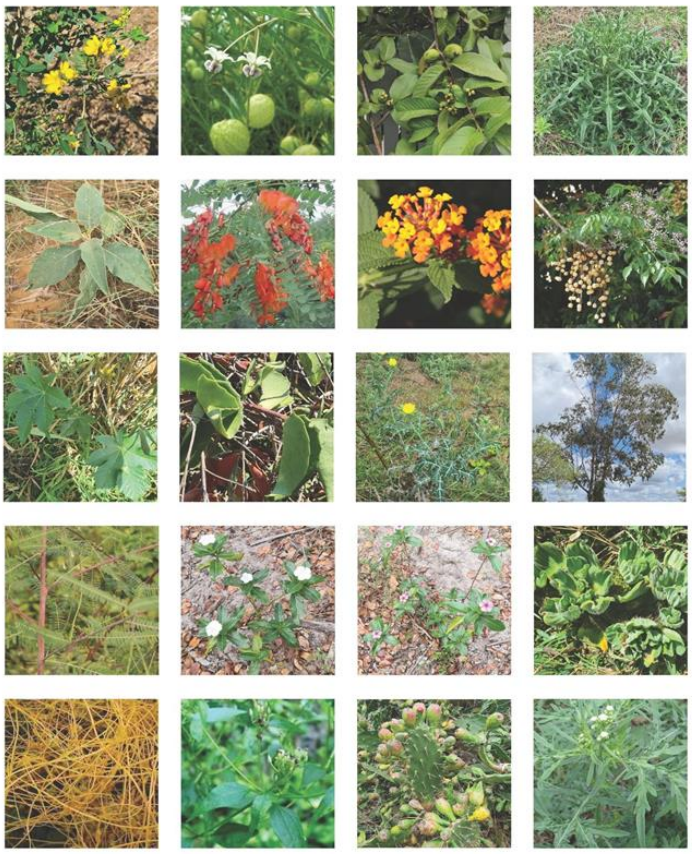
ASSESSMENT OF INVASIVE SPECIES STATUS AND DEVELOPMENT OF A RESTORATION STRATEGY & MANAGEMENT PLAN FOR MAPUTO NATIONAL PARK (MNP), MOZAMBIQUE

FINAL REPORT



Maputo, April 2022

Assessment of Invasive Species Status and Development of a Restoration Strategy & Management Plan for Maputo National Park (MNP), Mozambique

Report prepared by:

This report was prepared by Colterra Environmental Consultants and sponsored by BIOFUND with financial support of World bank/MozBio2 Project and technical assistance of WCS through COMBO+ Program.

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Cover photo: Invasive species in Maputo National Park. © Colette Terblanche & Terrence Liversage, Colterra Environmental Consultants.

Citation: Terblanche, C., Liversage, T., Nicolau, D., Bila, S., Nazerali, S., Costa., H., Duarte, E. (2022). Assessment of Invasive Species Status and Development of a Restoration Strategy & Management Plan for Maputo National Park (MNP), Mozambique. Colterra, BIOFUND, WCS. Maputo, Mozambique. 70 pp.

Acknowledgments: We would like to thank our donors World Bank and MozBio 2 Project for the support provided, as well as all the institutions and individuals who collaborated to develop this report.

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Abbreviations

ACU	Alien control unit
ANAC	National Administration of Conservation Areas
ANR	Assisted natural regeneration
APO	Annual Plan of Operation
BIOFUND	Foundation for Conservation of Biodiversity
IAP	Invasive Alien Plant
MCPE	Maputaland Centre of Plant Endemism
MNP	Maputo National Park
PA's	Protected Areas
PPE	Personal Protective Equipment
WCS	Wildlife Conservation Society

Definitions

Alien Control Units (ACU)	The division of the Maputo National Park along natural boundaries, e.g., rivers, roads, vegetation types, into easier manageable units.
Assisted Natural Regeneration (ANR)	The utilisation of techniques to accelerate and assist the re-establishment of vegetation by removing or reducing the natural barriers. Techniques include cessation of vegetation control practices like burning and disturbance with machinery; the use of vegetation thinning or removal of undesirable species to reduce competition and promote growth, and in some circumstances, supplementary planting of seedlings.
Alien Species	A species that is not indigenous; or an indigenous species translocated outside its normal distribution range in nature, but that has not spread outside its normal range without human intervention.
Biodiversity Offsets	Measurable conservation outcomes that come from actions aimed at offsetting significant residual adverse impacts on biodiversity arising from the development of an activity or project, after appropriate measures have been taken to avoid and minimize impacts and restore the affected areas.
Control methods	The methods available to control invasive alien plants, i.e. hand pulling, foliar spraying, herbicide application.
Emerging weed	Plants with invasive tendencies present outside of their natural distribution range, but not yet widely so. They can impact negatively on natural ecosystems, biodiversity, livelihoods, or human health if allowed to continue to expand to outside of their natural range and become naturalised.
Invasive Alien Plant (IAP)	A plant species not indigenous to an area, which has either been accidentally or intentionally introduced and whose presence threatens habitats, ecosystems, or other species. Their presence may result in economic or environmental harm, or harm to human health.
Mitigation hierarchy (MH)	Measures taken to avoid creating impacts from the outset (including direct, indirect, and cumulative impacts), such as careful spatial or temporal placement of elements of infrastructure, to completely avoid impacts on certain components of biodiversity.
Restoration Weed	Any plant, indigenous or alien, invasive or otherwise, which is growing where it is not desired.

Executive summary

This document describes the extent of the invasive alien plants (IAP's) in Maputo National Park (MNP) and provides a restoration strategy and management plan with a five-year costing that will allow MNP to effectively control IAP's and restore biodiversity where affected.

A field assessment of the status of invasive species was conducted from the 5th to the 13th of September 2021 covering the entire MNP. The park was divided along natural boundaries (rivers, roads, and vegetation types) into logical management unit compartments, which allows for coherent management interventions, referred to in this plan as Alien Control Units (ACU's).

A total of 32 alien plant species were identified. Parthenium (*Parthenium hysterophorus*) is an emerging weed in MNP and has been identified as the priority species to control, due to its potential to spread, potential impact on the biodiversity and because it has only started to invade. The dominant/most abundant IAP is Lantana (*Lantana camara*) followed by Chromolaena (*Chromolaena odorata*).

97% of MNP is at or below 5% density of IAP's per ACU. The western boundary, along the Futi river is above 20% density of IAP's. There are a few species of concern which occur in isolated areas: Barbados gooseberry (*Pereksia aculeata*), Mauritian hemp (*Furcraea foetida*) and Prickly pear (*Opuntia spp.*).

All ACU's were prioritised according to international best practices. The first priority areas, Category A, has been prioritised to prevent new introductions, control emerging weeds and control vectors/pathways of spread. The second priority is to keep clean areas clean – Category B1 areas, and thirdly to control areas invaded from lowest to highest densities - Category B2 & B4. Exceptions were made to areas with IAP's that are costly to remove and require a specific control method – Category B3. As there are funds to specifically control the Eucalyptus spp. and Pinus spp. close to the main gate, the area was not prioritised and was given it's own category – Category C. A boundary of 500m around the fence line and 1km along rivers flowing into MNP have been allocated as Category D. Funding should be allocated to the first priority Category A first and then the next priority depending on funding availability.

To get to a maintenance phase (all areas below 2% density) within five years, it is estimated that it will require an average of MZN 33,609,820 per year and a work force of 307 persons per year.

Because of the relatively low infestation levels, restoration of natural vegetation in treating IAP's areas can be left to naturally regenerate through successional means with management techniques which include: the planting of desirable woody species, the exclusion of fire or the prescribed burning of areas, depending on the vegetation type.

Control methods and a photo of each of the IAP's identified have been listed, with a detailed description of how to apply the methods described.

Monitoring the effectiveness of control is critical and biodiversity indicators are being developed as a separate exercise to this plan. The plan will have to be updated once the indicators have been established. This will only affect areas above 5% density where the biodiversity is affected. In areas below 5% density indicators here are whether the IAP's have been removed. A database of control efforts against the plan, as well as quality control of clearing operations are essential to the success of this plan.

This plan should be reviewed every five years.

1. Introduction

1.1. Background

Mozambique has seen a significant increase in economic growth in the last decade which has led to increased exploitation of natural resources and increased development of infrastructures, which has generally resulted in negative environmental and social impacts. There is an urgent need to find ways to reconcile the economic development of Mozambique with biodiversity conservation and delivery of ecosystem services, upon which most of the population directly depends.

In 2016, the World Bank developed the National Roadmap for Biodiversity Offsets which recommends that, in the coming years, offset actions in Mozambique should be concentrated within Protected Areas (PA's) to strengthen PA's. PA's are currently underfunded and are unlikely to be funded over the medium term according to the National Biodiversity Action Plan (2015). The National Administration of Conservation Areas (ANAC) financial plan shows the protected area network only receives 19% of its current funding from sustainable sources which is insufficient to provide adequate protection to biodiversity. The aim is for offsets to help implement effective management actions and support the achievement of the conservation objectives for which PA's have been created, thus protecting biodiversity.

The implementation of the mitigation hierarchy (MH) provides an opportunity for investors when developing projects to implement activities thereby avoiding or minimising impacts, restore biodiversity and ecosystem services in impacted areas and, if significant but acceptable residual impacts persist, design, and implement biodiversity offset projects, to achieve No Net Loss (NNL) or a Net Gain (NG) of biodiversity[1].

BIOFUND and WCS under COMBO+ Program have been working together to support the Government of Mozambique with developing procedures for an effective implementation of the Mitigation Hierarchy (MH) including Biodiversity Offsets according to the environmental legislation of Mozambique.

The legal obligation for the implementation of the mitigation hierarchy and biodiversity offsets is stated in the Regulation for Environmental Impact Assessment (Decree 54/2015) and the Regulation for the Protection, Conservation and Sustainable Use of Biological Diversity (Decree 89/2017). Furthermore, recently the Ministry of Land and Environment has approved the Ministerial Diploma of biodiversity offsets implementation in Mozambique. Those documents provide legal, technical, and financial procedures and guidelines for effective implementation of a biodiversity offset project.

One of the important steps for implementation of the guidelines is to test the viability of various measures on the ground. BIOFUND jointly with ANAC and WCS through the COMBO Program are implementing ecological restoration pilot projects in protected areas in Mozambique as learning procedures for future biodiversity offsets implementation. These projects include testing legal, technical, and financial procedures for the implementation of biodiversity offsets projects in Mozambique.

According to the biodiversity offset guidelines, future biodiversity offsets interventions within PAs may include (i). Protection, Improvement, Restoration, and Rehabilitation of habitats; ii. Restoration and reintroduction of populations of fauna and flora species; and iii. Reduction of human impacts on biodiversity within the PAs. All these activities could meet the objectives of an offset which would be

[1] See introductory video AQUI

an increase in an area's biodiversity, which would compensate for a set of specific residual impacts on this biodiversity.

This plan is a test project to be implemented as an intervention to protect and restore biodiversity.

1.2. Location and extent

The Maputo National Park (MNP) is a newly proclaimed (December 2021) amalgamation of the former Maputo Special Reserve and the Ponta do Ouro Marine Reserve in southern Mozambique. It is a total of 1700 km² in extent and runs from the border with South Africa in the south, along the coast and extends 18 nautical miles into the Indian Ocean, up until the northern point of Inhaca island. It also covers the coastal waters around Inhaca and the Portuguese island and into the Maputo Bay to the mouth of the Rio Maputo. This report focus' solely on the terrestrial area of the MNP.

The terrestrial area of the MNP, was proclaimed in 1932. It is located approximately 100 kilometres southeast of Maputo, Mozambique, and measures 1,040 km² in extent. It is composed of two main areas, the Core Area, and the Futi Corridor, with the main road to Maputo, N200, running through the park. Its boundaries are the Maputo Bay in the north; the Indian Ocean to the east; the Maputo River, the Futi River, and a line 2 km east of the Salamanga- Ponta do Ouro road in the west, and the southern end of Lake Xinguti and the southern restriction of Lake Piti in the south (Figure 1).

The MNP forms part of the 10,029 km² Lubombo Transfrontier Conservation Area (TFCA) which includes four distinct transfrontier conservation areas shared between Mozambique, South Africa, and the Kingdom of eSwatini and lies in the heart of the globally acknowledged Maputaland Centre of Plant Endemism (MCPE), one of only four identified in southern Africa.

Additionally, MNP is home to habitats for endemic and/or threatened species of fauna and flora, thus recently this protected area was designated as a Key Area for Biodiversity (KBA) according to the criteria of the new Global Standard from the International Union for the Conservation of Nature (IUCN) (WCS, Governo de Moçambique & USAID, 2021).

The MNP lies in a strategic position at the southern limit of the tropics where many species are at the southern limit of their range and contains species from more temperate zones to the south. Ecosystems such as floodplains, savanna, mangrove, swamp forest, dry licuáti forest and woodlands on sand, coastal dune forest, dry grasslands, and hygrophilous grasslands (fresh and saline) can be found and although not yet fully inventoried, is likely to be of high species richness (ANAC, 2021).

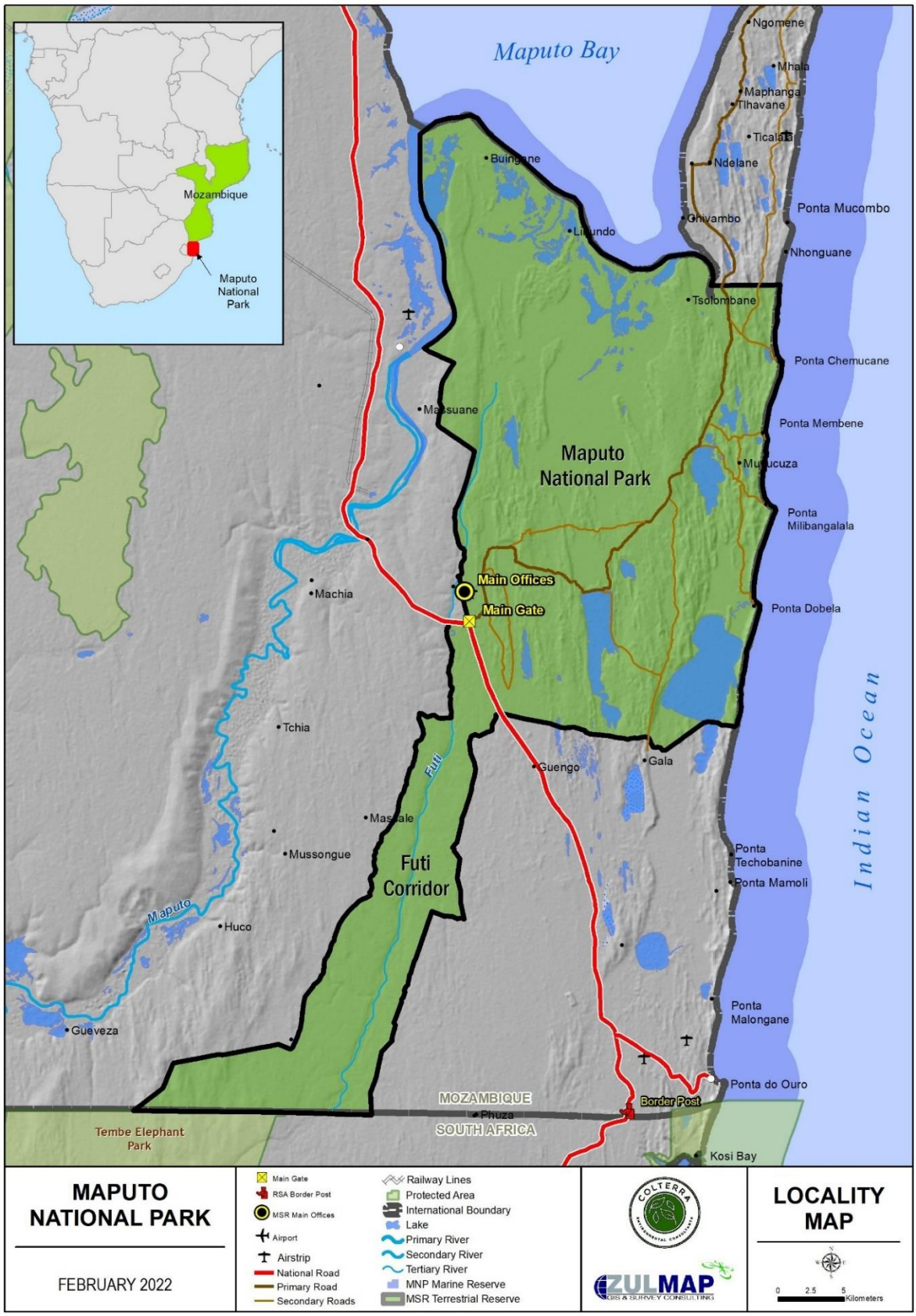

Figure 1. Location of the Maputo National Park.

1.3. Enabling Legal Framework

The following legislation is applicable to this document:

a. **Decree no 89/2017, Regulations of Law Nr. 16/2014 of 20 June, amended and republished by Law Nr. 5/2017 of 11 May, the Law on the Protection, Conservation and Sustainable Use of Biological Diversity:**
   - Chapter IX deals extensively with requirements and expected outcomes of the recovery, restoration, or rehabilitation of biological diversity.

b. **Law Nr. 5/2017 of May 11, the Law on the Protection, Conservation and Sustainable Use of Biological Diversity:**
   - Chapter III Section VI deals with the management of conservation areas and the promotion of biodiversity through management practices.
   - Chapter IV deals with the Recovery and Restoration of Biodiversity and thus is affected by Alien Invasive Species and their effect on biodiversity.

This document in part aims to adhere to the requirements listed above for the management of the park and assist in fulfilling the mandate stipulated.

c. **Decree No. 25/2008 approving the Regulation on the control of invasive exotic species**:
   - Article 8 of this Decree prohibits restricted activities involving invasive alien species. The National Authority (MICOA) can prohibit the performance of any activity which, by its nature, may influence the propagation of invasive alien species'.
   - 'Restricted activities' include the following:
   - Importing any kind of invasive alien species, whether by sea land or air, into the country.
   - Possessing any kind of invasive alien species.
   - Developing, creating, or otherwise propagating any kind of invasive alien species; and
   - Transporting, moving, or otherwise relocating any kind of invasive alien species.

