationalizing this plan, and continued mentoring can be seen as a package that will enable identified park staff to train other key stakeholders from relevant organisations as well as community representatives.

Community buy-in, support and participation is essential for IP management in PNF to be sustainable. Training approaches such as that outlined above should help in this regard. Their efficacy can be increased if they are implemented alongside a comprehensive communication and awareness-raising package that will help to harness the community as part of the solution to IP problems in PNF. Activities could include community meetings, media items, field days and volunteer IP management days. Native plant restoration projects implemented under the UNDP-GEF small grants programme are examples of work of this kind that has been successfully undertaken in Cape Verde to date.

The success of the community outreach work will help to establish the extent to which the community will work with the park authorities to undertake restoration work. It will then be possible to produce “restoration scenarios” under “low, medium and high community participation levels” using the data from the vegetation mapping and the field trials which will feed into project indicators.

MONITORING EVALUATION AND REVIEW

Monitoring will include the following:

Baseline and outcome monitoring: Periodic assessments of plant distribution and abundance, and habitat quality to document overall landscape changes and the effectiveness of our management actions. The mapping of *Lantana camara* and *Furcraea foetida* constitutes the beginning of this process. This will be built upon by:

- The mapping exercise to zone the park according to vegetation quality, access and landuse.
- Vegetation surveys in selected accessible areas that are representative of the range of vegetation types in the park. The exact method used is to be determined but it will most likely be some form of permanent transects or quadrats to be surveyed every 2-3 years. Parameters monitored must be quick and relatively easy to measure and repeatable such as percentage vegetation cover (Annex 7).
- Fixed point photographs which are a very vivid way of recording vegetation changes and are particularly useful for recording changes on steep slopes and cliffs (see Annex 7 for a fixed point photograph datasheet).

Activity and results monitoring:

IP management operations will be monitored to evaluate the efficiency of our methods. Time and motion studies, by logging the time taken for operations, form the basis for estimating the cost of operations – essential information for assessing efficiency and for future planning.

Added to this we need to understand the results our management interventions are having. Monitoring changes in vegetation cover over time in our experimental areas can help us in this respect.

Because of their toxicity it is particularly important to document herbicide application to minimise risks to non-targeted plants and animals, and human health and safety. Annex 7 contains an example of a form used when implementing herbicide treatments and other control methods. This builds upon the guidelines for safe herbicide use outlined in Annex 5.

Monitoring information will be used to modify and improve management priorities, methods and plans so it is essential that the information acquired is analysed early and often and Monitoring information will be used to modify and improve management priorities, methods and plans (management plans will be modified annually in the light of monitoring results) so it is essential that the information acquired is analysed early and often and reviewed at least annually as an integral part of an adaptive management approach.

IMPLEMENTATION SCHEDULE & RESTORATION INDICATORS

Table 2. PNF invasive plant management plan implementation schedule **SE- Seguimento Ecológico, CL- Coordenador Local, DC, Desenvolvimento Comunitário, CN- Coordenação Nacional**

Action	**Notes**	**Person days** [6]		**2012**				**2013**				**Coordination Responsibility**
		2012	2013	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Finalisation of IP management plan	Iterative production of plan	5	0									SE, CL
Revision of IP management plan	Revision following ToT & annually	5	5									SE, CL
Zonation of the Park	Park-wide mapping	40	0									SE
Revise zonation	Use info from ongoing monitoring and management work	0	10									SE
Training of trainers (ToT) in IP management for ecosystem restoration	Involving the whole team for a shared understanding	30	0									CN
Undertake a park-wide IP prevention programme	Mostly surveillance	30	30									SE
Undertake a park-wide early detection and rapid response programme	Time needs will depend finds	30	30									SE
Undertake field trials to optimise control techniques for individuals priority IPs	This included monitoring and data analysis	15	15									SE
Undertake field trials to optimise control and restoration techniques in small plots		0	30									SE
Promote restoration in field edges as part of a set-aside scheme	Mostly community liaison	5	15									SE, DC
Develop an inventory and database for introduced species in the park	Can be spread through the two years	10	5									SE
Develop and implement a capacity building,	With communities and other key	20	10									SE, DC

[6] Person day estimates are imprecise. More precise estimates can be derived when the team undergoes the planned training of trainers workshop when a detailed operational plan can be produced. Many activities complement each other e.g. the species recovery programmes and the control and restoration field trials so the demarcations used are somewhat arbitrary.

Action	Notes	Person days[6]		2012				2013				Coordination Responsibility
		2012	2013	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
awareness-raising and communications programme	stakeholders						■	■	■	■	■	
Monitor baseline vegetation change monitoring – transects and fixed point photographs	2012: establish transects and fixed points; 2013 fixed points only	20	5				■	■	■	■	■	SE
Review monitoring information	2013: Q1 and annually	10	10					■		■		SE

Table 3. The development of restoration indicators through the implementation of the IP management plan in PNF

Area	Indicator
Unvegetated areas (young ash slopes)	• Current extent of newly created native plantings documented • Target for extent of community restoration planting established
Grade 1 (easy and medium access)	• Rate of change in extent of native versus IP cover documented • Current extent of native vegetation maintained
Grade 1 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented
Grade 2 (easy and medium access)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
Grade 2 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented
Grade 3 (easy and medium access)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
Grade 3 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented
Grade 4 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
Grade 4 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented

PLANALTO LESTE (SANTO ANTÃO) – INVASIVE PLANT MANAGEMENT PLAN

SUMMARY

This IP management plan is a contribution to the overall management plan for Planalto Leste – which covers the Moroços and Cova, Paúl and Ribeira da Torre Natural Parks in Santo Antão (in preparation) that seeks to enhance natural, architectural, human and landscape heritage values, with a view to preserving biodiversity, geodiversity and sustainable use of resources. This plan comprises of the following elements:

Management principles that operationalise IP management within the ecosystem approach.
Zonation of the parks to prioritise management actions: Building upon the mapping work undertaken to date, the parks will be zoned according to the degree to which native communities are invaded by IPs ("native habitat quality"):

- Grade 1 – almost entirely intact native vegetation (0-10% IP cover)
- Grade 2 (10% to 50% IP cover)
- Grade 3 (50-90% IP cover)
- Grade 4 (<10 % IP cover).

Other parameters used to zone the park will be landuse - forestry, farming, ecosystem conservation; and accessibility – easy, medium, difficult and inaccessible.

The highest priority for cost-effective IP management (mainly prevention, early detection and rapid response) will be those areas of Grade 1 vegetation that are easy to access and have no landuse conflicts. The mapping to be undertaken, in conjunction with IP control trials, will provide information needed to improve estimates of the extent to which native vegetation can be maintained in different sites in Planalto Leste.

Prioritisation of invasive plant species for management: IP Species that threaten ecosystem management goals have been classified into the following categories:

- Widespread high impact species – species that threaten management goals across extensive areas of the parks: - *Lantana camara* and *Furcraea foetida*
- Localised high impact species – species that threaten management goals across in smaller areas of the parks relative to those above: *Acacia mearnsii, Bryophyllum pinnatum* and *Cyperus papyrus*.
- Species of possible concern – species which do not appear to threaten management goals at present but may do so in the future, e.g. *Arundo donax* and *Grevillea robusta*.

Invasive plant control plans are outlined for each of these groups. Recommended actions range from no treatment to prevention, early detection and rapid response to intensive control in high priority areas to experimental control and restoration efforts in representative samples of different habitat types. No systematic IP control has been undertaken in Cape Verde's PAs to date so initial experimental work will be undertaken to assess the efficiency and effectiveness of different control methods and the feasibility of upscaling these methods to larger areas of the park.

IP management will be used as part of rare species recovery programmes for the endangered sedge *Carex antoniensis* that is only found in isolated very humid locations in Ribeira de Paúl and *Carex paniculata* ssp. *Hanseni*, known only from the valleys of Cova/Paúl/Ribeira da Torre.

Capacity building, awareness raising and communications. Park staff and other stakeholders will require capacity building in order to effectively facilitate IP management. For this management to be sustainable it is essential that local communities and other stakeholders understand, support and participate in IP management. Capacity building, and communications and awareness raising activities are outlined in this plan.

Monitoring evaluation and review Monitoring will include: periodic assessments of plant distribution and abundance, and habitat quality to document overall landscape changes and the effectiveness of our management actions (baseline and outcomes monitoring); monitoring of IP management operations will help us to evaluate the efficiency of our methods (activity and results monitoring) and documentation of herbicide application will help to minimise risks to non-targeted plants and animals, and human health and safety.

Monitoring information will be used to modify and improve management priorities, methods and plans.

Finally an implementation schedule for IP management actions, together with provisional restoration indicators, is outlined.

INTRODUCTION

The plans for the individual PAs have been kept brief to make them easy to read and understand. However, for a fuller understanding, it is recommended that the reader also looks at the overview and introduction which details the principles that are the foundation of this plan. The annexes can be consulted to provide additional details as required.

Site description (derived from the UNDP GEF Project document)

Planalto Leste[7] – composed of the Moroços and Cova, Paúl and Ribeira da Torre Natural Parks in Santo Antão is described as follows in the UNDP GEF Project document:

Moroços Natural Park, Santo Antão (gazetted area: 818.1 ha). The area, which is at a high altitude (1400-1800 m). Most of Moroços Natural Park is at high altitude but it also includes parts of Vale de Garca and Alto Mira, with the lowest altitudes somewhere around 500 m. The park is an important recharge area for the local aquifer, consists of a sequence of climatic zones ranging from a dry zone at the lower elevations to a sub-humid zone on the slopes and peaks of several of its mountains. The climatic zones' diversity is also responsible for a high plant diversity, including floral communities that are still dominated by native species. This is the most significant biodiversity hotspot on Santo Antão Island. Today the area is practically deserted, with very few people living in the Park and in the area

[7] Planalto Leste or "the parks" are used to refer to both Moroços Natural Park and Cova, Paúl and Ribeira da Torre Natural Park throughout this document

immediately adjacent, although it is sometimes used by other communities as a source of medicinal and forage plants, many of which are endemic.

Cova, Paúl and Ribeira da Torre Natural Park, Santo Antão (gazetted area: 2092 ha). The area incorporates a significant representative area of humid mountain ecosystem and includes the greatest centre of endemic plant diversity in Cape Verde. It harbours large swaths of untouched land, although native vegetation is threatened by fuel wood collection and alien species invasion. The entire area suffers from a lack of planning or regulation of any kind[8]. Such management limitation threatens the area's biodiversity, water quality and tourism potential. There are at least 10 small communities, with an estimated population of less than 2,000 people, living within the PA's boundaries and in its immediate surroundings.

Objectives for the protected area

The objectives for the parks have yet to be formalised but they are likely to be similar to those for the Parque Natural do Fogo - to conserve and enhance natural, architectural, human and landscape heritage values, with a view to preserving biodiversity, geodiversity and sustainable use of resources; controlling soil erosion to protect resources and geological landscape; supporting traditional human activities, boosting the economic development and welfare of populations living in harmony with nature conservation (PNF management plan, 2007).

Invasive plants as a threat to protected area objectives

Invasive plants pose a threat to native plant species in Planalto Leste which they can out-compete, driving them to rarity and possibly eventual extinction. Other ecosystem impacts of IPs in the parks could include habitat degradation for native vertebrates and invertebrates, increased susceptibility to wildfires and reduced water availability. If no action is taken it is certain that IPs will spread in the parks causing increased impacts, even though existing impacts are already very serious. The most widespread IP species are *Lantana camara* (trepadeira) and *Furcraea foetida* (carrapato). Locally abundant IP species include *Acacia mearnsii* (molísima). Detailed profiles for the above species can be found in Annex 1.

This plan examines management options for these species within a prioritisation framework for different sites classified according to: degree of plant invasion, accessibility and landuse.

Indicators for the rate of change of native versus IP cover based on available information are provided in this document. These indicators will be refined using the information provided by the implementation of this IP management plan.

Principles of IP management within the ecosystem approach

The "ecosystem approach" - "A resource planning and management approach that recognizes the connections between land, air, water and all living things, including people, their activities and institutions"[9] can be translated into the IP management principles that

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[8] Planted forests are managed to some degree through enforcement operations of the forest guards

[9] www.mnr.gov.on.ca/en/Business/FW/2ColumnSubPage/STEL02_168425.html

are the foundation of this plan. These "fundamental principles of IP management within the ecosystem approach" are elaborated in detail in the overview and introduction.

ZONATION OF THE PARKS TO PRIORITISE MANAGEMENT ACTIONS AND ESTABLISH VERIFIABLE RESTORATION INDICATORS

IP management is costly, especially in highly invaded areas (Annex 6). It is not possible or practical to control all IP species in all areas of the parks at once. It is, therefore, vital to prioritise to help ensure that IP management is cost-effective. The IAS management hierarchy reminds us that for cost-effective IAS management our first priority is prevention; if this is not possible we can detect infestations early and eradicate or contain the infestation; where infestations are larger we may be able to sustainably control, actively restore, mitigate or in some cases do nothing.

To make informed decisions on management interventions it is necessary to have information on the baseline status of the landscape in question. To date species distribution maps have been produced for *Lantana camara* and *Furcraea foetida*. These maps outline areas infested with either or both species. It is estimated that these areas cover 162.5 ha or 7.7% of the park area. A significant percentage of the park area is unvegetated so the figure for the *percentage of vegetation infested by IPs* will be much higher.

Vegetation quality

Building upon this work, it is recommended that the distribution of different categories of vegetation quality in the parks is mapped to establish IP management priorities. Other things being equal the less degraded an area the higher the management priority (greatest conservation benefits for least cost).

The following vegetation quality categories are proposed:

- Grade 1 – almost entirely intact native vegetation (0-10% IP cover)
- Grade 2 (10% to 50% IP cover)
- Grade 3 (50-90% IP cover)
- Grade 4 (<10 % IP cover).

Figure 18. Vegetation quality: Clockwise from: Grade 1, Grade 2, Grade 3 and Grade 4

Ease of access

Some areas cannot be easily restored so may need to be deprioritised at least in the short term. This is true of areas that are very difficult to reach. Accessibility is a big issue in Planalto Leste. Some areas are accessible but very far from roads so it may be difficult for IP management teams to reach them easily. Many areas are on steep slopes or cliffs and are, for IP management purposes (other than for biological control), impossible to access. It is therefore recommended that the parks are mapped in terms of accessibility using the following categories:

- Easy access – access by IP teams in less than half an hour - round trip of less than one hour (e.g. close to tracks and/or settlements);
- Medium access – access by IP teams in half an hour to one hour (e.g. close to tracks but not near to habitation or close to habitation but not near tracks);
- Difficult access - access by IP teams in one hour or more (e.g. accessible but only accessible after a long car journey or a long walk or in challenging terrain);
- Inaccessible - not possible to access by practical means (on, or accessible only via, steep and dangerous slopes and cliffs).

Principal landuse types

Landuse can influence the IP management approach developed. For example, a plan to restore to 100% native species cover is unlikely to be implemented in areas designated for forestry or agriculture. However, it may be possible to restore a portion of lands designated in this way as a way of managing for multiple objectives.

The following principal landuse types will be mapped:

- Forestry and forest products (including cutting for fodder);
- Arable farming;
- Ecosystem conservation (i.e. no significant direct human landuse).

The above categories of vegetation quality (4 types), ease of access (4 types) and principal landuse (3 types) theoretically results in 48 separate combinations. However, some combinations will never arise e.g. inaccessible arable farming systems and grade 1 vegetation under forestry! The actual number of combinations is 34 (see Table 3).

Figure 19. Landuse types (from left to right): Forestry and forest products; arable farming; and ecosystem conservation.

For a consideration of how the zonation information will be used to provide information to strengthen restoration indicators see the section on adaptive management.

Table 4. Possible classifications combinations for IP management zonation based on the criteria of vegetation quality, ease of access and landuse type

Vegetation quality	Ease of access	Landuse Type
Grade 1	Easy access	Ecosystem conservation
Grade 1	Medium access	Ecosystem conservation
Grade 1	Difficult access	Ecosystem conservation
Grade 1	Inaccessible	Ecosystem conservation
Grade 2	Easy access	Forestry and forest products
Grade 2	Easy access	Arable farming
Grade 2	Easy access	Ecosystem conservation
Grade 2	Medium access	Forestry and forest products
Grade 2	Medium access	Arable farming
Grade 2	Medium access	Ecosystem conservation
Grade 2	Difficult access	Forestry and forest products
Grade 2	Difficult access	Arable farming
Grade 2	Difficult access	Ecosystem conservation
Grade 2	Inaccessible	Ecosystem conservation
Grade 3	Easy access	Forestry and forest products
Grade 3	Easy access	Arable farming
Grade 3	Easy access	Ecosystem conservation
Grade 3	Medium access	Forestry and forest products
Grade 3	Medium access	Arable farming
Grade 3	Medium access	Ecosystem conservation
Grade 3	Difficult access	Forestry and forest products
Grade 3	Difficult access	Arable farming
Grade 3	Difficult access	Ecosystem conservation
Grade 3	Inaccessible	Ecosystem conservation
Grade 4	Easy access	Forestry and forest products
Grade 4	Easy access	Arable farming
Grade 4	Easy access	Ecosystem conservation
Grade 4	Medium access	Forestry and forest products
Grade 4	Medium access	Arable farming
Grade 4	Medium access	Ecosystem conservation
Grade 4	Difficult access	Forestry and forest products
Grade 4	Difficult access	Arable farming
Grade 4	Difficult access	Ecosystem conservation
Grade 4	Inaccessible	Ecosystem conservation

Data acquisition

In some cases the information is already largely available from the maps produced for *L. camara* and *F. foetida* distribution, e.g. heavily infested areas will be Grade 4 vegetation and landuse and accessibility are known to a greater or lesser extent. Other information will need to be collected. It is very difficult to estimate resource requirements but an estimate based on the time taken for the previous mapping work is that this will constitute eight week's work for one individual over a six month period.

Recommended actions

Produce a zonation map for Planalto Leste as a basis for prioritising IP management actions. Review the map annually and modify as appropriate. However, a repeat of the comprehensive process whereby the initial map was produced should not be necessary.

PRIORITISATION OF INVASIVE PLANT SPECIES FOR MANAGEMENT

As outlined, *Lantana camara* and *Furcraea foetida* distributions in Planalto Leste have already been mapped (Figure 19). The next stage for both these "widespread high impact species" is management. There are other IPs that are locally abundant and likely to constitute threats to biodiversity and other ecosystem objectives – "localised high impact species". In addition there are species that are not yet considered to be problematic but may become so in the future – "species of possible concern". Recommended management approaches for species in each of these three categories are outlined below.

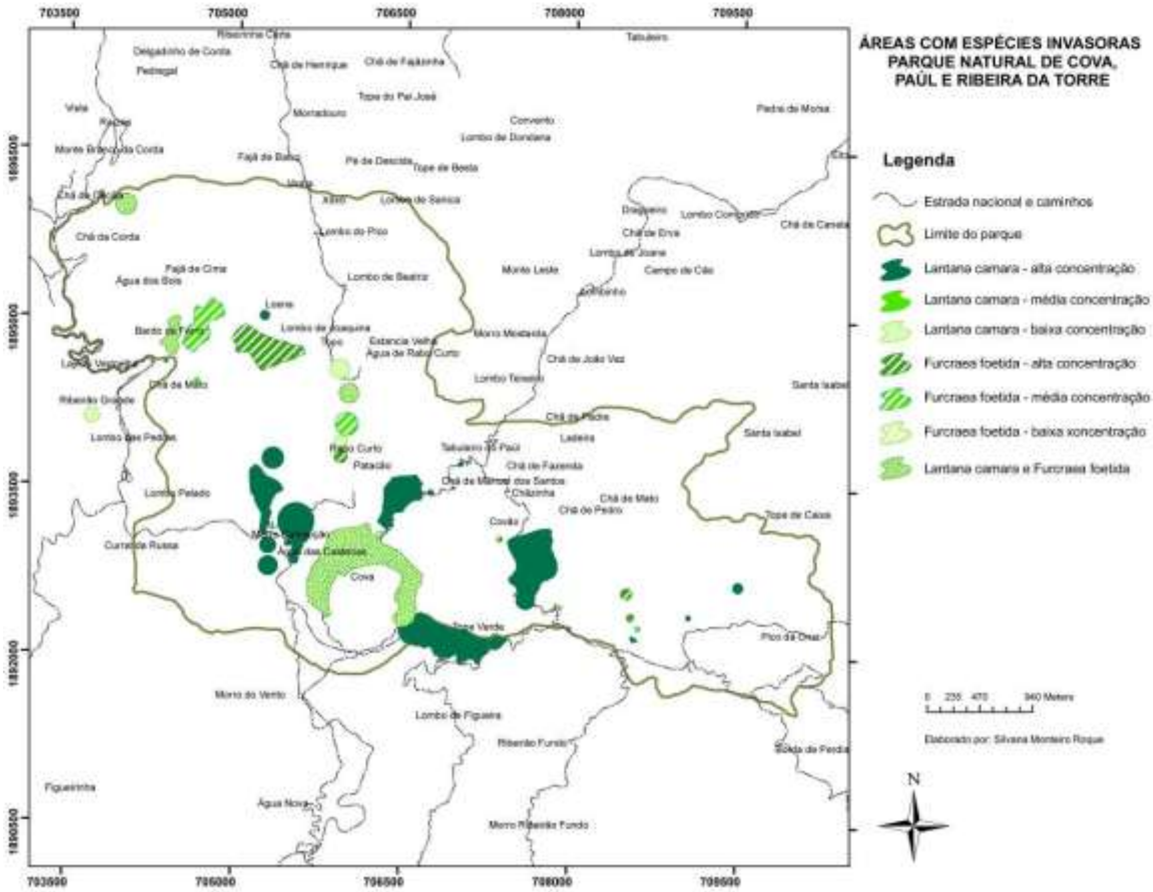

Figure 20. Map of *Lantana camara* and *Furcraea foetida* distributions in Planalto Leste.

Widespread high impact species

Lantana camara

Lantana camara is widely considered to be one of the world's most serious invasive plant species (see Annex 1 for a detailed species profile). It is very widespread in Moroços Natural Park and Cova, Paúl and Ribeira da Torre Natural Park where it competes with native species and introduced species of economic importance.

Figure 21. *Lantana camara* has taken over this field in Paúl (inset: *Lantana* flower).

Management recommendations for *L. camara* in the parks are as follows:

Prevention

As part of the park's awareness raising programme the technical team should raise awareness of the importance of not planting *L. camara*.

Early detection and rapid response

Initiate a programme of surveillance for *L. camara* in Planalto Leste with local stakeholders, as part of a park-wide surveillance programme for targeted IP species. Small individual plants seen along the edges of paths can be pulled up by hand as they are encountered. Such actions do not need to be individually documented. Park staff should prioritise their efforts in areas of high quality vegetation. People should report the sighting of isolated adult plants of *L. camara* (that cannot be easily and quickly pulled out by hand) in otherwise uninfested areas. The parks authorities will need to respond as follows:

1. Attempt eradication of relatively small infestations in accessible areas that are not close to existing larger infestations:

- Complete an invasive plant report form (as in the example in Annex 7)
- Control the *L. camara* plant(s). Depending upon considerations such as the terrain, size of infestation and presence of desired species the plant(s) should be removed

by hand or treated using herbicide[10] (triclopyr ester – Garlon 4® - as a cut stump or basal bark application or glyphosate as a foliar spray). Plants removed by hand can be put to use, burnt in a controlled burn or stacked in situ and left to decompose - being careful to minimise contact between the roots and the soil.

- Return to the eradication site at regular intervals to remove any *L. camara* regrowth by hand or the application of glyphosate as a foliar spray as appropriate.
- Continue this process until no plant has been seen for three years by which time the infestation can be declared eradicated.

This protocol assumes that plants will not recolonise via long-distance seed dispersal (e.g. by birds or people) and that the seedbank does not persist for more than three years. Observation of the area allocated for eradication will indicate whether these assumptions hold true.

2. Attempt containment when the infestation is relatively large and not close to existing larger infestations:

- Control plants at the edge of the infestation as outlined above to mimimise their spread.
- Control any small "satellite" infestations close to the main infestation as outlined above.

3. Do not actively manage if the infestation is large and close to larger existing infestations unless the plant threatens a particularly significant population of rare plants or severely impacts some other priority objective.

Control

With limited funding *Lantana camara* control will have to be on a small scale for the foreseeable future pending the refinement of techniques, the initiation of cost-recovery mechanisms or successful biological control efforts. Recommended control measures are outlined as follows:

Initiation of field trials to optimise control techniques for *L. camara* among other priority IPs

1) Control trials using different methods on individual *L. camara* plants.

This would be PART ONE of a project to optimise restoration methods. The initial treatments are based on practices that have been used successfully elsewhere. Undertaking this work under Cape Verdean conditions will help the implementation teams understand what methods/combination of methods works best under local conditions and help the teams gain practical experience of IP management methods.

Individual plants would be used as replicates with up to 10 replicates per treatment.

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[10] In all cases decisions to use herbicides as well as or instead of other methods should be based on the conservation targets and management goals for the site. In addition, the health and safety of applicators and others in the vicinity must be considered BEFORE pesticides are applied (see Annex 4 for more detailed information about these chemicals and Annex 5 for guidelines for the safe use of herbicides).

Control methods will be trailed for the following IP species in Santo Antão - *L. camara*, *Furcraea foetida*, *Acacia mearnsii* and *Bryophyllum pinnatum*[11].

Lantana camara

Manual control:

1. Cutting only
2. Cutting and uprooting

Chemical control:

3. Foliar spray of glyphosate – 2 % solution in water (2% of herbicide diluted with 98% of water)
4. Basal bark application of Garlon 4® (triclopyr ester) – 20% solution in diesel (20% of herbicide diluted with 80% of diesel)
5. Cut stump application of triclopyr ester – 20% solution in diesel

Furcraea foetida

Manual control:

1. Cutting and uprooting plants in vegetative state
2. Cutting and uprooting flowering stems

Chemical control:

3. Cut a well in the centre of the whorl and fill with triclopyr ester – 20% solution in diesel
4. Foliar application of triclopyr ester – 20% solution in diesel

Acacia mearnsii

Manual control:

1. "Saplings" (plants below 2.5 cm basal diameter) debarking to the ground
2. "Saplings" (plants below 2.5 cm basal diameter) Cutting and uprooting

Chemical control:

3. "Saplings" (plants below 2.5 cm basal diameter) cut stump application of triclopyr ester – 20% solution in diesel
4. "Young trees" (plants below 5 cm dbh) cut stump application of triclopyr ester – 20% solution in diesel
5. "Young trees" (plants below 5 cm dbh) basal bark application of triclopyr ester – 20% solution in diesel
6. "Older trees" (plants above 5 cm dbh) hack and squirt (600g/L in diesel) – 20% solution in diesel
7. "Older trees" (plants above 5 cm dbh) stem injection – "drill and fill" using triclopyr ester – 20% solution in diesel

Bryophyllum pinnatum

[11] Although is included as a localised high impact species no field trials are being conducted as to optimise management as it is found in very damp areas which makes herbicide application very challenging. Therefore hand weeding is recommended for this species, at least for the foreseeable future.

Manual control:

1. Cutting and uprooting

Chemical control:

2. Foliar spray of glyphosate – 2 % solution in water

Before this work is initiated implementing personnel will need to be trained in invasive plant management for ecosystem restoration (Annex 11).

Figure 22. Illustration of some weed control techniques: 1) Manual removal of foliage; 2) Manual uprooting; 3) Foliar spraying; 4) Foliar spray application to regrowth; 5) Basal bark application; 6) Cut stump application (all photographs courtesy of the Charles Darwin Foundation, Ecuador)

2) Field trials to be undertaken in small plots (up to 4 m x 4 m) to test the efficiency and effectiveness of different control methods. This would be PART TWO of a project to optimise restoration methods. It will be conducted one year after PART ONE is initiated. This should give enough time to monitor and utilise the results of part one in order to choose an integrated management approach.

Methods used should include hand weeding and herbicide use – a combination of methods (informed by the results of the field trials on individual species), i.e. an integrated management approach that uses the most appropriate combination of techniques for the circumstances to balance costs and benefits. Each treatment should be replicated at least four times. Parameters to be monitored will include time and cost of operations and native and invasive plant regeneration. See Annex 7 for examples of monitoring data sheets and templates which can be used to assess such parameters. These field trials will be undertaken in areas infested with Lantana camara only. This information gained re. effectiveness of techniques can be used to inform restoration work in areas invaded by other species. Of course there is not perfect correspondence between *Lantana*-infested areas and, for example areas infested by F. foetida or more than one species, but expanding this trial work for every invasion situation would be highly resource-intensive.

Initiation of a biological control programme for *Lantana camara*
Biological control offers the possibility of sustainable management of *L. camara* over large areas including those that are inaccessible. It is recommended that the following actions are initiated:

- Find out what species (if any) have been introduced to Cape Verde for biological control of *L. camara*
- Collect the insects that are currently feeding on *L. camara* leaves, rear them out as necessary and identify them to species
- Contact the teams working on IP biocontrol in South Africa to initiate a programme for biocontrol on IP in Cape Verde including *L. camara*.

These efforts should constitute part of a national effort to access biological control organisms that have been successfully developed elsewhere. These actions can be conducted at national level by the most appropriate authority and must comply with international guidelines for the export, shipment, import, and release of biological control agents and other beneficial organisms (Annex 8).

Active restoration
All IP management actions can be classified as restoration. The term "active restoration" is used here to refer to a system in which planting is undertaken as well as IP control in order to hasten the recovery of the system to its desired state. Active restoration, like intensive weeding is expensive and the following recommended actions are restricted to an experimental scale for the moment:

Field trials to be undertaken in small plots (up to 4 m x 4 m) to test the efficiency and effectiveness of different restoration methods. Methods used should comprise of weeding only (no active restoration), weeding followed by planting of a fast-growing cover crop to suppress weed regeneration followed by planting of native species, and weeding followed by planning of native species but not cover crops.

The same plots used in part 2 of the field trials to optimise control techniques can be used as control plots for these restoration field trials.

The results should help land managers develop cost-effective restoration techniques for degraded areas. Each treatment should be replicated at least four times. Parameters to be monitored will include time and cost of operations and native and invasive plant regeneration. See Annex 7 for examples of monitoring data sheets and templates which can be used to assess such parameters. Before this work is initiated implementing personnel will need to be trained in invasive plant management for ecosystem restoration (Annex 11).

A possible win-win situation may be to create native hedges close to arable areas to serve as windbreaks, to stabilise soil and to conserve water. The potential of such a "set-aside" scheme will be investigated as part of this plan.

Furcraea foetida

Furcraea foetida is invasive in several countries (see Annex 1 for a detailed species profile). It is very widespread in Planalto Leste where it competes with native species and introduced species of economic importance. *F. foetida* has been widely planted in Cape Verde for erosion control on steep slopes and on the side of roads and tracks. It has also been promoted as a fibre crop but it is not as appreciated as sisal which is easier to work and produces better quality products than *F. foetida*. The woody flowering stems of *F. foetida* are used as poles.

Figure 23. *Furcraea foetida* has invaded many areas in Planalto Leste.

Management recommendations for *F. foetida* in the parks are as follows:

Prevention

As part of the park's awareness raising programme the technical team should raise awareness of the importance of not planting *F. foetida*, for erosion control. It is not advisable to promote sisal (*Agave sisalana*) as an alternative as it can become invasive in the same habitats as *F. foetida*. Alternative species for erosion control could be promoted such as native grasses or other native species with wide-spreading root systems.

Early detection and rapid response

F. foetida will be included in the park-wide programme of surveillance. Responses to new *F. foetida* infestations will be as outlined above for *Lantana camara*. Opportunistic control of small *F. foetida* plants can be particularly useful – they are easy to pull out by hand and they often colonise edges of trails that are excellent habitat for many native plant species. The uprooted plants should be bagged (and left in the bag to rot) or if left in situ placed with the roots upwards to ensure that the plant does not re-establish. For adult plants an effective management method is based on the fact that this plant blooms only once in its lifetime and then dies. Cutting the flowering stem helps prevent a new colonisation by its bulblets in nearby areas. Provided that management is perfectly synchronised with the flowering period, this method allows for a reduction or at least control of the invasion. This provides a method of opportunistically controlling *F. foetida*. The stems are valued as poles so it ought to be possible for local people to cut the stems at no cost, a perfect example of a win-win. This type of action can be encouraged as part of the awareness-raising and communications efforts to be implemented as part of this plan.

Control

F. foetida will be one of the target species in the project to optimise control methods for the individual IP species. Other methods apart from manual weeding will be investigated.

Restoration

Because removal of *F. foetida* from a slope edge increases the risk of soil erosion, it has been suggested that any large plants removed should be replaced by a soil stabilising species. Trial replanting using non-invasive species will be undertaken.

Localised high impact species

Acacia mearnsii

Figure 24. *Acacia mearnsii* (known locally as molísima)

Acacia mearnsii (often known in Cape Verde by the synonym *Acacia mollisima*) has been planted as an agroforestry tree and is used for its wood and its leaves are used as fodder for livestock. It is invasive in many parts of the world and has become invasive in Planalto Leste (see Annex 1 for a detailed species profile).

Recommended management actions

Prevention

As part of the park's awareness raising programme awareness will be raised on the importance of not spreading *A. mearnsii* to new areas but maintaining it in delimited zones demarcated for sustainable use.

Early detection and rapid response

A. mearnsii will be included in the park-wide programme of surveillance. Responses to new *A. mearnsii* infestations will be as outlined above for *Lantana* camara.

Control

A. mearnsii will be one of the target species in the project to optimise control methods for the individual IP species.

Biological control prospects for *A. mearnsii* will be investigated as outlined for *L. camara*.

Bryophyllum pinnatum and *Cyperus papyrus*

Bryophyllum pinnatum (air plant), an introduced ornamental plant, is invasive in many parts of the world and is invasive in in Cova, Paúl and Ribeira da Torre Natural Park. It is particularly troublesome in the humid zones where *Carex* sp. and other rare species are present. *Cyperus papyrus* (papyrus sedge or paper reed) is also invasive in many parts of the world and is invasive in similar humid areas to *B. pinnatum* (see Annex 1 for detailed species profiles).

Figure 25. *Bryophyllum pinnatum* (air plant).

Figure 26. *Cyperus papyrus* which can take over *Carex* sp. habitat

B. pinnatum and *C. papyrus* will be subject to the type of recommended management actions management interventions outlined above for *A. mearnsii*. With the following exceptions:

Prevention

There will be no delimited zones demarcated for sustainable use as these plants are not economically important.

Control

There are not international biological control programmes for *C. papyrus* so biological control prospects will not be investigated for this species.

Species of possible concern

Species that come into this category include those that appear to be spreading in Planalto Leste and in neighbouring locations and those that are known to be invasive elsewhere although they do not appear to be having major impacts in the parks at present. *Arundo donax*, which is widely planted as an agroforestry species in Cova, Paúl and Ribeira da Torre Natural Park, can be classified in this former category while *Grevillea robusta* could be an example of a species in the latter category. A possible driver of the spread of *Arundo donax* is the removal of goats.

Figure 27. *Grevillea robusta* flowers, leaves and branches (left) and *Arundo donax* (right).

Recommended management actions

An inventory of introduced species in the parks should be made and the information entered in a database (see Annex 10). Distribution changes can be noted and management actions recommended if necessary. For example if certain species that are palatable to goats are spreading so that they pose a threat to biodiversity and/or other park management objectives it may be possible to reintroduce goat herbivory in a controlled manner that does not endanger native biodiversity, e.g. tethered grazing.

INVASIVE PLANT MANAGEMENT FOR RARE SPECIES RECOVERY

Isolated very humid locations in Ribeira de Paúl in Santo Antão are the only known locations for the Critically Endangered (sensu IUCN) endemic sedge *Carex antoniensis*. In some of these locations this unique species is threatened by the encroachment of *Cyperus papyrus* (papyrus sedge or paper reed). Regular careful hand weeding of papyrus is recommended as a very cost-effective contribution to saving *C. antoniensis* as part of a species recovery programme. This action should be accompanied by awareness raising activities that would publicise the unique biodiversity of Ribeira de Paúl and the practical action being undertaken to conserve it.

Another very rare endemic species is *Carex paniculata* ssp. *hansenii*. It has a slightly larger distribution (Paul and Ribeira da Torre), similar habitat requirements, and is subject to similar threats in terms of invasive species. The same kind of management and conservation plans for *C. antoniensis* could be applied to this similar species.

Figure 28. *Carex antoniensis*.

CAPACITY BUILDING, AWARENESS RAISING AND COMMUNICATIONS

Park staff and other stakeholders will require capacity building in order to effectively facilitate IP management. A format for a training course in IP management for ecosystem restoration is outlined in Annex 11. Intensive courses such as this, together with expert help in operationalizing this plan, and continued mentoring can be seen as a package that will enable identified park staff to train other key stakeholders from relevant organisations as well as community representatives.

Community buy-in, support and participation are essential for IP management in the parks. This is especially the case in the Cova, Paúl and Ribeira da Torre Natural Park which is the more populated of the two parks. The Training approaches such as that outlined above should help in this regard. Their efficacy can be increased if they are implemented alongside a comprehensive communication and awareness-raising package that will help to harness the community as part of the solution to IP problems in the parks. Activities could include community meetings, media items, field days and volunteer IP management days. Native plant restoration projects implemented under the UNDP-GEF small grants programme are examples of work of this kind that has been successfully undertaken in Cape Verde to date.

The success of the community outreach work will help to establish the extent to which the community will work with the park authorities to undertake restoration work. It will then be possible to produce “restoration scenarios” under “low, medium and high community participation levels” using the data from the vegetation mapping and the field trials which will feed into project indicators.

MONITORING EVALUATION AND REVIEW

Monitoring will include the following:

Baseline and outcome monitoring: Periodic assessments of plant distribution and abundance, and habitat quality to document overall landscape changes and the effectiveness of our management actions. The mapping of *Lantana camara* and *Furcraea foetida* constitutes the beginning of this process. This will be built upon by:

- The mapping exercise to zone the park according to vegetation quality, access and landuse.
- Vegetation surveys in selected accessible areas that are representative of the range of vegetation types in the parks. The exact method used is to be determined but it will most likely be some form of permanent transects or quadrats to be surveyed every 2-3 years. Parameters monitored must be quick and relatively easy to measure and repeatable such as percentage vegetation cover (Annex 7).
- Fixed point photographs which are a very vivid way of recording vegetation changes and are particularly useful for recording changes on steep slopes and cliffs (see Annex 7 for a fixed point photograph datasheet).

Activity and results monitoring:

IP management operations will be monitored to evaluate the efficiency of our methods. Time and motion studies, by logging the time taken for operations, form the basis for estimating the cost of operations – essential information for assessing efficiency and for future planning.

Added to this we need to understand the results our management interventions are having. Monitoring changes in vegetation cover over time in our experimental areas can help us in this respect.

Because of their toxicity it is particularly important to document herbicide application to minimise risks to non-targeted plants and animals, and human health and safety. Annex 7 contains an example of a form used when implementing herbicide treatments and other control methods. This builds upon the guidelines for safe herbicide use outlined in Annex 5.

Monitoring information will be used to modify and improve management priorities, methods and plans (management plans will be modified annually in the light of monitoring results) so it is essential that the information acquired is analysed early and often and reviewed at least annually as an integral part of an adaptive management approach.

IMPLEMENTATION SCHEDULE & RESTORATION INDICATORS

Table 5. Planalto Leste invasive plant management plan implementation schedule **SE- Seguimento Ecológico, CL- Coordenador Local, DC, Desenvolvimento Comunitário, CN- Coordenação Nacional**

Action	Notes	Person days[12]		2012				2013				Coordination Responsibility
		2012	2013	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Finalisation of IP management plan	Iterative production of plan	5	0									SE, CL
Revision of IP management plan	Revision following ToT & annually	5	5									SE, CL
Undertake a species recovery programme for *Carex antoniensis*	Plant exploration, localised weeding and monitoring	20	10									SE, DC
Undertake a species recovery programme for *paniculata* ssp. *Hanseni*		20	10									SE, DC
Zonation of the Parks	Park-wide mapping	40	0									SE
Revise zonation	Use info from ongoing monitoring and management work	0	10									SE
Training of trainers (ToT) in IP management for ecosystem restoration	Involving the whole team for a shared understanding	30	0									CN
Undertake a park-wide IP prevention programme	Mostly surveillance	30	30									SE
Undertake a park-wide early detection and rapid response programme	Time needs will depend finds	30	30									SE
Undertake field trials to optimise control techniques for individuals priority IPs	This included monitoring and data analysis	15	15									SE
Undertake field trials to optimise control and restoration techniques in small plots		0	30									SE
Promote restoration in field edges as part of a set-aside scheme	Mostly community liaison	5	15									SE, DC
Develop an inventory and database for introduced species in the parks	Can be spread through the two years	10	5									SE
Develop and implement a capacity building, awareness-raising and communications programme	With communities and other key stakeholders	20	5									SE, DC
Monitor baseline vegetation change monitoring – transects and fixed point photographs	2012: establish transects and fixed points; 2013 fixed	20	5									

[12] Person day estimates are imprecise. More precise estimates can be derived when the team undergoes the planned training of trainers workshop when a detailed operational plan can be produced. Many activities complement each other e.g. the species recovery programmes and the control and restoration field trials so the demarcations used are somewhat arbitrary.

Action	Notes	Person days [12]		2012				2013				Coordination Responsibility
		2012	2013	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
	points only											
Review monitoring information	2013: Q1 and annually	10	5									SE, CL

Table 6. The development of restoration indicators through the implementation of the IP management plan in Planalto Leste

Area	Indicator
Grade 1 (easy and medium access)	• Rate of change in extent of native versus IP cover documented • Current extent of native vegetation maintained
Grade 1 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented
Grade 2 (easy and medium access)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
Grade 2 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented
Grade 3 (easy and medium access)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
Grade 3 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented
Grade 4 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
Grade 4 (difficult access and inaccessible)	• Rate of change in extent of native versus IP cover documented

MONTE VERDE NATURAL PARK (SÃO VICENTE) – INVASIVE PLANT MANAGEMENT PLAN

SUMMARY

This IP management plan is a contribution to the overall management plan for Monte Verde Natural Park – in São Vicente (in preparation) that seeks to enhance natural, architectural, human and landscape heritage values, with a view to preserving biodiversity, geodiversity and sustainable use of resources. This plan comprises of the following elements:

Management principles that operationalise IP management within the ecosystem approach.
Zonation of the park to prioritise management actions and establish verifiable restoration indicators: Building upon the mapping work undertaken to date, the park will be zoned according to its potential for restoration:

- R1: Substantial restoration possible – remnants of native plant communities, not used for agriculture and accessible
- R2: Mixed use restoration possible - remnants of native plant communities, used for agriculture and accessible
- R3: inaccessible – restoration not possible at present

The zonation to be undertaken, in conjunction with IP control trials, will provide information needed to improve estimates of the extent to which native vegetation can be maintained in different sites in Monte Verde.

The IP strategy will focus on small selected areas within the R1 and R2 zones in the short term. No action can be undertaken in R3 areas at present but in future biological control may offer the possibility of IP management in areas that cannot be practically accessed by people.

All parts of Monte Verde are invaded to some extent so prevention, early detection and rapid response systems are not required for existing IPs. However, such a system will be initiated for IP species that are not currently known from the park to help ensure that new IP problems do not arise.

No systematic IP control has been undertaken in Cape Verde's PAs to date so initial experimental work will be undertaken to assess the efficiency and effectiveness of different control methods and the feasibility of upscaling these methods to larger areas of the park.

Prioritisation of invasive plant species for management: IP Species that threaten ecosystem management goals have been classified into the following categories:

- Widespread high impact species – species that threaten management goals across extensive areas of the park: - *Lantana camara*, *Furcraea foetida* and *Leucaena leucocephala*.
- Localised high impact species – species that threaten management goals across in smaller areas of the park relative to those above: e.g. *Desmanthus virgatus.*
- Species of possible concern – species which do not appear to threaten management goals at present but may do so in the future. None identified so far.

Weed control plans are outlined for each of these groups. Recommended actions range from no treatment to prevention, early detection and rapid response to experimental control and restoration efforts.

Active restoration receives more priority in this plan than in the IP management plans for Parque Natural do Fogo and Planalto Leste because no pristine native vegetation remains in Monte Verde. Restoration approaches will be trialled in Monte Verde and the possibility of initiating restoration actions as part of a set-aside programme and a project in conjunction with CV Telecom will be investigated.

Capacity building, awareness raising and communications. Park staff and other stakeholders will require capacity building in order to effectively facilitate IP management. For this management to be sustainable it is essential that local communities and other stakeholders understand, support and participate in IP management. Capacity building, and communications and awareness raising activities are outlined in this plan.

Monitoring evaluation and review Monitoring will include: periodic assessments of plant distribution and abundance, and habitat quality to document overall landscape changes and the effectiveness of our management actions (baseline and outcomes monitoring); monitoring of IP management operations will help us to evaluate the efficiency of our methods (activity and results monitoring) and documentation of herbicide application will help to minimise risks to non-targeted plants and animals, and human health and safety.

Monitoring information will be used to modify and improve management priorities, methods and plans.

Finally an implementation schedule for IP management actions, together with provisional restoration indicators, is outlined.

INTRODUCTION

The plans for the individual PAs have been kept brief to make them easy to read and understand. However, for a fuller understanding, it is recommended that the reader also looks at the overview and introduction which details the principles that are the foundation of this plan. The annexes can be consulted to provide additional details as required.

Site description (derived from the UNDP GEF Project document)

Monte Verde Natural Park, São Vicente (gazetted area: 312 ha). Almost the entire range of the floral species and communities of São Vicente Island are represented in Monte Verde, which has 34 endemic plant species, one of which exists only on São Vicente, as well as three rare bird species and one rare insect species. Of the 93 plant species identified in the area, 17 are noted as threatened on the Cape Verde Red List. The area is practically uninhabited (< 5 households within the area and no more than 40 around it), but its proximity to Mindelo (the Island's capital) and to other localities puts pressure on resources which is further exacerbated by a lack of access control and management. Threats to the area include land clearance for agriculture and home construction that destroys native plant communities, as well as visitors' impact on native plants, soil and water quality.

Objectives for the protected area

The objectives for Monte Verde have yet to be formalised but they are likely to be similar to those for the Parque Natural do Fogo - to conserve and enhance natural, architectural, human and landscape heritage values, with a view to preserving biodiversity, geodiversity and sustainable use of resources; controlling soil erosion to protect resources and geological landscape; supporting traditional human activities, boosting the economic development and welfare of populations living in harmony with nature conservation (PNF management plan, 2007).

Invasive plants as a threat to protected area objectives

Invasive plants pose a threat to native plant species in Monte Verde which they can out-compete, driving them to rarity and possibly eventual extinction. Other ecosystem impacts of IPs in the park could include habitat degradation for native vertebrates and invertebrates, increased susceptibility to wildfires and reduced water availability. No areas of the park are free of IPs and if no action is taken it is certain that IPs will cause increased impacts, even though existing impacts are already very serious. The most widespread IP species are *Lantana camara* (trepadeira), *Furcraea foetida* (carrapat) and *Leucaena leucocephala* (Leucena/Leucaena). Detailed profiles for the above species can be found in Annex 1.

This plan examines management options for these species within a prioritisation framework for different sites classified according to their restoration potential.

Indicators for the rate of change of native versus IP cover based on available information are provided in this document. These indicators will be refined using the information provided by the implementation of this IP management plan.

Principles of IP management within the ecosystem approach

The “ecosystem approach” - “A resource planning and management approach that recognizes the connections between land, air, water and all living things, including people, their activities and institutions”[13] can be translated into the IP management principles that are the foundation of this plan. These “fundamental principles of IP management within the ecosystem approach” are elaborated in detail in the overview and introduction.

ZONATION OF THE PARK TO PRIORITISE MANAGEMENT ACTIONS AND ESTABLISH VERIFIABLE RESTORATION INDICATORS

IP management is costly, especially in highly invaded areas (Annex 6). It is not possible or practical to control all IP species in all areas of the park at once. It is, therefore, vital to prioritise to help ensure that IP management is cost-effective. The IAS management hierarchy reminds us that for cost-effective IAS management our first priority is prevention; if this is not possible we can detect infestations early and eradicate or contain the infestation; where infestations are larger we may be able to sustainably control, actively restore, mitigate or in some cases do nothing.

Unlike the Parque Natural do Fogo and Planalto Leste (Santo Antão) Monte Verde has no contiguous areas of native vegetation, i.e. all parts of the park are invaded to some extent so

[13] www.mnr.gov.on.ca/en/Business/FW/2ColumnSubPage/STEL02_168425.html

prevention, early detection and rapid response systems are not required for existing IPs (see below for a prevention, early detection and rapid response systems for IP species that are not currently known from the park).

To make informed decisions on management interventions it is necessary to have information on the baseline status of the landscape in question. To date species distribution maps have been produced for *Lantana camara*, *Furcraea foetida* and *Leucaena leucocephala*.

Building upon this work, it is recommended that the park is mapped to establish IP management priorities. This zonation will be based on areas “potential for restoration”. Most of the land on Monte Verde is farmed and even if sufficient resources were available it would not be possible to restore this land to 100% native vegetation. Smaller portions of accessible land (mostly in the upper areas of the park) are not used for agriculture. The area in and around the mobile phone transmission installation run by CV Telecom is a prominent example. These areas have the potential for more extensive restoration. Other areas of Monte Verde cannot be easily restored so may need to be deprioritised at least in the short term. This is true of areas that are very inaccessible. Significant parts of Monte Verde are on steep slopes or cliffs and are for IP management purposes (other than for biological control) impossible to reach.

With the above in mind, the following vegetation zones, according to their potential for restoration, are proposed:

- R1: Substantial restoration possible – remnants of native plant communities, not used for agriculture and accessible
- R2: Mixed use restoration possible - remnants of native plant communities, used for agriculture and accessible
- R3: inaccessible – restoration not possible at present.

For a consideration of how the zonation information will be used to provide information to strengthen restoration indicators see the section on adaptive management.

Data acquisition

The mapping of these zones should be relatively straightforward. It is difficult to estimate resource requirements but an estimate based on the time taken for the previous mapping work is that this will constitute one month’s work for one individual.

Recommended actions

Produce a zonation map for Monte Verde as a basis for prioritising IP management actions. Review the map annually and modify as appropriate. However, a repeat of the comprehensive process whereby the initial map was produced should not be necessary.

PRIORITISATION OF INVASIVE PLANT SPECIES FOR MANAGEMENT

As outlined, *Lantana camara*, *Furcraea foetida* and *Leucaena leucocephala* distributions in Monte Verde have already been mapped (Figure 28). It is estimated that they cover 24.7 ha or 7.9% of the park area. Much of the park area is unvegetated so the figure for the *percentage of vegetation infested by IPs* will be much higher.

The next stage for both these "widespread high impact species" species is management. There may be other IPs that are locally abundant and likely to constitute threats to biodiversity and other ecosystem objectives – "localised high impact species". In addition there are species that are not yet considered to be problematic but may become so in the future – "species of possible concern". Recommended management approaches for species in each of these three categories are outlined below.

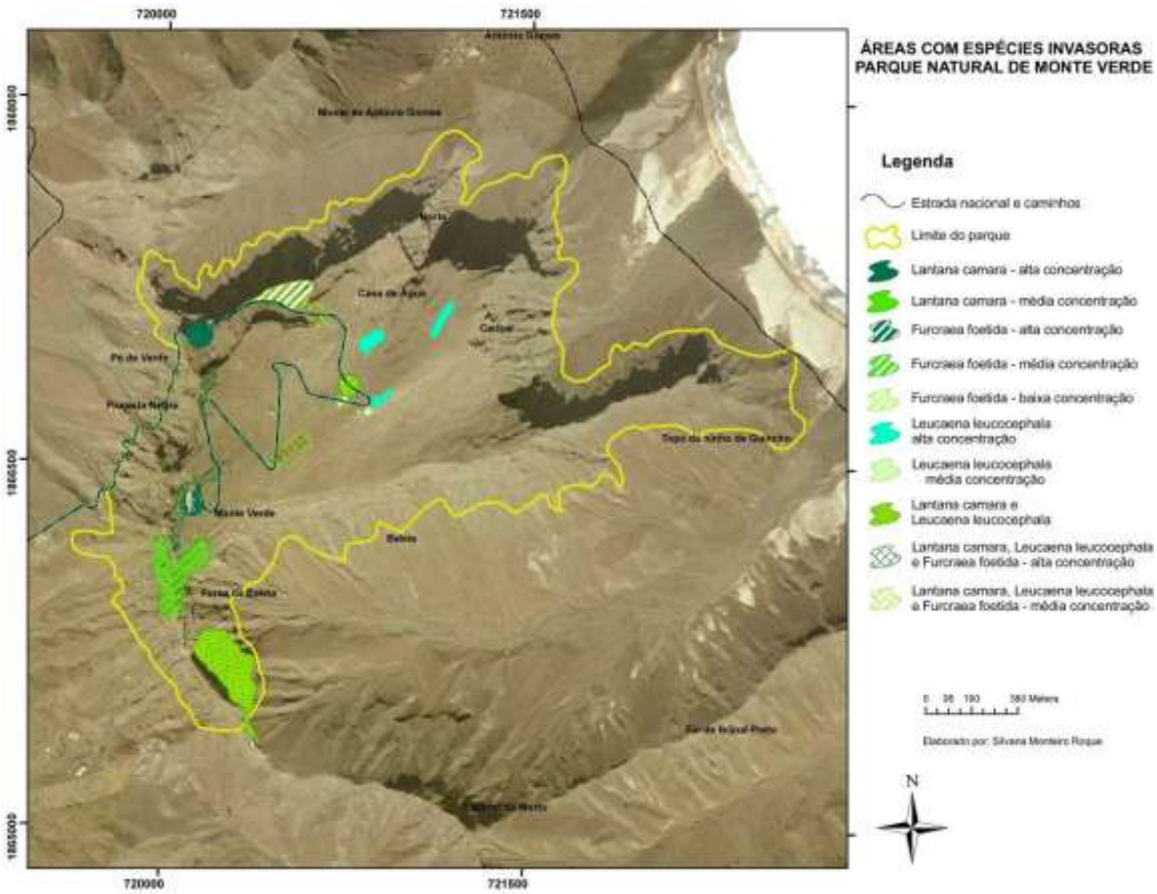

Figure 29. Map of *Lantana camara*, *Furcraea foetida* and *Leucaena leucocephala* distributions in Monte Verde.

Widespread high impact species

Lantana camara

Lantana camara is widely considered to be one of the world's most serious invasive plant species (see Annex 1 for a detailed species profile). It is very widespread in Monte Verde where it competes with native species and introduced species of economic importance.

Management recommendations for *L. camara* in the park are as follows:

Prevention

As part of the park's awareness raising programme the technical team should raise awareness of the importance of not planting *L. camara*.

Control

With limited funding *Lantana camara* control will have to be on a small scale for the foreseeable future pending the refinement of techniques, the initiation of cost-recovery mechanisms or successful biological control efforts. Recommended control measures are outlined as follows:

Figure 30. *Lantana camara* and *Furcraea foetida* at the edge of a field on Monte Verde.

Initiation of field trials to optimise control techniques for *L. camara* among other priority IPs (*F. foetida*, *Leucaena leucocephala* and *Desmanthus virgatus* in São Vicente).

The results of control and restoration trials using different on various species in Fogo and Santo Antão will be used to inform management in São Vicente. In addition, field trials will be conducted using individual plants of *Leucaena leucocephala* in São Vicente. *L. leucocephala* is not a problematic species in any of the protected areas in Fogo and Santo Antão.

This would be PART ONE of a project to optimise restoration methods. The initial treatments are based on practices that have been used successfully elsewhere. Undertaking this work under Cape Verdean conditions will help the implementation teams understand what methods/combination of methods works best under local conditions and help the teams gain practical experience of IP management methods.

Individual plants would be used as replicates with up to 10 replicates per treatment.

L. leucocephala

Manual control:

1. Cutting only
2. Cutting and uprooting

Chemical control:

3. Foliar spray of glyphosate – 2 % solution in water (2% of herbicide diluted with 98% of water)
4. Basal bark application of Garlon 4® (triclopyr ester) – 20% solution in diesel (20% of herbicide diluted with 80% of diesel)
5. Cut stump application of triclopyr ester – 20% solution in diesel

D. virgatus

Manual control:

1. Cutting only
2. Cutting and uprooting

Chemical control:

3. Foliar spray of glyphosate – 2 % solution in water (2% of herbicide diluted with 98% of water)

Figure 31. Illustration of some weed control techniques: 1) Manual removal of foliage; 2) Manual uprooting; 3) Foliar spraying; 4) Foliar spray application to regrowth; 5) Basal bark application; 6) Cut stump application (all photographs courtesy of the Charles Darwin Foundation, Ecuador)

2) Field trials to be undertaken in small plots (up to 4 m x 4 m) to test the efficiency and effectiveness of different control methods. This would be PART TWO of a project to optimise restoration methods. It will be conducted one year after PART ONE is initiated. This should give enough time to monitor and utilise the results of part one in order to choose an integrated management approach.

Methods used should include hand weeding and herbicide use – a combination of methods (informed by the results of the field trials on individual species), i.e. an integrated management approach that uses the most appropriate combination of techniques for the circumstances to balance costs and benefits. Each treatment should be replicated at least four times. Parameters to be monitored will include time and cost of operations and native and invasive plant regeneration. See Annex 7 for examples of monitoring data sheets and templates which can be used to assess such parameters. These field trials will be undertaken in areas infested with Lantana camara only. This information gained regarding the effectiveness of techniques can be used to inform restoration work in areas invaded by other species. Of course there is not perfect correspondence between *Lantana*-infested areas and, for example areas infested by *F. foetida* or more than one species, but expanding this trial work for every invasion situation would be highly resource-intensive.

Initiation of a biological control programme for *Lantana camara*
Biological control offers the possibility of sustainable management of *L. camara* over large areas including those that are inaccessible. It is recommended that the following actions are initiated:

- Find out what species (if any) have been introduced to Cape Verde for biological control of *L. camara*
- Collect the insects that are currently feeding on *L. camara* leaves, rear them out as necessary and identify them to species
- Contact the teams working on IP biocontrol in South Africa to initiate a programme for biocontrol on IP in Cape Verde including *L. camara*.

These efforts should constitute part of a national effort to access biological control organisms that have been successfully developed elsewhere. These actions can be conducted at national level by the most appropriate authority and must comply with international guidelines for the export, shipment, import, and release of biological control agents and other beneficial organisms (Annex 8).