The decree provides guidance for the methodology that has been prescribed in this document. Furthermore, Article 11 of the Decree suggests that appropriate methods should be taken to control and eradicate listed invasive alien species. This section underlines the need for an invasive alien species assessment as well as a control and rehabilitation plan to be implemented.

d. **Decree no. 54/2015 Regulation for Environmental Impact Assessment (EIA)**
   - These regulations provide the framework for the minimization and mitigation of environmental impacts as a result of development. This is relevant for this document as it provides for the implementation of offsets within the Maputo National Park.

e. **Mozambique Ministry of Land, Environment and Rural development's 2015 National strategy and Action plan of Biological Diversity of Mozambique**:
   - Alien invasive species are recognized as one of the greatest threats to biodiversity within Mozambique
   - **Target 9:** By 2025, reduce, by at least 10%, the area of occurrence of invasive species and establish/implement strategies for managing the impacts.

f. **A comprehensive list of invasive alien species found in Mozambique is being compiled and is not yet available.**

1.4. Methodology used

An initial literature review was conducted, and information gathered on IAP's and control in MNP and similar areas. A proposed method for the field assessment was compiled and sent for review. A meeting was held with ANAC, Biofund, WCS and Maputo National Park Management where the methodology was approved. A field assessment was conducted from the 5th to the 13th of September 2021.

The field assessment was conducted by dividing the park along natural boundaries such as roads, rivers, and vegetation types it into logical management unit compartments. These compartments are of a size and structure that allows for coherent management interventions and are referred to as Alien Control Units (ACU) (Lotter, 2007). ACUs were split between natural ACUs, and numbered N1 – N45, the villages (V20, V25, V29 & V33), agriculture units (A28, A30 & A31), and infrastructure units (ranging from I4- I42). A buffer of 50m was created around each of the village (V), agriculture unity (A), and I – ACU's to include possible spread of IAP's around these areas.

A map of the MNP with each ACU was loaded onto Avenza Maps™. Avenza is a mobile map app, which uses the phone's built-in GPS to track location, record tracks, navigate to a destination, and pin information about IAP locations, taxonomy, and densities, and to capture photos.

Every N-ACU was assessed by driving around and through the ACU where possible. Spot checks were also done by walking into ACU's. All transects walked, roads driven as well as IAP's found were recorded on Avenza Maps and recorded manually on the printed maps. The V, A, and I – ACUs were assessed thoroughly by walking and observing all IAP's present. These ACU's are associated with human disturbance and are often from where IAP's spread, hence require a thorough assessment. Figure 2 below shows the tracks driven and points taken during the field assessment.

In each ACU the following information was recorded: dominant and subdominant IAP's as well as all other IAP's found; the density (canopy cover) of the IAP's present in the ACU expressed as a percentage; the age class of the dominant IAP's; and all other alien plants such as mangos, lemon and avocado trees were noted but were excluded in the calculations for costs to clear.

The field assessment was sufficient to gain quality information to write this plan. The methodology used is as per international best practices. The information captured in the field visit was used to compile the IAP Restoration Strategy and Management Plan. The prioritisation per species and per ACU are explained in the relevant sections below.

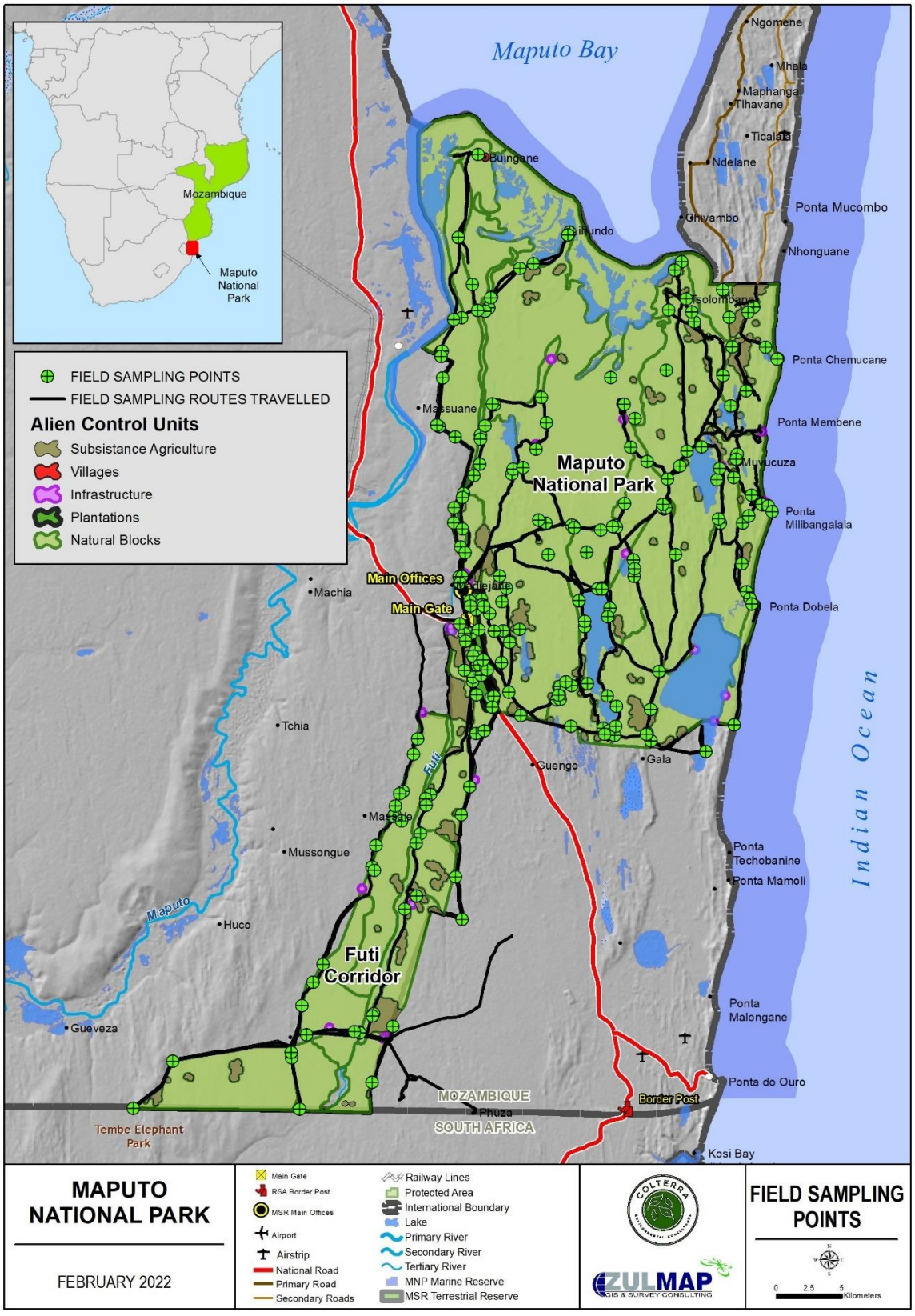

Figure 2. Field Assessment Map.

1.5. Brief overview of the threats posed by invasive alien plants

Invasive alien species pose a threat to biodiversity that is second in magnitude only to habitat loss, hence the failure to address the underlying causes of biological invasion and mitigate the impacts of invasive alien species may result in the loss of numerous species and genetic resources, which may significantly alter ecosystems (McNeely et al., 2001). Most invasive alien species suppress or replace indigenous species and on a large enough scale can lead to localized extinction of not only plant species which are in direct competition for resources, but also fauna which have evolved to depend on these plants are also vulnerable to decline (Bromilow, 2019). Mgobozi *et a*l. (2008) found that infestation by *Chromolaena odorata* had a marked effect on spider diversity. Areas with high infestation of IAP's had much lower spider diversity than uninfested areas. This shows a marked cascading impact through trophic levels of biodiversity caused by IAP invasions.

By changing vegetation composition, IAP can affect fire regime characteristics such as frequency, intensity, extent, type, and seasonality of fire. These regime changes could in turn promote the dominance of the IAP's, creating a positive feedback, plant–fire regime cycle (Brooks et al, 2004).

The degree to which a protected area is invaded can be correlated to the number of human activities (Usher, 1988; Lonsdale, 1999) and the closer the human habitation is to the fence line the more prone to invasion the protected area is due to intense edge effects caused by human activities.

The above factors, together with the legislation identifying the need to identify and mitigate the threat of invasive alien species, contribute to the urgency and importance of compiling this Plan.

2. Invasive Species Status

2.1. Alien plant species recorded

A total of 32 alien plant species were recorded in the MNP during the field visit conducted in September 2021 (see Table 1). The methodology used to record the species is explained in 1.6. All non-indigenous/alien plants seen were recorded. Not all alien plants are invasive, hence the need to prioritise species for control (see 3.1. for prioritisation). Species such as Canary weed (*Senecio madagascariensis*) and Purslane (*Portulaca oleracea*) grow in disturbed areas and once grasses have established the species will generally disappear.

There is a possibility that plant species might have been missed due to the time constraint during the field assessment or due to the time of year when the assessment was conducted, however the species identified are a very good indication of what is present in MNP. The list in Table 1 should not be seen as static and should be updated when a new IAP is identified.

Appendix 7.3 provides a photo of each of the alien plant species identified, the location if there are only a single/few of the alien plant species present and lists the recommended control methods.

Table 1. Alien plant species recorded in MNP

Common name	**Scientific name**
Common ragweed	*Ambrosia artemisiifolia*
Madeira vine	*Anredera cordifolia*
Yellow-flowered Mexican poppy	*Argemone Mexicana*
Milkweed	*Asclepias physocarpa*
Bougainvillea	*Bougainvillea spp.*
Creeping inch plant	*Callisia repens*
Madagascar periwinkle	*Catharanthus roseus*
Chromolaena	*Chromolaena odorata*
Spear thistle	*Cirsium vulgare*
Dodder	*Cuscuta campestris*
Eucalyptus/ Blue Gum	*Eucalyptus spp.*
Mauritian hemp	*Furcraea foetida*
Blue morning glory	*Ipomoea indica*
Lantana	*Lantana camara*
Prickly malvastrum	*Malvastrum coromandelianum*
Syringa	*Melia azedarach*
Prickly pear	*Opuntia ficus-indica*
Drooping prickly pear	*Opuntia monacantha*
Parthenium	*Parthenium hysterophorus*
Barbados gooseberry	*Pereskia aculeata*
Pine	*Pinus spp.*
Water lettuce	*Pistia stratiotes*
Purslane	*Portulaca oleracea*
Guava	*Psidium guajava*
Castor oil	*Ricinus communis*
Canary weed	*Senecio madagascariensis*
Easter cassia	*Senna pendula*
Spiny sesbania	*Sesbania bispinosa*
Red sesbania	*Sesbania punicea*
Silver-leaf bitter apple	*Solanum elaeagnifolium*
Dense-thorned bitter apple	*Solanum sisymbriifolium*
Singapore daisy	*Sphagneticola trilobata*

2.2. Dominant alien plant species

All alien plant species were recorded during the field visit as per the methodology described in 1.6. The dominant/most abundant and sub-dominant/second most abundant alien plant species were recorded per ACU.

For example: If 20% of a 10-hectare ACU is covered in IAP's, and the dominant IAP is Lantana (*Lantana camara*), and the sub-dominant is Chromolaena (*Chromolaena odorata*), while other species present are Guava (Psidium guajava) and Castor oil (Ricinus communis) then this information can be used to develop an effective control plan. In this example we know that there are similar clearing methods available for the dominant and sub-dominant species as well as Castor oil. It is just the Guava which will require a higher mixture of herbicide. Hence, we can now work out the persondays and thus costs to clear the ACU.

The invasive alien plant species that were recorded as dominant in most of the ACU's was Lantana (*Lantana camara)*. The relative dominancy of that species was 41% in all ACUs followed by Chromolaena (*Chromolaena odorata)* with 18% of dominancy, Table 2. Only species which were recorded as the dominant IAP in a particular ACU were used in the calculation, hence why there are only 12 species listed in Table 2 below. Table 2 serves only to show which IAP's are the most dominant IAP's. Please note that percentages were rounded off in Table 2, hence it slightly exceeds 100%.

Table 2. Dominant IAP's recorded.

Plants	**Dominant IAP**	**%**
Lantana	*Lantana camara*	41%
Chromolaena	*Chromolaena odorata*	18%
Eucalyptus/ Blue Gum	*Eucalyptus spp.*	8%
Guava	*Psidium guajava*	8%
Madeira vine	*Anredera cordifolia*	8%
Prickly pear	*Opuntia spp.*	6%
Madagascar periwinkle	*Catharanthus roseus*	5%
Dodder	*Cuscuta campestris*	2%
Mauritian hemp	*Furcraea foetida*	2%
Pine	*Pinus spp.*	2%
Castor oil	*Ricinus communis*	2%
Silver-leaf bitter apple	*Solanum elaeagnifolium*	2%

2.3. Densities per alien control unit

As part of the field assessment and to make control of IAP's easier, MNP was divided into alien control units (ACU) as explained in 1.6. In each ACU's the density (or canopy cover) of the alien plants present was assessed. The canopy cover of the alien plants in comparison to the cover of the indigenous species were assessed, e.g., 20% density of alien plants in an ACU means that 80% of the area is covered in indigenous vegetation. This information is important, together with knowing the IAP's that occur in the area as it is required to determine costs to clear an area.

The density estimation is based on a percentage. 0% being clean/ no alien plants occurring, while 100% will be a closed canopy area of only alien plants. The assessors determined the density through a visual assessment, based on over 20 years of experience doing field assessments for IAP's. This is an effective assessment method for an IAP Management Plan as per international best practises. The following classification was used to determine the densities per ACU:

- 0% clean
- 0,1 – 5% sparse
- 5,1 – 25% medium
- 25,1 – 50% dense
- 50.1 – 100% very dense

Please note that the 50,1 – 100% classification has been lumped together as there are no ACU's with densities over 60% in MNP. This is just to make the classification easier for this plan.

The results showed that 97% of MNP has between 0 – 5% densities of IAP's (Figure 3), hence very sparse infestation of IAP's, while only 3% of MNP is between 6 – 60% density. The invasion of IAP's in the MNP is still in the early phase of invasion in most areas. This is evident as most of the IAP's can only be found along roadsides or at homesteads and have not moved further into the vegetation.

Annexure 7.1. provides a list of the IAP's identified per ACU, as well as the densities assigned, and the priority allocated per ACU. Annexure 7.2 illustrates the densities per ACU with the MNP divided into five maps for easier viewing.

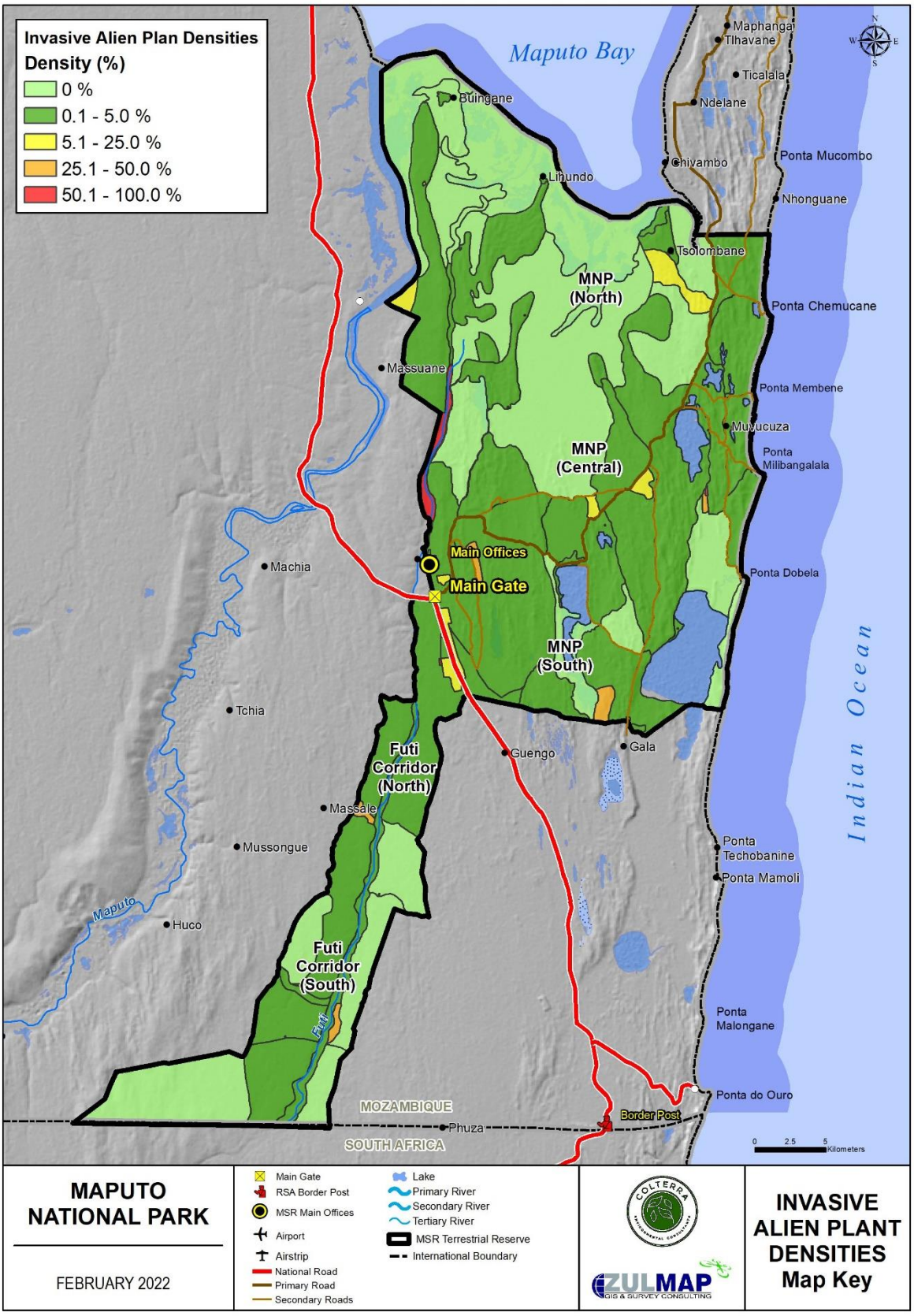

Figure 3. IAP densities in MNP per alien control unit.

2.4. Prioritisation between invasive alien plants

All alien plant species were recorded during the field assessment. While some alien plants species may be planted in gardens for decorative purposes and do not spread, others might be common weeds that occur where an area is disturbed and disappear once the disturbed site has re-established. There are also alien plants that can become invasive and can decrease the biodiversity of an area, referred to as invasive alien plants (IAP's). New IAP's that are just starting to invade an area is referred to as emerging weeds. From literature and knowledge of similar habitats it is known which species have the potential to invade into MNP, it is thus critical to prioritise alien plants identified to make sure that funding is not wasted on controlling a species that will not spread while the emerging weeds present are left and invade causing a reduction in biodiversity.

There are four categories for prioritisation of IAP's (Table 3), according to the prioritisation methods used in Tu, 2009:

Category 1 is emerging weeds: These are IAP's which have just started to invade MNP and are aggressive invaders. It is cost-saving to focus on these species as a priority to prevent large infestations which will be costly to control.