Active restoration
All IP management actions can be classified as restoration. The term "active restoration" is used here to refer to a system in which planting is undertaken as well as IP control in order to hasten the recovery of the system to its desired state. Active restoration, like intensive weeding is expensive and the following recommended actions are restricted to an experimental scale for the moment:

Field trials to be undertaken in small plots (up to 4 m x 4 m) to test the efficiency and effectiveness of different restoration methods. Methods used should comprise of weeding only (no active restoration), weeding followed by planting of a fast-growing cover crop to suppress weed regeneration followed by planting of native species, and weeding followed by planning of native species but not cover crops.

The same plots used in part 2 of the field trials to optimise control techniques can be used as control plots for these restoration field trials.

The results should help land managers develop cost-effective restoration techniques for degraded areas. Each treatment should be replicated at least four times. Parameters to be monitored will include time and cost of operations and native and invasive plant regeneration. See Annex 7 for examples of monitoring data sheets and templates which can be used to assess such parameters. Before this work is initiated implementing personnel will need to be trained in invasive plant management for ecosystem restoration (Annex 11).

A possible win-win situation may be to create native hedges close to arable areas to serve as windbreaks, to stabilise soil and to conserve water. The potential of such a "set-aside" scheme will be investigated as part of this plan. This process could be pioneered with receptive landowners and later replicated more widely if successful.

Another possible win-win situation which will be investigated is a collaborative restoration project with CV Telecom using the land in and around the telecommunications installation as the restoration area. CV Telecom has a disused nursery on site with access to a water supply. This could be used for raising native plants to be used in restoration planting. The exact nature of such a scheme would need to be elaborated but it has great potential.

Figure 32. Disused nursery at the CV Telecom facility in Monte Verde.

Furcraea foetida

Furcraea foetida is invasive in several countries (see Annex 1 for a detailed species profile). It is very widespread in Monte Verde where it competes with native species and introduced species of economic importance. *F. foetida* has been widely planted in Cape Verde for erosion control on steep slopes and on the side of roads and tracks. It has also been promoted as a fibre crop but it is not as appreciated as sisal which is easier to work and produces better quality products than *F. foetida*. The woody flowering stems of *F. foetida* are used as poles.

Figure 33. *Furcraea foetida* at the edge of a field on Monte Verde.

Management recommendations for *F. foetida* in the park are as follows:

Prevention

As part of the park's awareness raising programme the technical team should raise awareness of the importance of not planting *F. foetida*, for erosion control. It is not advisable to promote sisal (*Agave sisalana*) as an alternative as it can become invasive in the same habitats as *F. foetida*. Alternative species for erosion control could be promoted such as native grasses or other native species with wide-spreading root systems.

Early detection and rapid response

Opportunistic control of small *F. foetida* plants can be particularly useful – they are easy to pull out by hand and they often colonise edges of trails that are excellent habitat for many native plant species. The uprooted plants should be bagged (and left in the bag to rot) or if left in situ placed with the roots upwards to ensure that the plant does not re-establish. For adult plants an effective management method is based on the fact that this plant blooms only once in its lifetime and then dies. Cutting the flowering stem helps prevent a new colonisation by its bulblets in nearby areas. Provided that management is perfectly synchronised with the flowering period, this method allows for a reduction or at least control of the invasion. This provides a method of opportunistically controlling *F. foetida*. The stems are valued as poles so it ought to be possible for local people to cut the stems at no cost, a perfect example of a win-win. This type of action can be encouraged as part of the awareness-raising and communications efforts to be implemented as part of this plan.

Control

F. foetida will be one of the target species in the project to optimise control methods for the individual IP species. Other methods apart from manual weeding will be investigated.

Restoration

Because removal of *F. foetida* from a slope edge increases the risk of soil erosion, it has been suggested that any large plants removed should be replaced by a soil stabilising species. Trial replanting using non-invasive species will be undertaken. *F. foetida* management will be part of the active restoration work (field trials, initiation of a set-aside scheme and the potential restoration around CV Telecom) that will be undertaken in Monte Verde.

Leucaena leucocephala

Leucaena leucocephala has been planted as an agroforestry tree and is used for its wood and its leaves are used as fodder for livestock. It is invasive in many parts of the world and has become invasive in Monte Verde (see Annex 1 for a detailed species profile).

Figure 34. *Leucaena leucocephala* and *Furcraea foetida* at the edge of a field on Monte Verde.

Recommended management actions

Prevention

As part of the park's awareness raising programme awareness will be raised on the importance of not spreading *L. leucocephala* to new areas.

Control

L. leucocephala will be one of the target species in the project to optimise control methods for the individual IP species.

Biological control prospects for *L. leucocephala* will be investigated as outlined for *L. camara*.

Restoration

L. leucocephala management will be part of the active restoration work (field trials, initiation of a set-aside scheme and the potential restoration around CV Telecom) that will be undertaken in Monte Verde.

Localised high impact species

Desmanthus virgatus

Figure 35. *Desmanthus virgatus* ©W.J. Hayden

Mapping

The distribution of *Desmanthus virgatus* in Monte Verde will be mapped.

Control

D. virgatus will be one of the target species in the project to optimise control methods for the individual IP species.

Biological control prospects for *D. virgatus* will be investigated as outlined for *L. camara*.

Restoration

D. virgatus management will be part of the active restoration work (field trials, initiation of a set-aside scheme and the potential restoration around CV Telecom) that will be undertaken in Monte Verde.

Species of possible concern

No species of possible concern have been identified so far for Monte Verde. However, if such species are identified through surveillance activities appropriate management actions will be recommended.

Recommended management actions

An inventory of introduced species in the park should be made and the information entered in a database (see Annex 10). Distribution changes can be noted and management actions recommended if necessary. For example if certain species that are palatable to goats are spreading so that they pose a threat to biodiversity and/or other park management objectives it may be possible to reintroduce goat herbivory in a controlled manner that does not endanger native biodiversity, e.g. tethered grazing.

CAPACITY BUILDING, AWARENESS RAISING AND COMMUNICATIONS

Park staff and other stakeholders will require capacity building in order to effectively facilitate IP management. A format for a training course in IP management for ecosystem restoration is outlined in Annex 11. Intensive courses such as this, together with expert help in operationalizing this plan, and continued mentoring can be seen as a package that will enable identified park staff to train other key stakeholders from relevant organisations as well as community representatives.

Community buy-in, support and participation is essential for IP management in Monte Verde to be sustainable. The Training approaches such as that outlined above should help in this regard. Their efficacy can be increased if they are implemented alongside a comprehensive communication and awareness-raising package that will help to harness the community as part of the solution to IP problems in the park. Activities could include community meetings, media items, field days and volunteer IP management days. Native plant restoration projects implemented under the UNDP-GEF small grants programme are examples of work of this kind that has been successfully undertaken in Cape Verde to date.

The success of the community outreach work will help to establish the extent to which the community will work with the park authorities to undertake restoration work. It will then be possible to produce "restoration scenarios" under "low, medium and high community participation levels" using the data from the vegetation mapping and the field trials which will feed into project indicators.

MONITORING EVALUATION AND REVIEW

Monitoring will include the following:

Baseline and outcome monitoring: Periodic assessments of plant distribution and abundance, and habitat quality to document overall landscape changes and the effectiveness of our management actions. The mapping of *Lantana camara, Furcraea foetida* and *Leucaena leucocephala* constitutes the beginning of this process. This will be built upon by:

- The mapping exercise to zone the park according to its potential for restoration.
- Vegetation surveys in selected accessible areas that are representative of the range of vegetation types in the park. The exact method used is to be determined but it will most likely be some form of permanent transects or quadrats to be surveyed every 2-3 years. Parameters monitored must be quick and relatively easy to measure and repeatable such as percentage vegetation cover (Annex 7).

- Fixed point photographs which are a very vivid way of recording vegetation changes and are particularly useful for recording changes on steep slopes and cliffs (see Annex 7 for a fixed point photograph datasheet).

Activity and results monitoring:
IP management operations will be monitored to evaluate the efficiency of our methods. Time and motion studies, by logging the time taken for operations, form the basis for estimating the cost of operations – essential information for assessing efficiency and for future planning.

Added to this we need to understand the results our management interventions are having. Monitoring changes in vegetation cover over time in our experimental areas can help us in this respect.

Because of their toxicity it is particularly important to document herbicide application to minimise risks to non-targeted plants and animals, and human health and safety. Annex 7 contains an example of a form used when implementing herbicide treatments and other control methods. This builds upon the guidelines for safe herbicide use outlined in Annex 5.

Monitoring information will be used to modify and improve management priorities, methods and plans (management plans will be modified annually in the light of monitoring results) so it is essential that the information acquired is analysed early and often and reviewed at least annually as an integral part of an adaptive management approach.

IMPLEMENTATION SCHEDULE & RESTORATION INDICATORS

Table 7. Monte Verde invasive plant management plan implementation schedule **SE-Seguimento Ecológico, CL- Coordenador Local, DC, Desenvolvimento Comunitário, CN-Coordenação Nacional**

Action	Notes	Person days[14]		2012				2013				Coordination Responsibility
		2012	2013	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Finalisation of IP management plan	Iterative production of plan	5	0		■							SE, CL
Revision of IP management plan	Revision following ToT & annually	5	5			■				■		SE, CL
Zonation of the Park	Park-wide mapping	15	0			■	■					SE
Revise zonation	Use info from ongoing monitoring and management work	0	5							■		SE
Training of trainers (ToT) in IP management for ecosystem restoration	Involving the whole team for a shared understanding	20	0			■						CN
Undertake a park-wide IP prevention programme	Mostly surveillance	10	10					■	■	■	■	SE
Undertake a park-wide early detection and rapid response programme	Time needs will depend finds	10	10					■	■	■	■	SE
Undertake field trials to optimise control techniques for individuals priority IPs	This included monitoring and data analysis	5	5			■	■	■	■			SE
Undertake field trials to optimise control and restoration techniques in small plots		0	30							■	■	SE
Promote restoration in field edges as part of a set-aside scheme	Mostly community liaison	5	15					■	■	■	■	SE, DC
Promote a restoration project with CV Telecom	Mostly community liaison	15	15			■	■	■	■	■	■	CL, SE, DC
Develop an inventory and database for introduced species in the park	Can be spread through the two years	5	5			■	■	■	■	■	■	SE

[14] Person day estimates are imprecise. More precise estimates can be derived when the team undergoes the planned training of trainers workshop when a detailed operational plan can be produced. Many activities complement each other e.g. the species recovery programmes and the control and restoration field trials so the demarcations used are somewhat arbitrary.

Action	Notes	Person days[14]		2012				2013				Coordination Responsibility
		2012	2013	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Develop and implement a capacity building, awareness-raising and communications programme	With communities and other key stakeholders	20	10				■	■	■	■	■	SE, DC
Monitor baseline vegetation change monitoring – transects and fixed point photographs	2012: establish transects and fixed points; 2013 fixed points only	10	5				■	■	■	■	■	SE
Review monitoring information	2013: Q1 and annually	10	10					■		■		SE

Table 8. The development of restoration indicators through the implementation of the IP management plan in Monte Verde

Area	Indicator
R1 (substantial restoration possible)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work
R2 (mixed use restoration possible)	• Rate of change in extent of native versus IP cover documented • Target for rate of change of native versus IP cover established based on the results of: mapping: IP control trials; and community outreach work • Target for extent of community native hedge planting established based on the results of IP control trials and results of community outreach work
R3 (inaccessible – restoration not possible at present)	• Rate of change in extent of native versus IP cover documented

ANNEXES

Annex 1. Species profiles for major plant invaders in protected areas in Fogo, Santo Antão and São Vicente.

Acacia mearnsii (Black Wattle)

Scientific name

Acacia mearnsii De Wild.

Synonyms

Acacia decurrens Willd. var. *mollis* Lindl; *Acacia mollissima* hort. ex Willd. (in Cape Verde many people know this species by the name *Acacia mollissima*)

Common names

Black wattle, late black wattle, tan wattle, molísima

Family

Fabaceae (Leguminosae): sub-family Mimosoideae

Origin

Native to large parts of south-eastern Australia and Tasmania.

Naturalised distribution (global)

Locations in which *Acacia mearnsii* is naturalised include Australia (outside its native range), China, Japan, Taiwan, India, Israel, southern Europe, southern Africa, Madagascar, New Zealand, south-western USA and some oceanic islands with warm climates.

Introduced, naturalised or invasive in Fogo, Santo Antão and São Vicente

Acacia mearnsii is invasive in parts of Fogo and Santo Antão where it has escaped from planted areas. It suppresses most other species in dense infestations.

Habitat

Common in moist soil types of grassland, forest edges and gaps, road sides and riparian zones (banks of watercourses) and savanna.

Description

Acacia mearnsii is a round or shapeless tree growing to 15 m in height. It is an unarmed, evergreen tree with shallowly ridged branchlets. All parts are finely hairy. The trunk often bends when trees are grown outside plantations. The bark is smooth, grey, becoming black and fissured; and splits to give a resinous gum.

Its dark dull olive-green leaflets are twice-compound (bipinnate), and each part of the compound leaf (leaflet) is extremely small (less than 4 mm long) and covered in fine hairs. These leaflets are densely packed together. Raised glands occur at and between the junctions of pinnae pairs.

The flowers are cream-coloured or pale yellow, fragrant and occur in small spherical heads. The pod is straight or twisted, dark brown when ripe, up to 10cm long with 3 to 12 joints between the seeds.

Reproduction and dispersal

Acacia mearnsii produces many seeds that are potentially dispersed by birds or rodents, in mud on people and domestic animals, in contaminated soil and by water. It also sprouts profusely from root suckers, particularly when the roots are damaged, and readily coppices from damaged stems. The seeds can last for decades in the soil and their germination is stimulated by fire.

Economic and other uses

Acacia mearnsii is a fast growing but short-lived tree with hard, strong wood useful for fuelwood, poles, fencing posts and tool handles. It can also be used for wood chips – large quantities are exported from South Africa and used in the manufacture of chipboard, etc. It is suitable for bee forage and the bark is used in the tanning process and in the production of gum. It is widely cultivated in many parts of the temperate world, as an ornamental and agro-forestry tree, and readily escapes from these plantings. *A. mearnsii* was introduced to Cape Verde for its tannin-rich bark, for use as fuel wood and as a fodder crop, soil stabilisation and fog capture.

Environmental and other impacts

Acacia mearnsii is capable of invading native vegetation. The species suppresses undergrowth and therefore it is not suitable for use in areas which are vulnerable to erosion. It limits the establishment, regeneration or restoration of indigenous species and pastures. *A. mearnsii* is very water-demanding and is known to pose a serious threat to water resources in some countries and has a significant impact on biodiversity.

A. mearnsii is regarded as an environmental weed in many parts of the world. It has been nominated as among 100 of the "World's Worst" invaders by the IUCN Invasive Species Specialist Group and it has been listed as a noxious weed in Hawaii and as a Category 2 invader in South Africa (invaders with certain qualities, e.g. commercial use or for woodlots, animal fodder, soil stabilisation, etc. These plants are allowed in certain areas under controlled conditions).

Management

The precise management measures adopted for any plant invasion will depend upon many factors such as the terrain, the cost and availability of labour, the severity of the infestation and the presence of other invasive species. Some components of an integrated management approach are introduced below.

The best form of invasive species management is prevention. *Acacia mearnsii* should not be used in intercropping systems (despite its nitrogenising benefits) as it competes with the other plants for nutrients and light.

If prevention is no longer possible, it is best to treat the weed infestations when they are small to prevent them from establishing (early detection and rapid response). Controlling the weed before it seeds will reduce future problems. Control is generally best applied to the least infested areas before dense infestations are tackled.

A. mearnsii seeds are very long-lived so decades of follow-up work is required for sustainable management.

Cultural Control

Utilisation
In the south-western Uganda highlands *A. mearnsii* is managed and controlled from excessive spread from woodlots through harvesting the young saplings for both firewood and trellises for climbing beans. In addition, the bark from the saplings and poles is removed and used in hut and granary construction as it is very tough while the mature poles are highly prized in hut construction as they are quite durable in the ground. It is also a high quality fuel wood both as firewood and charcoal. The heavy harvesting controls its aggressive spread (D.L.N. Hafashimana pers. Comm). *A. mearnsii* is also used by local communities in Cape Verde for firewood, poles for simple construction (corrals, terrace covers, etc.), firewood, tool handles, also as mediocre fodder. Competitive cover crops can be planted in cleared areas to reduce regeneration (Bromilow 2001). *Acacia albida* (*Espinheiro-branco*) and *Sideroxylon marginata* (Marmulano) are two Cape Verde native species that are endangered and can be used in reforestation. Other possible species to use are the grasses (Perennial- *Cynodon dactylon*; Annual- *Brachypodium distachyon*), and some endemic shrubs (e.g. *Lotus latifolia*)

Manual and Mechanical Control
Seedlings and smaller saplings can be pulled out by hand when the soil is damp but care must be taken to remove the roots as *A. mearnsii* can resprout from its roots. Larger saplings may have to be dug out. Debarking the young trees to the ground (girdling) kills them off without coppicing (D.L.N. Hafashimana pers. comm.).

Chemical Control
When using any herbicide always read the label first and follow all instructions and safety requirements. If in doubt consult an expert. Seedlings and young trees can be sprayed with glyphosate while adult trees require other treatments.

A variety of chemical treatment agents and techniques are described by Motooka et al. 2003 (paraphrased from PIER 2010).

Saplings are sensitive to foliar applications of triclopyr (Garlon®, Remedy®).

Dicamba, glyphosate and picloram applied to cut-surface are effective, triclopyr probably effective, although applications to drilled holes in larger trees is probably necessary.

Cut-surface (notching) applications of picloram provided complete control, glyphosate and dicamba caused 80% control, and 2,4-D was inadequate at Kala'e, Molokai. Alton Arakaki (University of Hawaii) and Ed Misaki of the Nature Conservancy (TNC) confirmed the efficacy of picloram but got much better results with glyphosate and dicamba, each resulting in over 90% control at Kamakou Preserve.

Basal bark and stump bark treatments with 2,4-D or triclopyr are effective. Pat Bily (TNC) reported that basal bark applications with triclopyr ester at 20% in oil was effective, as was cut stump application of triclopyr amine at 50% in water. Hawaii Volcanoes National Park (HAVO) staff got good control with triclopyr amine at 10% in water applied to cut stumps (Chris Zimmer, HAVO). Anecdotes indicate that wattle is sensitive to basal bark treatment with diesel alone.

Any regrowth must be treated with herbicide.

Biological Control

In South Africa both seed feeding insects and a mycoherbicide are used to control *A. mearnsii* (Henderson 2001) - the seed weevil *Melanterius maculatus* and a native South African fungus *Cylindrobasidium laeve* that attacks damaged trees has been developed into a mycoherbicide and can be applied to cut stumps to prevent resprouting. A Cecidomyiidae gall midge that inhibits reproduction of *Acacia* species can prevent fruit formation (and thus reproduction) without affecting vegetative growth has recently been released in South Africa.

Legislation

Cape Verde has no noxious weed legislation.

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Cuscuta spp. (Dodder)

Scientific names

Various species of dodder attack crops and other plants. These include the following: *Cuscuta campestris* Yunck. *C. epilinum* Weihe, *C. epithymum* Murray, and *C. gronovii* Willd. Ex Schult.

Common names

Dodder has several common names, among them tangle gut, love vine, strangle gut, devil's gut, witches shoelaces, gold thread, pull down, devil's ringlet, hellbind, hair weed, devil's hair and angel hair. The various species of dodder also have common names, among them field dodder (*Cuscuta campetris*), flax dodder (*C. epilinum*), clover dodder (*C. epithymum*) and swamp dodder (*C. gronovii*).

Family

Convolvulaceae (formerly belonged to Cuscutaceae)

Origin

The native range of dodder is obscure but various species are likely to have originated from Europe, America and the Mediterranean region.

Naturalised distribution (global)

Dodder has become most commonly naturalised in temperate and subtropical regions and least abundant in the tropics of Central America, Africa, South-East Asia and the Pacific Ocean.

Introduced, naturalised or invasive in Fogo, Santo Antão and São Vicente

Dodder is invasive in parts of the Parque Natural do Fogo where it can be found parasitising native species such as tortolho (*Euphorbia tuckeyana*), *Lotus* sp. and *Satureja forbesii* as well as cultivated plants such as grape vines and valued introduced plants such as *Ricinus communis* (castor oil). It is not known to be invasive in Santo Antão and São Vicente but it has been collected in Santo Antão outside of the park limits from 1984, and the Checklist of Biodiversity of Cape Verde (Arechavaleta et al. 2005) lists *Cuscuta umbellata* as present on Santo Antão and São Vicente.

Habitat

Dodder attacks a wide range of naturalised species and native plants that are growing in grasslands, open woodlands, coastal vine thickets, gardens, degraded land, riparian zones (banks of watercourses) and wetlands.

Description

Dodder is a very distinctive annual stem parasitic plant with slender, leafless, thread-like, yellow to orange much-branched vines that coil about and fasten to their host plants with wort-like attachments called haustoria - a specialised root-like sucker which penetrates another plant (a host) and obtains water and nutrients from it. The seedling has only a rudimentary root for anchorage. The root and shoot below this initial attachment soon die, leaving no direct contact with the soil. Though it lacks normal roots and leaves, dodder does bear flowers and fruits.

Cuscuta campestris, one of the most common species of dodder, has stems that are thread-like, yellow or pinkish-yellow in colour, are much branched and grow to 0.8 mm in width. The stems entwine themselves around host-plants, with the help of haustoria.

C. campestris flowers are white or greenish, aggregated in groups of 3-8 in spreading inflorescences, cymose (flat-topped or convex flower cluster in which the uppermost flowers open first). Corolla is 2-2.5 mm long, bell-shaped. Calyx is 1.5-2 mm long, hemispherical. Flowers have 4-5 sepals which are united at base.

The fruit is a light-brown, 2-4-seeded boll. Seeds are oval, light-brown or brownish, to 1.25-2.5 mm long, 1-1.5 mm wide.

Reproduction and dispersal

Dodder seeds are dispersed by wind, water, birds, other animals, and by people on their footwear, clothing and tools and on planting material contaminated by dodder seeds. A major means of dispersal at a local scale is plant fragments that are carried by people (especially children) because of their bright colour and appeal and later throw them on other vegetation where they attach very fast and send their haustoria into their vascular systems.

Dodder seeds can remain viable in the field for several years. They germinate under relatively high temperatures and are initially be dependent upon the food stored within the seed. The dodder plant will die if it does not attach to a suitable host plant within several days after germination (before the food in the cotyledons is finished) since it cannot produce the food necessary to sustain its growth. The stem of the dodder plant entwines itself about the host plant and penetrates the host plant by means of haustoria. Once a dodder plant has attached to the host plant, the part of the dodder stem between the point of attachment and the soil dies. The dodder plant is then totally dependent upon the host plant for its food, inorganic salts and water. Consequently, although typically not killed, the host plant has less food for its own growth, loses vigour and sustains physical damage from the penetration of the dodder. Once a crop field is infected, the dodder problem can be expected each year for many years as it is a very difficult pest to eradicate.

Similar species

Dodder is very distinctive and it is unlikely to be confused with other plant species.

Economic and other uses

Dodder species are frequently used as a research tool, to create a bridge between different plants for transmission of diseases from one host to another. It also has medicinal properties. However, these uses cannot compensate for this plant's overall negative impacts.

Environmental and other impacts

Dodder is a parasite of a wide range of herbaceous plants. It can be a serious weed when broad leaved crops are grown as perennials (e.g. lucerne, clovers, citrus and sugar beet).
It causes damage by absorbing food material from the host plant. The dense mat of stems it

produces can also entangle the host and cause shading of the ground vegetation layer. Although it may not kill the host plant, dodder can severely weaken its host which makes them more vulnerable to pest and disease attacks. *C. campestris* has been listed as a noxious weed in South Africa (prohibited plants that must be controlled. They serve no economic purpose and possess characteristics that are harmful to humans, animals or the environment), Hawaii and most Australian states.

Management

The precise management measures adopted for any plant invasion will depend upon factors such as the terrain, the cost and availability of labour, the severity of the infestation and the presence of other invasive species. Some components of an integrated management approach are introduced below.

The best form of invasive species management is prevention. If prevention is no longer possible, it is best to treat the weed infestations when they are small to prevent them from establishing (early detection and rapid response). Controlling the weed before it seeds will reduce future problems. Control is generally best applied to the least infested areas before dense infestations are tackled. Consistent follow-up work is required for sustainable management.

Dodder is a difficult plant to control because of the unique parasitic qualities and prolific growth seed production.

Cultural control

Farming practices

In agricultural systems dodder can be controlled by planting uncontaminated crop seeds. Rotation with non-susceptible crops such as cereals can be helpful. It is important to control dodder on vegetation along road sides, boundary-strips and waste lands to remove sources of infestion.

Fire

Scattered infestations can be controlled using fire (spot-burning or flaming), for example, hand-held propane weed burners (flaming). The spot-burning must destroy the invaded tissue of host plants along with the dodder to prevent regeneration of the dodder from haustoria embedded in the host. More extensive infestations can also sometimes treated with a controlled burn. It is essential to follow safety protocols when working with fire. Spot burners are readily available in UK at a price of about £30.

Manual and Mechanical Control

In agricultural and natural habitats hand-pulling is suitable only for scattered infestations as the infested plants have to be removed with the parasite. This may involve cutting the host plant below the point at which the dodder is attached and removing the dodder. Before or after crop establishment, young seedlings are readily destroyed by shallow tillage (mechanical soil preparation, e.g. by digging, stirring, and overturning using machinery or hand tools such as shovels, pick axes, mattocks, hoes or rakes). Close mowing is an alternative means of control in lucerne and clovers.

Care must be taken to dispose of the weeded material in such a way that it does not form a new source of infestation. If no host plants are present the removed dodder plants can be left on the soil surface to dry and die as long as the dodder has not set seed. However, if the freshly removed dodder is allowed to contact a healthy host plant, new connections sometimes occur. If the dodder plants have set seed, remove the plants from the area to prevent future infestations. Plants can be sealed in a plastic bag, and disposed of. Alternatively the plants can be burned in a controlled manner. Burning kills only some of the dodder seed so it is best to gather up the ash, seal it in a plastic bag and dispose of it.

Chemical Control

When using any herbicide always read the label first and follow all instructions and safety requirements. If in doubt consult an expert.

Controlling dodder directly with chemical herbicides is difficult because herbicides are only effective against dodder when applied during a limited period of the plant's growth cycle prior to its attachment to the host plant.

Herbicide sprays, however, can be used on the dodder and its host. The dead plant can then be burned. This can be useful as a means of controlling scattered infestations.

Biological Control

Attempts have been made to control different dodder species with introduced insects and pathogens with varied success.

Legislation

Cape Verde has no noxious weed legislation.

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Furcraea foetida (Carrapat)

Scientific name

Furcraea foetida (L.) Haw

Synonyms

Agave foetida L. , *Agave gigantea* D. Dietr, *Furcraea gigantea* Vent. , *Furcraea gigantea* Vent. var. *willemetiana* Roem.

Common names

Carrapat, carrapato, piteira-de-cabo-verde, giant cabuya, green aloe, Mauritian hemp.

Family

Agavaceae

Origin

Native to the Greater Antilles, and from Guadeloupe south through northern South America to Brazil.

Naturalised distribution (global)

Locations within which *Furcraea foetida* is naturalised include USA, China and many oceanic islands with warm climates.

Introduced, naturalised or invasive in Fogo, Santo Antão and São Vicente

Furcraea foetida is invasive in Fogo, Santo Antão and São Vicente. It is found at a range of higher altitudes from 300 - 1600 m altitude in Santo Antão and 300 - 750 m in São Vicente. It is especially common on escarpments and cliffs. It suppresses most other species in dense infestations.

Habitat

A very troublesome weed of dry forests, agricultural areas, scrubland, disturbed habitats and slopes in tropical and subtropical regions. *Furcraea foetida* grows best in full sun but can grow in partial but not heavy shade.

Description

Furcraea foetida is a succulent with shiny light green leaves densely arranged in a rosette at the base of the plant. The rigid, straight or curved pointed leaves, which are usually about 1-2 m long and 14-20 cm wide on adult plants, usually have some prickles along their margins, mainly towards the base. After several years the plant produces a somewhat woody 4-12 m long flowering stem. Its whitish or greenish-white flowers are borne in a drooping position and strongly fragrant. These develop into numerous plantlets (bulblets or bulbils) on the branches of its flower clusters.

Reproduction and dispersal

The inflorescence produces bulblets rather than seeds that are dispersed locally, forming dense monotypic thickets. The only known natural means of dispersal is gravity which can be very effective on steep slopes. *Furcraea* blooms only once in its lifetime, after which it dies.

Similar species

Furcraea foetida can be confused with sisal (*Agave sisalana*) from which can be distinguished as follows:

- *A. sisalana* has relatively large dark green or greyish-green leaves that are usually 0.5-1.3 m long on adult plants. These leaves do not have any prickles on their margins.
- The flowers of *A. sisalana* are borne in an upright position and are yellow or yellowish-green in colour.

Economic and Other uses

Furcraea foetida has been widely planted in Cape Verde for erosion control on steep slopes and on the side of roads and tracks. It has also been promoted as a fibre crop but it is not as appreciated as sisal which is easier to work and produces better quality products than *Furcraea*. The woody flowering stems of *Furcraea* are used as poles.

Environmental and other impacts

- *Furcraea foetida* constitutes a major threat to native biodiversity. *Furcraea foetida* grows very fast in suitable sites. It spreads from the mother plant to form dense thickets that become unusable and inaccessible with most other vegetation replaced.
- *Furcraea* can also very effectively establish itself down slope from mother plants from its bulblets which are spread by gravity. In this way it colonises cliff sites where it is often found in dense colonies.
- *Furcraea* can take over trails and the woody stems can fall and block roads and paths.
- *Furcraea* is an environmental weed in many parts of the world. *Furcraea* is among 35 invasive species that have been declared as "species that threaten biodiversity" in several Pacific islands. As such, it is subject to a ban on new imports, propagation, planting and transfer from one island to another of any whole plant, fragment, cutting, fruit or seed. Its destruction is permitted.

Management

The precise management measures adopted for any plant invasion will depend upon factors such as the terrain, the cost and availability of labour, the severity of the infestation and the presence of other invasive species. Some components of an integrated management approach are introduced below.

The best form of invasive species management is prevention. If prevention is no longer possible, it is best to treat the weed infestations when they are small to prevent them from establishing (early detection and rapid response). Controlling the weed before it seeds will reduce future problems. Control is generally best applied to the least infested areas before dense infestations are tackled. Consistent follow-up work is required for sustainable management.

Cultural Control

Grazing by goats can be an effective method of control for smaller plants but this does not work for larger plants. Cattle do not usually eat this species. It is not collected for fodder in Cape Verde.

Manual and Mechanical Control

Small plants can be easily pulled out by hand, which can be a very effective way of controlling small isolated infestations. The uprooted plants should be bagged (and left in the bag to rot) or if left in situ placed with the roots upwards to ensure that the plant does not re-establish. For adult plants an effective management method is based on the fact that this plant blooms only once in its lifetime and then dies. Cutting the flowering stem helps prevent a new colonisation by its bulblets in nearby areas. Provided that management is perfectly synchronised with the flowering period, this method allows for a reduction or at least control of the invasion (Hivert, 2003).

Chemical Control

When using any herbicide always read the label first and follow all instructions and safety requirements. If in doubt consult an expert.

Furcraea foetida, with its waxy leaves, can resist aqueous sprays of glyphosate, hexazinone, and triclopyr and to soil applications of hexazinone. It is susceptible to foliar sprays of 2,4-D in diesel and very sensitive to foliar sprays of triclopyr in diesel or in crop oil (paraffin-based petroleum oil).

Biological Control

The editor is not aware of a biological control programme for this species.

Legislation

Cape Verde has no noxious weed legislation.

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Jacaranda mimosifolia (Jacaranda)

Scientific name

Jacaranda mimosifolia D. Don

Synonyms

Jacaranda chelonia Grisb.; *J. ovalifolia* R. Br.

Common names

Jacaranda, fern tree

Family

Bignoniaceae

Origin

Native to South America (southern Bolivia and north-western Argentina).

Naturalised distribution (global)

Locations within which *Jacaranda mimosifolia* is naturalised include the warmer parts of eastern Australia, southern Africa, Hawaii, south-eastern USA and outside its native range in southern South America.

Introduced, naturalised or invasive in Fogo, Santo Antão and São Vicente

Jacaranda mimosifolia is invasive in parts of Fogo where it has escaped from planted areas. It suppresses most other species in dense infestations. It is not considered to be an invasive species in Santo Antão and São Vicente though it occasionally reproduces naturally at non-in Santo Antão.

Habitat

Jacaranda mimosifolia can grow in bushland, grassland, wooded ravines and riverbanks. The spreading growth habit and the dense foliage shade out native plants and prevent their regeneration.

Description

Deciduous or evergreen tree, 5-15 m tall. Its main distinguishing feature is its spectacular lavender blue blooms which has led to its popularity as an ornamental tree. *Jacaranda mimosifolia* is fast growing and resprouts easily if damaged.

Its bark is thin and grey-brown in colour, smooth when the tree is young though it eventually becomes finely scaly. The twigs are slender and slightly zigzag; they are a light reddish-brown in colour. Twice-pinnately compound leaves, up to 45 cm long.

Its flowers are beautiful, lavender blue, tubular, 2.5 cm long, appear in dense 15 - 25 cm terminal clusters with often the entire tree in flower and later the ground turning blue as the flowers fall off. It fruit is a round, flat, reddish brown, woody capsule, 4 - 5 cm in diameter containing numerous small winged seeds.

Economic and other uses

Its main value is as an ornamental tree widely grown in urban areas worldwide. It also has medicinal properties. However, these uses cannot compensate for this plant's overall negative impacts.

Environmental and other Impacts

Jacaranda mimosifolia is regarded as an invasive species in parts of South Africa and Queensland, Australia, where it can out-compete native species. It can form thickets of seedlings beneath planted trees from which the species may expand and exclude other vegetation.

J. mimosifolia has been listed as a Category 3 invader in South Africa (no further planting is allowed – except with special permission – nor is trade in propagative material. Existing plants must be prevented from spreading).

Management

The precise management measures adopted for any plant invasion will depend upon factors such as the terrain, the cost and availability of labour, the severity of the infestation and the presence of other invasive species. Some components of an integrated management approach are introduced below.

The best form of invasive species management is prevention. If prevention is no longer possible, it is best to treat the weed infestations when they are small to prevent them from establishing (early detection and rapid response). Controlling the weed before it seeds will reduce future problems. Control is generally best applied to the least infested areas before dense infestations are tackled. Consistent follow-up work is required for sustainable management.

Manual and Mechanical Control

Seedlings and smaller saplings can be pulled out by hand when the soil is damp but care must be taken to remove the roots as *Jacaranda mimosifolia* can resprout from its roots. Larger saplings may have to be dug out. Debarking the young trees to the ground (girdling) kills them off without coppicing.

Chemical Control

When using any herbicide always read the label first and follow all instructions and safety requirements. If in doubt consult an expert.

Seedlings and young trees can be sprayed with glyphosate while adult trees require other treatments.

J. mimosifolia is very difficult to control once established. Large trees can be treated with herbicide as follows: cut surface application (notching, cut stump herbicide application and stem injection). Any regrowth must be treated with herbicide. The editor is not aware of any experience in using basal bark application against *J. mimosifolia.*

Biological Control

The editor is not aware of a biological control programme for this species.

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Lantana camara (Lantana)

Scientific name

Lantana camara L.

Synonyms

L. aculeata L.; *Camara vulgaris* Benth.; *L. armata* Schauer; *L. scabrida* Sol.; *L. tiliifolia* Cham.

Common names

Freira (Fogo), trepadeira (Santo Antão and São Vicente), Lantana, tick berry, Spanish flag

Family

Verbenaceae

Origin

Native to Mexico, Central America, the Caribbean and tropical South America.

Naturalised distribution (global)

Locations within which *Lantana camara* is naturalised include Africa, Australia, India, south-eastern Asia and many oceanic islands with warm climates.

Introduced, naturalised or invasive in Fogo, Santo Antão and São Vicente

Lantana camara is invasive in Fogo, Santo Antão and São Vicente. It suppresses most other species in dense infestations.

Habitat

Lantana camara occurs along roadsides, in degraded lands, in riparian zones (banks of watercourses), along fence lines and in pastures and parklands, in plantations, forest edges and gaps and is seen invading large areas of native vegetation (notably in protected areas).

Description

A much-branched, upright (erect), arching or scrambling shrub that usually grows 2-4 m tall and forms dense thickets. It can occasionally grow like a vine (as a scandent shrub) due to its patterns of short branches and if there is support by other vegetation, in which case it can reach up to 15 m in height.

The young stems are usually green and square-shaped (quadrangular) in cross-section. They are rough to the touch, often armed with short prickles, and can be hairy. As they mature the stems become rounded and turn grey or brown in colour. In some wild varieties the stems are armed with small or large spines, in others they are smooth. The leaves are simple and oppositely arranged along the stem. They have leaf stalks (petioles) that are 5-30 mm long and a crenate or serrated (toothed) margin. The leaf blades are mostly egg-shaped in outline with broad end at base (ovate) and are 2-12 x 1.5-7 cm in size. The texture of the leaf is quite rough (scabrous), however, the underside can be softly hairy.

Its dense flower clusters consist of numerous small tubular flowers (9-14 mm long and 4-10 mm across). These flower clusters are borne on stalks originating in the leaf forks. The flowers can be a wide variety of colours (white, cream, yellow, orange, red, pink, purple and are usually made up of three circles of florets – each one commonly of a different colour (except in some cultivated varieties bred to have single colours) . There are over 100 different combinations of flower colours in wild varieties. The fleshy fruit is glossy in appearance and black, purplish-black or bluish-black when mature, 3-6 mm in diameter containing 1-2 seeds (1.5 mm long). Flowering and fruiting throughout the year with a peak during the first two months of the rainy season.

Reproduction and dispersal

This plant reproduces by seeds, which are readily dispersed by birds and other animals (e.g. rodents) that eat the fruit. Existing colonies may also spread laterally via the production of suckers or when branches take root after coming into contact with the soil (by layering). Stem fragments or pieces of the rootstock (crown) can also give rise to new plants after being moved by machinery or dumped in garden waste.

Economic and other uses

Many weedy and non-weedy cultivars of this species are grown as ornamentals. The stems can be used to make artisanal products such as carrying cages for chickens and other items that required bendable stems for construction. However, these uses cannot compensate for this plant's overall negative impacts. In Santo Antão and São Vicente, *Lantana camara* is not utilised for these purposes

Environmental and other Impacts

Lantana camara is one of the most problematic invasive plants in many parts of the world.

L. camara forms extensive, dense and impenetrable thickets in forestry plantations, orchards, pasture land, waste land and in natural areas. The rapid spread of *L. camara* is associated with human induced disturbance. However, it can also invade forest gaps. In areas where natural fires occur they stimulate thicker regrowth. The fallen leaves produce allelopathic substances that prevent other plants germinating and growing beneath *L. camara* which results in no understory below the thickets and a "monoculture" of the alien plant.

Its extensive seed production favours rat populations. In New Caledonia, by increasing fire intensity as a result of its large dry biomass as well as its smothering effect, it displaces natural scrub communities (Sharma et al. 1988).

L. camara is poisonous to livestock and children have been known to die after eating unripe berries. It is also unpalatable, and in large doses (approximately 1% of total body weight) is poisonous, particularly to cattle. If untreated *L. camara* poisoning can result in photosensitisation, loss of appetite, jaundice, liver and other organ/tissue damage, and even death (Queensland Government, 2003). In Australia it is also considered a serious weed of the plantation timber and orchard industries (Swarbrick et al. 1998). The value of lost production from the Australian grazing sector resulting from the presence of lantana is expected to be approximately $46.2 million annually. Most of the pasturelands in India have been invaded to some or other degree resulting in lost productivity of approximately US$924 million per year (Pimentel et al. 2001).

L. camara has been nominated as among 100 of the "World's Worst" invaders by the IUCN Invasive Species Specialist Group and it has been listed as a noxious weed in many countries and states including South Africa (prohibited plants that must be controlled. They serve no economic purpose and possess characteristics that are harmful to humans, animals or the environment) and Australia.

Management

The best form of weed control is prevention. If prevention is no longer possible, it is best to treat the weed infestations when they are small to prevent them from establishing (early detection and rapid response).

Cultural Control

<u>Grazing</u>
Attempts to control *Lantana camara* using large grazers are detrimental. Few large browsers are entirely freed from the plants ability to cause ulcers and other lesions, especially around and in their mouths. In fact, intense grazing is likely to favour *L. camara* infestations by suppressing competition from palatable species.

<u>Fire</u>
Burning is not very effective and can actually encourage lantana regeneration if there is no follow-up action.

Manual and Mechanical Control
Seedlings and smaller saplings can be pulled out by hand when the soil is damp but care must be taken to remove the roots as *Lantana camara* can resprout from its roots. Larger saplings may have to be dug out. Manual control of any but the smallest plants is difficult because of the plant’s rough prickly stems and it long taproots.

Chemical Control
When using any herbicide always read the label first and follow all instructions and safety requirements. If in doubt consult an expert.

The information below on specific products has been adapted from the PIER *Lantana camara* datasheet:

L. camara is susceptible to several herbicides, including glyphosate, triclopyr, 2,4-D, picloram and imazapyr.

Glyphosate is most effective as an overall foliar spray. Glyphosate used as basal bark application with the surfactant Quiksorb® (Monsanto) looked promising in trials in Kona and Kaua‘i but erratic in Hilo, a wetter site (Motooka *et al*., 2003).

Triclopyr ester (Garlon 4®) as a basal bark application is effective but foliar applications of triclopyr are ineffective. Kline and Duquenel reported moderate control with triclopyr ester at 10% of product as a basal bark application and triclopyr amine (Garlon 3A®) at 50% of product applied to the cut-surface.

Foliar applications of 2,4-D (Aqua-Kleen®, Barrage®, Weedone®) and picloram (Grazon®, Tordon®, Access®, Pathway®) are effective. Imazapyr (Arsenal®, Habitat®, Chopper®, Stalker®) at 10% of product applied to the cut-surface and at 1% applied foliarly provided good control.

Work carried out in the South African Kruger National Park by Erasmus et al. (1993) showed that chemical control was cheaper and caused less disturbance resulting in higher biodiversity than mechanical control. When using any herbicide always read the label first and follow all instructions and safety requirements. If in doubt consult an expert.

Biological Control
Biological control has been attempted in many parts of the tropics with varying degrees of success as different varieties/biotypes display differences in susceptibility to insect herbivores. It is generally accepted that biocontrol is the only long-term and sustainable method of *L. camara* control and a suite of agents is available (once approved for introduction and release). Evaluation of the biocontrol programme in South Africa has demonstrated that the benefits of biocontrol against *L. camara* have outweighed the costs and the recent release of a number of promising additional biocontrol agents, which have established, will further reduce growth rates and seed production. The focus in the recent past on agents that attack plant parts other than the leaves also looks promising - leaf attacking agents are not that effective in areas where the plant loses its leaves during the dry season.

Legislation
Cape Verde has no noxious weed legislation.

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Leucaena leucocephala (Leucaena)

Scientific name

Leucaena leucocephala (Lam.) de Wit

Synonyms

Acacia leucocephala (Lam.) Link; *Leucaena glauca* (L.) Benth. (misapplied); *Mimosa leucocephala* Lam.

Common names

Leucaena, Leucena, leucaena, acácia-leucaena, coffee bush, cow tamarind, horse tamarind, jumbie bean, leadtree, white leadtree, wild tamarind.

Family

Fabaceae (Leguminosae) : sub-family Mimosoideae

Origin

Native to southern tropical America.

Naturalised distribution (global)

Locations within which *Leucaena leucocephala* is naturalised include parts of South America (outside its native range), Asia, southern USA, southern Europe, Australia, Africa and many oceanic islands with warm climates.

Introduced, naturalised or invasive in Fogo, Santo Antão and São Vicente

Leucaena leucocephala is invasive in parts of São Vicente where it has escaped from cultivation. It is not invasive within the boundaries of the Santo Antão parks, but is abundant at the lower elevations of Ribeira de Torre and Ribeira Grande.

Habitat

A very troublesome weed of riparian zones (banks of watercourses) and roadsides in tropical and subtropical regions. It is also found in open woodlands, gardens, parks, waste areas, disturbed sites and on coastal foreshores and offshore islands.

Description

Leucaena leucocephala is a shrub or small tree usually growing 2-10 m tall, but occasionally reaching 15 m or more in height.

The younger stems are green and usually densely covered in fine greyish coloured hairs (finely pubescent). Older stems have a relatively smooth, greyish or greyish-brown, bark with numerous small raised spots (lenticels).

The leaves (up to 35 cm long) are twice-compound (bipinnate) and have 3-10 pairs of branchlets (pinnae). They are alternately arranged along the stems and borne on stalks (petioles) 2-5 cm long. A small raised structure (gland) is usually present on the leaf stalk (petiole), or just below where the lowest pair of branchlets (pinnae) meet. pinnae are 2-10 cm long and each bears 5-22 pairs of leaflets (pinnules). These leaflets (7-21 mm long and 1.5-5 mm wide) are elongated (narrowly-oblong to lanceolate) in shape with pointed tips (acute apices), and are either hairless (glabrous) or have hairy (ciliate) margins.

The flowers are borne in dense globular clusters (12-30 mm across), which look like a 'pompom' when the flowers open. These clusters are borne in the leaf forks (axils) on stalks (peduncles) 2-6 cm long, with one to three clusters present in each leaf fork (axil). Each of the small flowers has five tiny sepals (2-2.5 mm long), five small greenish-white coloured petals (2-4 mm long), and ten prominent pale yellow or whitish coloured stamens (6-10 mm long).

The fruit are elongated (linear), flattened, pods with a pointed tip (beaked apex). These pods (8-22.5 cm long and 10-20 mm wide) are initially green in colour, but turn brown or reddish-brown as they mature. Several pods will usually develop from each flower cluster. Each of these pods contains 10-25 hard seeds (6-10 mm long and 3-6 mm wide) that are glossy brown, flattened (compressed), and somewhat oval (elliptic-oblong) in shape.

Reproduction and dispersal

Leucaena leucocephala is a prolific seed producer and it also resprouts after its stems are cut or damaged.

The seeds are often dispersed by small animals (rodents and birds) and cattle. The light pods may also be spread short distances by wind and can float on water.

The use of *L. leucocephala* as an agroforestry species continues to increase its spread and it is from such plantings that it often spreads to degraded lands, livestock pastures, forest plantations and wild vegetation areas.

Similar species

There are two sub-species of *Leucaena leucocephala*: *L. leucocephala* subsp. *leucocephala* and *L. leucocephala* subsp. *glabrata*. These two sub-species can be distinguished by the following differences:

L. leucocephala subsp. *leucocephala* is a relatively small and much-branched tree with younger stems that are densely covered with fine greyish-coloured hairs (they are puberulous).

L. leucocephala subsp. *glabrata* is a relatively large and sparsely-branched tree with younger stems that are hairless (glabrous).

Economic and other uses

Leucaena leucocephala is widely cultivated, mostly in farming situations, for forage (leaves and shoots), firewood, poles, medicine (roots), shade, soil conservation and improvement (it is a nitrogen fixer), tannin, dye. It is also planted as a windbreak, a garden ornamental and as an urban shade tree.

Environmental and other impacts

Leucaena leucocephala grows very fast in suitable sites; pollarding and coppicing to form dense, homogenous thickets that are difficult to control once established. Invaded areas become unusable and inaccessible with most other vegetation replaced. *L. leucocephala* constitutes a threat to native biodiversity. Once *L. leucocephala* establishes itself it displaces native vegetation and can promote suitable conditions for the establishment of even more aggressive invaders. The mimosine in the leaves of *L. leucocephala* can cause hair loss, infertility and stomach problems in livestock, especially those that are not ruminants.

L. leucocephala is an environmental weed in many parts of the world. It has been nominated as among 100 of the "World's Worst" invaders by the IUCN Invasive Species Specialist Group and it has been listed as a noxious weed in Western Cape South Africa (prohibited plants that must be controlled. They serve no economic purpose and possess characteristics that are harmful to humans, animals or the environment) and a Category 2 invader (invaders with certain qualities, e.g. commercial use or for woodlots, animal fodder, soil stabilisation, etc. These plants are allowed in certain areas under controlled conditions) in the rest of the country.

Management

The precise management measures adopted for any plant invasion will depend upon factors such as the terrain, the cost and availability of labour, the severity of the infestation and the presence of other invasive species. Some components of an integrated management approach are introduced below.

The best form of invasive species management is prevention. If prevention is no longer possible, it is best to treat the weed infestations when they are small to prevent them from establishing (early detection and rapid response). Controlling the weed before it seeds will reduce future problems. Control is generally best applied to the least infested areas before dense infestations are tackled. Consistent follow-up work is required for sustainable management.

Cultural Control

Utilisation

Leucaena leucocephala has many uses and it may be possible to use heavy harvesting as a means of controlling its aggressive.

Grazing

Grazing by goats has been used as an effective control method in carefully managed situations .

Manual and Mechanical Control

Seedlings and smaller saplings can be pulled out by hand when the soil is damp but care must be taken to remove the roots as *Leucaena leucocephala* can resprout from its roots. The roots have a tendency to break when pulled. Larger saplings may have to be dug out. Manual control is very difficult for older plants.

In such cases cutting must be followed by herbicide application to the cut stump. When using any herbicide always read the label first and follow all instructions and safety requirements. If in doubt consult an expert.

Chemical Control

When using any herbicide always read the label first and follow all instructions and safety requirements. If in doubt consult an expert.

Seedlings and young trees can be sprayed with glyphosate.

The information below on specific products has been adapted from the PIER *Leucaena leucocephala* datasheet:

Leucaena leucocephala is sensitive to foliar-applied triclopyr and to cut-surface applications of picloram. Dicamba is ineffective in cut-surface applications. Triclopyr ester (Garlon 4) applied as a basal bark and cut stump bark treatment is effective, 2,4-D in diesel and sometimes diesel alone is effective in basal bark treatments (Motooka et al., 2003). Triclopyr can be effective as a stem injection (Meyer, 2008; p. 24).

Biological control
In some countries, a psyllid insect pest, *Heteropsylla cubana*, defoliates *Leucaena leucocephala*, resulting in severely reduced fodder as well as wood but does not kill the plants. However, in many cases biological control agents have been introduced to control the psyllid so it no longer does so much damage. There are also insect seed predators that affect the seed production but do not seem to stem its spread.

In South Africa permission was recently granted for the release of the seed-feeding bruchid beetle, *Acanthoscelides macrophthalmus* as a biological control agent against *L. leucocephala*.

Legislation
Cape Verde has no noxious weed legislation.

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Annex 2. An outline of the main approaches to invasive plant management

In this annex each approach is presented separately but in reality it is likely that any IP programme will combine elements of prevention, early detection and rapid response, eradication, control and mitigation as part of an integrated approach to ecosystem restoration which follows the principles of the ecosystem approach.

Prevention

As the old saying goes “prevention is better than cure”. Prevention involves stopping a potentially invasive species before it enters an area (country, island within a country, ecosystem or part of an ecosystem) where it does not already exist. The responsibility for prevention at the national and inter-island level usually falls to customs and biosecurity officials. Preventive measures are usually much more cost-effective than trying to control or eradicate an established species.

It is likely that eradication from a protected area will be expensive and practically impossible once IPs have become well established in the PA. But the spread of IPs into non-infested areas can be limited in many cases.

Elements of a proactive IP prevention plan[15] include the following:

Limiting the introduction of IP seeds into an area;

Early detection and eradication of small patches of IPs;

Minimizing disturbance to desirable vegetation along roadsides, trails, and waterways;

Managing land to build and maintain healthy communities of native and desirable plants to compete with IPs;

Careful monitoring of high-risk areas such as human and animal transportation corridors and disturbed or bare ground;

Revegetating disturbed sites with desirable plants; and

Evaluating annually the effectiveness of the prevention plan so appropriate adaptations can be implemented the following year.

Early detection and rapid response

Even the best prevention efforts cannot stop all introductions so regular surveillance is important, as this is when new IP incursions are discovered. If detection is early enough it is possible to eradicate or contain the new incursion before it can establish and spread to become a serious infestation.

Elements of early detection and rapid response system[16] include the following:

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[15] Adapted from http://www.dcnr.state.pa.us/forestry/invasivetutorial/Prevention.htm

[16] Adapted from http://www.dcnr.state.pa.us/forestry/invasivetutorial/Prevention.htm#early

- Access to up-to-date reliable scientific and management information;
- Access to rapid and accurate species identification;
- The establishment of a standard procedure for rapid risk assessment;
- Provision of effective mechanisms for coordinating the efforts of concerned stakeholders
- Provision of adequate technical assistance (e.g. monitoring, information sharing and management techniques) and rapid access to funding for rapid response efforts.

The system's success will depend in part on public participation in efforts to report and respond to invasions.

Eradication

When an IP has invaded, a decision has to be made as to whether to attempt to eradicate it, control it or manage in some other kind of way. Eradication is the removal of every individual of a targeted population in a set area until no individuals remain. This can be time-consuming and expensive, but it means that the impacts of the targeted species are eliminated in the long-run. When we use the term eradication we must be clear about its meaning and not use it interchangeably with control. Using the term eradication when control would be more appropriate is likely to upset many stakeholders once it becomes clear that the target species will not be eliminated. This may end up jeopardising support for the intervention. A successful control programme may be judged as unsuccessful if it was promoted as an eradication programme.

Three conditions MUST be met if your eradication is to succeed:

1. All individuals must be put at risk
2. The target species must be removed faster than it reproduces
3. Re-invasion risks must be small

Since plants produce seeds, putting all individuals of a targeted IP population at risk at once is virtually impossible. Seeds may continue to germinate and grow for many years after an initial eradication operation. This is why weeds which have established populations are so hard to eradicate in a single operation. A combination of methods may be required to remove seeds and seedlings, as well as adult plants. Ongoing surveillance to detect and remove seedlings will also be necessary.

Elements of an eradication system correspond to those of an early detection and rapid response system outlined above.

Control

In situations where eradication is not feasible, the IP population can be controlled and its impacts managed. Long-term control programmes can have many benefits but they are expensive and the IP continues to have an impact, albeit reduced, upon biodiversity. Control can be implemented at various spatial scales. If implemented at the scale of a whole infestation the objective is to manage the impact of the entire infestation. If it is implemented at the edge of an infestation the aim of control is containment - to restrict the spread of the target species.

There are a number of control tools available: cultural, manual and mechanical, chemical and biological. In most instances a situation-specific combination of methods will be used as part of an Integrated Pest Management (IPM) approach. IPM is consistent with the ecosystem approach to IP management. The exact approach adopted should seek to contribute to long term ecosystem goals as effectively as possible i.e. the most long term benefit for the lowest long term cost.

Cultural control

Cultural control involves actions that focus on manipulating the ecosystem in some way to favour your desired outcome (more productive agriculture, enhanced biodiversity, more effective water conservation, etc.). Methods used may involve a combination of approaches that directly target an IP species or help to create conditions that favour desired species.

Methods that directly target an IP species include the use of fire, the use of grazers (sometimes classified as biological control), control through utilisation (which is likely to involve some kind of manual management of the IP).

Methods that help to create conditions that favour the desired species include the use of uncontaminated crop seed, soil fertility manipulation, habitat manipulation to encourage natural enemies of the target species (which could be also classified as biological control) and the planting of cover crops. Active restoration, planting of desired species in areas from which IPs have been controlled could be characterised as a cultural control method.

Manual and mechanical control

Manual and mechanical control involves the use of labour and machine to clear IPs. Where infestations are small and easily accessible, manual control is often the best choice because individual plants may be specifically targeted. Manual control can be labour-intensive and often expensive (see Annex 6 for invasive plant management cost information) in dense infestations or when an IAS is wide-spread and occurs in remote or rugged areas. Although manual control is target specific it can result in non-target or environmental damage. Uprooting for example can affect non-target species and clearance of large areas can pose an increased risk of soil erosion.

An important advantage of mechanical control is that it is target specific and that non-target and environmental impacts are usually minor.

Chemical control

The use of chemicals in protected areas is always subject to controversy because of fears negative effects on people and the environment, but herbicides are used routinely in protected areas throughout the world. This management plan only considers glyphosate and triclopyr (Garlon) for use in Cape Verde as people are not widely acquainted with herbicide use in the country and these chemicals have been widely used in nature reserves for many years and are relatively safe to people and the environment (see Annex 4 for more detailed information about these chemicals and Annex 5 for guidelines for the safe use of herbicides).

Decisions to use herbicides as well as or instead of other methods should be based on the conservation targets and management goals for the site. In addition, the health and safety of applicators and others in the vicinity must be considered BEFORE pesticides are applied.

Simply put, one should be confident that the proposed herbicide will do more conservation good than harm and not endanger the health of the applicators or others in the area.

Herbicides can be applied in a variety of ways. The most appropriate application method is determined by the weed being treated, the herbicide being applied, the skills of the applicator, and the application site.

Methods of application can be broadly classified as follows:

1) Foliar application (to intact, green leaves)
   a. Spot application (backpack applicator, spray bottle);
   b. Wick application (wipe-on);
   c. Boom application;
2) Basal bark application (around the circumference of the trunk on the intact bark);
3) Frill; hack and squirt (to cuts in the trunk/stem);
4) Injection (into the inner bark);
5) Cut stump application (to cut stems and stumps);
6) In pellet form at the plant's base (rarely used in natural areas);
7) To the soil before the target species seeds germinate and emerge (rarely used in natural areas).

Details of these application methods are provided in Annex 5.

Biological control,

Biological control or biocontrol is the use of biological agents to control a target species, for example by releasing or enhancing a natural enemy of the species, or by using naturally synthesized substances. Biological control can be used against all types of IAS – including IPs, vertebrates, plant pathogens, and invertebrates.

There are many approaches to biological control which can be split up into two main categories: 1. Self-sustaining; 2. Non - self sustaining

1. Self-sustaining methods:

- Classical biological control: the introduction of a natural enemy from the original range of the target species
- Habitat management: enhancing the populations of native predators and parasitoids (which could also be classified here under cultural control).
- Adding to the IAS' enemies (reared or cultured and released in large numbers) when an outbreak of the IAS has happened

2. Non–self-sustaining methods:

- Inducing host resistance against the IAS. For example farmers will breed crops that are resistant to certain diseases.
- Biological chemicals. These are chemicals that are naturally produced by living species.

- The use of pathogens, parasitoids or predators that will not be able to reproduce or survive in the environment.
- The mass release of sterile males. Sterilized males will still compete for females and subsequently in the next generation fewer offspring will be produced.

In comparison with other biocontrol methods classical biological control, when successful, can be highly cost-effective, permanent and self-sustaining. They offer hope for control of large invasions and invasions in inaccessible areas. Disadvantages of biocontrol include the lack of certainty about the level of control that will be achieved, and the delays until the bio-control agents achieve full impact.