Category 2 is where most IAP's fall under. These are IAP's which can have a negative effect on the biodiversity. This includes species such as Lantana and Chromolaena which have already become established in MNP and require a control plan to control. Control is done by prioritising the ACU's if all ACU's have category2 species.

Category 3 are also IAP's as per Category 2 which can have a negative effect on the biodiversity of MNP, however they require a specific control method to control, which can be costly and requires a dedicated effort to eventually control the species. This includes species such as Prickly pear and Pereskia. Unfortunately, no biocontrol agents are registered for these species in Mozambique.

Category 4 are disturbance weeds. These are alien plants which can be seen around new development nodes and roadsides. Once the area has recovered, the weeds normally disappear. They are not invasive, and it is not recommended to treat the plants as the natural vegetation will eventually outcompete these species.

Table 3. Categories for prioritisation of IAP's

Categories for prioritisation of IAP's	
Priority	**Explanation**
1	Emerging weeds – (plants that have just started to invade, and which have the potential to spread exponentially)
2	IAP's that can have a negative effect on the biodiversity and can be controlled when clearing the ACU where the IAP occurs
3	IAP's that can have a negative effect on the biodiversity; require a specific clearing method to control; is costly to control and invasions are quite isolated
4	Disturbance weeds (only spreads in disturbed areas)

Table 4 lists the species identified and the priority ranking of each species.

Table 4. IAP Priority list for the MNP.

IAP PRIORITY LIST		
Common name	**Scientific name**	**Priority**
Parthenium	*Parthenium hysterophorus*	1
Lantana	*Lantana camara*	2
Chromolaena	*Chromolaena odorata*	2
Syringa	*Melia azedarach*	2
Guava	*Psidium guajava*	2
Castor oil	*Ricinus communis*	2
Madeira vine	*Anredera cordifolia*	2
Blue morning glory	*Ipomoea indica*	2
Easter cassia	*Senna pendula*	2
Red sesbania	*Sesbania punicea*	2
Dense-thorned bitter apple	*Solanum sisymbriifolium*	2
Silver-leaf bitter apple	*Solanum elaeagnifolium*	2
Pine	*Pinus spp.*	2
Eucalyptus/ Blue Gum	*Eucalyptus spp.*	2
Water lettuce	*Pistia stratiotes*	3
Mauritian hemp	*Furcraea foetida*	3
Pereskia	*Pereskia aculeata*	3
Prickly pear	*Opuntia ficus-indica*	3
Drooping prickly pear	*Opuntia monacantha*	3
Singapore daisy	*Sphagneticola trilobata*	4
Bougainvillea	*Bougainvillea spp.*	4
Yellow-flowered Mexican poppy	*Argemone Mexicana*	4
Milkweed	*Asclepias physocarpa*	4
Spear thistle	*Cirsium vulgare*	4
Prickly malvastrum	*Malvastrum coromandelianum*	4
Dodder	*Cuscuta campestris*	4
Purslane	*Portulaca oleracea*	4
Canary weed	*Senecio madagascariensis*	4
Common ragweed	*Ambrosia artemisiifolia*	4

IAP PRIORITY LIST		
Common name	**Scientific name**	**Priority**
Madagascar periwinkle	*Catharanthus roseus*	4
Creeping inch plant	*Callisia repens*	4
Spiny sesbania	*Sesbania bispinosa*	4

3. Restoration Strategy & Management Plan

3.1. Management Plan

It is very seldom that a protected area has sufficient budget available to control all ACU's in one year and have funds for follow up treatment, hence it is therefore crucial to prioritise areas for control.

The field assessment results have shown that IAP densities are generally very low, and infestations are relatively new in most areas. This can be determined by Chromolaena (*Chromolaena odorata*), and Lantana (*Lantana camara*) often only found along roadsides. It has, in most cases, not spread further than five metres from the edge of the road into the surrounding vegetation.

Around 97% of MNP is at 5% density of IAP's per ACU or below. The aim should be for the entire MNP to reach below the 2% threshold density of IAP's within 5 years.

It was observed that the main pathways of spread were development nodes, villages, old homesteads, offices and field ranger camps, hence invasive alien plants found at these sites were often also seen along the roads close to these sites and in the vegetation surrounding these areas. An example is the variety of IAP's found at the new development at Ponta Milibengalala, which was more than likely brought in with building material. These IAP's have established and are now starting to spread to the surrounding vegetation.

The western border, in the core area along the Futi river, is heavily invaded with various IAP's. This is due to the human settlement along the fence line, as well as IAP's being dispersed down the river during high flow which causes disturbance to vegetation and introduces an array IAP's into the vegetation along the river edge. Water lettuce found in parts of the Futi river is being spread by animals, particularly hippo, moving between different pools of water within the river.

The Management Plan priority areas are divided into categories A – D. The main priority areas to fund are Category A, followed by Category B.1. – B.3, and then B4.. Funding for Category C areas has been received before this plan was compiled hence this area was not prioritised. Category C areas do not impact heavily on biodiversity, however visually it does not look appealing to enter the park with Eucalyptus and Pine trees hence the decision was taken by the Park Management to source funds to control the area. The Category D area (buffer zone around MNP) should only be considered if control of IAP's in MNP are effectively controlled and sufficient long-term funding is available.

The prioritisation of areas should not be seen as static as new IAP's may be introduced, unexpected fires change prioritisation and budgets can change. The prioritisation has been summarised in Table 5 and explained below.

The principles used to prioritise areas (ACU's) are as follow:

A. **Prevention, early detection & rapid response, and control pathways/vectors of spread**
B. **Keep clean areas clean, and control infestations from lowest to highest densities**
C. **Eucalyptus and Pine ACU's - funding received**
D. **Buffer zone**

Prioritisation runs from the highest priority, Category A, to the lowest priority, Category D. The categories are explained below and detailed in Table 5 and illustrated in Figure 4. A breakdown of each ACU and the IAP's identified as well as the densities per ACU are detailed in Appendix 7.1. Appendix 7.2. provides a detailed breakdown of Figure 5 by splitting the map of the MNP into 5 maps to show in detail the ACU boundaries and the numbers allocated to each ACU.

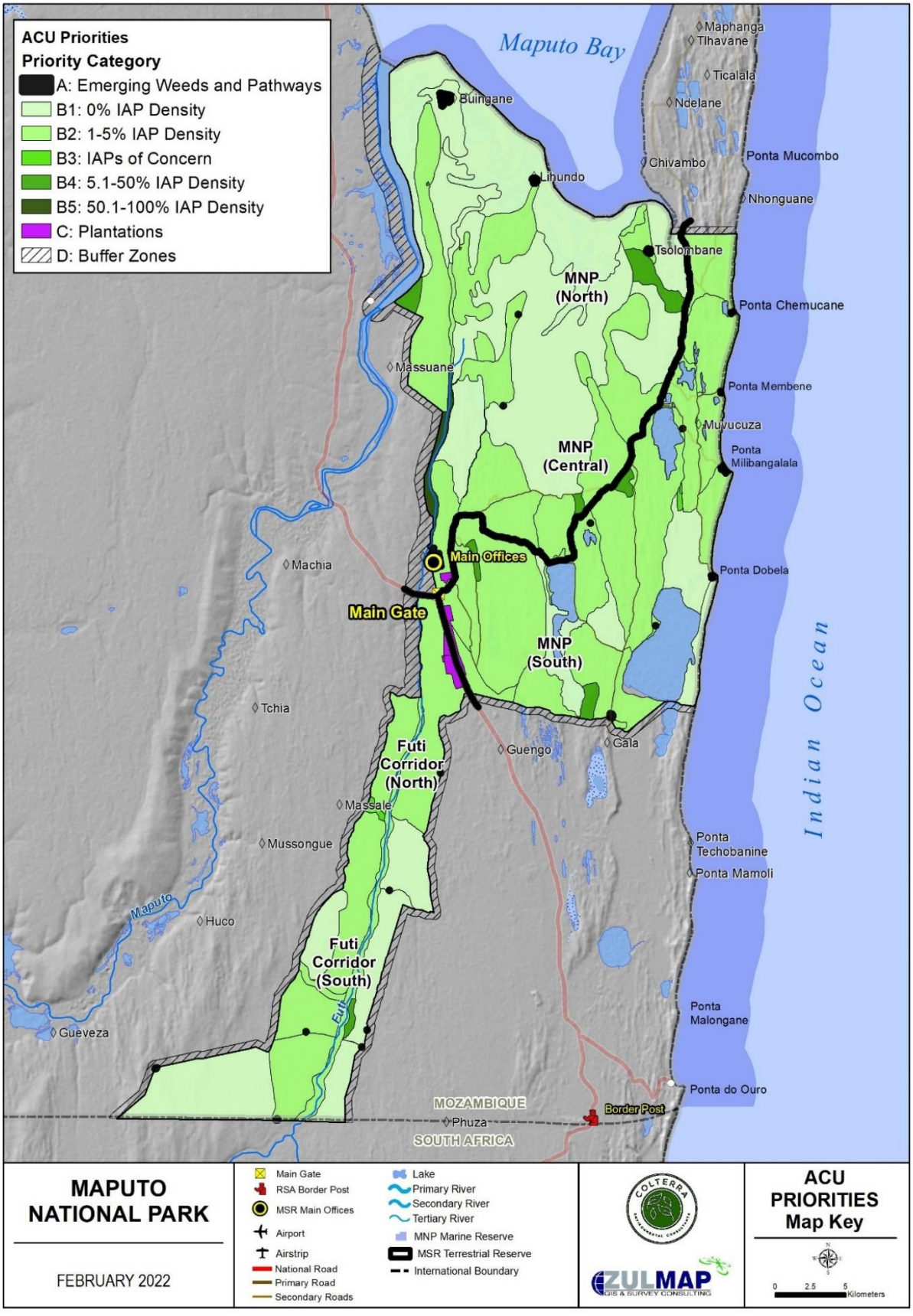

Figure 4. The IAP Priorities per ACU.

IAP's are spread in four major phases: Introduction, Establishment, Invasion and Spread (Hobbs & Humphries 1995). Most efforts are typically spent on management and control of the last two phases where IAP's impacts are more measurable. This is not resource-efficient over the long-term. A more efficient and effective way to protect biodiversity in the long-term is to expend resources to prevent new invasions and on early detection and rapid response before the species can become established (Chornesky *et al.* 2005; Leung et al. 2002).

CATEGORY A: Prevention, early detection & rapid response, and control pathways/vectors of spread

Prevention:

New introductions need to be prevented from entering MNP. Prevention refers to the exclusion of IAP's from any given area. Prevention of IAP's refers to stopping both intentional and unintentional introductions of IAP's. Here follows a few examples which are relevant to MNP:

Intentional introductions:
- Plants introduced for agriculture, forestry, and biofuels production
- Plants introduced for soil improvements or for erosion control
- Plants introduced for ornamental use, e.g., planted in gardens at homes and offices

Unintentional introductions:
- Contaminants of agricultural produce, seed, or feed brought in to feed animals in bomas
- Plants stuck in propeller of boats and in the mud of a vehicle's wheels
- Road building machinery,
- Construction equipment
- Building materials
- Imported soils for example to fix roads
- Tourists and their luggage/equipment

Educating field rangers and management staff to report any new IAP's spotted could assist with early detection. Signs at entrance gates making tourists aware of the potential of introducing IAP's as well as contact numbers if they spot any new infestations could be an effective way of reducing the risk of new introductions. Staff should also be prohibited from planting non-indigenous species in their gardens.

Early Detection and rapid response:

Early detection is the next most effective step after prevention. Once a new IAP is detected rapid response is critical to eradicate or contain the infestation before it spreads (Chornesky et al. 2005; Hobbs & Humphries 1995). Potential invasions can be quickly managed avoiding impacts on biodiversity and livelihoods, and subsequently saving management resources (Leung et al. 2002; Rejmánek & Pitcairn 2002). Many IAS are difficult or impossible to manage once they are well established, but many can be eradicated or contained if caught at an early stage.

Detecting new infestations and taking action to eradicate requires rapid response. Hence a small team driving around the park and checking all the pathways of spread are required. Actions to eradicate may take many repeated treatments over many years. If a decision is taken to react to a new infestation, then it should be documented. The location, species treated, size of the area

treated, density/ number of plants present, time taken to apply the treatment, treatment used, as well as recommended follow-up time. Photos of the IAP's at the site are also useful to document. Timeous follow up is critical to prevent the spread of the IAP's at the site. Each follow-up treatment should be documented.

Control pathways/vectors of spread

Prevention is closely partnered with the identification of invasion pathways and vectors of spread (how IAP's may be transported to a new location). While there may be hundreds of alien plants that could become invasive in MNP, there are relatively few pathways by which new IAP's can enter and become established (Ruiz & Carlton 2003).

In MNP the pathways of spread/vectors of spread are as follows:

- N200 tar road (the road to Maputo that runs through the MNP)
- The main dirt road through MNP to Inhaca Island
- Futi river
- Boundary fences where infestation of IAP's is high outside the fence
- Staff planting IAP's at offices and staff houses
- Seed brought in with construction material
- Soil brought in to fix roads
- Old homesteads that have been demolished and abandoned were found to have several IAP's and some have started to spread into adjacent vegetation
- Inhabited homesteads where IAP's are planted as hedges or for medicinal purposes.

The site should be monitored for up to a few years depending on the species and monitoring data should be evaluated and plans for further treatments modified as appropriate.

Funding Category A areas are critical and should receive the highest priority. A dedicated team should be employed throughout the year to focus on category A areas.

CATEGORY B: Keep clean areas clean, and control infestations from lowest densities to highest densities

It is less costly and more effective to send a team once a year to survey the 0% density areas to check for any new IAP's that might have spread than to leave these areas and not monitor it and have new IAP's establish and spread.

Specific IAP's such as Pereskia (*Pereskia aculeata*), Mauritian hemp (*Furcraea foetida*) and Prickly pear (*Opuntia spp*.) have been given their own ACU and priority number. These invasions are not new invasions and the species do not spread very fast. These IAP's are costly to control and require specific training before attempting control, hence the reason for them being listed in their own ACU with their own prioritisation. They are not rated very high on the prioritisation list as they can be left for a year or two and the infestation will not increase drastically. There needs to be sufficient funds for initial clearing, as well as follow up clearing to be done, before attempting control. In many countries including the bordering country, South Africa, there are very effective biocontrol agents available for controlling Prickly pear and to a lesser extent Pereskia.

Water lettuce found in N22c and N37 (along the Futi river) is also of concern as it is being spread by animals and can reach other water bodies. It should be treated on its own and not part of the ACU – Futi river. There are also very effective biocontrol agents available to treat Water lettuce in South Africa, and the Tembe Elephant Park adjoining MNP uses biocontrol to treat the water lettuce invasion in the park. Biocontrol agents have not been approved for use by Mozambique, and it should be investigated for future control to reduce control costs.

CATEGORY C: The Eucalyptus and Pine ACU's – funding received

These ACU's were given their own prioritisation category as there is sufficient budget available to control the ACU's. These species also require specific, specialised techniques for clearing. They also have a very low potential of spreading into the surrounding vegetation. In normal circumstances the Eucalyptus and Pine areas would have been included in Category B, however the park management is concerned with the visible impact these species have when you enter the park and would like to remove it first as funding has been received to control it.

CATEGORY D: Buffer zones

Buffer zones have been included into the prioritisation of the MNP as infestation from outside of the park is of concern. This is the last priority and should only be considered if there are funds available to control all the above categories. The buffer zone includes a 500m buffer area around the MNP as well as a 1 km buffer for all roads and rivers leading into the park. The densities of these areas were not assessed; however, the densities allocated to it are probably quite accurate, as all the park fences were driven along during the field assessment and the presence of IAP's on the outside of the park were noted.

Table 5. The IAP Priority list of ACU's

THE IAP PRIORITY LIST OF ACU'S				
No	**Priorities**	**Areas**	**Action required**	**Reason for priority**
CATEGORY A: PREVENT, DETECT, RAPIDLY REMOVE NEW INFESTATIONS, AND CONTROL VECTORS OF SPREAD				
A.	Prevention, early detection, and rapid response, and control pathways/ vectors of spread	All roads, rivers, development nodes, old and currently inhabited homesteads, offices, staff houses, and gates.	Removal as soon as possible with rapid response team	Prevent new invasions, and rapidly remove new infestations to prevent establishment
CATEGORY B: KEEP CLEAN AREAS CLEAN, AND CONTROL INFESTATIONS FROM LOWEST DENSITIES TO HIGHEST DENSITIES				
B.1.	0% IAP density Alien Control Units (ACU).	All green ACU's in IAP Density map.	Monitor. Drive all roads annually and control IAP's where spotted	Keep clean areas clean
B.2.	1 – 5% IAP density	All yellow areas in IAP Density map.	IAP infestation mainly along roads. Control required twice annually.	Prevent further spread.
B.3.	IAP's of concern	*Furcraea foetida – V32* *Opuntia monacantha – N32a & N35a, Pereskia aculeata N38c, Pistia stratiotes – N22 & N37c*	Invasions are very localized. Control using correct control methods.	Isolated infestations. Control to prevent spread.
B.4.	5,1 - 50% IAP density	All light and dark orange areas on the IAP Density map.	Control lower density areas first. Only control if sufficient funds available for follow up clearing. Twice annual control required.	Lower density areas have potential to become denser.
B.5.	50,1 – 100% IAP density	All the red areas in the IAP Density map.	Control lower density areas first. Only control if sufficient funds available for follow	Higher densities are lowest priority as the cost will remain the

			up clearing. Twice annual control required.	same if left for another couple of years
CATEGORY C: EUCALYPTUS AND PINE ACU's				
C.	Gum & Pine	*Eucalyptus spp*. and *Pinus spp*. along main road	Control according to control & rehabilitation plan	Unsightly at the park entrance. Different priority as specific funding is available to control.
CATEGORY D: BUFFER ZONES				
D.	Buffer zones:	1km on either side of rivers/streams flowing into MNP Main road to Maputo Buffer area 50m on eastern boundary.	Control only after sufficient long-term funds for MNP have been secured and MNP is in a maintenance phase (below 5% density)	High infestation of IAP's outside eastern boundary of MNP, which is spreading into MNP

<u>The following factors are important to remember when implementing an IAP Management Plan:</u>

- The rate of control of IAP's needs to exceed the rate of spread.
- Prevention of new introductions through regularly controlling pathways of spread is crucial to prevent new infestations
- Integrate IAP activities with other management activities to achieve maximum beneficial effect including the fire management plan
- Be flexible. Adapt the Plan to accommodate fires, drought, and new invasions
- Plan to succeed: Sufficient funds should be allocated to the highest-priority categories first, so that they are adequately resourced
- Ideally an emergency fund should be set aside for any new IAP infestations
- Staff should be trained in identifying and reporting any emerging weeds for a clearing team to control as soon as possible
- A database of work completed should be kept at a central location. The date, ACU cleared, the hectares, the person days per hectare used, the IAP's cleared, and the densities should be captured. This will assist with planning future follow -up clearing
- Do not start work without having sufficient funds to do follow up clearing. Follow up at the right time (generally every three months depending on the species) are critical for control.