The major concern about the introduction of a biocontrol agent is that it will attack non-target species such as native plants and crop species. For this reason any proposed biological control agent must be tested for its specificity to the target species and feeding trials undertaken on a range of non-target species. This process is part of the code of conduct for the import and release of exotic biological control agents produced by the International Plant Protection Convention and included in this management plan as Annex 8.

Impact mitigation

In some cases prevention, early detection and rapid response, eradication and control options may be considered too costly to implement over a large area or too uncertain of success to rely on them without a "Plan-B". In such cases a variety of impact mitigation measures may be implemented. These measures aim to reduce the impacts of an IP on species or places that have high biodiversity, cultural or economic value. Impact mitigation for IP could include translocation of native species to protected areas close to settlements, field genebanks of representative samples of native species from which populations can be bred for subsequent reintroduction into wild areas and seedbanks where seeds are stored in freezers to help ensure the survival of the species.

Annex 3. Environmental impact assessment guidelines for the use of herbicides as part of an integrated approach to the management of major invasive plants in Cape Verde's PAs

These guidelines are designed to assist the planning of all pesticide[17]-use management and coordination activities in Cape Verde's protected areas. Personnel in land management positions that have particular responsibility for compliance with this process include: ecological specialists, conservation and land management project coordinators, conservation and land management researchers, and resource managers.

DETERMINATION OF HERBICIDE-USE NEED. All herbicide-use activities in PAs must be consistent with the standards and guidelines and other management direction in applicable forest land and resource management plans. Forest plans generally mandate principles of Integrated Pest Management (IPM) for management of forest pests such as insects, diseases, animals, and unwanted vegetation.

The IPM process involves the collection and synthesis of available knowledge on pest/host relationships. This information includes:

1. The ecology of pest/host systems;
2. The impacts of unregulated pest populations on resource values;
3. The effects of alternative management strategies on pests and resources of immediate concern, other pest organisms, and the forest ecosystem in general; and
4. The economic and social implications of alternative management strategies.

The objective of the process is to identify strategies that are effective and ecologically and socially acceptable.

Land management and IP management objectives affect the entire project planning process. Objectives of IP management projects can range from avoiding a potential IP problem to suppression of an IP population. Objectives may determine: the feasibility of the action proposed; the timing of the treatment, the number of treatments needed; if a herbicide-use alternative is selected, which herbicide is most appropriate; and so on.

Biological and Ecological Conditions. Base decisions to use herbicides on biological and ecological conditions, specific resource objectives for a given area, and public perception of the need for specific pest management action.

Public Concerns. Residents and visitors to PAs may be concerned about IP problems as well as proposed management methods. Land managers must be in a position to respond to these concerns. When herbicides are being considered for IP problems in PAs, involve the public early in an open process to determine the issues associated with a proposed action.

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[17] In this document we focus on herbicide use but similar guidelines will apply to use of other types of pesticide such as insecticides, acaricides and fungicides

DETERMINATION OF KIND OF HERBICIDE NEEDED. Determine the kind of herbicide needed for IP management project based on the species involved. Select the herbicide most appropriate for the job.

HERBICIDE-USE PROPOSALS. Use the Herbicide-Use Proposal of the type proposed in Figure A3.1. as part of the environmental analysis process to show a proposed herbicide use is appropriate.

Herbicides Proposed for Use in Protected Areas. In PAs, PA authority personnel prepare or coordinate all proposals for herbicide uses on the PA. These proposals are reviewed and approved by the approval authority.

Herbicides Proposed for Use in Research. Project leaders or research scientists planning to use herbicides in research must prepare a Herbicide-use Proposal for field experiments. The Herbicide-Use Proposal is not required for laboratory screening studies.

Review. The designated authority review the Pesticide-Use Proposal for completeness and accuracy of information. These personnel should also review biological evaluations or environmental assessments that include biological, human health and safety, environmental, and economic information pertinent to the proposed use. These documents explain why the proposed action is necessary.

Concurrence. Reviewers shall show concurrence by initialling the Herbicide-use Proposal if the review indicates a proposed pesticide use is appropriate

Approval. Regional Foresters or their designated representatives must approve all proposed pesticide uses on PA lands. Approval is indicated by signing the Pesticide-Use Proposal.

Documentation and Filing. Keep the Herbicide-use Proposals on file until all projects covered by the proposal are completed.

PLANNING FOR PROJECT IMPLEMENTATION. Planning for herbicide project implementation involves evaluation of how the project work is to be performed and by whom. Every herbicide-use project has somewhat different needs and requirements. Thorough advance planning is necessary to ensure that all needed services and supplies are provided in an efficient manner consistent with project objectives. Plan for the operational use of herbicides in PAs by determining the appropriate method of application and equipment/personnel needs, and by developing project work plans.

Choosing Application Methods. Evaluate all aspects, from management and economic constraints to mitigation measures, when deciding upon the application method for a herbicide-use project.

Equipment/Personnel Needs. Planning for the appropriate kinds of equipment and personnel needed for a particular pesticide-use project is extremely important and should be done well in advance of the intended treatment.

Project Work Plans. Prepare a project work plan to assist in determining the kinds of equipment and personnel needed for a herbicide-use project.

Project work plans must present the organizational and operational details of projects. Work plans are the basis for determining cost and personnel requirements. Work plans also serve as valuable training tools for new personnel and are useful in identifying and correcting trouble spots. The scope of a plan depends on the magnitude of the operation; herbicide chosen; the rate, timing, and method of application; the number and nature of sensitive or high-value areas requiring monitoring within and adjacent to the treatment area; and public concerns about the program.

As a minimum, project work plans involving herbicides shall consist of:

1. A precise statement of the treatment objective(s);
2. A description of equipment, materials, and supplies, including herbicide formulation and application methods to be used;
3. A description of the organization of field crews and lines of responsibility;
4. A description of interagency coordination;
5. A copy of the Herbicide-Use Proposal for the project; and
6. A description of the process by which treatment effectiveness will be determined.
7. A description of personal protective clothing and equipment required.

15 - QUALITY CONTROL PLANNING. Quality control in herbicide application includes all actions taken to ensure herbicides have been applied effectively, safely, and with minimal potential for adverse effect on the environment and unnecessary exposure to herbicide workers and the public. Planning for quality control involves:

1. The determination and establishment of procedures to ensure project effectiveness;

2. The use of models that can predict herbicide applications; and

3. Training of personnel who influence quality during herbicide application.

Product Effectiveness. Use only those herbicide products approved for use in Cape Verde by the appropriate national agencies. Use them according to all label directions.

Herbicide product labels provide maximum application rates for various plants and sites. In some situations, field tests or other recommendations may indicate lower application rates may be equally effective. Implement the results of field tests or other recommendation when the proposed application is sufficiently similar to test conditions.

In some circumstances it may be appropriate to analyse a delivered product for potency and acceptability. Testing for product acceptability may be necessary if there has been:

1. Prior failure of a herbicide to perform as well as projected;

2. Prior failure of a manufacturer or distributor to deliver a properly formulated product;

3. Prior instances of unacceptable microbial or other foreign matter contamination; or

4. Prior experience with products varying in their level of potency or infectiousness.

SAFETY PLANNING. Develop a safety plan to protect the public and employees from unsafe work conditions when herbicides are involved. Design the safety plan to ensure workers:

1. Are fully trained in the hazards of herbicide use and hazard communication requirements;
2. Use protective clothing and equipment prescribed on the herbicide label;
3. Understand the importance of personal hygiene when working with herbicides; and
4. Understand emergency procedures in the event of accidental exposure or spill.

16.1 - General Safety Plan.

1. Prepare safety plans for all herbicide-use projects, except:

a. Housekeeping-type uses;
b. Minor uses of less than 0.5 kg active ingredient for any one project (except projects using highly toxic compounds such as sodium cyanide, strychnine, or other products of concern, which require safety plans); and
c. Field experiments.

2. When a treatment program is comprised of many similar projects such as small noxious weed treatment sites, a generic safety plan can be developed to cover all such projects. At a minimum a safety plan should:

a. Prescribe specific communication, transportation and emergency medical actions to be taken in the event of an emergency (for example, an accidental exposure or spill);
b. Designate one person to supervise the use, transportation, mixing, storage, and disposal of herbicides and their containers;
c. Detail action to be taken during or after the herbicide application if there is evidence of illness or physical reaction to the herbicide;
d. Provide the name, address, and telephone number of the nearest hospital and the physician to be contacted in case of illness;
e. Include chemical composition, appropriate precautionary label statements, and registration number of the herbicide to enable prompt and accurate transmission of the information in case of accident or illness;
f. List known antidotes to herbicides planned for use;
g. Prescribe actions to rescue or eliminate possible hazards to humans, animals, and vegetation from accidental spills;
h. Prescribe disposal procedures; and

Herbicide Risk Assessment. Another method of helping to ensure safety in herbicide use is to conduct risk assessments. Analyses estimate the possible herbicide doses to workers and the public who may be affected by a herbicide application; and the potential effects on fish, wildlife, and other non-target organisms. These estimated doses are then compared with levels of no observed effects based on tests of laboratory animals.

A herbicide risk assessment does not, in itself, ensure safety in herbicide use. The analysis must be tied to an action plan which provides mitigation measures to avoid potential risks identified by the risk assessment.

Figure A3.1. Model Herbicide Use Proposal Form

<table>
<tr><td rowspan="4">HERBICIDE USE PROPOSAL</td><td colspan="2">DEPARTMENT/AGENCY</td><td colspan="2">CONTACT/PHONE NO.</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>REGION</td><td colspan="2">LOCATION</td><td>DATE SUBMITTED</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
</table>

1) OBJECTIVE a) Project No. b) Specific Target Species c) Purpose	
2) PESTICIDE a) Common Name b) Formulation c) % AI,AE,or kg / litre. d) Registration No.	
3) a) Form Applied b) Use Strength (%) or Dilution Rate c) Diluent	
4) Kgs. AI Per Hectare or Other Rate	
5) APPLICATION a) Method b) Equipment	
6) a) Hectares or Other Unit to be Treated b) Number of Applications c) Number of Sites d) Specific Description of Sites e) Location of Sites	
7) a) Month(s) of Year	
8) SENSITIVE AREAS a) Areas to be Avoided b) Areas to be Treated with Caution	
9) REMARKS a) Precautions to be Taken b) Use of Trained / Certified Personnel c) Local Coordination d) Other Pesticides Being Applied to Same Site e) Monitoring f) Other	
Approval (Signatures of Approving Official)	Date

Annex 4. Properties of glyphosate and triclopyr (adapted from Tu et al. 2001)

Glyphosate

Adapted from: M. Tu, C. Hurd, R. Robison & J.M. Randall (2001)

Herbicide Basics

Chemical formula: N-(phosphonomethyl) glycine

Herbicide Family:

None generally recognized

Target Species: most annual and perennial plants

Forms: salts

Formulations: SL, EC

Mode of Action: amino acid synthesis inhibitor

Water Solubility:

900,000 ppm

Adsorption potential: high

Primary degradation mech: slow microbial metabolism

Average Soil Half-life:

47 days

Mobility Potential: low

Dermal LD50 for rabbits:

>5,000 mg/kg

Oral LD50 for rats:

5,600 mg/kg

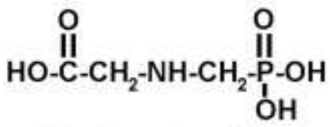
LC50 for bluegill sunfish:

120 mg/L

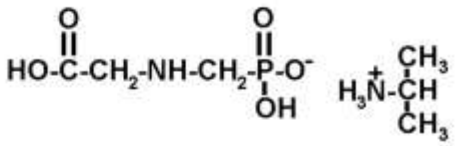
Trade Names: RoundUp®, RoundUp-Pro®, Rodeo®, GlyPro®, Accord®, Glyphomax®, Touchdown®

Synopsis

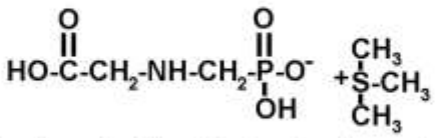
Glyphosate is a non-selective, systemic herbicide that can control most annual and perennial plants. It controls weeds by inhibiting the synthesis of aromatic amino acids necessary for protein formation in susceptible plants. Glyphosate is strongly adsorbed to soil particles, which prevents it from excessive leaching or from being taken-up from the soil by non-target plants. It is degraded primarily by microbial metabolism, but strong adsorption to soil can inhibit microbial metabolism and slow degradation. Photo- and chemical degradation are not significant in the dissipation of glyphosate from soils. The half-life of glyphosate ranges from several weeks to years, but averages two months. In water, glyphosate is rapidly dissipated through adsorption to suspended and bottom sediments, and has a half-life of 12 days to ten weeks. Glyphosate by itself is of relatively low toxicity to birds, mammals, and fish, and at least one formulation sold as Rodeo® is registered for aquatic use. Some surfactants that are included in some formulations of glyphosate, however, are highly toxic to aquatic organisms, and these formulations are not registered for aquatic use. Monsanto's patent for glyphosate expired in 2000, and other companies are already selling glyphosate formulations.



Glyphosate acid



Glyphosate isopropylamine salt



Glyphosate trimethylsulfonium salt

Herbicide Details

Chemical Formula: N-(phosphonomethyl) glycine

Trade Names: Monsanto discovered and held the patent for glyphosate, and was for many years, the only company that manufactured and sold this herbicide. The patent expired in 2000, however, and already several other companies are making and selling glyphosate formulations. Some of the current trade names include: Roundup Ultra®, Roundup Pro®, Accord®, Honcho®, Pondmaster®, Protocol®, Rascal®, Expedite®, Ranger®, Bronco®, Campain®, Landmaster®, and Fallow Master® by Monsanto; Glyphomax® and Glypro® by Dow AgroSciences; Glyphosate herbicide by Du Pont; Silhouette® by Cenex/Land O'Lakes; Rattler® by Helena; MirageR® by Platte; JuryR® by Riverside/Terra; and Touchdown® by Zeneca. As of November 2001, Rodeo® (previously manufactured by Monsanto) is now being manufactured by Dow AgroSciences and Monsanto is now producing Aquamaster®.

Manufacturers: Current manufacturers include Monsanto, Cenex/Land O'Lakes, Helena, Platte, Riverside/Terra, Dow AgroSciences, and Zeneca.

Use against Natural Area IPs: Glyphosate is a broad-spectrum, nonselective systemic herbicide that kills or suppresses many grasses, forbs, vines, shrubs, and trees. Care should be taken, especially in natural areas, to prevent it from being applied to desirable, native plants, because it will likely kill them. In terrestrial systems, glyphosate can be applied to foliage, green stems, and cut-stems (cut-stumps), but cannot penetrate woody bark. Only certain formulations of glyphosate (e.g., Rodeo®) are registered for aquatic use, as glyphosate by itself is essentially non-toxic to submersed plants, but the adjuvents often sold with glyphosate may be toxic to aquatic plants and animals.

Glyphosate is one of the most commonly used herbicides in natural areas, because it provides effective control of many species. Natural area weeds in USA that have been controlled with glyphosate include: bush honeysuckle (*Lonicera maackii*), cogon grass *(Imperata cylindrica*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn *(Frangula alnus*), Japanese honeysuckle (*Lonicera japonica*), smooth brome (*Bromus inermis*), dewberries (*Rubus* spp.), bigtooth aspen (*Populus grandidentata*), black cherry (*Prunus serotina*), sweetclover (*Melilotus officinalis*), leafy spurge (*Euphorbia esula*), St. John's wort/Klamath weed (*Hypericum perforatum*), bindweed (*Convolvulus arvensis*) and velvetgrass (*Holcus lanatus*).

In aquatic or wetland systems in USA, glyphosate has successfully controlled common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), reed canarygrass (*Phalaris arundinacea*), glossy buckthorn (*Frangula alnus*) and hybrid cattail (*Typha x glauca*).

Mode of Action: Glyphosate kills plants by inhibiting the activity of the enzyme 5-enolpyruvylshikimic acid-3-phosphate synthase (EPSP), which is necessary for the formation of the aromatic amino acids tyrosine, tryptophan, and phenylalanine. These amino acids are important in the synthesis of proteins that link primary and secondary metabolism. EPSPs are present in the chloroplast of most plant species, but are not present in animals. Animals need these three amino acids, but obtain them by eating plants or other animals.

Glyphosate is therefore, relatively non-toxic to animals. Certain surfactants or other ingredients that are added to some glyphosate formulations are toxic to fish and other aquatic species.

Glyphosate can also act as a competitive inhibitor of phosphoenolpyruvate (PEP), which is one of the precursors to aromatic amino acid synthesis. It also affects other biochemical processes, and, although these effects are considered secondary, they may be important in the total lethal action of glyphosate.

Dissipation Mechanisms:
Summary: Glyphosate is degraded primarily by microbial metabolism. Glyphosate is believed to be susceptible to photodegradation, but the extent to which this occurs is uncertain. Glyphosate is not significantly degraded by other chemical mechanisms in the field. Glyphosate is strongly adsorbed to soil, which can slow microbial metabolism but prevents excessive movement in the environment. Glyphosate is non-volatile.

Volatilization
Glyphosate does not volatilize readily when applied in the field.

Photodegradation
Although originally thought to be unaffected by sunlight, later studies found glyphosate to be susceptible to photodegradation. Lund-Hoie and Friestad (1986) reported a half-life of four days for glyphosate in deionized water under UV light.

Microbial Degradation
Glyphosate is degraded primarily by microbial metabolism. Two steady rates of degradation have been identified. It has been hypothesized that the more rapid rate of degradation represents the metabolism of unbound glyphosate molecules, while the slower rate represents the metabolism of glyphosate molecules bound to soil particles. The degradation of glyphosate is slower in soils with a higher adsorption capacity. Degradation rate was also affected by the particular microbial community of each soil. The primarily metabolite of glyphosate is aminomethylphosphonic acid, which is non-toxic and degraded microbially at a somewhat slower rate than the parent compound. A number of other minor, biodegradable metabolites have also been identified.

Adsorption
Glyphosate is water-soluble, but it has an extremely high ability to bind to soil particles. Adsorption of glyphosate increases with increasing clay content, cation exchange capacity, and decreasing soil pH and phosphorous content. Glyphosate is adsorbed to soil particles rapidly during the first hour following application and slowly thereafter. Strong adsorption to soil particles slows microbial degradation, allowing glyphosate to persist in soils and aquatic environments. Because glyphosate rapidly binds to soils, it has little or no herbicidal activity (“killing power”) once it touches soil. Glyphosate can also be inactivated by adsorption if mixed with muddy water.

Adsorption prevents glyphosate from being mobile in the environment except when the soil particles themselves are washed away. Comes et al. (1976) found that glyphosate sprayed directly into a dry irrigation canal was not detectable in the first irrigation waters flowing through the canal several months later, although glyphosate residues remained in the canal soils. In most cases, glyphosate is quickly adsorbed to suspended and bottom sediments.

Chemical Decomposition

Glyphosate is not readily hydrolyzed or oxidized in the field.

Behaviour in the Environment

Summary: Glyphosate binds readily with soil particles, which limits its movement in the environment. It is degraded through microbial metabolism with an average half-life of two months in soils and two to ten weeks in water. In plants, glyphosate is slowly metabolized.

Soils

Glyphosate is highly water soluble, but unlike most water-soluble herbicides, glyphosate has a very high adsorption capacity. Once glyphosate contacts soil it is rapidly bound to soil particles rendering it essentially immobile. Unbound glyphosate molecules are degraded at a steady and relatively rapid rate by soil microbes. Bound glyphosate molecules also are biologically degraded at a steady, but slower rate. The half-life of glyphosate in soil averages two months but can range from weeks to years. Although the strong adsorption of glyphosate allows residues to persist for over a year, these residues are largely immobile and do not leach significantly. Feng and Thompson (1990) found that >90% of glyphosate residues were present in the top 15 cm of soil and were present as low as 35 cm down the soil column in only one of 32 samples. Adsorption to soil particles prevents glyphosate from being taken-up by the roots of plants.

Water

Because glyphosate binds strongly to soils, it is unlikely to enter waters through surface or sub-surface runoff except when the soil itself is washed away by runoff, and even then, it remains bound to soil particles and unavailable to plants. Most glyphosate found in waters likely results from runoff from vegetation surfaces, spray drift, and intentional or unintentional direct overspray. In most cases, glyphosate will dissipate rapidly from natural water bodies through adsorption to organic substances and inorganic clays, degradation, and dilution. Residues adsorbed to suspended particles are precipitated into bottom sediments where they can persist until degraded microbially with a half-life that ranges from 12 days to 10 weeks. At least one study found that >50% of the glyphosate added directly to the waters of an irrigation canal were still present 14.4 km downstream.

Vegetation

Glyphosate is metabolized by some, but not all plants. It is harmless to most plants once in the soil because it is quickly adsorbed to soil particles, and even when free, it is not readily absorbed by plant roots. The half-life of glyphosate on foliage has been estimated at 10.4 to 26.6 days. Roy et al. (1989b) found 14% and 9% of applied glyphosate accumulated in the berries of treated blueberry and raspberry bushes, respectively. These residues dissipated from the fruit with a half-life of <20 days for blueberries and <13 days for raspberries.

Environmental Toxicity

Birds and Mammals

Glyphosate is of relatively low toxicity to birds and mammals. The LD50 of glyphosate for rats is 5,600 mg/kg and for bobwhite quail, >4,640 mg/kg. EPA's Re-registration Eligibility

Decision states that blood and pancreatic effects and weight gain were noted during subchronic feeding studies with rats and mice. Other studies show developmental and reproductive impacts to animals given the highest dose.

Newton et al. (1984) examined glyphosate residues in the viscera of herbivores following helicopter application of glyphosate to a forest in Oregon and found residue levels comparable to those found in litter and ground cover (<1.7 mg/kg). These residue levels declined over time and were undetectable after day 55 (Newton et al. 1984). Although carnivores and omnivores exhibited much higher viscera residue levels (5.08 mg/kg maximum), Newton et al. (1984) concluded that carnivores were at lower risk than herbivores due to the lower relative visceral weights and a proportionally lower level of food intake.

Batt et al. (1980) found no effect on chicken egg hatchability or time to hatch when an egg was submerged in a solution of 5% glyphosate. Sullivan and Sullivan (1979) found that black-tailed deer showed no aversion to treated foliage and consumption of contaminated forage did not reduce total food intake. Significant impacts to bird and mammal populations due to large-scale habitat alterations following treatment of forest clearcuts with glyphosate have been reported.

<u>Aquatic Species</u>
Glyphosate itself is of moderate toxicity to fish. The 96-hour LC50 of technical grade glyphosate for bluegill sunfish and rainbow trout are 120 mg/L and 86 mg/L, respectively. Fish exposed to 5 mg/L of glyphosate for two weeks were found to have gill damage and liver damage was observed at glyphosate concentrations of 10 mg/L. The technical grade of glyphosate is of moderate toxicity to aquatic species, and the toxicity of different glyphosate formulations can vary considerably. For example, Touchdown 4-LC® and Bronco® have low LC50s for aquatic species (<13 mg/L), and are not registered for aquatic use. On the other hand, Rodeo® has relatively high LC50s (>900 mg/L) for aquatic species and is permitted for use in aquatic systems. The surfactant in Roundup® formulations is toxic to fish, however, Rodeo® has no surfactant, and is registered for aquatic use.

The surfactant X-77 Spreader®, which is often used in conjunction with Rodeo®, is approximately 100 times more toxic to aquatic invertebrates than Rodeo® alone. The surfactant MONO818® is included in Roundup® formulations because it aids the break-down of surface tension on leaf surfaces, but it may also interfere with cutaneous respiration in frogs and gill respiration in tadpoles (Tyler 1997 a,b). In addition, MONO818® is highly toxic to fish. The LC50 of MONO818® is 2-3 mg/L for sockeye, rainbow, and coho fry. The LC50 of Roundup® for bluegill sunfish and rainbow trout is only slightly higher at 6-14 mg/L and 8-26 mg/L, respectively. Similarly for *Daphnia*, the 96-hour LC50 of glyphosate alone is 962 mg/L, but the LC50 of Roundup® drops to 25.5 mg/L. Roundup® is therefore not registered for use in aquatic systems.

Despite these toxicity levels, Hildebrand et al. (1980) found that Roundup® treatments at concentrations up to 220 kg/ha did not significantly affect the survival of *Daphnia magna* or its food base of diatoms under laboratory conditions. In addition, Simenstad et al. (1996) found no significant differences between benthic communities of algae and invertebrates on untreated mudflats and mudflats treated with Rodeo® and X-77 Spreader®. It appears that under most conditions, rapid dissipation from aquatic environments of even the most toxic glyphosate formulations prevents build-up of herbicide concentrations that would be lethal to most aquatic species.

Other Non-Target Organisms

Roberts and Berk (1993) investigated the effects of Roundup® on chemoattraction of the protozoa *Tetrahymena pyriformis* and found that it significantly interfered with chemoreception but not motility. Doses of glyphosate <10 ppm were stimulatory to soil microflora including actinomycetes, bacteria, and fungi, while concentrations > 10 ppm had detrimental impacts on microflora populations in one study (Chakravarty & Sidhu 1987). While some short-term studies (< 30 days) found glyphosate caused significant impacts to microbial populations, Roslycky (1982) found that these populations rebound from any temporary increase or decrease within 214 days. Similarly, Tu (1994) found that microorganisms recovered rapidly from treatment with glyphosate and that the herbicide posed no long-term threat to microbial activities.

Application Considerations:

Glyphosate can be applied using conventional, recirculating, wet apron, hooded and hand-operated sprayers; controlled drop, rope-wick, roller, and carpet applicators; mistblowers; injectors; and wipe-on devices. Feng et al. (1990) found that 10 meter buffer zones limited unintentional effects through chemical drift and off-target deposits into streams during application, while Marrs et al. (1993) concluded that 20 meters was a safe buffer width. Liu et al. (1996) found that increasing the glyphosate concentration was more effective in controlling weeds than increasing the droplet size. Thielen et al. (1995) concluded that the cations of hard water, including Ca^{++} and Mg^{++}, can greatly reduce the efficacy of glyphosate when present in a spray solution. Addition of ammonium sulfate or other buffer can precipitate out heavy elements in "hard" water if added before the herbicide is mixed with water.

When glyphosate is used as an aquatic herbicide, do not treat the entire water body at one time. Treat only one-third to one-half of any water body at any one time, to prevent fish kills caused by dissolved oxygen depletion.

Safety Measures:

Some glyphosate formulations are in EPA toxicity categories I and II (the two highest categories) for eye and skin exposure. Care should be taken and protective clothing worn to prevent accidental contact of these formulations on skin or eyes.

Human Toxicology:

EPA classified glyphosate as a "Group E" carcinogen or a chemical that has not shown evidence of carcinogencity in humans (EPA 1993).

Date Authored: April 2001; U**pdated:** November 2001; **Adapted by J. Mauremootoo**: April 2012

TRICLOPYR

Triclopyr

Adapted from: M. Tu, C. Hurd, R. Robison & J.M. Randall

Herbicide Basics

Chemical formula: [(3,5,6-trichloro-2-pyridinyl)oxy] acetic acid

Herbicide Family:

Pyridine (Picolinic acid)

Target Species: Broadleaf herbs and woody species

Forms: salt & ester

Formulations: EC, SL

Mode of Action: Auxin mimic

Water solubility: 430 ppm (acid), 23 mg/L (ester), 2,100,000 mg/L (salt)

Adsorption potential: Intermediate (higher for ester than salt)

Primary degradation mech: Microbial metabolism, photolysis, and hydrolysis

Average Soil Half-life: 30 days

Mobility Potential: Intermediate

Dermal LD50 for rabbits:

>2,000 mg/kg

Oral LD50 for rats:

713 mg/kg

LC50 for bluegill sunfish:

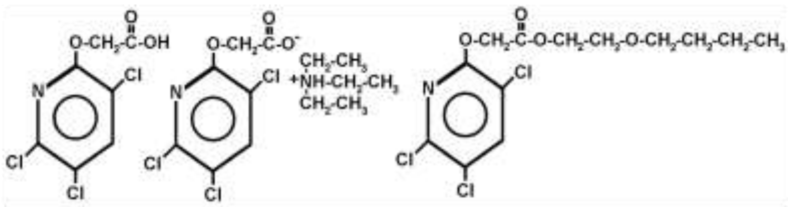
148 mg/L

Trade Names: Garlon® and Access®

Manufacturers: Dow Agro-Sciences and Platte

Synopsis

Triclopyr is a selective systemic herbicide used to control woody and herbaceous broadleaf plants along right-of-ways, in forests, and in grasslands and parklands. It has little or no impact on grasses. Triclopyr controls target weeds by mimicking the plant hormone auxin, causing uncontrolled plant growth. There are two basic formulations of triclopyr - a triethyamine salt, and a butoxyethyl ester. In soils, both formulations degrade to the parent compound, triclopyr acid. Degradation occurs primarily through microbial metabolism, but photolysis and hydrolysis can be important as well. The average half-life of triclopyr acid in soils is 30 days. Offsite movement through surface or sub-surface runoff is a possibility with triclopyr acid, as it is relatively persistent and has only moderate rates of adsorption to soil particles. In water, the salt formulation is soluble, and with adequate sunlight, may degrade in several hours. The ester is not water-soluble and can take significantly longer to degrade. It can bind with the organic fraction of the water column and be transported to the sediments. Both the salt and ester formulations are relatively non-toxic to terrestrial vertebrates and invertebrates. The ester formulation, however, can be extremely toxic to fish and aquatic invertebrates. Because the salt cannot readily penetrate plant cuticles, it is best used as part of a cut-stump treatment or with an effective surfactant. The ester can be highly volatile and is best applied at cool temperatures on days with no wind. The salt formulation (Garlon 3A®) can cause severe eye damage.