3.2. Restoration Strategy

Assisted natural regeneration (ANR) is recognized as a cost-effective woody vegetation restoration method that can restore biodiversity and ecosystem services in areas of intermediate levels of degradation (Evans et al, 2015). ANR relies on residual seeds and plants at the site or dispersed from vegetation nearby. ANR utilizes various techniques to assist in the natural re-establishment of vegetation, such as cessation of vegetation control practices like burning and disturbance with machinery; the use of vegetation thinning or removal of undesirable species to reduce competition and promote growth, and in some circumstances, supplementary planting of seedlings. Although most frequently applied in tropical forests, ANR is gaining momentum as an important mechanism for restoring woody vegetation across a range of ecosystems (Chazdon, 2008; Gilroy et al., 2014; Shono et al., 2007). ANR aims to accelerate, rather than replace, natural successional processes by removing or reducing the barriers to natural regeneration (Shona et al 2020).

Vegetation that is allowed to naturally regenerate has several advantages for biodiversity conservation over complete re-planting, even when plantings are comprised of native species. First, under ANR, the vegetation is comprised of indigenous species which adapted to local conditions, resulting in vegetation that is more resilient to local climate variation and disturbance. Second, natural regeneration can result in high species diversity including trees, shrubs, forbs, and grasses, whereas under environmental planting, generally only a few species of tree and grass are planted (Evans et al, 2015).

CATEGORY A-B2

The vast majority of IAP's within the MNP occur in low densities of below 5% (Category A – B2), and where there is higher infestation within these ACU's, it is at a very localized scale. This is still the initial colonisation phase for these species and have not had a significant effect on indigenous species in these areas. The control of IAP's in these categories will be a sufficient intervention for the restoration of the natural vegetation.

CATEGORY B3 – B5

In Category B3 – B5 areas where there is higher level of infestation by IAP's and the potential negative effect on the indigenous vegetation may have started to occur, care should be taken when control methods are implemented to create as little disturbance as possible to the remaining natural vegetation. The use of fire or the exclusion of fire should be considered depending on the vegetation type's adaptation to fire to promote the reestablishment of species which may have been displaced by the IAP infestation. For species such as Barbados gooseberry (*Pereskia aculeata*) and Chromolaena (*Chromolaena odorata*), high fire loads after control may cause hotter than normal fires which can kill indigenous vegetation and seeds in the soil bank. If possible, fire should be excluded from these areas until the fire load has been reduced and the area should only be burnt on a cool day if necessary.

CATEGORY C

A conspicuous feature within the MNP in the presence of Eucalyptus trees (*Eucalytus spp*.) along with a small area of Pine trees (*Pine spp*.), found on either side of the N200 (the main road leading from Ponta do Ouro to Maputo). There are approximately 460 ha of Eucalyptus and Pine remaining of the estimated 800 ha that was previously recorded. The tree densities of the remaining plantation areas being comparatively low at about 150 trees per ha to those found in commercial plantations, about 1100 trees per ha.

Park management has endeavoured to start the removal of the trees within the original 800 ha area and has cut down and removed the timber from more than 300 ha as well as treated the stumps with herbicide to stop re-sprouting or coppice growing from the stumps. This ANR practice was started within the last two years and has been very successful in restoring natural vegetation to these areas by reducing competition from non-indigenous Eucalyptus trees and thus accelerating the natural succession processes.

These areas occur predominantly within the Woody Grassland vegetation type, which is defined by having sparse tree and woody shrub patches interspaced by grass species. The sparse nature of the Eucalyptus and Pine trees does mimic the structure of the Woody Grassland vegetation in that the Eucalyptus trees are interspaced by naturally occurring grass species. This has the effect of having the herbivores utilize the plantation areas, both cleared and currently standing, in similar ways as they do the surrounding vegetation type.

The most effective method to assist with the regeneration of these plantation areas, would be to continue with the clearing plan as stipulated in the Control Plan for Category C, in section 3.3.2. This approach was successfully adopted in the iSimangaliso Wetland Park in South Africa on a larger scale than what is present within the MNP. There it was decided to not remove the stumps from the ground as this would cause unnecessary disturbance to the soil and the process would remove the natural grass species which occur between the stumps and reverse some of the natural rehabilitation processes occurring. The stumps will also naturally decompose over time. The outcome of this exercise is that biodiversity is returning without any intervention. A study to measure the return of biodiversity over a period was conducted which showed the success of the reestablishment of indigenous species, however it has not yet been published (C. Myhill, personal communication, 13 October 2021.)

Once the competition from Eucalyptus and Pine trees have been removed in the Category 3 areas natural colonization of tree and shrub species from the surrounding vegetation through natural dispersion mechanisms will occur. Therefore, the natural vegetation type for that area will return to the surrounding undisturbed vegetation. This will however take time for the tree and shrub species to establish and mature. The rate of the process of colonization and establishment of indigenous tree and shrub species can be increased through a ANR technique whereby desired trees and shrub species are introduced into the area planting seedlings which can be grown in a nursery. Seeds can be sourced from desired tree species within the surrounding natural vegetation, germinated and grown out to be planted out. This however requires specialized expertise as well as management of the process.

The final ANR technique/ factors to consider is fire management. Typical African landscapes and vegetation types are adapted to and are modified through the use or suppression of fire. Fire frequency and intensity may help or hinder the successional process within the woody grassland vegetation type. With specific reference to the current objectives to remove Eucalyptus and Pine trees, fire can be used to remove excess branches and tree material remaining once the trees have been felled and the utilizable wood removed. This is widely recognised as best practice to reduce

potential fuel load for future un-prescribed fires which may come through the area. The post fire area will also be ideal for the planting of seedlings, if it is decided to follow the practice of replanting, as the competition from grasses and other herbaceous vegetation will be at its lowest and allow the seedlings to establish. This will also have the added benefit of stimulation of germination of some species whose seeds are located within the soil seedbank. Once an initial fire has been used, fire should be excluded from the area as far as possible to allow the woody vegetation which has either been planted or has emerged naturally to establish to survive future fires which might come through the area. This could be a period of 3-5 years, depending on fire fuel load, which is influenced by grass growth, and which is dependent on rainfall, grazing pressure and species composition. Woody grassland vegetation structure is heavily influenced by these factors and subsequently fire as well and would form part of the development of a fire management plan for park management throughout the park. The MNP fire management plans need to consider the restoration of these areas.

All the areas cleared need to remain relatively undisturbed after clearing until indigenous vegetation has established. Disturbance from vehicles accessing the area, heavy grazing, browsing pressure and uncontrolled fires can delay rehabilitation of the area. Follow-up treatment of at least every six months to remove any IAP seedlings should be implemented.

3.3. Control

There are various control methods available to control the IAP's identified. Table 6 outlines the control methods that will be most effective at MNP, taking into consideration that it is a high biodiversity area hence herbicides should only be used where damage to biodiversity by IAP's outweigh the possible negative impacts of herbicides. If workers are trained to apply herbicides correctly, and there is sufficient supervision there is very little chance of herbicides impacting the environment.

The herbicides and control methods selected below have been tried and tested, and are registered for control in South Africa, however no such registration could be found in Mozambique, hence these are used at own risk.

A detailed breakdown explaining the practical implementation of the Management Strategy is explained in Appending 6. Guidelines for Control. It breaks down the types of Control Methods available as listed in Table 6, as well as the Herbicide application, Safety Precautions, Training required before work can start, Equipment required, as well as Personal Protective Clothing per worker.

Table 6. Control methods

Common name	Scientific name	Size	Control method	Herbicide	Mixture	Control method explanation
Common ragweed	*Ambrosia artemisiifolia*	Disturbance weed. Should dissappear if disturbance is reduced. No herbicide available for treatment.				
Madeira vine	*Anredera cordifolia*	Mature/ Adult	Cut stump	Triclopyr (butoxy ethyl ester) 240 g/L (wetter included)	100 ml/ 10 litres water, 10 ml wetter + dye	Cut stump. Remove any plant material and place on pile. Spray plant material and stem. Leaves are semi-succulent. Follow up essential.
Yellow-flowered Mexican poppy	*Argemone Mexicana*	Mature/ Adult	Hand pull	No herbicide available	N/A	N/A
Milkweed	*Asclepias physocarpa*	Mature/ Adult	Hand pull	No herbicide available	N/A	N/A
Bougainvillea	*Bougainvillea spp.*	Mature/ Adult	Cut stump	Imazapyr 100 g/L SL	300 ml/ 10 litres water	Cut plant to ankle height and apply herbicide to cut stump
Creeping inch plant	*Callisia repens*	Mature/ Adult	Hand pull	Spreads easily. Leave to dry. Follow up for any seedlings.		
Madagascar periwinkle	*Catharanthus roseus*	Mature/ Adult	Hand pull	No herbicide available	N/A	N/A
Chromolaena	*Chromolaena odorata*	Seedlings	Hand pull	N/A	N/A	N/A
		Mature/ Adult	Cut stump	Imazapyr 100 g/L SL	200 ml/ 10 litres water	Cut plant to ankle height and apply herbicicide to cut stump
		Re-growth	Foliar spray	Triclopyr (butoxy ethyl ester) 240 g/L EC	75 ml/ 10 litres water, 10 ml wetter + dye	Any re-growth (between knee height and 1 m) can be foliar sprayed.
Spear thistle	*Cirsium vulgare*	Mature/ Adult	Hand pull	No herbicide available	N/A	N/A
Dodder	*Cuscuta campestris*	Mature/ Adult	Hand pull	No registered available	N/A	Spread by birds. Very hard to eradicate.
Eucalyptus/ Blue Gum	*Eucalyptus spp.*	Seedlings, saplings & coppice	Foliar spray	Triclopyr (butoxy ethyl ester) 240 g/L EC	400 ml/ 10 litres water, 50 ml wetter + dye	Spray with knapsack sprayer if not heigher than 1 m

		Mature/ Adult	Cut stump/ Fell	Triclopyr (butoxy ethyl ester) 240 g/L EC (wetter included)	400 ml/ 10 litres water, 10 ml wetter + dye	Clear fell with chainsaw
			Cut stump/ Fell	Imazapyr 100 g/L SL	500 ml/ 10 litres water	Clear fell with chainsaw
Mauritian hemp	*Furcraea foetida*	Mature/ Adult	Frill	Triclopyr (butoxy ethyl ester) 240 g/L EC (wetter included)	400 ml / 1 litre of oil	Cut around base of stem and apply herbicide
Blue morning glory	*Ipomoea indica*	Mature/ Adult	Cut stump	Triclopyr (butoxy ethyl ester) 480 g/L	50 ml/ 10 litres water, 50 ml wetter + dye	Cut stem and apply herbicide to the cut stem. Leave remaining plant to die off.
Lantana	*Lantana camara*	Mature/ Adult	Cut Stump	Imazapyr 100 g/L SL	200 ml/ 10 litres water	Cut plant to ankle height and apply herbicide to cut stump
Prickly malvastrum	*Malvastrum coromandelianum*	Mature/ Adult	Hand pull	No herbicide registered	N/A	N/A
Syringa	*Melia azedarach*	Mature/ Adult	Cut stump	Imazapyr 100 g/L SL	300 ml/ 10 litres water	Cut plant apply herbicide to cut stump
Prickly pear	*Opuntia ficus-indica*	Mature/ Adult	Stem injection	Glyphosate (isopropylamine) 360 g a.e./l SL	3.3 litres/ 10 litres water	Stem injection. Inject 2ml in pre-made holes in the stem of the plant (4-12 pre-made holes for plants with 20-250 cladodes)
Drooping prickly pear	*Opuntia monacantha*	Mature/ Adult	Stem injection	Glyphosate (isopropylamine) 360 g a.e./l SL	3.3 litres/ 10 litres water	Stem injection. Inject 2ml in pre-made holes in the stem of the plant (4-12 pre-made holes for plants with 20-250 cladodes)
Parthenium	*Parthenium hysterophorus*	Seedlings	Hand pull	N/A	N/A	Wear protective clothing as can cause an allergic reaction
		Mature/ Adult	Foliar spray	Picloram	500 ml/ 10 litres water	Selective herbicide. Will not kill grasses but will kill broadleaf plants. Follow up at least every 30 days.

Barbados gooseberry	*Pereskia aculeata*	Mature/ Adult	Foliar spray & burn	Triclopyr (butoxy ethyl ester) 240 g/L EC	100 ml/ 10 litres water, 50 ml wetter (Actipron Super) & dye	Apply as a high volume spray in non-sensitive areas. Plants should be reduced to not higher than 2 m. After treatment remove dead top growth, e.g. controlled burn
Pine	*Pinus spp.*	All	Fell/ Ring bark	It does not coppice. No herbicide required		
Water lettuce	*Pistia stratiotes*	All	Hand pull	No herbicide available	N/A	Considerable success in South Africa with biocontrol - weevil Neohydronomus affinis
Purslane	*Portulaca oleracea*	Mature/ Adult	Hand pull	No registered available	N/A	N/A
Guava	*Psidium guajava*	Seedlings	Hand pull	N/A	N/A	N/A
		Mature/ Adult	Cut stump	Imazapyr 100 g/L SL	1,250 ml/ 10 litres water	Cut stump to ankle height and apply herbicide to the stem
Castor oil	*Ricinus communis*	All	Cut stump	Imazapyr 100 g/L SL	300 ml/10 litres water	Cut stump to ankle height and apply herbicide to the stem
Canary weed	*Senecio madagascariensis*	Mature/ Adult	Hand pull	No herbicide registered	N/A	N/A
Easter cassia	*Senna pendula*	Mature/ Adult	Cut stump	Imazapyr 100 g/L SL	200 ml/ 10 litres water	Cut stump to ankle height and apply herbicide to the stem
Spiny sesbania	*Sesbania bispinosa*	Mature/ Adult	Cut stump	Imazapyr 100 g/L SL	200 ml/ 10 litres water	
Red sesbania	*Sesbania punicea*	Mature/ Adult	Cut stump	Imazapyr 100 g/L SL	200 ml/ 10 litres water	
Silver-leaf bitter apple	*Solanum elaeagnifolium*	Mature/ Adult	Foliar spray	Triclopyr (butoxy ethyl ester) 240 g/L EC	100 ml/ 10 litres water, 10 ml wetter + dye	Apply foliar spray
Dense-thorned bitter apple	*Solanum sisymbriifolium*	Mature/ Adult	Foliar spray	Triclopyr (butoxy ethyl ester) 240 g/L EC	100 ml/ 10 litres water, 10 ml wetter + dye	Apply foliar spray
Singapore daisy	*Sphagneticola trilobata*	Mature/ Adult	Handpull	No herbicide available	N/A	N/A

3.4. Costs

The costs to control IAP's has been calculated for a 5-year period for MNP. After five years the park should be at a maintenance level (below 2% density for the entire park within 5 years) if the plan is followed. The priority areas are calculated in year one and the lesser priority areas in subsequent years. As there is currently funding available specifically for controlling Category C: Gum and Pine Areas, these areas were included for year 1 and 2. The costs for this category should not be included when approaching donors for funding. If there is not enough funding available as per the plan then priority areas which there are funding for should be focused on, starting from Category A areas.

MNP pays monthly wages and do not pay according to productivity, hence the costs were calculated on monthly wages. The risk is that the amount of work a person can do per day has been calculated as per the South African Working for Water Programme Personday rates per hectare (Table 7), however if workers work slower than the anticipated personday rate per hectare then the hectares that are required to be cleared in Table 8, will not be met. Table 9 provides a breakdown of costs per year for five years, while Table 10 – 14 provides a more detailed budget per year. For a breakdown of the costs for training, herbicide, protective clothing, equipment, and wages per year, the Action Plans per priority areas as sub-documents to this plan can be viewed.

To control the Category A and B1 areas a team of 4 people each plus a supervisor should be employed to control these areas. It is important to control B1 which are at 0% these areas, as there will always be new IAP's cropping up and it should be controlled before it establishes. Once a priority area has been controlled a is under 2% density then the area should be followed up using the team allocated for B1 areas.

For effective implementation of this plan, a manager is required to keep very close control of the hectares cleared per month, and to adjust where needed. The success of this plan depends on effective training of workers to do the work, quality control management every day, and a good record keeping system of areas cleared versus planned to monitor progress.

All effort should be made to employ local people from as close to the work site as possible to keep the transport costs low.

Table 7. Person day estimates for MNP

PERSONDAY ESTIMATES FOR MNP (persons required to clear one hectare of varying density)						
Treatment of general IAP's in the MNP		**Sparse**	**Med/ Scattered**	**Dense**	**Very dense**	**Closed**
Treatment	**Size class**	**0-5%**	**5,1-25%**	**25,1-50%**	**50,1-75%**	**75,1-100%**
Initial clearing (cut stump)	Seedlings	1.5	3	6	10	12
	Young	1.5	3.5	7.5	12	15
	Adult	1.5	3.5	7.5	12	15
Follow-up clearing (cut stump)	Seedlings	3	3	6	8	8
	Young	3	3	6	8	8
	Adult	3	3	6	8	8
Follow-up clearing (foliar spray)	Seedlings	1	1	2	5	5
	Young	1	1	2	5	5
	Adult	1	1	2	5	5

Table 8. Summary of total hectares, persondays, workers and costs required for a total of five years

CATEGORIES	**TOTAL 5- YEAR COSTS**			
	HECTARES	**PERSONDAYS**	**WORKERS REQUIRED (per yr on average over 5 yrs)**	**COST**
A: Emerging weeds, homesteads, offices	388	4620	4	MZN 2 294 653
B.1: 0%	42478	4620	4	MZN 2 294 653
B.2: 1 -5%	53777	288362	250	MZN 133 044 724
B.3: IAP's of concern: Opunitia, Pereskia & Furcraea	158	3160	6	MZN 5 676 485
B4: 5,1 -50%	1740	24800	28	MZN 15 216 864
B5: 50,1 -100%	566	8824	12	MZN 7 179 228
C: Eucalyptus & Pine areas	538	4304	4	MZN 2 342 490
D: Buffer zone				
TOTAL	**99645**	**338690**	**307**	**MZN 168 049 096**

Table 9. Five-year costing plan to control IAP in MNP

CATEGORIES	1			2			3			4			5		
	Total person days	Workers required	COST	Total person days	Workers required	COST	Total person days	Workers required	COST	Total personds ays	Workers required	COST	Total person days	Workers required	COST
A: Emerging weeds, homesteads, offices	924	4	MZN 450 330	924	4	MZN 408 429	924	4	MZN 469 434	924	4	MZN 451 379	924	4	MZN 515 080
B.1: 0%	924	4	MZN 450 330	924	4	MZN 408 429	924	4	MZN 469 434	924	4	MZN 451 379	924	4	MZN 515 080
B.2: 1 -5%	70000	303	MZN 30 509 613	74900	324	MZN 31 881 201	58800	255	MZN 28 271 115	63108	273	MZN 30 201 578	21554	93	MZN 12 181 218
B.3: IAP's of concern: Opunitia, Pereskia & Furcraea	0	0	MZN -	0	0	MZN -	2054	11	MZN 3 934 515	948	11	MZN 1 492 679	158	8	MZN 249 292
B4: 5,1 -50%	0	0	MZN -	0	0	MZN -	11000	58	MZN 7 118 258	5400	32	MZN 3 783 595	8400	50	MZN 4 315 012
B5: 50,1 -100%	0	0	MZN -	0	0	MZN -	0	0	MZN -	2400	16	MZN 3 982 526	6424	44	MZN 3 196 702
C: Eucalyptus & Pine areas	3766	16	MZN 2 036 550	538	2	MZN 305 940	0	0	MZN -	0	0	MZN -	0	0	MZN -
D: Buffer zone		0	MZN -												
TOTAL	75614	327	MZN 33 446 822	77286	335	MZN 32 187 141	73702	332	MZN 39 323 888	73704	341	MZN 40 363 136	38384	203	MZN 20 972 382

Table 10. Year one: Breakdown of costs – A detailed costing plan can be found in the Action Plan

CATEGORIES	1								
	Initial clearing			Follow up clearing			Total persondays	Workers required	COST
	Pd/ha	Personds ays	Hectares	Pd/ha	Person days	Hectares			
A: Emerging weeds, homesteads, offices	0,1	462	388	0,1	462	388	**924**	**4**	**MZN 450 330**
B.1: 0%	0,1	462	21239	0,1	462	21239	**924**	**4**	**MZN 450 330**
B.2: 1 -5%	2,5	50000	20000	1	20000	20000	**70000**	**303**	**MZN 30 509 613**
B.3: IAP's of concern: Opunitia, Pereskia & Furcraea		0			0		**0**	**0**	**MZN -**
B4: 5,1 -50%	0	0	0	0	0	0	**0**	**0**	**MZN -**
B5: 50,1 -100%	0	0	0	0	0	0	**0**	**0**	**MZN -**
C: Eucalyptus & Pine areas	5	2690	538	2	1076	538	**3766**	**16**	**MZN 2 036 550**
D: Buffer zone								**0**	**MZN -**
TOTAL		**53614**	**42165**	**3**	**22000**	**42165**	**75614**	**327**	**MZN 33 446 822**

Table 11. Year two: Breakdown of costs – A detailed costing plan can be found in the Action Plan

CATEGORIES	2								
	Initial clearing			Follow up clearing			Total persondays	Workers required	COST
	Pd/ha	Person days	Hectares	Pd/ha	Person days	Hectares			
A: Emerging weeds, homesteads, offices	0,1	462	388	0,1	462	388	**924**	**4**	**MZN 408 429**
B.1: 0%	0,1	462	462	0,1	462	462	**924**	**4**	**MZN 408 429**
B.2: 1 -5%	2,5	32500	13000	0,8	42400	53000	**74900**	**324**	**MZN 31 881 201**
B.3: IAP's of concern: Opunitia, Pereskia & Furcraea	0	0	0	0	0	0	**0**	**0**	**MZN -**
B4: 5,1 -50%				0	0	0	**0**	**0**	**MZN -**
B5: 50,1 -100%	0	0	0	0	0	0	**0**	**0**	**MZN -**
C: Eucalyptus & Pine areas	1	538	538	0	0	0	**538**	**2**	**MZN 305 940**
D: Buffer zone									
TOTAL	**4**	**33962**	**14388**	**1**	**43324**	**53850**	**77286**	**335**	**MZN 32 187 141**

Table 12. Year three: Breakdown of costs – A detailed costing plan can be found in the Action Plan

CATEGORIES	3									
	Initial clearing			Follow up clearing			Total persondays	Workers required	COST	
	Pd/ha	Person days	Hectares	Pd/ha	Person days	Hectares				
A: Emerging weeds, homesteads, offices	0,1	462	388	0,1	462	388	**924**	**4**	**MZN**	**469 434**
B.1: 0%	0,1	462	462	0,1	462	462	**924**	**4**	**MZN**	**469 434**
B.2: 1 -5%	3	30000	10000	1	28800	36000	**58800**	**255**	**MZN**	**28 271 115**
B.3: IAP's of concern: Opunitia, Pereskia & Furcraea	8	1264	158	5	790	158	**2054**	**11**	**MZN**	**3 934 515**
B4: 5,1 -50%	8	8000	1000	3	3000	1000	**11000**	**58**	**MZN**	**7 118 258**
B5: 50,1 -100%	0	0	0	0	0	0	**0**	**0**	**MZN**	**-**
C: Eucalyptus & Pine areas	0	0	0	0	0	0	**0**	**0**	**MZN**	**-**
D: Buffer zone										
TOTAL	**19**	**40188**	**12008**	**9**	**33514**	**38008**	**73702**	**332**	**MZN**	**39 323 888**

Table 13. Year four: Breakdown of costs – A detailed costing plan can be found in the Action Plan

CATEGORIES	4									
	Initial clearing			Follow up clearing			Total persondays	Workers required	COST	
	Pd/ha	Person days	Hectares	Pd/ha	Person days	Hectares				
A: Emerging weeds, homesteads, offices	0,1	462	388	0,1	462	388	**924**	**4**	**MZN**	**451 379**
B.1: 0%	0,1	462	462	0,1	462	462	**924**	**4**	**MZN**	**451 379**
B.2: 1 -5%	3	32331	10777	1	30777	30777	**63108**	**273**	**MZN**	**30 201 578**
B.3: IAP's of concern: Opunitia, Pereskia & Furcraea	0	0	0	3	948	316	**948**	**11**	**MZN**	**1 492 679**
B4: 5,1 -50%	8	5920	740	2	3480	1740	**9400**	**56**	**MZN**	**5 191 237**
B5: 50,1 -100%	12	3600	300	4	1200	300	**4800**	**33**	**MZN**	**4 963 238**
C: Eucalyptus & Pine areas	0	0	0	0	0	0	**0**	**0**	**MZN**	**-**
D: Buffer zone										
TOTAL	**23**	**42775**	**12667**	**10**	**37329**	**33983**	**80104**	**381**	**MZN**	**42 751 490**

Table 14. Year five: Breakdown of costs – A detailed costing plan can be found in the Action Plan

CATEGORIES	5								
	Initial clearing			Follow up clearing			Total persondays	Workers required	COST
	Pd/ha	Person days	Hectares	Pd/ha	Person days	Hectares			
A: Emerging weeds, homesteads, offices	0,1	462	388	0,1	462	388	**924**	**4**	**MZN 515 080**
B.1: 0%	0,1	462	462	0,1	462	462	**924**	**4**	**MZN 515 080**
B.2: 1 -5%	3	0	0	1	21554	21554	**21554**	**93**	**MZN 12 181 218**
B.3: IAP's of concern: Opunitia, Pereskia & Furcraea	0	0	0	1	158	158	**158**	**8**	**MZN 249 292**
B4: 5,1 -50%	0	0	0	1	1740	1740	**1740**	**10**	**MZN 1 859 703**
B5: 50,1 -100%	0	0	266	2	1732	866	**1732**	**12**	**MZN 1 641 296**
C: Eucalyptus & Pine areas	0	0	0	0	0	0	**0**	**0**	**MZN -**
D: Buffer zone									
TOTAL	**3**	**924**	**1116**	**5**	**26108**	**25168**	**27032**	**131**	**MZN 16 961 667**

4. Monitoring & Evaluation

The success of an IAP Restoration Strategy and Management Plan should ideally be measured by the recovery of a habitat/ecosystem, thus the restoration of biodiversity after control methods have been applied.

97% of the MNP has an invasion density of 5% and less and the biodiversity in these ecosystems have not been altered, except where old homesteads use to be. To measure the restoration of biodiversity in these areas will not be an effective monitoring tool. An effective monitoring tool for Category A & B.1 areas is to keep a record of the reduction in densities of IAP's. This requires a good record keeping database of areas cleared where the number of plants removed per ACU, the type of IAP, the method used, and the date needs to be recorded for timeous follow up. Table 15 below provides an example of daily record keeping that should be entered into a database.

Table 15. Daily record keeping (for Category A – B.1)

Area	N200 – Tar Road
Date	8 May 2022
Size of area cleared	5 hectares – measured in Avenza
IAP treated	56 x Parthenium plants, 2 x lantana
Number of persons used	4
Clearing methods applied	Foliar spray
Estimated follow up date	one month – 8 June 2022

Around 2,5% of areas in the MNP are between 5,1 – 60% density. It can be assumed that the biodiversity of the areas with very high densities have been affected. Mgobozi, *et al.* (2008) showed that the removal of IAP's benefits biodiversity with immediate effect even if the area has been invaded for a long period of time. A study is currently being conducted in MNP to determine the baseline biodiversity indicators per vegetation type. Once the indicators have been established this chapter will be amended to include biodiversity indicators as a measure per ACU to know whether IAP control has been effective after control.

It is important to keep a database of all the areas treated, IAP's treated, methods used, costs per hectare, herbicides used, transport costs to the site, and importantly the date when the clearing took place. This is important as timeous follow up treatment is key to the success of control and will assist managers to monitor progress, evaluate the plan and make informed changes to the plan when required. Before and after photos at the same point is important for record keeping and for funders records. This is explained in more detail in the Action Plans for each of the categories.

5. Conclusion

This plan should not be read as a static plan but needs to be adjusted where necessary to accommodate density changes due to fire, floods or any other reason. The introduction of new IAP's through wind, water, vehicles, etc. should be monitored and the teams sent to address the new IAP's.

A study is being conducted to develop biodiversity indicators per vegetation type. Once the study has been completed the indicators should be included in chapter 4, Monitoring and Evaluation.

Action Plans per category have been developed which provide a detailed approach to tackle each category in this Plan. The Action Plans also provide detailed costs and are part of the Offset Restoration Project.

This plan should be reviewed every five years.

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6. Appendix

6.1. IAP field assessment results

Priority Category	Name	HA	Dominant IAP	Sub-dominant IAP	Density	Additional IAP
A	N200	43	*Parthenium hysterophorus*	None	1%	None
A	MNP Main Road	181	*Lantana camara*	*Chromolaena odorata*	1%	None
A	I31 Ponta Chemucane	5	*Anredera cordifolia*	None	1%	None
A	I34 Ponta Milibangalala	13	*Ricinus communis*	*Argemone Mexicana*	2%	*Psidium guajava, Opuntia spp., Malvastrum coromandelianum, Solanum elaeagnifolium*
A	I10 Ponta Dobela	4	*Catharanthus roseus*	None	1%	None
A	V20	14	*Chromolaena odorata*	*Psidium guajava*	5%	*Senna pendula*
A	V25	52	*Opuntia spp.*	*Catharanthus roseus*	1%	None
A	V29	11	*Lantana camara*	*Psidium guajava*	5%	*Catharanthus roseus, Bougainvillea spp.*
A	I11	1	None	None	0%	None
A	I14	1	None	None	0%	None
A	I21	1	None	None	0%	None
A	I39 4x4 camp	1	None	None	0%	None
A	I40 Phuza Ranger Camp	1	None	None	0%	None
A	I42	1	None	None	0%	None
A	I43	1	None	None	0%	None
A	I4 Main offices/houses	44	*Psidium guajava*	*Lantana camara*	2%	*Eucalyptus spp., Sesbania bispinosa, Callisia repens*

Priority Category	Name	HA	Dominant IAP	Sub-dominant IAP	Density	Additional IAP
A	I9 Gala Gate	8	*Psidium guajava*	*Catharanthus roseus*	5%	None
A	I36 Guengo Ranger Camp	1	*Catharanthus roseus*	None	1%	None
A	I44 Border Patrol Camp	3	*Catharanthus roseus*	None	1%	None
A	I45 Gueveza Ranger Camp	2	None	None	1%	None
A	**TOTAL**	**388**				
B1	N7b	1051	None	None	0%	None
B1	N10	692	None	None	0%	None
B1	N13	655	None	None	0%	None
B1	N19b	1703	None	None	0%	None
B1	N24	2603	None	None	0%	None
B1	N25	926	None	None	0%	None
B1	N26	8023	None	None	0%	None
B1	N20c	13536	None	None	0%	None
B1	N22a	212	None	None	0%	None
B1	N28c	2078	None	None	0%	None
B1	N35b	1727	None	None	0%	None
B1	N39	1570	None	None	0%	None
B1	N40b	1581	None	None	0%	None
B1	N41	1096	None	None	0%	None
B1	N43	961	None	None	0%	None
B1	N45	4065	None	None	0%	None
B1	**TOTAL**	**42478**				
B2	A29	144	*Lantana camara*	*Catharanthus roseus*	5%	*Opuntia spp., Solanum elaeagnifolium*
B2	A31	9	*Cuscuta campestris*	None	1%	None

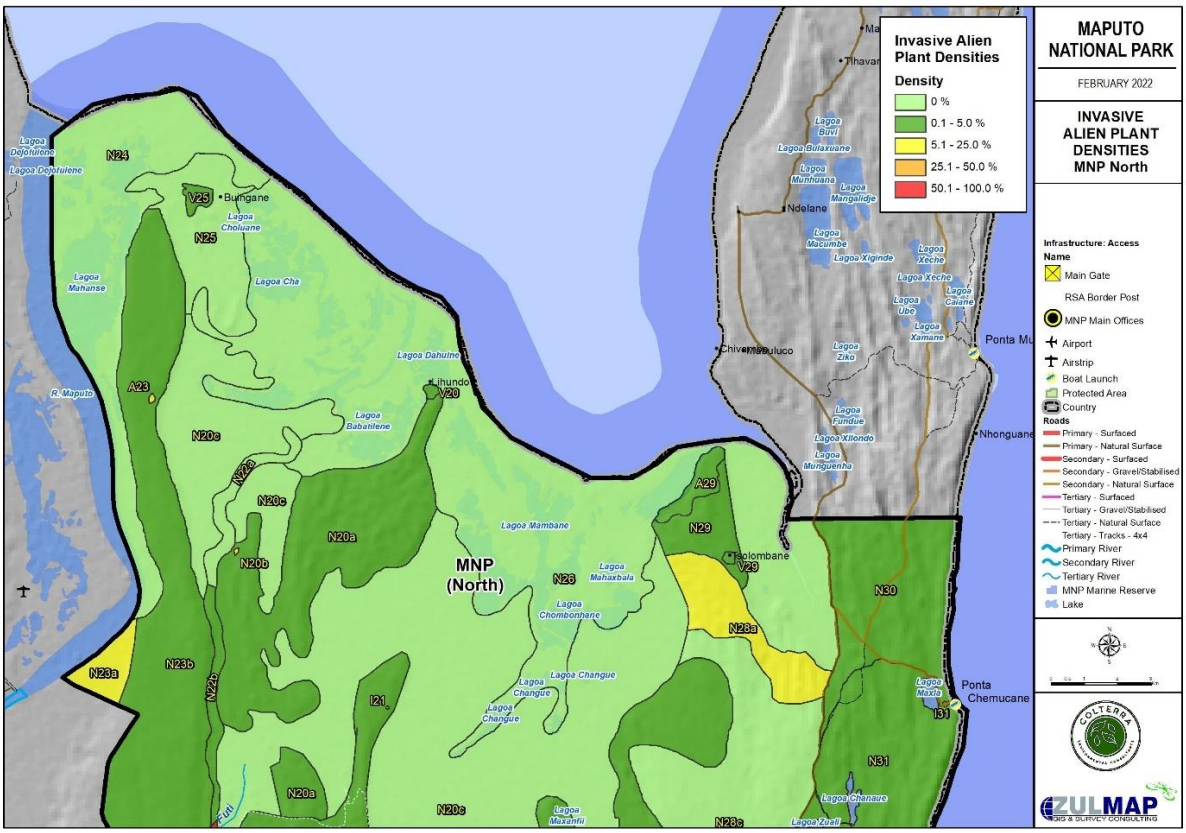
Priority Category	Name	HA	Dominant IAP	Sub-dominant IAP	Density	Additional IAP
B2	I38	1	*Solanum elaeagnifoliu m*	*Catharanthus roseus*	1%	None
B2	N1	558	*Lantana camara*	*Catharanthus roseus*	1%	None
B2	N2	479	*Chromolaena odorata*	*Lantana camara*	2%	*Psidium guajava, Eucalyptus spp.*
B2	N3	860	*Lantana camara*	*Chromolaena odorata*	3%	*Eucalyptus spp., Psidium guajava*
B2	N4	1206	*Lantana camara*	*Chromolaena odorata*	1%	Anredera cordifolia
B2	N5b	4904	*Lantana camara*	*Eucalyptus spp.*	1%	*Catharanthus roseus*
B2	N6	968	*Lantana camara*	*Chromolaena odorata*	1%	*Eucalyptus spp., Anredera cordifolio*
B2	N7a	76	*Chromolaena odorata*	*Lantana camara*	5%	None
B2	N8a	1489	*Chromolaena odorata*	*Anredera cordifolia*	1%	*Lantana camara*
B2	N9a	45	*Chromolaena odorata*	None	5%	*Lantana camara*
B2	N9b	813	*Anredera cordifolia*	*None*	1%	None
B2	N11	3423	None	None	0%	None
B2	N12b	2152	*Psidium guajava*	None	1%	None
B2	N14	1385	*Anredera cordifolia*	*Psidium guajava*	1%	None
B2	N16a	1082	None	None	0%	None
B2	N16c	60	*Eucalyptus spp.*	*Ricinus communis*	2%	None
B2	N17	1153	*Psidium guajava*	None	1%	None
B2	N18	1648	*Anredera cordifolia*	None	1%	None
B2	N21	1193	*Lantana camara*	*Anredera cordifolia*	1%	*Solanum elaeagnifolium*