Triclopyr acid Triethylamine salt Butoxyethyl ester

Herbicide Details

Chemical Formula: [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid

Trade Names: There are two basic formulations of triclopyr: a triethylamine salt (triclopyr amine or salt), and a butoxyethyl ester (triclopyr ester). The amine formulation is sold under the trade name Garlon 3A® and is marketed as Turflon Amine® or as Brush-B-Gone®. The ester formulation is sold under the trade name Garlon 4® and is marketed as Turflon Ester®. Other trade names include Access®, Crossbow®, ET®, PathFinder II®, Redeem®, and Remedy®. These products also may be mixed with picloram or 2,4-D to increase their versatility.

Manufacturers: Dow Agrosciences (formerly known as DowElanco or Dow Chemical), Platte

Use against Natural Area IPs: Triclopyr is used to control broadleaf herbs and woody species. It is particularly effective at controlling woody species with cut-stump or basal bark treatments. Susceptible species include the brooms (*Cytisus* spp., *Genista* spp., and *Spartium* spp.), the gorses (*Ulex* spp.), and fennel (*Foeniculum vulgare)*. Triclopyr ester formulations are especially effective against root- or stem-sprouting species such as buckthorns (*Rhamnus* spp.), ash (*Fraxinus* spp.), and black locust (*Robinia pseudoacacia*), because triclopyr remains persistent in plants until they die.

Even though offsite movement of triclopyr acid through surface or sub-surface runoff is a possibility, triclopyr is one of the most commonly used herbicides against woody species in natural areas. Bill Neil, who has worked extensively on tamarisk/saltcedar (*Tamarix* spp.) control, concluded that Pathfinder II®, a triclopyr ester formulation by DowElanco, is the most cost effective herbicide for combating saltcedar. On preserves across the U.S., triclopyr has provided good control of tree-of-heaven (*Ailanthus altissima*), salt cedar (*Tamarix* spp.), glossy buckthorn (*Frangula alnus*), common *buckthorn (Rhamnus cathartica*), sweet fennel (*Foeniculum vulgare*), Brazilian peppertree (*Schinus terebinthifolius*), and Chinese tallow tree (*Sapium sebiferum*). TNC preserves in Hawaii have successfully used triclopyr to control blackwood acacia (*Acacia melanoxylon*), bush honeysuckle (*Lonicera maackii*), Chinese banyan (*Ficus microcarpa*), corkystem passionflower (*Passiflora suberosa*), eucalyptus (*Eucalyptus globulus*), Florida prickly blackberry (*Rubus argutus*), Mexican weeping pine (*Pinus patula*), Monterey pine (*Pinus radiata*), strawberry guava (*Psidium cattleianum*), tropical ash (*Fraxinus uhdei*), and velvet leaf (*Miconia calvescens*). Triclopyr can also be used in forest plantations to control brush without significant impacts to conifers. Spruces (*Picea* spp.) can tolerate triclopyr, but some species of pine (*Pinus* spp.) however, can only tolerate triclopyr during the dormant fall and winter months.

Mode of Action: Triclopyr is an auxin mimic or synthetic auxin. This type of herbicide kills the target weed by mimicking the plant growth hormone auxin (indole acetic acid), and when administered at effective doses, causes uncontrolled and disorganized plant growth that leads to plant death. The exact mode of action of triclopyr has not been fully described, but it is believed to acidify and "loosen" cell walls, allowing cells to expand without normal control and coordination. Low concentrations of triclopyr can stimulate RNA, DNA, and protein synthesis leading to uncontrolled cell division and growth, and, ultimately, vascular tissue destruction. Conversely, high concentrations of triclopyr can inhibit cell division and growth.

Dissipation Mechanisms:

Summary: Both the ester and amine formulations are degraded by sunlight, microbial metabolism, and hydrolysis. In soils, both the ester and amine formulations will degrade rapidly to the parent compound, triclopyr acid. The acid and ester formulations bind well with soils, and therefore, are not likely to be mobile in the environment. The salt however, does not readily adsorb and can be mobile. The ester can be highly volatile.

Volatilization

Ester formulations of triclopyr can be highly volatile, and care should be taken in their application. The potential to volatilize increases with increasing temperature, increasing soil moisture, and decreasing clay and organic matter content.

Photodegradation

Both the ester and salt formulations are degraded readily in sunlight to the parent compound, triclopyr acid, which is also photodegradable. A study of photolysis found the half-life of triclopyr acid on soil under midsummer sun was two hours. Photodegradation can be particularly important in water. Johnson et al. (1995) found triclopyr acid dissolved in water had a half-life due to photolysis of one to 12 hours.

Microbial Degradation

Microbial metabolism accounts for a significant percentage of triclopyr degradation in soils. In general, warm, moist soils with a high organic content will support the largest microbial populations and the highest rates of herbicide metabolism. Johnson et al. (1995a) found that microbial degradation of triclopyr was significantly higher in moist versus dry soils, and higher at 30º C than at 15º C (DT50 is 46 days versus 98 days in dry soils, and 57 days versus 199 days in moist soils, respectively. Additionally, the presence of sunlight plays a role in the rates of microbial metabolism of triclopyr. Johnson et al. (1995a) found that microbial metabolism was slowed when soil was deprived of light.

Chemical Decomposition

Hydrolysis of both the salt and ester to the acid form occurs readily in the environment and within plants. McCall and Gavit (1986) reported that the ester was converted to an acid with a half-life of three hours, and that the rate of hydrolysis in water increased with an increase in pH.

Adsorption

Adsorption temporarily or permanently immobilizes triclopyr, but adsorption is not degradation. Adsorption is more important for the immobilization of the ester than of the salt formulation. The ester binds readily with the organic component of the soil, with adsorption rates increasing as organic content increases and soil pH decreases. The salt form is soluble in water and binds only weakly with soil. The strong bond between the ester and soils accounts for the relatively low mobility of the ester in soils, whereas the salt form is much more mobile. In practice, however, both compounds are degraded rapidly to triclopyr acid, which has an intermediate adsorption capacity.

Behaviour in the Environment

Summary: In soils, both formulations are degraded by photolysis, microbial metabolism, and hydrolysis to the parent compound, triclopyr acid. Triclopyr acid has an intermediate adsorption potential, limiting movement of the acid in the environment. The acid degrades with an average half-life of 30 days. In water, the salt will remain in the water column until it is degraded, which can occur in as little as a few hours under favourable conditions. The ester formulation, however, is not water-soluble and can take significantly longer to degrade in water. Within plants, both the salt and ester formulations are hydrolysed to the acid form, and transported through the plant. Residues can persist in the plant until the tissues are degraded in the environment.

Soils

Both the ester and salt formulations degrade rapidly in soils to triclopyr acid, and thereafter, behave similarly in soils. Adsorption, photodegradation, microbial metabolism, and volatility, can all play a role in the dissipation of triclopyr from soils. The reported half-life of triclopyr in soils varies from 3.7 to 314 days, but averages 30 days, depending on the formulation applied and the specific soil and environmental conditions. If soil conditions are warm and moist, microbial metabolism can be the primary means of degradation.

Johnson et al. (1995a) reported an average half-life of triclopyr acid in four laboratory soils of 138 days, but this time varied significantly with soil temperature. At 15ºC half-lives ranged from 64-314 days, while at 30ºC half-lives were 9-135 days. In Southwest Oregon, Newton et al. (1990) found 24-51% of triclopyr residues remained after 37 days in a dry and cool climate. Following an increase in warmth and moisture, however, dissipation increased dramatically and triclopyr residues exhibited a half-life of 11-25 days. In a study of triclopyr persistence in soil and water associated with rice production, triclopyr had a half-life of less than ten days in the three soil types tested. In a pasture near Corvallis, Oregon, the half-life of triclopyr acid was estimated to be 3.7 days.

Because of the importance of photodegradation and a decrease in the size of microbial populations with soil depth, triclopyr located deeper in the soil column (>15 cm) degrades more slowly than residues near the surface. Traces of triclopyr residues have been found at soil depths of 45 cm as late as 477 days after application. Sandy soils that are highly permeable may therefore, retain triclopyr longer. Most studies, however, found that triclopyr generally does not tend to move in significant quantities below the top 15 cm of soil.

Water

In water, the two formulations can behave very differently. The water-soluble salt is degraded in the water column through photolysis and hydrolysis. The ester, however, is not water-soluble and can be persistent in aquatic environments. The ester binds to organic particles in the water column and precipitates to the sediment layers. Bound ester molecules will degrade through hydrolysis or photolysis to triclopyr acid, which will move back into the water column and continue to degrade. The rate of degradation is dependent on the water temperature, pH, and sediment content.

Triclopyr acid has an intermediate soil adsorption capacity. Thus, movement of small amounts of triclopyr residues following the first significant rainfall are likely, but further leaching is believed to be minor. Movement of triclopyr through surface and subsurface runoff in areas with minimal rainfall is believed to be negligible. In southwest Oregon, Norris et al. (1987) found that neither leaching nor long-distance overland water flow contributed significant amounts of the herbicide into a nearby stream, and concluded that the use of triclopyr posed little risk for non-target organisms or downstream water users. Triclopyr can, however, enter waterways via aerial drift and inadvertent overspray. When the acid was applied to rice paddy fields, residues remained in the water column and were not found in significant amounts in the soil. Degradation in water was rapid and showed a half-life of four days.

Vegetation

Both the ester and salt formulations are hydrolysed to the acid after entering plant tissue. The acid tends to remain in plants until they die or drop leaves and begin to decay. Newton et al. (1990) reported that triclopyr in evergreen foliage and twigs showed remarkable persistence. Although concentrations of triclopyr in the soil will decrease quickly and remain low through the winter, levels can rise again in the spring if a new supply of contaminated foliage falls from defoliating crowns. The residues of some herbicides in fruit have been shown to persist up to one month. There is therefore a potential for long-term exposure of triclopyr to animal species that eat wild fruit. In non-target plants, triclopyr soil residues can cause damage via root uptake (Newton et al. 1990).

Environmental Toxicity

Birds and Mammals

Triclopyr is regarded as only slightly toxic to birds and mammals. The oral LD50 for rats is 630-729 mg/kg. The LD50s for mallard ducks and bobwhite quail are 1,698 mg/kg and 2,935 mg/kg, respectively. Newton et al. (1990) predicted that triclopyr would not be present in animal forage in doses large enough to cause either acute or chronic effects to wildlife, and concluded that the tendency for triclopyr to dissipate quickly in the environment would preclude any problems with bioaccumulation in the food chain. Garlon 3A® can cause severe eye damage to both humans and wildlife, due to the high pH of its water-soluble amine salt base. Care must be taken during mixing and application to prevent accidental splashing into eyes.

In a study of the potential effects of herbicide residues on forest songbirds, sub-lethal doses of triclopyr ester (500 mg/kg in the diet for 29 days) were found to cause weight loss and behaviour alterations in zebra finches. In a 1987 study of triclopyr metabolism using one cow, all traces of triclopyr were eliminated from the cow's urine within 24 hours, and no residues were detected in its milk or faeces. This study, however, did not track whether any triclopyr was absorbed into the cow's tissues, or whether the triclopyr recovered in the urine was still active.

Aquatic Species

Triclopyr acid and the salt formulation are slightly toxic to fish and aquatic invertebrates. The LC50 of the acid and the salt formulation for rainbow trout are 117 mg/L and 552 mg/L, respectively, and for bluegill sunfish 148 mg/L and 891 mg/L, respectively. The ester formulation is highly toxic to fish and aquatic invertebrates, with an LC50 (96-hour) of 0.74 mg/L in rainbow trout and 0.87 mg/L in bluegill sunfish. The hydrophobic nature of the ester allows it to be readily absorbed through fish tissues where is it rapidly converted to triclopyr acid. The acid can be accumulated to a toxic level when fish are exposed to sufficient concentrations or for sufficient durations.

The extent to which the toxic effects of the ester are reduced by degradation is poorly understood. Studies have shown that the ester formulation degrades rapidly to less toxic forms. However, there is a significant chance of acute lethal effects to fish exposed to low level residues for more than six hours. In addition, delayed lethal effects were seen in fish exposed to high concentrations for a short duration. Considering that Thompson et al. (1991) concluded that organisms subjected to direct overspray were exposed to a high level of herbicide for short periods of time while organisms downstream were exposed to low levels for longer periods, these findings are of concern.

Nevertheless, most authors including the authors of the fish mortality study have concluded that if applied properly, triclopyr would not be found in concentrations adequate to kill aquatic organisms. As a measure of precaution, however, Kreutzweiser et al. (1991) suggest that some water bodies remain at risk of lethal contamination levels including shallow and slow moving water bodies where dissipation is slow, and heavily shaded streams that experience reduced photodegradation.

Other Non-Target Organisms

Triclopyr inhibited growth of four types of ectomycorrhizal fungi associated with conifer roots at concentrations of 1,000 parts per million (ppm) and higher. Some evidence of inhibition of fungal growth was detected in bioassays with as little as 100 ppm triclopyr. Typical usage in forest plantations, however, results in triclopyr residues of only four to 18 ppm on the forest floor.

Application Considerations:

<u>Application Under Unusual Conditions:</u>
Several natural area managers have found that Garlon 4® and 3A® are effective when applied in mid-winter as a cut-stump treatment against buckthorns (*Rhamnus cathartica* and *R. frangula*). It is often easier to get to these plants when boggy soils around them are frozen. Randy Heidorn, Deputy Director for Stewardship of the Illinois Nature Preserve Commission (INPC), recommends three protocols to increase the safety of triclopyr ester application in winter:

(1) use a mineral oil based carrier;

(2) make sure that at the time of application, no water is at or above the ground surface, and no snow or ice is present that might serve as a route to spread the herbicide following a thaw, and;

(3) initiate a monitoring program to assess ambient water concentrations of triclopyr ester in communities that seasonally have water at or above the ground surface with little or no discharge (i.e. bogs).

Safety Measures
The salt formulation in Garlon 3A® can cause severe eye damage because of the high pH of its water-soluble amine salt base. Care should be taken to prevent splashing or other accident contact with eyes.

Human Toxicology
Because studies into the carcinogenicity of triclopyr have produced conflicting results, EPA has categorized triclopyr as a "Group D" compound, or a chemical that is not classifiable as to human carcinogenicity. The salt formulation in Garlon 3A® can cause severe eye damage.

Date Authored: April 2001; **Date adapted by J. Mauremootoo:** April 2012

Annex 5. Guidelines for the safe use of herbicides (adapted from Tu et al. 2001).

PURPOSE

These Guidelines are designed to ensure that you carefully consider the overall impacts of herbicide use on your conservation targets, other native species, and the ecosystem. Base all decisions whether to control weeds, and whether to use herbicides instead of other methods, on the conservation targets and management goals for the site. In addition, the health and safety of applicators and others in the vicinity must be considered **BEFORE** pesticides are applied. Simply put, one should be confident that the proposed herbicide will do more conservation good than harm and not endanger the health of the applicators or others in the area.

TO USE HERBICIDES OR NOT TO USE HERBICIDES?

Determining the right course of action in IP management can be difficult. For land managers, whether to apply herbicides is an ethical decision that is not taken lightly. Herbicides are often used as a last resort, when other attempts have failed, and action is imperative.

The following checklist summarizes the steps that need to be taken to ensure that proper consideration has been given to current IP problems, and that the use of herbicides is warranted for each individual case.

1. Determine whether IPs threaten conservation targets or management goals on the site. Use herbicides (versus other control methods) only if confident they can be used safely and **will do more conservation good than harm**. If you decide to use herbicides, be sure to record your reasons for doing so.

2. Develop safety protocols for STORING, MIXING, TRANSPORTATING, HANDLING SPILLS, and DISPOSING OF UNUSED HERBICIDES & CONTAINERS **BEFORE** obtaining herbicides.

3. Follow all regulations regarding herbicide use. You **MUST** read and follow product labels. It is a violation of national law in many countries to use an herbicide in a manner inconsistent with its label.

4. Check with the relevant authority **BEFORE** obtaining herbicides if you have any questions about regulations or liability issues.

5. Herbicides may be applied only by individuals who received training in the safe use of herbicides. Volunteers may NOT apply herbicides unless they are properly trained AND have signed a consent & release form.

6. Applicators MUST wear all protective gear required specified on the label of the herbicide they are using. Provide all safety and protective gear requested by the employee(s) applying the herbicide. The health and safety of the applicator are of foremost concern.

SITE CONDITIONS

Site conditions to be considered include accessibility, proximity to open water, depth to groundwater, the presence of rare species and other conservation targets, and the site's sensitivity to trampling that could occur when the herbicide is being applied.

To prevent contamination of water bodies, management plans should carefully consider the hydrology of the system that is being treated. Hypothesize potential runoff scenarios and take appropriate measures (such as buffer zones) to prevent them. Underground aquifers and streams should be considered as well.

The herbicides covered in this management plan are regarded as posing <u>relatively</u> low risk for use in natural areas because they are not likely to contaminate groundwater, have limited persistence in the environment, and are of low toxicity to animals.

ENDOCRINE DISRUPTING COMPOUNDS

The presence of synthetic chemicals in the environment, especially those designed to control unwanted species (insecticides and herbicides), and the acute and long-term effects of those chemicals on wildlife and humans have been of concern since the publication of Rachel Carson's book "Silent Spring" in 1962. New evidence indicates that the functioning of animals (including humans) endocrine systems can be severely altered by low-level cumulative exposure to some synthetic chemicals. Many different classes of industrial chemicals released into the environment exhibit potential endocrine-disrupting activities, such as mimicking or blocking the action of natural animal hormones. Exposure to these compounds during critical periods of development (in utero, or early postnatal) can result in irreversible damage to wildlife and to humans. In general, the compounds found in insecticides are usually more toxic than those in most herbicides, as most herbicides block or alter biochemical processes found exclusively in plants.

Numerous studies have reported that agricultural and industrial waste chemicals adversely affect wildlife populations. Endocrine-altering compounds, however, can also be found naturally (such as the phytoestrogen genistein, that is found in soy protein). Some studies suggest that the effects of synthetic chemicals are negligible relative to those of naturally occurring plant estrogens. Many synthetic compounds are known to bioaccumulate, which may greatly magnify their effects. It has also been suggested that combinations of synthetic compounds act synergistically with effects far greater than those of any one compound.

Some studies suggest that synthetic endocrine-disrupting chemicals alter growth, development, and reproduction rates, and can cause abnormal Behavior in various wildlife species. Further, there is increasing concern regarding potential effects of synthetic endocrine disruptors on human reproduction and development, including, but not limited to, increased breast and ovarian cancers, infertility, increased testicular cancer, decreased semen quality, and increased spontaneous abortion rates.

A review by CAST (Council for Agricultural Science and Technology) published in 2000, concluded that current scientific evidence does not clearly link endocrine-disrupting chemicals with decreased male reproductive capacity or increased rates of breast cancer in women. However, this review did not completely dismiss the potential role that these chemicals may have as causative agents for adverse human health effects. Herbicides are only a small subset of all synthetic chemicals produced, and thus far, only 2,4-D has been implicated for possible endocrine-disrupting impacts. Some reproductive and developmental problems in wildlife populations have been attributed to endocrine-disrupting chemicals, but evidence of other effects are far from conclusive.

HERBICIDE PROPERTIES

Consider the following herbicide properties when deciding which compound to use:

1. Effectiveness against the target species.
2. Mechanisms of dissipation (persistence, degradation, and likelihood of movement via air or water to non-target organisms).
3. Behavior in the environment (in soils, water, and vegetation).
4. Toxicity to birds, mammals, reptiles, aquatic species, and to other non-target organisms (including algae, fungi, and soil organisms).
5. Application considerations
6. Safety
7. Human toxicology

In general for work in natural areas, it is best to select compounds that are effective against the weed, not likely to drift, leach to groundwater or wash into streams, nontoxic to people and other organisms, not persistent in the environment, and is easy to apply. In some circumstances, a single application of a more toxic or persistent chemical that kills the weed, however, may be preferable to a less persistent, less toxic compound that must be applied repeatedly. Strive to do the job with the smallest **total** negative impact to the environment.

PROTECTIVE GEAR FOR APPLICATORS

The health and safety of the applicator are of foremost concern. Applicators MUST wear all protective gear required on the label of the herbicide they are using. See the following textbox for additional information regarding personal protection needs.

All applicators should wear the following when mixing or applying herbicides:

1. Rubber boots,
2. Protective aprons or suits (e.g., disposable tyvek suits) or sturdy overalls that are not used for other activities,
3. Rubber gloves (tyvek and nitrile gloves are recommended - one study indicated that neoprene can be penetrated by herbicides under field conditions),
4. Safety glasses or goggles.

Some applicators may even wish to wear respirators where not required. A dust mask may be worn when a respirator is not required, but pesticide safety officers point out that dust masks usually fit loosely and do not stop volatile compounds. Furthermore, they can indirectly increase chances of exposure if they cause heating, sweating, and irritation, which induce the wearer to repeatedly wipe or scratch their face.

PERSONAL PROTECTION IN HERBICIDE HANDLING

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Herbicide labels indicate the minimum protective equipment required. This may vary by application technique. Cotton, leather, canvas, and other absorbent materials are not chemical resistant, even to dry formulations.

- Always wear at least a long-sleeved shirt, long trousers, sturdy shoes or boots, and socks. The more layers of fabric and air between you and the pesticide, the better the protection.
- A thick layer of spray starch on clothing will add some protection from pesticides.
- Hands and forearms usually receive the most pesticide exposure. Wear chemical-resistant gloves, and tuck shirt sleeves into gloves (gloves should reach up the forearm, with cuffs to catch runs and drips).
- Canvas, cloth, and leather shoes or boots are almost impossible to clean adequately. Wear chemical-resistant rubber boots that come up at least halfway to the knee if the lower legs and feet will be exposed to herbicides or residues.

AVOIDING CONTAMINATION

- Wear chemical-resistant gloves (rubber or plastic such as butyl, nitrile, or polyvinyl chloride are common types).
- Make sure gloves are clean, in good condition, and worn properly. Replace gloves often. Wash and dry hands before putting on gloves. Wash gloves before removing them.
- Wash hands thoroughly before eating, drinking, using tobacco products, or going to the bathroom.
- Cuff gloves if pesticide is expected to run down towards the sleeves. Tuck sleeves into gloves.

EYE AND RESPIRATORY PROTECTION

- PPE labelling might require goggles, face shields, or safety glasses with shields. Some formulas or handling activities pose more risks to eyes than others. Dusts, concentrates, and fine sprays have the highest risk of causing pesticide exposure.
- There are many types of dust-mist masks and respirators, all of which must fit and be used properly to be effective.
- Respiratory protection is most important in enclosed spaces or when the applicator will be exposed to pesticides for a long time.
- Pesticides that can volatilize require the use of respirators. Check label requirements.

PERSONAL CLEAN-UP AFTER HERBICIDE USE

- Wash gloves and footwear (if possible) with detergent and water before removing them.
- Change clothing and put clothes used during application in a plastic box or bag, and keep it away from children or pets Use a mild liquid detergent and warm water to wash your hands, forearms, face, and any other body parts that may have been exposed to pesticides. Take a warm shower and wash your hair and body at the end of the work day.

LAUNDRY

- Do not wash work clothing and personal protective equipment in the same wash water with the family laundry. Handle with care and wash your hands after loading the machine.
- If washing by hand make sure you use rubber gloves.
- If you have chemical-resistant items, follow the manufacturer's washing instructions. Wash boots and gloves with hot water and liquid detergent. Wash twice, once outside and once inside. Air-dry boots and gloves.
- Rinse clothes in a machine or by hand.
- Wash in plenty of water for dilution and agitation.
- If using a washing machine, using heavy-duty liquid detergent in hot water for the wash cycles.
- After washing the clothes, run the washer through one complete cycle with detergent and hot water, but no clothing, to clean the machine.
- Hang items to dry if possible in plenty of fresh air. Do not hang in living areas.
- Using a clothes dryer is acceptable, but over time the machine may become contaminated with pesticide residues.

Whenever they are applying herbicides, even if they are out in the field. All applicators should have access to an eyewash kit and at least 12 litres of clean water.

Decontamination kits are available from many suppliers or can be assembled independently. Rubber buckets or tubs with tight sealing lids are convenient for homemade kits and should include:

1. Two (or more) 10 litre containers filled with potable water,
2. Eyewash kits or eyewash bottles with buffered isotonic eyewash,
3. Hand or body soap (bring enough for all workers to thoroughly wash their hands when in the field),
4. Paper or other disposable towels,
5. A full tyvek coverall with foot covers,
6. A map and directions to the nearest medical facilities. Such maps should be posted in prominent locations at all preserve offices and work buildings. Include a copy as an Appendix to your weed control plan.

POSTING TREATED AREAS

Always keep treated areas off limits to the public at least until the herbicide dries. Treated areas may be kept off limits for longer periods if the herbicide is persistent in the environment.

When posting areas that are accessible to the public (trails, visitor centres etc.), place notices at the usual points of entry or along the perimeter of treated sites. The posting should include a notice that the area has or will be treated, the name of the herbicide used, the date of the treatment, appropriate precautions to be taken, the date when re-entry is judged to be safe, and a phone number for additional information. The notices should be removed after it is judged safe to re-enter the area.

STORING HERBICIDES

Store herbicides in a well-ventilated, cool, dry area where food and drinks are never stored or prepared. Most pesticides should not be stored for any length of time below 4° C. The floor should be concrete or lined with plastic or other impermeable material to prevent leaks from reaching the soil.

The area should be inaccessible to the public and/or locked except when chemicals are being removed or returned. Containers should be labelled to indicate the following: contents (ratio of herbicide, surfactant, water, etc.), date mixed, and approximate volume remaining when placed in storage. The containers must be stored carefully and never stacked.

Heavy plastic garbage bags, a shovel, and an absorbent (e.g., cat litter, corn chicken feed, vermiculite or checmical-absorbing fabric designed for the material you are mixing) must be available for use in cleaning-up small leaks or spills. For more information on spills see below.

MIXING HERBICIDES

USE EXTREME CAUTION WHEN MIXING HERBICIDES! Dermal exposure to a small amount of a concentrated herbicide can be equivalent to the exposure received after a full day of working in a treated field. Before mixing any herbicide, READ THE LABEL. Herbicide labels are legal documents and users are obligated to read and obey them.

Establish a mixing area. Herbicides should be mixed only in pre-designated areas - preferably either in an industrial sink near the storage site or in an area near the treatment site(s) in which damage from small spills or other herbicide contamination would be minimal. Field mixing sites should have relatively few native or other desirable species, not be susceptible to erosion or runoff, and rarely, if ever, be visited by the public or preserve staff. In addition, mixing sites should provide easy access for containment and clean-up of spills.

At the mixing site, assemble the appropriate equipment including safety and clean-up gear and measuring and mixing utensils. Heavy plastic garbage bags, a shovel, and an absorbent (e.g. cat litter) must be easily available at field mixing sites in case of a larger spill. Remember to wear all protective gear while handling and mixing herbicides. Avoid metal measuring utensils as some pesticides can react with metal. Clearly label herbicide-measuring equipment to avoid confusion with equipment used for measuring food. Wash all utensils before storage to prevent contamination of future mixes.

Prior to mixing, determine the order that chemicals will be added to the mix. Generally, adjuvants are added prior to the herbicide, but consult the label for specific instructions. When mixing, start by filling the spray tank or other mixing vessel half to three-quarters full with water. The water should be clean and clear to prevent contamination of the mixture or clogging of tank nozzles and hoses. The water should have a neutral or slightly acidic pH, as alkaline water can cause the pesticide to breakdown prior to application. Add a buffer or acidifier to the water if necessary.

Carefully measure the herbicide concentrate and add it to the tank water. Small measuring errors can lead to large errors in the amount of pesticide applied. Be aware of if you are using the active ingredient (a.i.) or acid equivalent (a.e.) of the herbicide (see sidebar below for more details). The measuring container should be rinsed and the rinsate added to the tank solution. The container of liquid herbicides should be triple rinsed with ¼ container volume of water. Add rinsate to the tank solution or store it in a separate container labelled "WATER AND RINSATE FOR HERBICIDE ONLY, NONPOTABLE"

ACTIVE INGREDIENT (A.I.) VS. ACID EQUIVALENT (A.E.)

Labels on herbicide containers and instructions for mixing herbicides sometimes use units of herbicide active ingredient (a.i.) or acid equivalent (a.e.). The herbicide may be sold in different concentrations, but units of a.i. or a.e. provide standard measures, so the mixing instructions can apply in all cases. In order to follow these instructions, you will need to determine how many a.i. or a.e. are in an ounce, or quart or litre, of the concentrate on hand.

The "active ingredient" (a.i.) of an herbicide formulation is responsible for its herbicidal activity or ability to kill or suppress plants. The a.i. is always identified on the herbicide label by either its common name or chemical name, or both. Herbicide formulations available for sale commonly contain other so-called "inert" compounds too.

The "acid equivalent" (a.e.) of an herbicide is just the acid portion of the a.i., and it is this acid portion that is responsible for herbicidal effects. The acid portion (or parent acid) is generally associated with other chemical compounds to form a salt or an ester, which is more stable and better able to move through a plant's waxy cuticle, and into the plant. The salt or ester is the a.i.