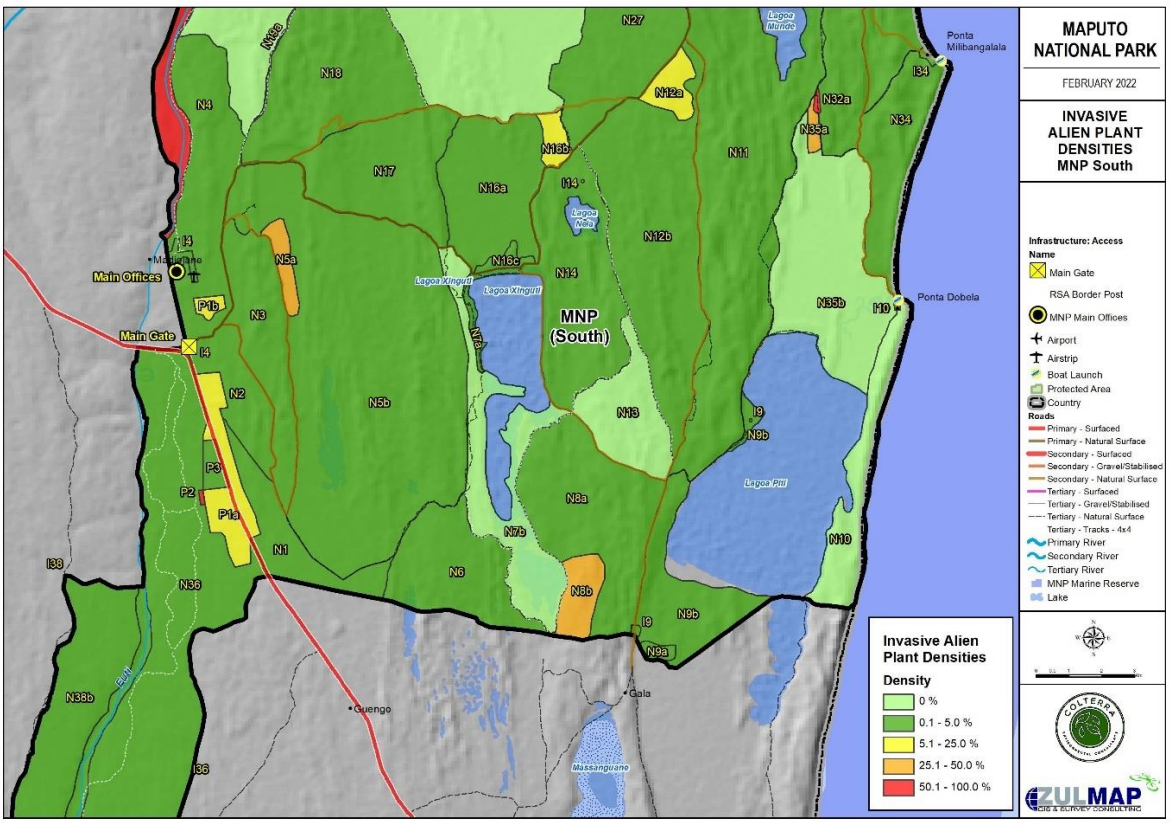
Priority Category	Name	HA	Dominant IAP	Sub-dominant IAP	Density	Additional IAP
B2	N22b	191	*Lantana camara*	None	5%	None
B2	N20a	2775	*Lantana camara*	*Solanum elaeagnifolium*	1%	*Asclepias physocarpa*
B2	N23b	3676	*Anredera cordifolia*	*Lantana camara*	1%	None
B2	N27	1532	*Lantana camara*	None	1%	None
B2	N28b	2250	*Lantana camara*	None	1%	None
B2	N29	367	*Lantana camara*	None	1%	None
B2	N30	1595	*Lantana camara*	*Cuscuta campestris*	1%	None
B2	N31	1913	*Lantana camara*	*Cuscuta campestris*	1%	None
B2	N32b	1362	*Lantana camara*	*Opuntia monacantha*	1%	*Catharanthus roseus, Psidium guajava*
B2	N33	981	*Lantana camara*	*Psidium guajava*	1%	*Catharanthus roseus*
B2	N34	891	*Lantana camara*	*Psidium guajava*	1%	*Anredera cordifolia, Catharanthus roseus, Melia azedarach*
B2	N36	3531	*Chromolaena odorata*	*Psidium guajava*	5%	*Parthenium hysterophorus, Malvastrum coromandelianum, Solanum elaeagnifolium*
B2	N37	1536	*Psidium guajava*	*Pistia stratiotes*	2%	*Solanum elaeagnifolium, Ricinus communis*
B2	N38a	203	*Chromolaena odorata*	*Psidium guajava*	5%	None
B2	N38b	3927	*Chromolaena odorata*	*Solanum elaeagnifolium*	1%	None
B2	N42	1451	*Chromolaena odorata*	*Opuntia monacantha*	1%	None

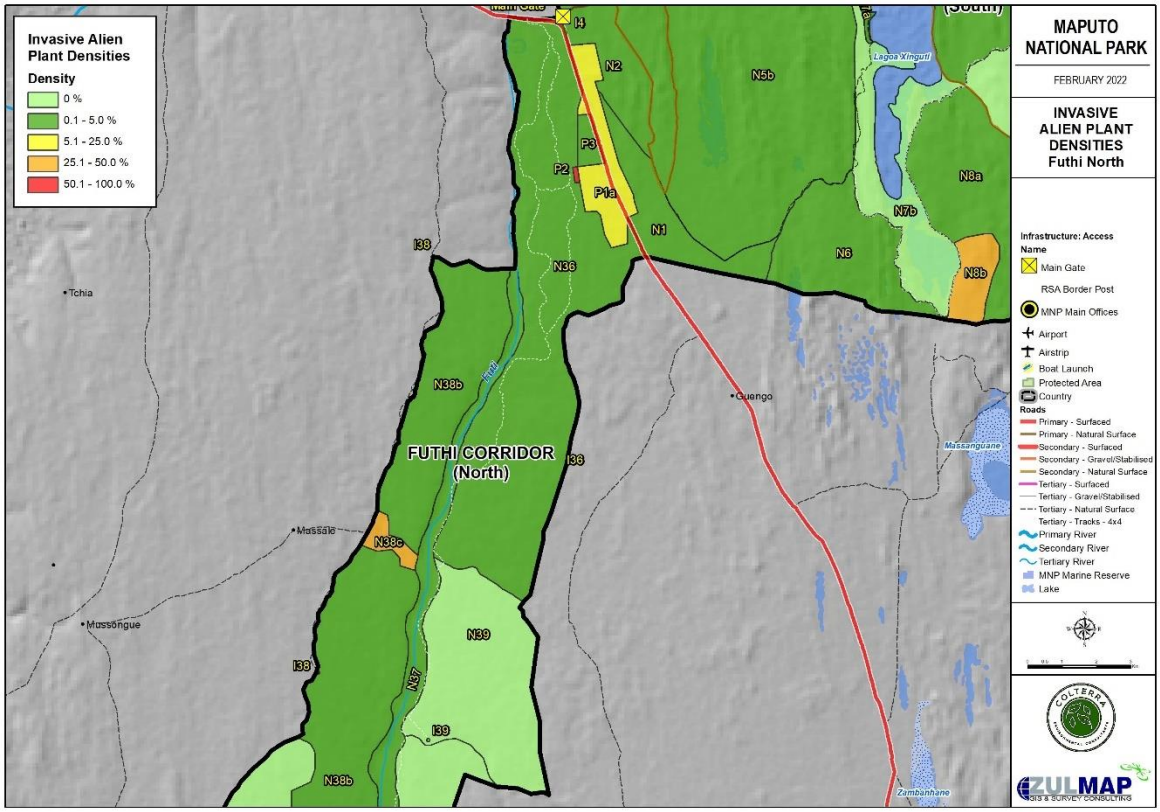
Priority Category	Name	HA	Dominant IAP	Sub-dominant IAP	Density	Additional IAP
B2	N44	1946	*Eucalyptus spp.*	*Opuntia monacantha*	1%	None
B2	**TOTAL**	**53777**				
B3	N32a	10	*Opuntia monacantha*	*Lantana camara*	60%	None
B3	N35a	46	*Opuntia monacantha*	*Psidium guajava*	50%	None
B4	N38c	98	*Chromolaena odorata*	*Pereskia aculeata*	40%	None
B3	V32	4	*Furcraea foetida*	*Catharanthus roseus*	40%	*Psidium guajava, Lantana camara*
B3	**TOTAL**	**158**				
B4	A23	4	*Lantana camara*	*Ricinus communis*	20%	*Solanum elaeagnifolium*
B4	N5a	131	*Lantana camara*	None	30%	None
B4	N8b	249	*Lantana camara*	*Chromolaena odorata*	30%	*Senna pendula, Anredera cordifolio*
B4	N12a	184	*Lantana camara*	*Chromolaena odorata*	20%	*Psidium guajava*
B4	N16b	110	*Lantana camara*	*Opuntia monacantha*	20%	*Melia azedarach, Psidium guajava*
B4	N19a	53	*Lantana camara*	*Chromolaena odorata*	10%	*Anredera cordifolia, Asclepias physocarpa*
B4	N20b	2	*Opuntia spp.*	None	10%	None
B4	N23a	233	*Chromolaena odorata*	*Lantana camara*	20%	*Anredera cordifolia*
B4	N28a	657	*Lantana camara*	*Catharanthus roseus*	10%	*Bougainvillea spp., Solanum elaeagnifolium*
B4	N40a	118	*Chromolaena odorata*	*Psidium guajava*	30%	*Melia azedarach, Solanum elaeagnifolium*
B4	**TOTAL**	**1740**				
B5	N22c	566	*Lantana camara*	*Chromolaena odorata*	60%	*Pistia stratiotes, Ricinus communis, Cirsium vulgare,*

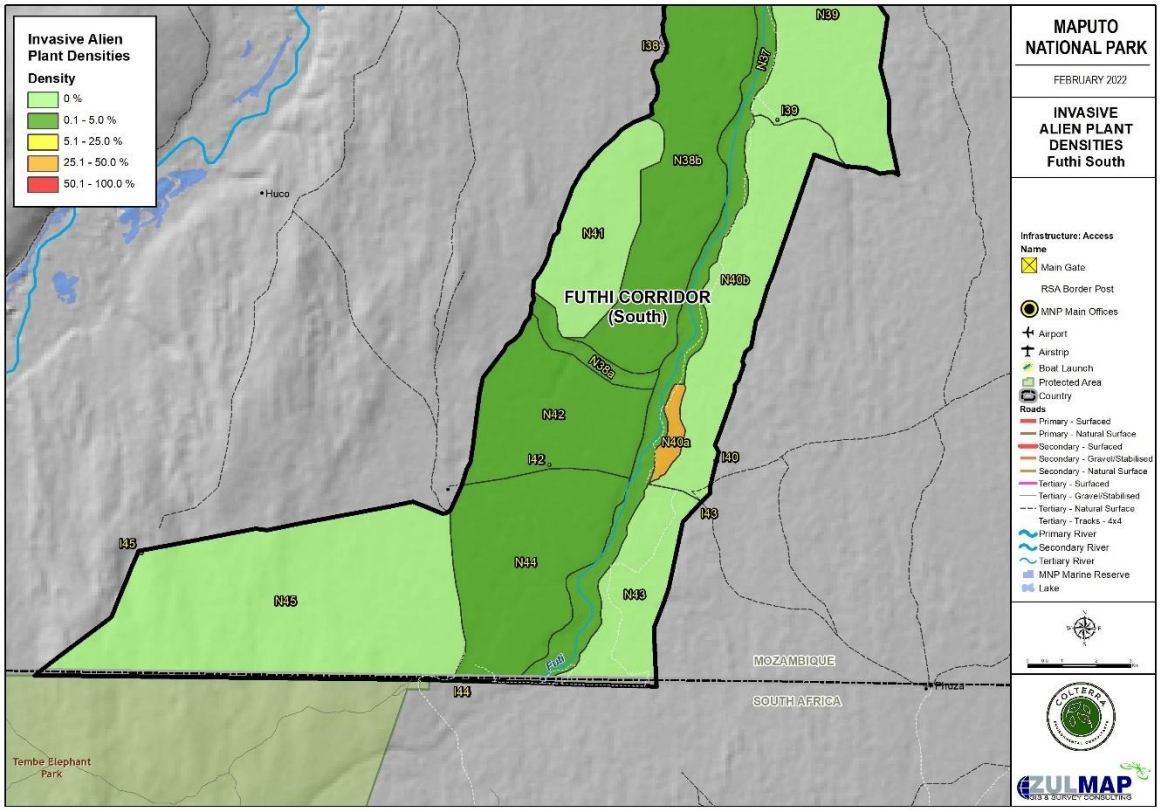
Priority Category	Name	HA	Dominant IAP	Sub-dominant IAP	Density	Additional IAP
						Psidium guajava, Solanum sisymbriifolium, Asclepias, physocarpa
B5	**TOTAL**	**566**				
C	P1a	410	*Eucalyptus spp.*	*Parthenium hysterophorus*	15%	None
C	P1b	45	*Eucalyptus spp.*	*Parthenium hysterophorus*	15%	None
C	P2	6	*Eucalyptus spp.*	None	100%	None
C	P3	77	*Pinus spp.*	*Eucalyptus spp.*	5%	*Parthenium hysterophorus*
C	**TOTAL**	**538**				
D	MNP Boundary Buffer	9822	*Lantana camara*	*Chromolaena odorata*	5%	None
D	**TOTAL**	**9822**				

6.2. IAP density maps

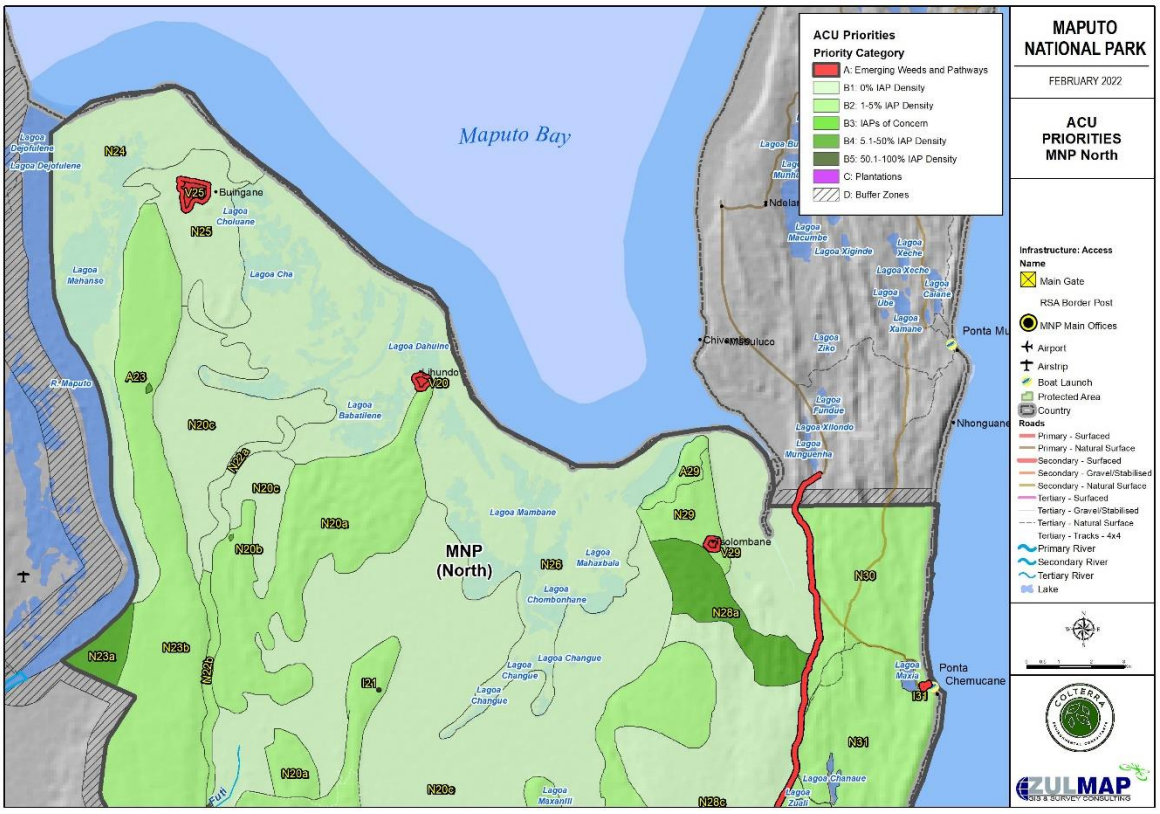


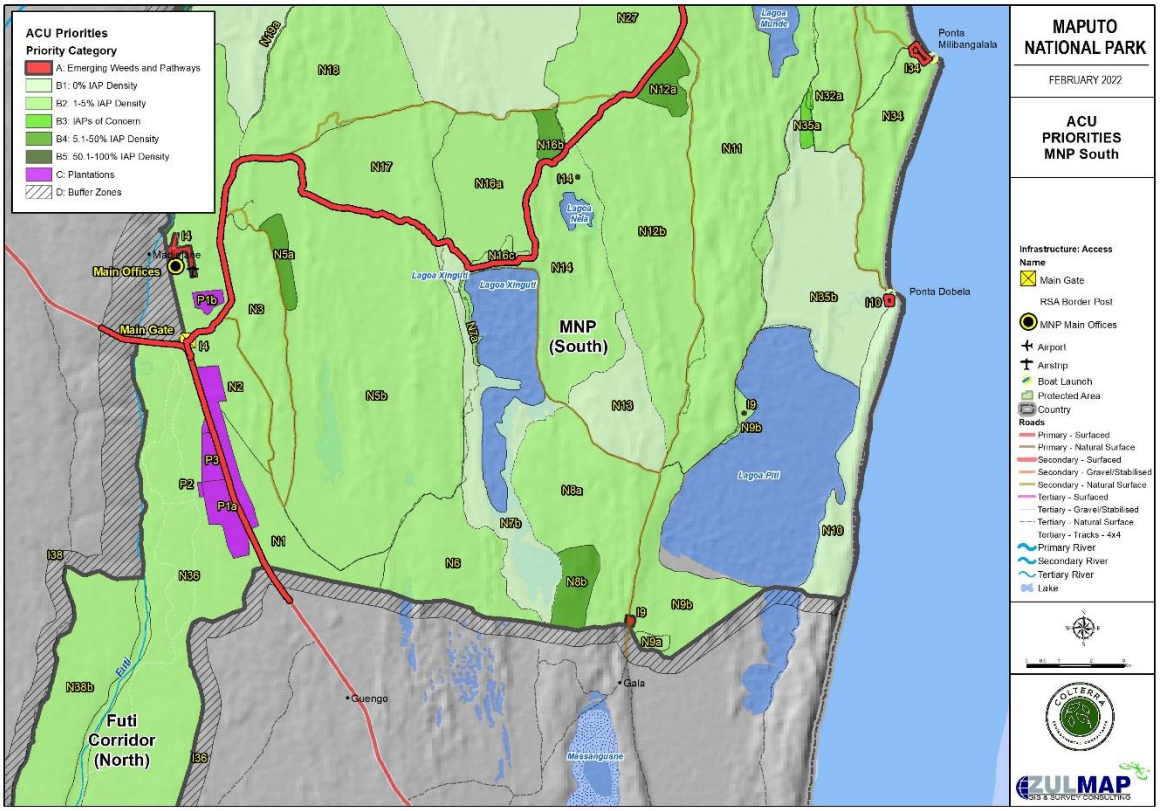


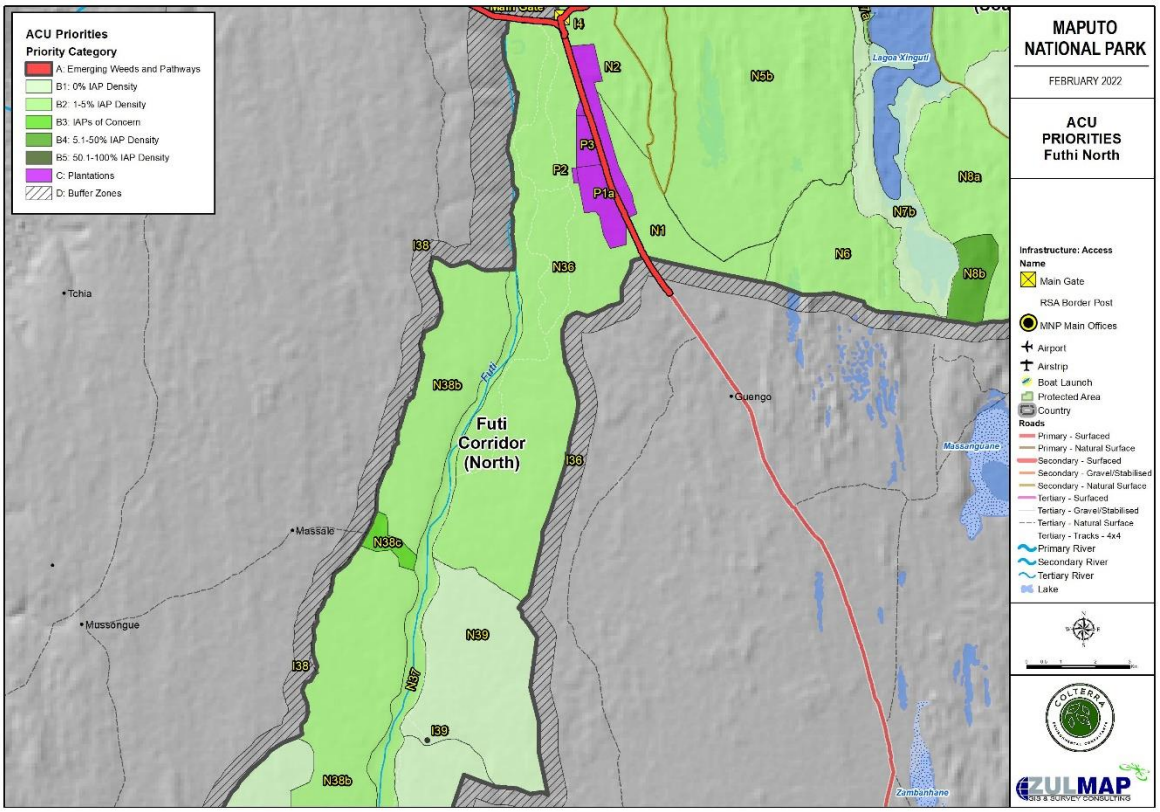

Invasive Alien Plant Densities
Density
0 %
0.1 - 5.0 %
5.1 - 25.0 %
25.1 - 50.0 %
50.1 - 100.0 %
MAPUTO NATIONAL PARK
FEBRUARY 2022
INVASIVE ALIEN PLANT DENSITIES Futhi North
Infrastructure: Access
Name
Main Gate
RSA Border Post
MNP Main Offices
Airport
Airstrip
Boat Launch
Protected Area
Country
Roads
Primary - Surfaced
Primary - Natural Surface
Secondary - Surfaced
Secondary - Gravel/Stabilised
Secondary - Natural Surface
Tertiary - Surfaced
Tertiary - Gravel/Stabilised
Tertiary - Natural Surface
Tertiary - Tracks - 4x4
Primary River
Secondary River
Tertiary River
MNP Marine Reserve
Lake
FUTHI CORRIDOR (North)
I4
N2
N5b
P3
P2
P1a
N1
N8a
N7b
N6
N8b
I38
N36
N38b
I36
N38c
N39
I39
N37
N38b
Tchia
Massaie
Mussongue
Guengo
Massanguane
Zambanhane
Lagoa Xinguti
COLTERRA
ZULMAP

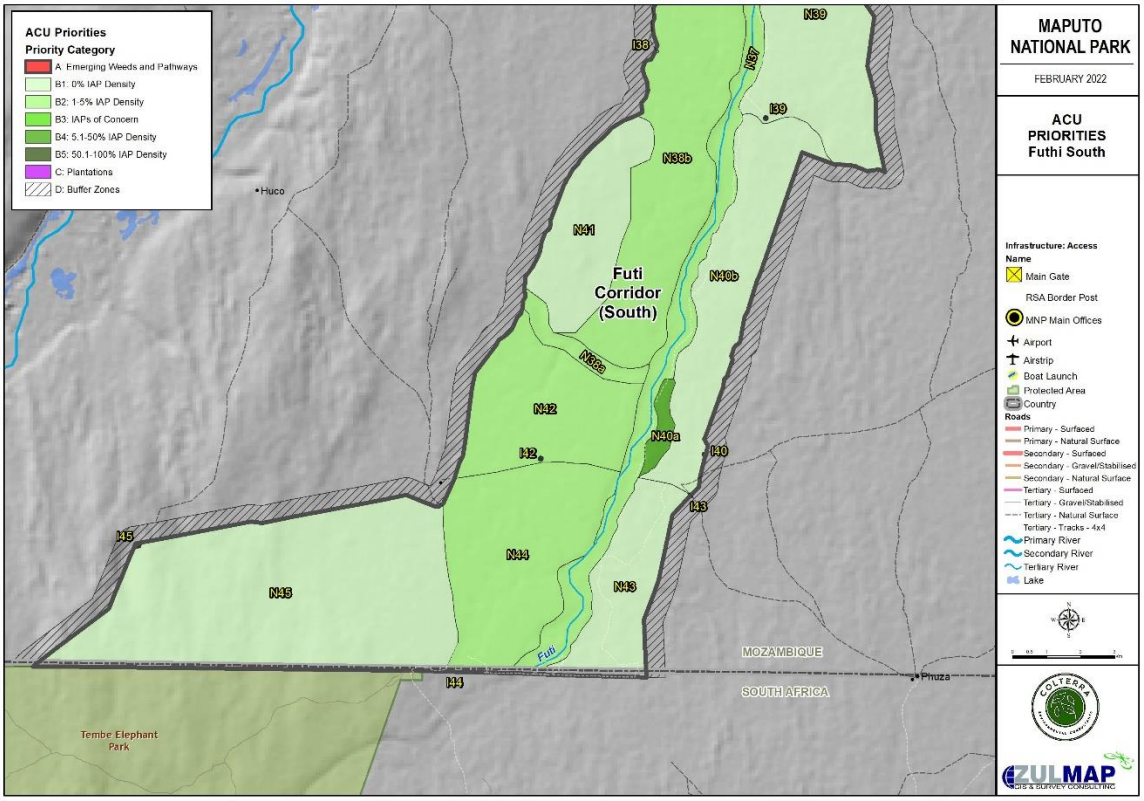


6.3. IAP priority maps




ACU Priorities
Priority Category
A: Emerging Weeds and Pathways
B1: 0% IAP Density
B2: 1-5% IAP Density
B3: IAPs of Concern
B4: 5.1-50% IAP Density
B5: 50.1-100% IAP Density
C: Plantations
D: Buffer Zones
MAPUTO NATIONAL PARK
FEBRUARY 2022
ACU PRIORITIES MNP South
Main Offices
Main Gate
MNP (South)
Futi Corridor (North)
Ponta Milibangalala
Ponta Dobela
Guengo
Gala
Infrastructure: Access
Name
Main Gate
RSA Border Post
MNP Main Offices
Airport
Airstrip
Boat Launch
Protected Area
Country
Roads
Primary - Surfaced
Primary - Natural Surface
Secondary - Surfaced
Secondary - Gravel/Stabilised
Secondary - Natural Surface
Tertiary - Surfaced
Tertiary - Gravel/Stabilised
Tertiary - Natural Surface
Tertiary - Tracks - 4x4
Primary River
Secondary River
Tertiary River
Lake
ZULMAP


ACU Priorities
Priority Category
A: Emerging Weeds and Pathways
B1: 0% IAP Density
B2: 1-5% IAP Density
B3: IAPs of Concern
B4: 5.1-50% IAP Density
B5: 50.1-100% IAP Density
C: Plantations
D: Buffer Zones
MAPUTO NATIONAL PARK
FEBRUARY 2022
ACU PRIORITIES Futhi North
Futi Corridor (North)
Tchia
Massalé
Mussongue
Guengo
Zambanhane
Infrastructure: Access
Name
Main Gate
RSA Border Post
MNP Main Offices
Airport
Airstrip
Boat Launch
Protected Area
Country
Roads
Primary - Surfaced
Primary - Natural Surface
Secondary - Surfaced
Secondary - Gravel/Stabilised
Secondary - Natural Surface
Tertiary - Surfaced
Tertiary - Gravel/Stabilised
Tertiary - Natural Surface
Tertiary - Tracks - 4x4
Primary River
Secondary River
Tertiary River
Lake
ZULMAP


ACU Priorities
Priority Category
A: Emerging Weeds and Pathways
B1: 0% IAP Density
B2: 1-5% IAP Density
B3: IAPs of Concern
B4: 5.1-50% IAP Density
B5: 50.1-100% IAP Density
C: Plantations
D: Buffer Zones
Huco
N39
I38
N38a
I39
N38b
N41
Futi Corridor (South)
N40b
N38c
N42
N40a
I42
I40
I43
I45
N44
N43
N45
Futi
I44
MOZAMBIQUE
SOUTH AFRICA
Pnuza
Tembe Elephant Park
MAPUTO NATIONAL PARK
FEBRUARY 2022
ACU PRIORITIES Futhi South
Infrastructure: Access
Name
Main Gate
RSA Border Post
MNP Main Offices
Airport
Airstrip
Boat Launch
Protected Area
Country
Roads
Primary - Surfaced
Primary - Natural Surface
Secondary - Surfaced
Secondary - Gravel/Stabilised
Secondary - Natural Surface
Tertiary - Surfaced
Tertiary - Gravel/Stabilised
Tertiary - Natural Surface
Tertiary - Tracks - 4x4
Primary River
Secondary River
Tertiary River
Lake
ZULMAP

6.4. Photos and location of the alien plant species identified

Here follows images of the 32 alien plant species identified during the field assessment held in MNP in September 2021. The control methods for each species are listed in 3.3, Table 6.

Name	Photo	Location
1. Common ragweed (*Ambrosia artemisiifolia)*	 Photo credit: C. Terblanche	Along disturbed areas in the Futi River
2. Madeira vine (*Anredera cordifolia*)	 Photo credit: https://www.bellingenurbanlandcare.org.au/wp-content/uploads/IMG_0793.jpg	Sparsely located along forest edges
3. Yellow-flowered Mexican poppy (*Argemone mexicana*)		Ponta Milibangalala

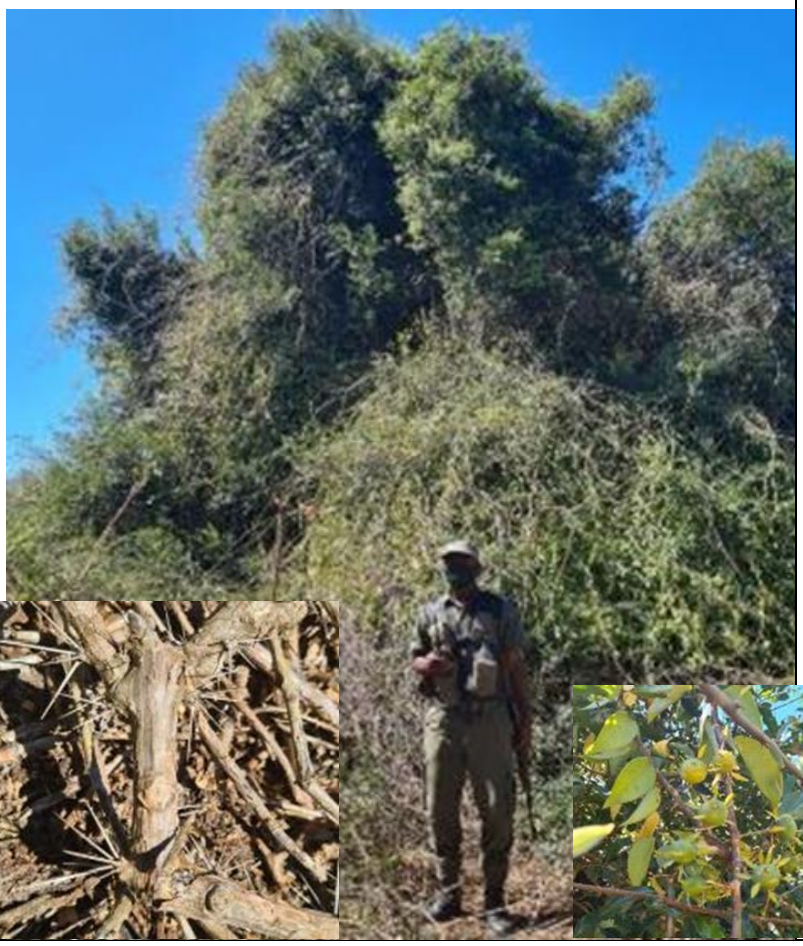
	Photo credit: C. Terblanche	
4. Milkweed (*Asclepias physocarpa*)	 Photo credit: C. Terblanche	Along road edges. Very sparsely distributed.
5. Creeping inch plant (*Callisia repens*)	 Photo credit: C. Terblanche	Houses close to main office.
6. Madagascar periwinkle (*Catharanthus roseus*)	 Photo credit: C. Terblanche	At field ranger camps, homesteads and along roads

7. Chromolaena (*Chromolaena odorata*)	 Photo credit: https://tse4.mm.bing.net/th?id=OIP.-sy0gq8Hm0qd1Wafp5LLnQHaFj&pid=Api&P=0&w=225&h=168	Located throughout the MNP
8. Spear thistle (*Cirsium vulgare*)	 Photo credit: C. Terblanche	Along the Futi river
9. Dodder (*Cuscuta campestris*)	 Photo credit: https://tse4.mm.bing.net/th?id=OIP.mFngY4BLduPUL5VOWX9F8wHaFj&pid=Api&P=0&w=220&h=165	Around old homesteads

10. Blue Gum (*Eucalyptus spp*.)	 Photo credit: https://www.publicdomainpictures.net/pictures/150000/velka/eucalyptus-tree.jpg	Plantation remnants along R200 road to Maputo
11. Mauritian hemp *(Furcraea foetida)*	 Photo credit: C. Terblanche	Localized patch (-26,419271, 32,905117).
12. Blue morning glory (*Ipomoea indica*)	 Photo credit: T. Liversage	Localized patches (-26.516690, 32.913801).

13. Lantana (*Lantana camara*)	 Photo credit: C. Terblanche	Widespread throughout MNP
14. Prickly malvastrum *(Malvastrum coromandelianum)*	 Photo credit: C. Terblanche	Various disturbed sites at MNP
15. Syringa *(Melia azedarach*)	 Photo credit: Large – C. Terblanche, Small:	Old agriculture areas near Ponta Milibangalala and along Futi river.

16. Prickly pear (*Opuntia ficus-indica*)	 Photo credit: http://worldofsucculents.com/wp-content/uploads/2015/07/Opuntia-ficus-indica-Indian-Fig1.jpg	Mainly around old homesteads
17. Drooping prickly pear (*Ficus monacantha*)	 Photo credit: C. Terblanche	Multiple isolated stands (-26,463222, 32,894266)

18. Parthenium *(Parthenium hysterophorus)*	 Photo credit: C. Terblanche	Along R200 tar road to Maputo
19. Barbados gooseberry (*Pereskia aculeate*)	 Photo credit: C. Terblanche	-26.646876, 32.677021

20. Pine (*Pinus spp.*)	 Photo credit: T. Liversage	Plantation remnants along R200 tar road to Maputo.
21. Water lettuce (*Pistia stratiotes)*	 Photo credit: C. Terblanche	Pools in Futi river (-26.405524, 32.730090).
22. Purslane (Portulaca oleracea)	 Photo credit: C. Terblanche	Ponta Milibangalala

23. Guava (*Psidium guajava*)	 Photo credit: T. Liversage	Mainly at homesteads and along the western boundary of the Core Area
24. Castor oil (*Ricinus communis*)	 Photo credit: https://tse4.mm.bing.net/th?id=OIP.yA9k52NKFHqgKKlrRvO_nAHaE8&pid=Api&P=0&w=278&h=185	Along roads, at development nodes & homesteads, especially Ponta Milibangalala.
25. Canary weed (*Senecio madagascariensis*)	 Photo credit: C. Terblanche	Ponta Milibangalala

26. Easter cassia (*Senna pendula*)	 Photo credit: C. Terblanche	Only found in this location - 26.608700, 32.822001.
27. Spiny sesbania (*Senna bispinosa*)	 Photo credit: https://tse2.mm.bing.net/th?id=OIP.MQV9U1gPDbuTG1OLTGzomQHaFj&pid=Api&P=0&w=227&h=170	Road leading to main office.
28. Red sesbania *(Sesbania punicea)*	 Photo credit: https://tse1.mm.bing.net/th?id=OIP.-AD6vSYk6wFkuRE_lM4UlAHaE3&pid=Api&P=0&w=249&h=164	Northern area of Futi river, sparse (-26.315471, 32.735876)

29. Silver-leaf bitter apple *(Solanum elaeagnifolium)*	 Photo credit: C. Terblanche	Around cattle kraal areas in northern parts (-26.267331, 32.714861) and spread sparsely throughout the MSR along roads.
30. Dense-thorned bitter apple (*Solanum sisymbriifolium*)	 Photo credit: C. Terblanche	Along the Futi river.
31. Singapore daisy *(Sphagneticola trilobata)*	 Photo credit: https://tse2.mm.bing.net/th?id=OIP.hXuoHL-OzI0J-TDj5jNmxAHaFi&pid=Api&P=0&w=234&h=175	Ponta Milibangalala

32. Bougainvillea (*Bougainvillea spp.*)	 Photo credit: T. Liversage	Isolated patch at old homestead Futi corridor (-26.656263, 32.692538)

6.5. Guidelines for Invasive Alien Plant Control

This section provides a step-by-step guidance on the many aspects to be undertaken prior to work starting.