Weak acid herbicides are formulated as salts or esters through the addition of a salt or ester molecular group to the parent acid molecule. This allows the herbicide acid to mix properly with adjuvants and enhances the compound's ability to move into plant tissue. Once the herbicide enters the plant, the salt or ester group is cleaved off the parent molecule, allowing the acid to affect the plant.

Because the salt or ester molecular group can vary dramatically in size, a measure of the per cent a.i., especially in the case of a weak acid herbicide, does not adequately reflect the percentage of acid in the formulation. Thus, the a.e. is used to determine the amount of the product to be applied.

Product labels for weak acid herbicides will list the product's percentage of active ingredient, as well as other inert ingredients, at the top of the label. The percentage of acid equivalent in the formulation is usually listed below these percentages in a separate table or paragraph.

TRANSPORTING HERBICIDES

Herbicides should be transported in tightly sealed containers placed in a well-constructed and watertight carrying box or bucket, such as a Rubbermaid tub or cat litter bucket. A good container will prevent leaks in vehicles, onto applicators, or to the environment. Each program should develop techniques and use materials that will best serve the needs of a particular site or circumstance. In some cases, you may want to carry only a small amount of herbicide to treat weeds encountered while conducting daily activities in the field.

Jack McGowan-Stinski of TNC's Michigan program uses large five-gallon (45 litre) buckets with tight lids to transport herbicides and application equipment into the field. The buckets are large enough to hold all the necessary equipment and can be carried by groups of volunteers. Jennifer Hillmer of TNC's Ohio Program often treats weeds distributed over great distances while working in the field by herself. Jennifer keeps pesticides in a crook-necked squirt bottle for easy application and carries the squirt bottle and other application equipment in a four-litre, square, leak-proof, Nalgene bottle, which can be carried in her backpack along with other field equipment. Jennifer recommends laboratory supply companies as a good place to find equipment for herbicide application and storage.

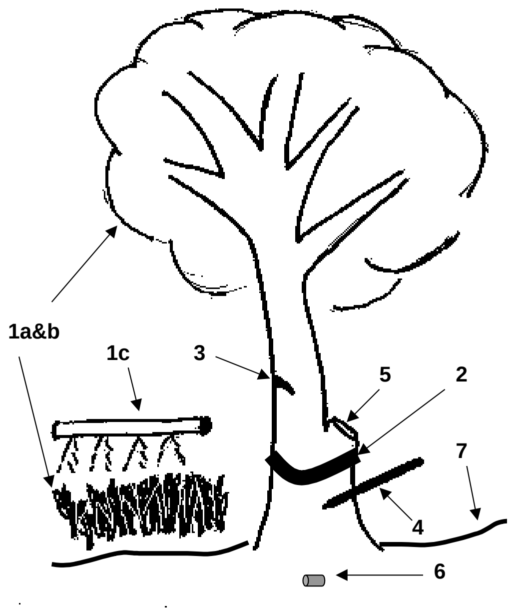
APPLICATION OF HERBICIDES

Application Methods

Herbicides can be applied in a variety of ways. The most appropriate application method is determined by the weed being treated, the herbicide being applied, the skills of the applicator, and the application site. Standard application techniques can sometimes be modified to better suit the needs of natural area management. A few land managers have come up with simple but ingenious techniques and tools that save money, are more effective and safer, and are easier to use than standard methods. We include some of these in the detailed descriptions of techniques below, and encourage you to innovate because there is still plenty of room for improvement.

Methods of application (diagrammed below) can be broadly classified as follows:

1) Foliar application (to intact, green leaves)
    a. Spot application (backpack applicator, spray bottle);
    b. Wick application (wipe-on);
    c. Boom application;
2) Basal bark application (around the circumference of the trunk on the intact bark);
3) Frill; hack and squirt (to cuts in the trunk/stem);
4) Injection (into the inner bark);
5) Cut stump application (to cut stems and stumps);
6) In pellet form at the plant's base (rarely used in natural areas);
7) To the soil before the target species seeds germinate and emerge (rarely used in natural areas).



1. Foliar Applications

These methods apply herbicide directly to the leaves and stems of a plant. An adjuvant or surfactant is often needed to enable the herbicide to penetrate the plant cuticle, a thick, waxy layer present on leaves and stems of most plants. There are several types of foliar application tools available.

A. Spot applicators – Spray herbicide directly onto target plants only, and avoid spraying other desirable plants. These applicators range from motorized rigs with spray hoses to backpack sprayers, to hand-pumped spray or squirt bottles, which can target very small plants or parts of plants. Crook-necked squirt bottles and similar equipment are easy to carry over distances and through dense vegetation.
B. Wick (wipe-on) applicators - Use a sponge or wick on a long handle to wipe herbicide onto foliage and stems. Use of a wick eliminates the possibility of spray drift or droplets falling on non-target plants. However, herbicide can drip or dribble from some wicks.
    i. "Paint sticks" and "stain sticks" have been used successfully for wick application. These sticks have a reservoir in the handle that can hold herbicide, which soaks a roller brush at the end of the handle. The brush is wiped or rolled across leaves and stems.
    ii. The "glove of death" is a technique developed by TNC land stewards for applying herbicide in an otherwise high quality site. Herbicide is sprayed directly onto a heavy cotton glove worn over a thick rubber/latex (or nitrile) glove. The wearer of the glove can then apply the herbicide with total precision and little or no runoff.
C. Boom applicator - A boom, a long horizontal tube with multiple spray heads, is mounted or attached to a tractor, ATV (or other four-wheel drive vehicle), helicopter, or small plane. The boom is then carried above the weeds while spraying herbicide, allowing large areas to be treated rapidly with each sweep of the boom. Offsite movement due to vaporization or drift and possible treatment of non-target plants can be of concern when using this method.

2. Basal Bark application

This method applies a 15 to 30 cm band of herbicide around the circumference of the trunk of the target plant, approximately 30 cm above ground. The width of the sprayed band depends on the size of the plant and the species' susceptibility to the herbicide. The herbicide can be applied with a backpack sprayer, hand-held bottle, or a wick. Ester formulations (e.g. Garlon 4®) are usually best for basal bark treatments, as esters can pass most readily through the bark (as compared to salts). Esters can be highly volatile, however, so basal bark treatments should be performed only on calm, cool days. During summer, treatment is best carried out in the mornings, which tend to be cooler. The basal bark treatment works best on young trees with smooth bark. It is usually not effective against older plants with thick corky bark.

3. Frill or Hack & Squirt

The frill method, also called the "hack and squirt" treatment, is often used to treat woody species with large, thick trunks. The tree is cut using a sharp knife, saw, or axe, or drilled with a power drill or other device. Herbicide is then immediately applied to the cut with a backpack sprayer, squirt bottle, syringe, or similar equipment. Because the herbicide is placed directly onto the thin layer of growing tissue in the trunk (the cambium), an ester formulation is not required.

Jack McGowan-Stinski (TNC-Michigan) recommends using the drill treatment rather than cutting, for trees with dbh (diameter at breast height) greater than 7.5 cm. He has volunteers use "tree steps" to drill holes into trees. Tree steps are large metal screws that can be screwed into a tree trunk by hand to provide steps for tree climbing. When applying herbicide, tree steps are lightweight drilling tools that can be easily carried into the field and used by untrained volunteers.

Jack recommends drilling one hole for each 2.5 cm in dbh (a 25 cm dbh tree would require at least ten holes). Holes should be drilled at a slight downward angle to prevent the herbicide from running out, and should be deep enough to penetrate the inner bark or growing tissue.

Some added recommendations made by Jack for using the drill method include: 1) Spray-paint tree steps with a neon colour to prevent them from being lost if dropped in dense vegetation. 2) Spray-paint circles directly onto the trees around the drilled holes. This will ensure that no holes are overlooked by the herbicide applicator. After the hole is filled with herbicide, the applicator can spray paint a line through the hole to indicate that it was treated.

4. Injection
Herbicide pellets can be injected into the trunk of a tree using a specialized tool such as the EZ-Ject Lance. The EZ-Ject lance's 1.5 m long, metal tube has "teeth" on one end that grip the trunk of the tree. A sharp push on the other end of the tube sends a brass capsule of herbicide into the tree trunk. It is a convenient way of applying herbicide and requires minimal preparation or clean up. In addition, it is an easy and safe way to apply herbicides with minimal exposure.

There are however, some serious drawbacks to this method. The lance and capsules are expensive ($425 per lance; approximately $500 per 4,800 capsules, depending on herbicide), and full-sized lances can be unwieldy, particularly in thickets. The lance furthermore, is difficult to thrust with enough power to drive the capsules far enough into thick barked trees to be effective. A large number of capsules placed close together are often necessary to kill large trees.

At the Albany Pine Bush Preserve in New York, glyphosate gel pellets were injected using an EZ-Ject Lance into trees with an average dbh of eight centimetres. In some cases, crowns of treated trees later showed signs of stress, but most of these re-sprouted vigorously and none of the treated trees died (Hawver et al. 2000).

Herbicides can also be injected into herbaceous stems by using a needle and syringe. Jonathan Soll (TNC-Oregon) reports 100% control of small patches of Japanese knotweed (*Polygonum cuspidatum*) with no off-target effects, by injecting every single stem near the base with herbicide. He adds that this method may actually use more herbicide than foliar spraying (since you use high concentrations of the herbicide), and caution with the needle and syringe is necessary since you are carrying around a sharp object.

A low tech method of stem injection is the use of a battery-powered drill to make holes in the bark rapidly followed up by application of the herbicide compound using a dropper bottle, spray applicator or syringe. This method is probably appropriate in many developing countries.

5. Cut-Stump application
This method is often used on woody species that normally re-sprout after being cut. Cut down the tree or shrub, and immediately spray or squirt herbicide on the exposed cambium

(living inner bark) of the stump. The herbicide must be applied to the entire inner bark (cambium) within minutes after the trunk is cut. The outer bark and heartwood do not need to be treated since these tissues are not alive, although they support and protect the tree's living tissues.

Herbicide can be applied to cut stumps in many ways, including spray and squirt bottles, or even paint brushes. Care must be taken to avoid applying too much herbicide, and allowing it to run-off the stump and onto the ground. Herbicide can also dribble from bottles or brushes and fall on desirable plants or the ground. To help avoid these problems, Jack McGowan-Stinski (TNC-Michigan) developed an inexpensive and easy to assemble application tool using PVC pipe and a sponge through which the herbicide can be applied.

Sometimes even treated stumps will re-sprout, so it is important to check them at regular intervals (2 to 6 months) for at least a year. Depending on the vigour of the re-sprouts, these can be treated by cutting, basal bark applications, or foliar applications. Even when foliar applications are called for, treating re-sprouts is usually far easier and requires much less herbicide than treating the tree (before it was cut down) with a foliar application.

The cut stump treatment allows for a great deal of control over the site of herbicide application, and therefore, has a low probability of affecting non-target species or contaminating the environment. It also requires only a small amount of herbicide to be effective.

Selecting a Method

Minimize
Select a technique(s) that (1) minimizes risks of contact to the applicator and others that may be in the area during and after herbicide application, AND (2) minimizes release of herbicide to the environment, particularly if the herbicide could contact non-target species. Avoid using boom application where possible (1c above) because it can result in a relatively high amount of herbicide contacting non-target species and bare ground. Also, avoid using pellets and pre-emergence herbicides (6 & 7 above, respectively) because they are relatively persistent in the environment.

Use a dye
Mix a dye with the herbicide so applicators can see which plants have been treated and if they have gotten any herbicide on themselves or their equipment. Some pre-mixed herbicides include a dye (e.g., Pathfinder II® includes the active ingredient triclopyr, a surfactant, and a dye). Ester based herbicides like Garlon 4® require oil-soluble dyes like colorfast purple®, colorfast red®, and basoil red® (for use in basal bark treatments), which are sold by agricultural chemical and forestry supply companies. Clothing dyes like those produced by Rit® will work in water-soluble herbicides such as Garlon 3A®.

Who May Apply Herbicides?
Those who apply herbicides must have received training in the safe use of herbicides. Volunteers may NOT apply herbicides unless they are properly trained AND have signed a consent & release form.

Protection against Herbicides

When using herbicides, the safety of the applicator, to others, and to the environment is of utmost importance. Be sure to read the earlier textbox on “Personal Protection in Herbicide Handling” regarding specific equipment requirements, how to avoid contamination, eye and respiratory protection, how to clean-up after herbicide use, and how to launder clothes and equipment used during herbicide application.

When to Apply Herbicides

The best time to apply an herbicide is determined primarily by the herbicide’s mode of action and the physiology of the target plants. In seasonal climates, it is often best to apply herbicides in autumn or prior to the dry season, 3 to 6 weeks before the target plant goes dormant for the season. This is because many plants apparently transfer sugars and nutrients from their stems and leaves to belowground storage organs at this time and will carry herbicides along to these areas as well. Contrary to assumptions that plants will be most vulnerable when weak, herbicides are usually ineffective when applied during a drought or other stressful conditions. This is because most herbicides work by attacking growing tissue and metabolic processes, which plants ‘shut down’ when stressed. In fact, late winter or early spring are often good times to apply herbicide because this is when plants begin growing again, and can efficiently translocate the herbicide throughout their tissues. Fosamine ammonium, the dormancy enforcer, is best applied in the late fall just before leaf drop. The herbicidal effects of fosamine ammonium however, are not observed until the following spring when treated plants fail to re-foliate.

In some cases, the site of application may determine the best time to apply a herbicide. For example, buckthorns (*Rhamnus* spp.) growing in wet, boggy areas are easiest to treat during winter when the ground is frozen. Check the label or consult your distributor for the best application time under the conditions at your site.

Note that with some herbicides there is a long time lag between time of herbicide application and the first evidence that they are working. This is particularly true of herbicides that work by inhibiting amino acid or lipid synthesis, because the plant(s) can rely on stored supplies to continue growing.

Record Keeping

When using herbicides it is critical to keep records of all plants/areas treated, amounts and types of herbicide used, and dates of application. This information will be important in evaluating the project’s success, improving methodology, and identifying mistakes. In addition, it documents the procedure for future site managers and biologists. Records of abundance/condition of the targeted weeds and nearby desirable plants before and after treatment will also be valuable in evaluating the effectiveness of the herbicide.

HERBICIDE DISPOSAL

Equipment cleanup

Following use, application equipment and empty containers should be triple rinsed with clean water using 10% of the container volume for each rinse. If possible, rinse equipment in the treatment area and apply the wastewater to weeds or store for future use as a dilutant. Left over herbicide mix that will not be used later should be treated as hazardous waste.

Container disposal

If no specific agri-chemical container recycling program is available, puncture the empty container to prevent anyone from using it as a container again, and then dispose of or destroy it.

Equipment and applicator clean-up

After use, first clean and store application equipment and then thoroughly rinse personal protection gear (gloves, boots, etc.) with cold water from a hose or container that is hand-held (gloves off) and was not used during application work. All personal protection gear should then be washed in mild soap and water. Finally, applicators should wash their hands and any herbicide-exposed areas of their bodies. Applicators should shower and change clothing as soon as possible. Clothes used during the application must be washed and dried separately from other clothing before it is worn again, even if it appears uncontaminated.

Contaminated clothing

If herbicide concentrate spills on clothing, the clothing should be discarded or, where permitted, burned immediately. Wrap contaminated clothing and other materials in newspaper before placing in trash or landfill. In cases where small quantities are involved it may be possible to dispose of contaminated clothing in the trash.

RESPONDING TO SPILLS

Rules and regulations regarding pesticide spills vary between states and counties. Therefore, before obtaining herbicides, call the local fire department or county Hazardous Materials Office for information on local regulations. In most cases, the proper response to a spill depends on the volume and concentration of herbicide released, location of the spill, and the chemical(s) involved. If possible, inquire as to whether a report would be required in a hypothetical situation in which all the herbicide was spilled (1) on the soil in the interior of the preserve and (2) along a public road. A rule of thumb employed by some public land management agencies is not to call for help from the local Hazardous Materials Office for herbicide spills unless they contaminate too much soil to dig up and place in plastic garbage bags. However, since our goal is to protect biodiversity, land managers are expected to minimize damage to native populations. Hazardous Materials officers we spoke to considered spills under 450 litres to be "small". Most emergency systems appear to be designed to deal with these larger volumes used in agriculture and industry, which are far larger than those typically used in natural areas.

Be sure to carry a "Pesticide Kit" for emergency spills (see the following Pesticide Spill Kit equipment list). If a spill occurs, keep people away from affected areas until the clean-up process is complete. When small volumes of dilute herbicide are spilled they may be treated by carefully digging up the affected soil and litter, and spreading this material at the legal rate or concentration. Small diesel (sometimes used as a crude surfactant) and gasoline spills may be treated by adding organic material (e.g., cow manure or compost) to the affected area and keeping it moist. It may take several years for the spilled material to degrade.

PESTICIDE KIT EQUIPMENT LISTS

Adapted from work by Jack McGowan-Stinski and Jennifer Hillmer

PESTICIDE SPILL KITS

- Emergency phone numbers
- Labels and material safety data sheets (MSDSs) of all pesticides on hand
- Personal Protective Equipment: gloves, footwear, apron, goggles, face shield, respirator
- Heavy plastic bags for material storage
- Absorbent materials (cat litter, vermiculite, paper, etc.)
- Neutralizing agents (bleach and hydrated lime)
- Sweeping compound for dry spills
- Shovel, broom, dustpan
- Heavy duty detergent, chlorine bleach, and water
- Sturdy plastic container that closes tightly and will hold the largest quantity of pesticide on hand
- First aid supplies
- Fresh water (at least 12 litres; bring extra for wash-up after application)
- Eyewash
- Soap (dish soap or hand soap)
- Towels
- Change of clothes
- Additional items required by labelling

ADDITIONAL HERBICIDE FIELD EQUIPMENT

- Extra application equipment (e.g., squeeze bottles, nalgene bottles, sponges)
- Funnel
- Herbicide dyes
- Herbicide in original containers
- Extra water, soap, towels, plastic bags

Updated: June 2003

Adapted by John Mauremootoo: April 2012

Annex 6. Invasive plant management cost information

Documentation relating to the cost of invasive plant control and ecosystem restoration efforts is not readily available, in part because of the challenges of accounting accurately for the complete costs of operations. Individual efforts, targeting a particular species in a particular region, are often part of a larger program focused on a whole suite of species in a larger region. Accounts generally do not include any costs associated with coordination of the program, which of course is essential. However, some information, albeit imperfect, does exist which gives managers an idea of the cost implications of any proposed ecosystem restoration actions.

The principal cost of any IP management effort will be labour costs. Invasive plant management labour costs have been documented for Mauritius - on the offshore island of Ile aux Aigrettes, and in heavily invaded forest on the mainland in 2001 (Mauremootoo and Towner-Mauremootoo 2002). It is estimated that is takes between 315 and 2000 person hours to weed one hectare of heavily invaded forest (manual clearance and uprooting of IPs). Staff work 5 hour days, 22 days per month. This translated to a labour cost of between $US492 - $3,125 at 2001 costs and exchange rates.

The most heavily infested areas are then planted with nursery-grown native pioneer species. The initial heavy weeding must soon be followed up by intensive light weeding because the sudden increase in light levels in the newly weeded areas results in a rapid germination of the very large weed soil seed bank. Such high intensity maintenance weeding may take another 1920 man-hours per hectare in the first year of management. The effort then diminishes rapidly in subsequent years as the weed soil seedbank is exhausted and planted native species grow, thus decreasing light levels on the ground and increasing competition with regenerating weeds. Once a good canopy is established (within 4-10 years following initial weeding) the area needs to be weeded only once every five years (ca. 440 man-hours per hectare or 88 hours per ha. per year). This translates into a long-term maintenance cost of ca. $US140 per ha.

Preliminary work using cut stump herbicide applications suggest that herbicide use can reduce the labour costs for weeding by half or more. Foliar sprays to weed regrowth are also likely to result in significant cost savings.

Other costs of IP management include the following item: herbicides, post-herbicide application cleanup activities, transport, monitoring and equipment.

A sample time and motion monitoring template has been produced for this management plan (Annex 7) to be used to enter time data for operations. This can be then translated into monetary terms and combined with other costs (fixed costs, e.g. equipment and overhead costs, e.g. programme coordination) to give an approximate overall cost of IP management.

Costs of each item can be estimated in advance but accurate cost estimates will only be possible once time and motion studies are undertaken on IP control efforts. These estimates will inform future planning.

The studies in Mauritius send a clear message that initial weeding of large IP infestations is very labour-intensive and expensive. **Management efforts should focus on less degraded areas** unless there are overwhelming reasons for working in heavily invaded areas, e.g. all areas are heavily invaded (as is the case in Mauritius), heavily invaded areas contain very important endangered species habitats, heavily invaded areas can provide a showcase area for restoration accessible to the public or that the work is being undertaken to improve restoration techniques that can be later applied to other areas.

Annex 7. Example monitoring data sheets and templates

This annex gives examples of data sheets for the following:

- Estimate of vegetation cover to ascertain changes in vegetation patterns in PAs
- Invasive plant detection to provide surveillance information for new IP locations to inform management operations (rapid response and other management options)
- Fixed point photograph datasheet to ensure that fixed point photography is performed systematically to provide a rapid and easy to communicate way to record landscape changes over time
- Time and motion monitoring for IP management to derive time and cost estimates for IP management activities
- Herbicide application monitoring to document procedures used in order to assess their effectiveness.

Estimate of vegetation cover

Figure A7.1. Example template for recording IP and native species cover data in selected areas

Category	Vegetation Cover	Species 1	Species 2	Species 3
Absent	0%			
Present but less than 1% cover	<1%			
Light	1-25%			
Moderate	25-50%			
Heavy	50-75%			
Extreme	75-100%			

Figure A7.2. Example datasheet for reporting a new invasive plant protection (Adapted from Kohl 2011).

INVASIVE PLANT REPORT FORM

Collection information

Collector name____

Organisation____

Address____

Characteristics and Location

Plant name (common and/or scientific name)_______________________________________

Site and density of infestation: Describe the extent of infestation and estimate numbers

Habitat description: Describe general habitat types such as planted forest interior, crop field, pasture, disturbed ground, settlement

Location landmarks: Provide enough details so the site can be found again. Note landmarks such as roads, buildings, cliff edges and other natural and cultural features

Geographic coordinates

1. Latitude_______________**N Longitude** _______________**E**

2. UTM__________________**E**_________________________**N**

Nearest settlement____________________________________

Photograph taken (Yes/No)

Photograph available from:

Collector name______________________________**Organisation**___________________________

Address____

Photo code name____

Fixed point photography

Figure A7.3. Example fixed point photograph datasheet (Adapted from WWF 2007).

Code:			**Photographer:**			**Date:**	
Photo number	**Time**	**Slope**	**UTM E**	**UTM N**	**Compass Bearing**	**Slope**	**Descriptions**

Time and Motion monitoring

Figure A7.4. Example template for recording time and motion data

Code	Date	GPS Location	Management prescription	Operation time in person hours									Notes
				Herbicide preparation	Travel	Hand weeding	Herbicide application	Monitoring	Planting	Herbicide	Clean up	Other operations	

Major operations such as weeding and planting can be timed for named locations. Other operations, e.g. preparing herbicides, travel and clean up after herbicide use are likely to pertain to a variety of locations. The time taken for these operations can be noted and the total figure divided by the number of locations treated to derive a mean or weighted mean time per location.

Herbicide application monitoring

Figure A7.5. Example IP treatment implementation form (can be used for herbicide treatments or other control methods (adapted from US Forest Service. Pacific Northwest Region (2008).

Project Name:____

Implementation date: ____

Responsible Officer: Name____

Position____

Target Species:

____

Treatment method(s): Herbicide (   ) Manual ( ) Mechanical ( ) Cultural ( )

Herbicide Formulation(s):

Herbicide application method:

Herbicide rates used:

Hectares treated: ______________Is this a re-treatment, if so, how many previous visits? _______

Species of interest found in area:

( ) Animals ( ); Plants – conservation interest; Plants ( ) economic interest

Species names:

____

____

When using herbicides it is critical to keep records of all plants/areas treated, amounts and types of herbicide used, and dates of application. This information will be important in evaluating the project's success, improving methodology, and identifying mistakes. In addition, it documents the procedure for future site managers and biologists. Records of abundance/condition of the targeted weeds and nearby desirable plants before and after treatment will also be valuable in evaluating the effectiveness of the herbicide

Annex 8. International Guidelines for the Export, Shipment, Import, and Release of Biological Control Agents and Other Beneficial Organisms (International Standard for Phytosanitary Measures No. 3).

ENDORSEMENT

ISPM No. 3 was first endorsed by the 28th Session of the FAO Conference in November 1995 as: *Code of conduct for the import and release of exotic biological control agents*. The first revision was endorsed by the Interim Commission on Phytosanitary Measures in April 2005 as the present standard, ISPM No. 3 (2005).

INTRODUCTION

SCOPE

This standard[18] provides guidelines for risk management related to the export, shipment, import and release of biological control agents and other beneficial organisms. It lists the related responsibilities of contracting parties to the IPPC ('contracting parties'), National Plant Protection Organizations (NPPOs) or other responsible authorities, importers and exporters (as described in the standard). The standard addresses biological control agents capable of self-replication (including parasitoids, predators, parasites, nematodes, phytophagous organisms, and pathogens such as fungi, bacteria and viruses), as well as sterile insects and other beneficial organisms (such as mycorrhizae and pollinators), and includes those packaged or formulated as commercial products. Provisions are also included for import for research in quarantine facilities of non-indigenous biological control agents and other beneficial organisms.

The scope of this standard does not include living modified organisms, issues related to registration of biopesticides, or microbial agents intended for vertebrate pest control.

REFERENCES

Convention on Biological Diversity, 1992. CBD, Montreal.

Glossary of phytosanitary terms, 2004. ISPM No. 5, FAO, Rome.

Guidelines for pest risk analysis, 1996. ISPM No. 2, FAO, Rome.

Guidelines for phytosanitary certificates, 2001. ISPM No. 12, FAO, Rome.

Guidelines for a phytosanitary import regulatory system, 2004. ISPM No. 20, FAO, Rome.

Guidelines on lists of regulated pests, 2003. ISPM No. 19, FAO, Rome.

International Plant Protection Convention, 1997. FAO, Rome.

Pest reporting, 2002. ISPM No. 17, FAO, Rome.

[18] Nothing in this standard shall affect the rights or obligations of contracting parties under other international agreements. Provisions of other international agreements may be applicable, for example the Convention on Biological Diversity.

Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms, 2004. ISPM No. 11, FAO, Rome.

DEFINITIONS

Definitions of phytosanitary terms used in the present standard can be found in ISPM No. 5 (*Glossary of phytosanitary terms*).

OUTLINE OF REQUIREMENTS

This standard is intended to facilitate the safe export, shipment, import and release of biological control agents and other beneficial organisms. Responsibilities relating to this are held by contracting parties, National Plant Protection Organizations (NPPOs) or other responsible authorities, and by importers and exporters.

Contracting parties, or their designated authorities, should consider and implement appropriate phytosanitary measures related to the export, shipment, import and release of biological control agents and other beneficial organisms and, when necessary, issue related import permits.

As described in this standard, NPPOs or other responsible authorities should:

- carry out pest risk analysis of biological control agents and other beneficial organisms prior to import or prior to release;
- ensure, when certifying exports, that the phytosanitary import requirements of importing contracting parties are complied with;
- obtain, provide and assess documentation as appropriate, relevant to the export, shipment, import or release of biological control agents and other beneficial organisms;
- ensure that biological control agents and other beneficial organisms are taken either directly to designated quarantine facilities or mass-rearing facilities or, if appropriate, passed directly for release into the environment;
- encourage monitoring of release of biological control agents or beneficial organisms in order to assess impact on target and non-target organisms.

Responsibilities of, and recommendations for, exporters include ensuring that consignments of biological control agents and other beneficial organisms comply with phytosanitary import requirements of importing countries and relevant international agreements, packaging consignments securely, and providing appropriate documentation relating to biological control agents or other beneficial organisms.

Responsibilities of, and recommendations for, importers include providing appropriate documentation relating to the target pest(s) and biological control agent or other beneficial organisms to the NPPO or other responsible authority of the importing country.

BACKGROUND

The International Plant Protection Convention (IPPC) is based on securing common and effective action to prevent the spread and introduction of pests of plants and plant products, and the promotion of appropriate measures for their control (Article I of the IPPC, 1997). In this context, the provisions of the IPPC extend to any organism capable of harbouring or spreading plant pests, particularly where international transportation is involved (Article I of the IPPC, 1997).

The IPPC (1997) contains the following provision in relation to the regulation of biological control agents and other beneficial organisms. Article VII.1 states:

"With the aim of preventing the introduction and/or spread of regulated pests into their territories, contracting parties shall have sovereign authority to regulate, in accordance with applicable international agreements, the entry of plants and plant products and other regulated articles and, to this end, may: ...

c) prohibit or restrict the movement of regulated pests into their territories;
d) prohibit or restrict the movement of biological control agents and other organisms of phytosanitary concern claimed to be beneficial into their territories."

Section 4.1 of ISPM No. 20 (*Guidelines for a phytosanitary import regulatory system*), contains a reference to the regulation of biological control agents; it states:

"*Imported commodities that may be regulated include articles that may be infested or contaminated with regulated pests. ... The following are examples of regulated articles: ... pests and biological control agents.*"

This revision of ISPM No. 3 provides guidelines related to phytosanitary measures, as well as recommended guidelines for safe usage of biological control agents and other beneficial organisms. In some cases, the scope of these guidelines may be deemed to extend beyond the scope and provisions of the IPPC as described above. For example, although the primary context of this standard relates to phytosanitary concerns, "safe" usage as mentioned in the standard is intended to be interpreted in a broader sense, i.e. minimizing other non-phytosanitary negative effects. Phytosanitary concerns may include the possibility that newly introduced biological control agents may primarily affect other non-target organisms, but thereby result in harmful effects on plant species, or plant health in habitats or ecosystems. However, it is not intended that any aspects of this standard alter in any way the scope or obligations of the IPPC itself as contained in the New Revised Text of the IPPC (1997) or elaborated on in any of the other ISPMs.

The structure of this revised standard broadly follows the same structure of the original ISPM No. 3, and its content is based primarily on risk management relating to the use of biological control agents and other beneficial organisms. It is recognized that the existing standards on pest risk analysis (ISPM No. 2: *Guidelines for pest risk analysis* and ISPM No. 11: *Pest Risk Analysis for quarantine pests including analysis of environmental risks and living modified organisms*, 2004) provide the appropriate fundamental processes for carrying out pest risk assessments for biological control agents and other beneficial organisms. In particular, ISPM No. 11 includes provisions for pest risk assessment in relation to environmental risks, and this aspect covers environmental concerns related to the use of biological control agents.

The IPPC (1997) takes into account internationally approved principles governing the protection of the environment (Preamble). Its purpose includes promoting appropriate phytosanitary measures (Article I.1). When carrying out pest risk analysis in accordance with this and other appropriate ISPMs, and in developing and applying related phytosanitary measures, contracting parties should also consider the potential for broader environmental impacts resulting from releasing biological control agents and other beneficial organisms[19] (for example, impacts on non-target invertebrates).

Most of this standard is based on the premise that a biological control agent or other beneficial organism may be a potential pest itself, and in this sense Article VII.1c of the IPPC (1997) applies because contracting parties may prohibit or restrict the movement of regulated pests into their territories. In some situations, biological control agents and other beneficial organisms may act as a carrier or pathway for plant pests, hyperparasitoids, hyperparasites and entomopathogens. In this sense, biological control agents and other beneficial organisms may be considered to be regulated articles as described in Article VII.1 of the IPPC (1997) and ISPM No. 20: *Guidelines for a phytosanitary import regulatory system*.

Purpose of the standard

The objectives of the standard are to:

- facilitate the safe export, shipment, import and release of biological control agents and other beneficial organisms by providing guidelines for all public and private bodies involved, particularly through the development of national legislation where it does not exist.

- describe the need for cooperation between importing and exporting countries so that:

    • benefits to be derived from using biological control agents or other beneficial organisms are achieved with minimal adverse effects

    • practices which ensure efficient and safe use while minimizing environmental risks due to improper handling or use are promoted.

Guidelines in support of these objectives are described that:

- encourage responsible trade practices

- assist countries to design regulations to address the safe handling, assessment and use of biological control agents and other beneficial organisms

[19] Available expertise, instruments and work in international fora with competence in the area of risks to the environment should be taken into account as appropriate.

- provide risk management recommendations for the safe export, shipment, import and release of biological control agents and other beneficial organisms
- promote the safe use of biological control agents and other beneficial organisms.

REQUIREMENTS

1. Designation of Responsible Authority and Description of General Responsibilities

1.1 Contracting parties

Contracting parties should designate an authority with appropriate competencies (usually their NPPO) to be responsible for export certification and to regulate the import or release of biological control agents and other beneficial organisms, subject to relevant phytosanitary measures and procedures.

Contracting parties should have provisions for implementing appropriate phytosanitary measures for the export, shipment, import or release of biological control agents and other beneficial organisms.

1.2 General responsibilities

The NPPO or other responsible authority should establish procedures for the implementation of this standard, including for the assessment of relevant documentation specified in section 4.

The NPPO or other responsible authority should:

- carry out pest risk analysis prior to import or release of biological control agents and other beneficial organisms
- ensure, when certifying exports, that the regulations of importing countries are complied with
- provide and assess documentation as appropriate, relevant to the export, shipment, import or release of biological control agents and other beneficial organisms
- ensure that biological control agents and other beneficial organisms are taken either directly to designated quarantine facilities or, if appropriate, passed to mass rearing facilities or directly for release into the environment
- ensure that importers and, where appropriate, exporters meet their responsibilities
- consider possible impacts on the environment, such as impacts on non-target invertebrates.

The NPPO or other responsible authority should maintain communication and, where appropriate, coordinate with relevant parties including other NPPOs or relevant authorities on:

- characteristics of biological control agent and other beneficial organisms
- assessment of risks including environmental risks
- labelling, packaging and storage during shipment

- dispatch and handling procedures
- distribution and trade
- release
- evaluation of performance
- information exchange
- occurrence of unexpected and/or harmful incidents, including remedial action taken.

2. Pest Risk Analysis

The NPPO of the importing country should determine whether an organism is required to be subjected to pest risk analysis (PRA). The NPPO or other responsible authority may also be responsible for ensuring that other national legislative requirements are met; however, these may not be IPPC obligations.

Pest risk assessment should be conducted in accordance with ISPM No. 2 (*Guidelines for pest risk analysis*) and/or stage 2 of ISPM No. 11 (*Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms,* 2004) as appropriate, taking into account uncertainties, and potential environmental consequences, as provided for in those standards. In addition to conducting pest risk assessment, contracting parties should also consider possible impacts on the environment, such as impacts on non-target invertebrates.

Most contracting parties require PRA to be completed prior to import and technical justification, as described in ISPM No. 20 (*Guidelines for a phytosanitary import regulatory system*), such as through PRA, is required to determine if pests should be regulated and the strength of phytosanitary measures to be taken against them. Where applicable, if pest risk assessment of the proposed organism has not been undertaken or completed prior to import, it should be completed prior to release (see section 7). However, it is recognized that biological control agents and other beneficial organisms may need to be imported for research and evaluation in secure facilities prior to release. ISPM No. 20 also states that contracting parties may make special provision for the import of biological control agents and other beneficial organisms for scientific research, and that such imports may be authorized subject to the provision of adequate safeguards. The NPPO should be prepared for such imports with the expectation that, where necessary, a full PRA in accordance with ISPM No. 11 (*Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms,* 2004) will be completed prior to release. When non-phytosanitary risks are identified, these may need to be referred to other appropriate authorities for possible action.

It may be important that further scientific investigations are carried out in the exporting country prior to importing the biological control agents or other beneficial organisms in order to verify the accuracy and reliability of the risk assessment. Among other options, and where appropriate, NPPOs or other responsible authorities may consider possibilities for such scientific investigations, in cooperation with the authorities of the exporting country and in accordance with relevant procedures and regulations.

3. Responsibilities of Contracting Parties prior to Import

3.1 Responsibilities of the importing contracting party

The importing contracting party or its NPPO or other responsible authority should:

3.1.1 Promote awareness of, and compliance with this standard and introduce necessary phytosanitary measures to regulate the import, shipment or release of biological control agents and other beneficial organisms in its country, and make provision for effective enforcement.

3.1.2 Evaluate the documentation on the target pest and on the biological control agent and beneficial organisms supplied by the importer (see section 4) in relation to the level of acceptable risk. The contracting party should establish appropriate phytosanitary measures for import, shipment, quarantine facilities (including approval of research facilities, and phytosanitary measures for containment and disposal) or release of biological control agents appropriate to the assessed risk. If the biological control agent or other beneficial organism is already present in the country, regulation may only be needed to ensure there is no contamination or infestation of this organism, or that interbreeding with local genotypes of the same species does not result in new phytosanitary risks. Inundative release may be restricted for these reasons.

3.1.3 Issue regulations stating requirements to be fulfilled by the exporting country, the exporter and the importer[20]. Where appropriate, these may include:

- the issuing of an accompanying authorising document (import permit or licence)
- phytosanitary certification, in accordance with ISPM No. 12: *Guidelines for phytosanitary certificates*
- a specific certification document
- authoritative identification of organisms during quarantine and provision of a reference specimen
- specification of the source of the biological control agent or other beneficial organism(s), including origin and/or point of production where relevant
- precautions to be taken against inclusion of natural enemies of the biological control agent or other beneficial organism and of contamination or infestation
- requirements regarding packaging for shipment during transport and storage
- procedures for the disposal of packaging
- means to validate documentation
- means to validate the contents of consignments

[20] Provisions of other international agreements may address the import of biological control agents or other beneficial organisms (for example the Convention on Biological Diversity).

- conditions under which the package may be opened
- designation of point(s) of entry
- identification of the person or organization to receive the consignment
- requirements for the facilities in which the biological control agent or other beneficial organisms may be held.

3.1.4 Ensure that procedures are in place for the documentation of:

- pest risk analysis
- the import (identity, origins, dates)
- nurturing, rearing or multiplication
- release (quantities released, dates, locations), and
- any other relevant data.

Such records may be made available to the scientific community and the public, as may be appropriate, while protecting any proprietary rights to the data.

3.1.5 If appropriate, ensure entry of consignments, and processing where required, through quarantine facilities. Where a country does not have secure quarantine facilities, import through a quarantine station in a third country, recognized by the importing contracting party, may be considered.

3.1.6 Consider, through pest risk analysis, the risk of introducing other organisms associated with the biological control agent or beneficial organism. Considerations (keeping in mind the principles of necessity and minimal impact) should include phytosanitary measures requiring the culturing of imported biological control agents and other beneficial organisms in quarantine before release. Culturing for at least one generation can help in ensuring purity of the culture and freedom from hyperparasites and pathogens or associated pests, as well as facilitating authoritative identification. This is particularly advisable when biological control agents and other beneficial organisms are collected from the wild.

3.1.7 Where possible, ensure the deposition in collections of authoritatively identified reference specimens of the imported biological control agent or other beneficial organism (and host(s) where appropriate). It is preferable to deposit a series of specimens, where available, to accommodate natural variation.

3.1.8 In the case of sterile insect technique, the sterile insect may be marked to differentiate it from the wild insect.

3.1.9 Consider, through pest risk analysis (consistent with the principles of necessity and minimal impact), if, after a first import or release, further imports of the same biological control agent or other beneficial organism may be exempted from some or all of the requirements for import. The publication of lists of approved and prohibited biological control agents and other beneficial organisms may also be considered. If appropriate, biological control agents that are prohibited should be included in lists of regulated pests (established and updated by contracting parties in accordance with the IPPC (1997) and ISPM No. 19: *Guidelines on lists of regulated pests*).

3.2 Responsibilities of the NPPO of an exporting country

The NPPO of an exporting country should ensure that the phytosanitary import requirements of the importing country are satisfied and that phytosanitary certificates are issued in accordance with ISPM No. 12: *Guidelines for phytosanitary certificates*, where required by the importing country for consignments of biological control agents or other beneficial organisms, if these are considered as potential pests or pathways for plant pests.

The NPPO is also encouraged to follow the appropriate elements of this standard where the importing country has no legislation concerning the import of biological control agents and other beneficial organisms.

4. Documentary responsibilities of importer prior to import

4.1 Documentary requirements related to the target organism

Prior to the first importation, the importer of biological control agents or other beneficial organisms should provide information as required by the NPPO or other responsible authority of the importing contracting party. For all biological control agents or other beneficial organisms, this information includes accurate identification of the target organism(s), generally at the species level. Where a biological control agent intended to control a pest is being imported, the information on the target pest may also include:

- its world distribution and probable origin
- its known biology and ecology
- available information on its economic importance and environmental impact
- possible benefits and any conflicting interests surrounding its use
- known natural enemies, antagonists and other biological control agents or competitors of the target pest already present or used in the proposed release area or in other parts of the world.

For all biological control agents or other beneficial organisms, other information relevant to a PRA may also be requested by the NPPO or other responsible authority of the importing contracting party.

4.2 Documentary requirements related to the biological control agent or other beneficial organism

Prior to first import, the importer of biological control agents or other beneficial organisms should coordinate with the exporter to provide documentation, accompanied by appropriate scientific references, to the NPPO or other responsible authority of the importing contracting party with information on the biological control agent or beneficial organism including:

- sufficient characterization of the biological control agent or other beneficial organism to allow for its accurate identification, in general to the species level at minimum

- a summary of all available information on its origin, world distribution, biology, natural enemies, hyperparasites, and impact in its area of distribution

- available information on host specificity (in particular, a list of confirmed hosts) of the biological control agent or beneficial organism and any potential hazards posed to non-target hosts

- description of natural enemies and contaminants of the agent and procedures required for their elimination from laboratory colonies. This includes, where appropriate, procedures to identify accurately and, if necessary, eliminate from the culture the host upon which the biological control agent or beneficial organism was cultured. Information on any phytosanitary measures taken prior to shipment should also be provided.

4.3 Documentary requirements related to potential hazards and emergency actions

Prior to first importation, the importer of biological control agents or other beneficial organisms is encouraged to provide documentation to the NPPO or other responsible authority that:

- identifies potential health hazards and analyzes the risks[21] posed to staff operatives exposed when handling biological control agents or other beneficial organisms under laboratory, production and application conditions.

- details emergency action plans or procedures already in existence, should the biological control agent or beneficial organism display unexpected adverse properties.

4.4 Documentary requirements related to research in quarantine

An importer of biological control agents or other beneficial organisms proposed for research in quarantine should provide as much information as possible as described in points 4.1–4.3. However, it is recognized that field collected organisms imported by researchers in initial shipments of potential biological control agents may not be described with regard to their exact taxonomic identity, host range, impact on non-target organisms, distribution, biology, impact in an area of distribution, etc. This information will be determined after candidate biological control agents are studied under quarantine security.

The researcher, in conjunction with the quarantine facility to be used, should also provide the following information:

- the nature of the material proposed for importation

- the type of the research to be carried out

[21] Available expertise, instruments and work in international fora with competence in the area of risks to human health should be taken into account as appropriate.

- detailed description of containment facilities (including security and the competency and qualifications of the staff)

- an emergency plan that will be implemented in the case of an escape from the facility.

This information may be required by the NPPO or other responsible authority prior to approval of the research to be conducted. The NPPO or other responsible authority may verify the accuracy of the documentation provided and examine the facilities, and may require modifications as necessary.

5. Responsibilities of Exporter

The exporter of biological control agents or other beneficial organisms is encouraged to ensure that:

- all phytosanitary import requirements specified in the regulations of the importing country or on an import permit are complied with (see also section 3.2, which describes the related responsibilities of the NPPO)

- all appropriate documentation accompanies the consignment

- packaging is secure in order to prevent escape of the contents

- organisms for SIT have been treated to achieve the required sterility for SIT purposes (e.g. using irradiation with the required minimum absorbed dose). The treatment(s) used and an indication of the effectiveness of sterilization should also be provided.

5.1 Specific responsibilities regarding organisms intended for inundative release

Exporters of biological control agents or other beneficial organisms for inundative release should provide documentation on measures undertaken to ensure that levels of contamination acceptable to the importing NPPO or other responsible authority are not exceeded.

6. Responsibilities of the NPPO or other responsible authority of the importing contracting party upon import

6.1 Inspection

Where required (see section 3.1.5) after checking the documentation, inspection should take place at an officially nominated quarantine facility.

6.2 Quarantine

The NPPO should ensure that biological control agents or other beneficial organisms are cultured or reared in quarantine, if appropriate (see section 3.1.6), for as long as considered necessary.

6.3 Release

The NPPO or other responsible authority may allow biological control agents or other beneficial organisms to be passed directly for release, provided that all conditions have been complied with (particularly as described in section 3) and required documentary evidence is made available (see section 4).

7. Responsibilities of the NPPO or other responsible authority before, upon and following release

Prior to release, NPPOs or other responsible authorities are encouraged to communicate details of the intended release that may affect neighbouring countries. To facilitate information sharing in this manner, details of intended releases may also be communicated to relevant RPPOs prior to release.

If pest risk analysis was not undertaken prior to import in accordance with ISPM No. 2 (*Guidelines for pest risk analysis*) and/or ISPM No. 11 (*Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms,* 2004), it should be undertaken prior to release, taking into account uncertainties, as provided for in those standards. In addition to conducting pest risk assessment, contracting parties should also consider possible impacts on the environment, such as impacts on non-target invertebrates.

The NPPO or other responsible authority may verify the effectiveness of sterilization treatment(s) prior to release of sterile insects.

7.1 Release

The NPPO or other responsible authority should authorize and audit official requirements related to the release of biological control agents or other beneficial organisms, e.g. requirements related to release only in specific areas. This audit may be used to alter the requirements related to import or release of the organism.

7.2 Documentation

Documentation sufficient to allow trace-back of released biological control agents or other beneficial organisms should be maintained by the NPPO or other responsible authority.

7.3 Monitoring and evaluation

The NPPO or other responsible authority may monitor the release of biological control agents or other beneficial organisms in order to evaluate and, as necessary, respond to the impact on the target and non-target organisms. Where appropriate, it should include a marking system to facilitate recognition of the biological control agent (e.g. sterile insects) or other beneficial organism in comparison with the organism in its natural state and environment.

7.4 Emergency measures

The NPPO or other responsible authority of the importing contracting party is responsible for developing or adopting emergency plans or procedures, as appropriate, for use within the importing country.

Where problems are identified (i.e. unexpected harmful incidents), the NPPO or other responsible authority should consider possible measures or corrective actions and, where appropriate, ensure that they are implemented and that all relevant parties are informed.

7.5 Communication

It is recommended that the NPPO or other responsible authority ensures that local users and suppliers of biological control agents or other beneficial organisms, and farmers, farmer organizations and other stakeholders, are kept sufficiently informed and educated on the appropriate measures for their use.

7.6 Reporting

The contracting party should abide by any reporting obligations under the IPPC, e.g. where an organism used as a biological control agent or beneficial organism has shown pest characteristics.

Annex 9. Outline of a national IAS strategy for Cape Verde

The following outline structure for a National IAS Strategy for Cape Verde is based on the structure adopted by IUCN in their Global Strategy on Invasive Alien Species (McNeely et al. 2001)

The Strategy would represent a first step towards a comprehensive and cooperative approach to the management the IAS threat in the country. It would recognise the roles and responsibilities of all levels of government in regulating the management of IAS and the importance of the involvement of non-governmental and civil society organisations, the private sector and the general public. The especial importance of regional and international cooperation to enhance actions undertaken at national and local levels should be emphasised given the Cape Verde's status as a Small Island Developing State (SIDS).

The Strategy should present a vision e.g. "of a nation in which the negative impacts of invasive alien species on the economy, environment and society are avoided, eliminated or minimised."

The proposed outline comprises of eleven interlinked elements: five hierarchical "Management Elements" and six "Cross-Cutting Elements". The management elements are those "on the ground actions" that directly address the Strategy's vision. The cross-cutting elements are enabling actions that must be undertaken if the management elements are to successfully address the Strategy's vision.

The Management Elements, with their accompanying goal or goals are listed in order of priority based on the maxim that "prevention is better than cure", in line with CBD Guiding Principle 2.1-2.

Proposed Table of Contents:

Foreword

Executive summary

Introduction

The management elements

1. Prevention

2. Early detection & rapid response

3. Eradication

4. Control and management

5. Restoration

Annex 10. Outline of an invasive plants database for Cape Verde

The following fields are recommended for a proposed database of invasive plants for Cape Verde.

The first worksheet (Base) gives information on the taxonomy of the species and its local name(s), its origin, distribution in Cape Verde in terms of island, presence in a protected area, its use in Cape Verde and proposed management action.

The second worksheet (sp for management) lists the species. Management site, management aim and suggested management method to be used. The third worksheet (References) lists relevant literature. A prototype of the database has been produced in MS Excel.

Data fields: Worksheet 1 (Base)

	Column A	Column B		Column A	Column B
1	Kingdom		25	Protected Area	Monte Verde
2	Phylum		26		Fogo
3	Class		27		Cova/Paúl/Ribeira daTorre
4	Order		28		Moroços
5	Family		29	Habitat types	
6	Species		30	Use in Cape Verde	Medicinal
7	Authors		31		Firewood
8	Common names		32		Agriculture
9	Origin		33		Ornamental/Pet
10	Cape Verde	Island	34		Other
11	Distribution by island	II	35	Impact in Cape Verde	biodiversity
12		IP	36		ecosystem services
13		Santo Antão	37	Impact elsewhere	biodiversity
14		Sao Vicente	38		ecosystem services
15		Santa Luzia	39		Priority for management
16		Branco			
17		Raso			
18		Sao Nicolau			
19		Santiago			
20		Boa Vista			
21		Maio			
22		Sal			
23		Fogo			
24		Brava			

Data fields: Worksheet 2 (Sp for management)

	Column A	Column B	Column C	Column D	Column E
1	Family	Species	Management site	Aim of management	Suggested management method(s)

Data fields: Worksheet 3 (References)

	Column A	Column B	Column C	Column D	Column E
1	Number	Author	Year	Journal title	Journal

Annex 11. Proposed course in invasive plant management for ecosystem restoration

Formulate recommendations for the national project team to improve their knowledge and links with research and development institutions in their respective intervention domains.

A training course of 6 days duration is proposed for the national project team in order to improve their theoretical and practical knowledge of invasive plant management.

The proposed course would comprise of lectures and interactive practical sessions in a teaching venue and in the field. Case studies used would be as applicable to the Cape Verdean situation as possible with a large proportion of cases presented coming from participants' own experience to maximise relevance. Below is a draft outline of the composition of such a course.

DAY 1 Assessment of IAS awareness levels of workshop participants Overview of the workshop, workshop evaluation and needs assessment, and introduction of participants Introduction to IAS, and invasion pathways IAS impacts – environmental, social and economic The ecosystem approach and IP management as part of ecosystem restoration	**DAY 4** Establishing integrated IP management control trials Establishing treatments to be tested Establishing trial plots Establishing monitoring and data analysis protocols **Safe herbicide use** Develop safety protocols for storing, mixing, transporting, applying, handling spills, and disposing of unused herbicides & containers
DAY 2 Prevention Early Detection and Rapid Response Eradication Control (based on relevant case studies): • Cultural • Manual & Mechanical • Girdling (stripping the bark) • Flaming – what category does this come under • Chemical Biological Planning a control programme	**DAY 5** Using chemicals in the field Full use of chemical treatments as part of integrated IP management Mixing of compounds Use of different techniques On-site safety Implementation of safety protocols for storing, mixing, transporting, applying, handling spills, and disposing of unused herbicides & containers; Personal clean-up after herbicide use
DAY 3 Field work Herbicide use – environmental risk management Herbicide use – health and safety Herbicide use as an element of integrated IP management: application techniques (dummy applications): Foliar spray Cut stump application Basal bark application Stem injection	**DAY 6** Monitoring and Reporting Mitigation Raising Awareness & Support International and National Strategic and Policy Dimensions Discussion session of outstanding practical problems in participants' countries or organizations hampering capacity, workshop evaluation and IAS needs assessment

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Annex 13. Terms of reference

UNDP – United Nations Development Programme Country Office in Cape Verde

Terms of Reference

GEF Project Implementation / International Consultant:

Invasive Alien Species Specialist

United Nations Development Programme / Global Environment Facility

"Consolidation of Cape Verde's Protected Areas System"

Location:	[Praia], [Cape Verde]
Application Deadline:	[30 days after publication]
Category	Environment and Energy
Type of Contract:	[suggested: Individual Contract]
Languages Required:	Written French and Portuguese; good oral command of English is a plus
Starting Date (date when the selected candidate is expected to start):	[1.10.2011]
Duration of Contract:	45 days
Expected Duration of Assignment:	45 days
Background	
Cape Verde, a small insular and archipelagic country, exposed to economic and environmental vulnerabilities, requires appropriate strategies for the management of the nation's natural resources. Cape Verde has ratified the Convention on Biological Diversity in 1995 and in 1999 drafted the national strategy and action plan on Biodiversity. On 24 February 2003 the Decree-Law No. 3/2003 on the legal regime of natural areas was	

published, which creates 47 protected areas, subdivided into 6 categories: national park, natural park, natural reserves, protected landscape, natural monument and sites of scientific interest. With the legal mandate to protect natural areas, guaranteed by that decree, there is a need to elaborate appropriate management tools, which are fundamental to sound management of natural and cultural resources in a sustainable manner.

In this context the Government of Cape Verde has obtained funding from the Global Environment Facility (GEF) and United Nations Development Programme (UNDP) to implement a project entitled "Consolidation of Cape Verde's Protected Area System". It is a national execution project and is implemented by the General Directorate for Environment (DGA) through its Project Management Unit in Praia as well as its two Project Site Units on Santo Antão and Fogo, as well as its two Island-Wide Offices (IWO) on Sal and Boavista. The project has the following objective:

"To consolidate and strengthen Cape Verde's protected areas (PA) System through the establishment of new terrestrial and marine PA units and the promotion of participatory approaches to conservation"

The project will: (i) strengthen the legal, policy, institutional and financial framework to support an expanded protected land and seascape estate; (ii) more specifically, support the establishment of a Protected Area Autonomous Authority (PAAA) with a technically and managerially capable staff complement; and (iii) forge strategic partnerships for enhancing the overall sustainability of the Protected Area (PA) system, including improvements in its financial sustainability. The governance framework to be supported by the project will result in improvements in the management effectiveness of the entire national PA system, through capacity strengthening of institutions and units, management and business planning, policies, laws and regulations.

The project is divided into three components (based on outcomes) for implementation as follows:

Outcome 1: The governance framework for the expansion, consolidation and sustainability of the National PA system is strengthened

Under Outcome 1, the PA governance supportive frameworks for Cape Verde's PA System will be strengthened with respect to their policy, legal, institutional and financial aspects, and the total coverage of coastal marine areas will be increased. More specifically, a Protected Areas Autonomous Authority (PAAA) will be created, which will be adequately staffed and engaged in strategic partnerships, with a mandate to coordinate and enforce integrated PA planning and management.

Outcome 2: Management effectiveness at selected terrestrial and coastal/marine PAs is enhanced

Under Outcome 2, the project will make operational four terrestrial Natural Parks (on Fogo, São Vicente and Santo Antão) and three marine protected areas (MPA, on Sal and Boavista), extending PA management to five islands that have not previously benefited from a GEF intervention.

Outcome 3: The sustainability of PAs is strengthened through community mobilization, sectoral engagement and local capacity building for sustainable resource management within PAs/MPAs and adjacent areas

Under Outcome 3, the project will ensure the sustainability of all efforts towards a consolidated, expanded and more effective PA System in Cape Verde. Both terrestrial and marine protected areas are impacted by activities of communities living within and around their boundaries, as well as by other economic actors and decision-makers. As a result, the effective and sustainable management of PAs will only be possible through the active mobilisation and engagement of these stakeholders.

Duties and Responsibilities

In this context the project plans a consultancy for an Invasive Alien Species Specialist with the following Terms of Reference. The consultant under supervision of the National Project Coordinator (NPC) and in close collaboration with the national project team, will:

1. Review the types of invasive alien species (IAS) and their extent already identified in the terrestrial protected areas of the project,sites on the islands of: Sao Vicente: Monte Verde; Fogo: Fogo Natural Park; Santo Antão: Cova/Ribeira de Paul/Ribeira da Torre, Morroços;

2. Elaborate a strategy for IAS management including estimates for labour requirements and periodicity of IAS control measures;

3. Submit a proposal for a national strategy on invasive alien species, showing various methodologies for determining the status levels as well as technological means of control, and present this strategy to the project team;

4. Prepare an implementation plan for a national strategy on IAS, with concrete application procedures for implementation in the sites of the project;

5. Formulate and submit a consultancy report in Praia for approval by the National Project Coordinator (NPC);

6. Formulate recommendations for the national project team to improve their knowledge and links with research and development institutions in their respective intervention domains.

Competencies

- Communication skills for complex information and techniques targeted towards subject matter specialists as well as wider general audiences;
- Good competency in pedagogical approaches in order to transmit skills at various levels;
- Ability to communicate effectively orally as well as an excellent level of written skills in order to be able to present, negotiate and summarize work sessions;
- Good skills for efficient facilitation during meetings between various stakeholders (government, NGOs, CBOs, international community and communal levels).
- Ability to work both independently as well as in coordination with the local project team in an interdisciplinary manner

Required Skills and Experience
• A good understanding of challenges linked to biodiversity conservation versus natural resource use, and particularly invasive alien species (IAS) management; if possible in Cape Verde or at least in the sub-region; • Advanced university education at MSc or PhD level with expertise in the area of biology, ecology, environmental impact assessment and participatory research approaches; • At least 10 years of professional experience, of which at least five are at international level • Strong skills in monitoring and evaluation, and experience in managing interdisciplinary research projects; • Ability to produce high quality reports, publications and project proposals; • Previous experience with GEF projects is an added plus; • Excellent writing skills in French and Portuguese, and a good working knowledge of English is an added plus.

Contact Person: Antonio Querido, email: Antonio.querido@cv.jo.un.org

Annex 14. Acronyms and abbreviations

ACRONYMS

a.e.	Acid equivalent
a.i.	Active ingredient
CBD	Convention on Biological Diversity
CNP	Cova, Paúl and Ribeira da Torre Natural Park
dbh	Diameter at breast height (1.3 m) – used for measuring trees
GEF	Global Environment Facility
IP	Invasive Plant
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IUCN	World Conservation Union (International Union for the Conservation of Nature)
MADRRM	Ministry of Environment, Rural Development and Marine Resources
MNP	Moroços Natural Park
MSDS	Material safety data sheets (for pesticides)
PA	Protected area
PA	Protected area
PNF	Parque Natural do Fogo (or Chã das Caldeiras Natural Park)
PPE	Personal protective equipment
SEPA	Former name of the DGA - General Direction of Environment
SIDS	Small Island developing states
UNDP	United Nations Environment Facility
WWF	World Wide Fund for Nature