6.5.1. Planning and preparation

Planning and preparation are fundamental to achieving cost-effective and successful IAP control.

For clearing to start, sufficient resources need to be available for long term control, thus initial clearing and follow up treatments until the infestation is under control. The following items need to be considered:

- Financial Resources: Costs should be calculated on correct person/days per hectare (see 4.2. Budgeting).
- The control methods need to be decided so that costs can be determined (see 4.3. Control methods).
- The procurement of PPE required for the workers needs to be assessed (see 4.4. PPE).
- The procurement of equipment required for the control methods need to be assessed (see 4.5. Equipment).
- The general safety standards such as enough drinking water, and a field ranger accompanying each team, should also be considered (see 4.6. General Safety Standards).
- Training is essential before work can start. See 4.7. Training, which lists the required training.
- A safe storage area for the herbicides, PPE and equipment should also be allocated (see 4.3.2.6).

6.5.2. Types of control methods

6.5.2.1. Mechanical Control

Mechanical control involves the physical destruction or total removal of plants. Mechanical techniques vary, and include hand-pulling, felling, uprooting, ringbarking, cutting/slashing, strip-barking, or mowing. Mechanical methods are not feasible in dense infestations as these can be labour intensive and time-consuming. Removing all IAP's using mechanical control methods in a densely infested area can also cause severe soil disturbance and erosion. These methods are generally more appropriate for sparse infestations and for species that do not coppice after cutting. It is advised that once the plants are treated that they are left at the site and not removed and transported. This is necessary to prevent seeds from spreading to new areas.

a. Hand pulling

Hand pulling is the removal of plants by hand, ensuring that the root is also removed. Hand pulling is only recommended when an area is sparsely invaded, has a high rainfall (the soil should ideally be damp or

soft), warm temperatures, and sandy soils; and the plants are small enough to be pulled out successfully with the roots intact. Hand pulling does create soil disturbance, but if the area is sparsely invaded such disturbances are unlikely to be ecologically damaging. “Hand pulling is only recommended when an

area is sparsely invaded.”

b. Manual removal using hand tools

Manual removal using hand tools such as cane knives, tree loppers and slashers can be used to remove IAP’s. The use of hand tools is probably the most widely adopted, and often the most effective, of all the methods.

Methods of cutting the plants include**:**

- Ringbarking: Useful for killing large trees. A cane knife or axe is used to remove the tree’s bark and cambium, in a horizontal band about 30cm wide (about 50cm from the ground). Herbicide, if used, should be applied immediately after ringbarking on the cut area.

Ringbarking. The tree will be cut right around to remove the cambium (outer layer). Photo credit: T. Liversage.

Cut stump: Plants with a stem/trunk diameter larger than 10mm can be cut as low to the ground as possible (not higher than ankle height) with a cane knife. Herbicide, if used, should be applied to the cut surface immediately after cutting.

Photo showing correct height of plant to be cut for cut stump treatment. Apply herbicide immediately after cutting. Photo credit: C. Terblanche.

Frilling: Trees can be frilled by cutting an angled groove into the bark and cambium, right the way around the tree trunk. This can be achieved with either a cane knife or axe, depending on how hard the bark and cambium layers of the tree are. Herbicide is then applied into the groove, which kills the tree as it seeps into the cambium tissue. This is the preferred method of killing small trees, as it is usually much quicker and therefore more cost-effective than ringbarking.

Frilling applied. Herbicide should be applied as soon as possible into the exposed area. Photo credit: T. Liversage.

c. Manual removal using mechanised tools

A variety of mechanised tools can be used for IAP clearing. They include:

Clear felling/ Chainsaw: A chainsaw is ideal for felling large trees such as Gum and Pine trees and can be used to cut logs and branches into shorter lengths. This enables the removal of logs more easily. Training for chainsaw operators is essential. Operators need to understand the techniques of felling, i.e., ensuring that the tree falls in the desired direction. Each operator must also understand and be

able to apply the necessary safety precautions during the felling process. Understanding the effective use and operation of the chainsaw itself is critical. The operator should also have the means and knowledge to undertake any required onsite servicing of the motor and sharpening of the chain. It is advisable that no other persons be working close to where a tree is being felled.

6.5.2.2. Chemical Control

Chemical control of IAP's involves the use of herbicides to kill targeted plants. Managers and herbicide operators must have a basic understanding of how herbicides function, as this will guide the correct selection of herbicides for different purposes and plants. The use of inappropriate herbicides and the incorrect use of the appropriate herbicides are wasteful, expensive practices. They often do more harm than good. This is especially problematic when working near watercourses. Some herbicides can quickly contaminate freshwater systems and/or be transported downstream where they may remain active in the ecosystem. This is especially the case for herbicides with a high soil residual effect, i.e., herbicides that remain active after contact with soil. Herbicides are classified as either selective or non-selective. Selective herbicides are usually specific to a particular group of plants, e.g., those specified for use on broad leaf plants will be effective on most broad leaf plants but should not kill narrow leaf species such as grasses. Non-selective herbicides can kill any plant thus care should be taken when using a non-selective herbicide. Always aim to select the most environmentally friendly product.

It is advisable to purchase herbicide from a reputable supplier who can offer in and off-field advice on the product. This can result in substantial savings, e.g., there will be an increased likelihood of using the correct mixing ratios, and a decreased incidence of over-application. A common misconception by users of herbicides is that by increasing the dosage of the chemical they will also be increasing its efficacy. Mixing ratios quoted by the manufacturer are tested for optimum results and it is important that these ratios be adhered to. Overdosing wastes expensive herbicide is unlikely to have any discernible effect on the target species, and may impact negatively on the surrounding (i.e., non-target) plants.

Water or diesel can be used as a "carrier" for certain herbicides. However, water is the preferred carrier, because diesel is expensive and can have negative impacts on the natural environment. There is also often a risk of diesel theft. Diesel should never be used for foliar applications due to its very negative impact on the environment. Diesel should only be used in direct application to stems.

There is a variety of herbicides that are registered and effective for the control of IAP's. The list has been added as a supplementing document to this plan, with a photo of the IAP found, location and the suggested herbicide to be used.

There are three methods for available for control:

a. Foliar spraying

This method uses a knapsack sprayer to spray IAP's below 1 metre in height. Leaves are sprayed to the point of run-off. Correct training is essential before applying this method. It is advisable to invest in good quality knapsack sprayers and ensure replacement parts can be purchased. Regular servicing and cleaning of working parts is critical, as leaking sprayers can result in herbicide seeping onto workers, or onto the ground and thereby impacting on indigenous vegetation. Foliar spraying is generally regarded as a cheaper method than cut stump treatment, because fewer people are

required to treat larger areas. It does, however, require large amounts of clean water (for mixing with herbicides), and therefore only practical where water is available. Protective gear must be used.

Foliar spraying can only be applied when there is no wind as drifting can appear which happens when the wind transports the herbicide to vegetation next to the target area. This might not be problematic in areas of high-density infestations: excess herbicide will either drift or drip onto other target IAP's, it is however problematic when there are many non-target species close by. The misting effect, where tiny droplets drift via a breeze to non-target species, often occurs when using high velocity nozzles. Ideally, low velocity and high-volume nozzles should be used for drenching, while high velocity, low volume nozzles should be used for misting. Where foliar spraying is applied in low density areas, a selective herbicide should rather be used.

Example of foliar spraying application:

Foliar spraying application. It is advised that correct protective clothing is to be worn, and plants not higher than a metre be sprayed. Photo credit: T. Liversage.

b. Handheld spraying

Handheld spraying is a means to apply herbicide after cut stumping, ringbarking, frilling, and strip-barking. The most common and convenient handheld sprayer has a 1.5 litre capacity and a nozzle that can be set to achieve the correct spray width. As with knapsack sprayers, it is advisable to invest in a good quality handheld sprayer for which replacement parts can easily be purchased. Always ensure workers receive training on how to maintain handheld sprayers properly. Handheld sprayers are inexpensive, and

application of herbicide is accurate.

Cut stump treatment. Cut the stump as low as possible to the ground and apply herbicide with a 1,5 litre sprayer immediately after cutting. One person can walk and carry a cane knife and a spray bottle. Photo credit: C. Terblanche.

It is best to use a herbicide with a dye as it makes it easier to see the coverage of the herbicide when sprayed and to see which stumps have been sprayed or not. Photo credit: C. Terblanche.

6.5.2.3. Biocontrol

There are no biocontrol agents registered in Mozambique for use on the IAP's identified in MNP.

6.5.3. Personal Protective Equipment (PPE)

The use of Personal Protective Equipment (PPE) by persons controlling IAP's in the field is required to protect them against injuries that may occur whilst on duty. The list in the table below can be used to procure PPE required.

Personal Protective Equipment Requirement List		
Item	**Specification**	**Amount**
Overall	100% cotton, two-piece overalls are best for absorbing perspiration. However, various cotton/polyester blends are available.	1 per person
Rubber gloves	Wrist length rubber gloves for field work are sufficient	1 per person
Safety boots	Steel toecaps are recommended for workers working with hand tools or with large trees	1 per person
Hat	Hardhat for chainsaw felling operations. Wide brim sun hat for general operations	1 per person
Safety glasses	Clear safety glasses which allow air to pass through	1 per person
Face mask	A face mask that covers the nose and mouth is essential when mixing herbicides and for foliar spraying	1 per person
Raincoat	Standard two-piece raincoat	1 per person
Chainsaw safety pants	Standard safety chainsaw long pants that provide protection	1 per chainsaw operator

6.5.4. Equipment

The following equipment is required depending on the type of control to be applied. The amount is indicated to act as a procurement guideline.

Equipment Requirement List		
Item	**Specifications**	**Amount**
Funnel	An industrial funnel with a wide neck, not bigger than a 25-litre container opening	1 per team
Measuring jug	A one litre measuring jug measuring millimetres	1 per team

Sharpening stone	A standard sharpening stone with a handle is ideal for sharpening cane knives and slashers	2 per team
25-litre water container	Transparent plastic water container with screw on lids	2 per team – for water (if they are not carrying their own water) 2 per team – for mixing herbicides
Basin	Large plastic basin for decanting herbicide. Should be wide enough to fit two 25 litre containers	1 per team
Soap, bucket & towel	Any type of soap, 5-litre bucket with handle, and towel	1 each per team
First Aid Kit	A standard basic first aid kit made for field use	1 per team
Fire beaters	This is optional, but useful in fire season	2 per team
Cane knife	A cane knife with a short plastic handle with a broad blade end	1 each per person in team
Handheld sprayer	A 1.5 litre sprayer which has replacement parts available	1 each per person in team – if applying cut stump treatment
Knapsack sprayer	A 16-litre knapsack sprayer which has replacement parts available	1 each per person in team – if applying foliar spray treatment
Chainsaw	Buy well-known brand names and make sure it comes with maintenance tools to maintain it	1 per chainsaw operator
Brush-cutter	As above. Make sure to obtain the correct blade for the operation	1 per operator

6.5.5. Herbicide guidelines

a. **Herbicide use terminology**

Active ingredient

Each herbicide has a chemical compound that makes it effective, this is referred to as the active ingredient. Herbicides sold under different brand names may have the same active ingredient. It is critical that an herbicide with the correct active ingredient is selected. The concentration of the active ingredient can also differ from one product to the next. As such, the mixing ratios may differ. It is critical that the recommended mixing ratios are adhered to, and the guideline document and label supplied with the product should always be consulted prior to calibration.

Residual effect

The residual effect is the length of time that an herbicide will remain active once in the soil. Some herbicides disperse immediately on contact with soil, while others can remain active in the soil for

up to two years. The shorter the residual effect of an herbicide, the less likely it is that non-target species will be killed. The residual effect of an herbicide should be checked before purchasing.

Dye

Dye is often mixed with herbicides to ensure a clear visual indication of which plants have been treated and which have not. This allows workers to see where they have applied the herbicide and allows for easy inspection of work a few days later. Some herbicides contain a pre-mixed dye that eliminates the need for on-site mixing of dye. If a dye must be added, ensure that it is of good quality and that it is chemically

compatible with the active ingredient and adjuvant. The use of different colour dyes for different herbicides is a useful approach as it makes it easy for workers to differentiate which herbicide to apply to which plants where such a distinction is required (e.g., red dye can be selected for herbicide used to treat Lantana, and blue for Castor oil, etc.).

Recommended adjuvants

Some herbicides require the use of a "wetter", or adjuvant, to be effective. Always check if a product

has a recommended adjuvant or if an adjuvant must be added for targeting specific IAP's. Herbicides applied to leaves by foliar application often require a specific adjuvant, as do those applied to trees with very waxy stems. Always check with the manufacturer if there is any uncertainty regarding adjuvants.

b. **Herbicide control tips and precautions**

Herbicide, if used correctly, plays an integral part in IAP control. The following tips and precautions have been compiled to assist with herbicide application and management:

• Only use herbicides that are registered for use on this specific species to be treated.

• Spray plants during the active growing period.

• Spray plants before the seeds are produced, namely, between flowering and fruit set.

• Avoid using herbicides on drought-stressed or diseased plants or in extremely hot or cold conditions.

• Herbicide should not be applied during wet conditions, before or after rain. If it rains after application, it is important to monitor the effect as one may need to re-apply.

• Carefully read and understand the instructions on the label prior to initiating chemical control. Most selective herbicides will lose selectivity at a high enough dose, highlighting the importance of adhering to instructions on the label.

• Always store herbicides in the original container and in secure storage areas out of reach of children and animals.

• All persons must wear the required personal protective equipment when working with herbicides. These include overalls, rubber gloves and a face mask.

• Avoid skin contact with herbicides and avoid breathing in the vapour.

• Herbicide should always be applied immediately after the selected mechanical control method (e.g., after frilling, ringbarking, cut stumping or strip- barking). Once the stem has dried it will not absorb the herbicide.

• Remember to keep herbicide in the shade while at the work site to keep it cool.

• To avoid spills, keep herbicide containers in a big plastic container/bucket. When mixing herbicides, ensure that you use a funnel to avoid spilling. Should you spill the herbicide, it can be poured back into the container from the plastic bucket.

• Containers containing mixed herbicide should be clearly marked (e.g., 'glyphosate mix'). Likewise, containers filled with water to be used for mixing herbicide should also be clearly marked to ensure that people do not drink from them.

• Always use a measuring jug to measure the correct quantity required.

• To mix herbicides, half fill the appropriate size container with water, and then add the herbicide using the measuring jug. Secondly, close the container and shake, and then fill the rest of the container with water.

• Remember to keep the herbicide away from food.

c. **Storage of herbicides**

Herbicides should be stored in a storeroom with the following specifications:

- Adequate ventilation is required to allow fresh air to circulate. Whirlybirds and windows can provide sufficient ventilation. If the air is stagnant or if there is a smell of herbicides when opening the storeroom then it is a good indication that there is not enough ventilation.
- Clean water needs to be available near the storeroom.
- The floor must be non-porous. This is important so that when the floor is cleaned (which needs to be on a regular basis), no residue of herbicides remain.
- Place herbicide containers on wooden pallets to increase ventilation and make mopping up after spillages easier.
- 'No Smoking' and 'No Fire' signs should be posted on the door of the storeroom, as well as a sign stating that it is a chemical store, and who the responsible person is for the store.
- Keep the storeroom locked to prevent herbicide getting into the wrong hands, e.g., children.
- A spill kit needs to be kept in the storeroom to mop up any spill. The spill kit must contain a bucket with sand and a spade. The sand is to be placed on the spill to absorb the liquid. Once the sand has absorbed the spill, it is to be collected and disposed of where it cannot contaminate the environment.
- Obtain the Material Safety Data Sheet from the supplier of the herbicide and ensure that you are familiar with the product before using it. Keep the Material Safety Data Sheet in the storeroom in case of an emergency.
- Always store herbicides in the original labelled container to avoid confusion with other products.
- Do not store other products in the store, such as protective clothing, food, etc. as they may become contaminated.

- Empty herbicide containers, or herbicides that have reached their expiry date, need to be safely disposed of. It is important that all empty containers are spiked before disposal. This ensures that they cannot later be used for carrying drinking water, food etc.
- When issuing herbicide from the storeroom a log should be kept of the amount, type of herbicide issued and to whom.

d. **General Safety Standards**

• Each person should carry at least two litres of drinking water with him/her each day. Alternatively bring 25 litre containers filled with clean water and clearly mark that it is drinking water.

• Emergency procedures need to be in place and the team needs to be aware of what to do in case of an emergency.

• Each team should be equipped with a radio. If none is available, a vehicle parked close by will be useful to transport anyone who may be injured.

• If it is fire season, ensure that the workers are aware of the risks, have been trained in basic firefighting and have the correct equipment available.

6.5.6. Training

The following training courses are recommended for use when implementing an IAP management plan in MNP:

Recommended training courses:

No.	Training Course	Days	Host	Who needs to attend
a	IAP Identification Course	2	Knowledgeable person to identify all IAP in MNP	All workers and supervisors MNP staff (field rangers & management)
b	Control Methods/ Herbicide Application	1	Knowledgeable person to practically show all control methods	Workers and supervisors
c	First Aid Training – Level 1	4	Certified service provider	One person per team
d	Safety guidelines for working in Game Reserves	1	MNP Management	All workers and supervisors

Here follows a breakdown of the content of the recommended training courses:

a. IAP Identification

Identification of the IAP's found in the MNP is essential before a team can start working. A photo with the control method of each IAP to be treated should be provided to each worker. Field identification is an essential part of this course. Photos can be different to seeing the plant in-field. Workers need to be very familiar each species. Driving time to identify each species can take time, hence the 2-day training course indicated in the table above.

b. Control Methods /Herbicide application

The control methods or each IAP to be controlled in MNP should be shown in-field. Monitoring is required to see if the application is correct. Basic items such as the height to apply cut stump treatment to correct mixing and application of herbicides are essential for successful control. Additional training items should include setting out daily work tasks for workers and monitoring productivity.

c. First Aid Training

It is recommended that at least one person per team attends a basic first aid training course - Level 1 by a certified service provider so that any injuries sustained in-field can be treated and if a serious injury occurs a person can be stabilized until assistance arrives.

d. Safety guidelines for working in Game Reserves

Workers should be trained in general safety precautions when working in the MNP, which includes safety reaction to elephants, hippo, and crocodiles; as well as what to do in case of an emergency; the importance of working in groups; reporting where they will be working and when leaving; and any other safety measures that is part of the MNP procedures.