WWF
SOUTH AFRICA

A PRACTICAL GUIDE TO MANAGING INVASIVE ALIEN PLANTS

A concise handbook for land users in the Cape Floral Region

This handbook has been produced in collaboration with these partners to guide the management of invasive alien plants in the Cape Floral Region.

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CITY OF CAPE TOWN ISIXEKO SASEKAPA STAD KAAPSTAD
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Cover photo: Member of a clearing team stacking biomass in the Vyeboom Wetland near the Theewaterskloof Dam.
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Supporting documents for more information are available as appendices at www.wwf.org.za/report/invasive_plants_appendices

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WWF is one of the world's largest and most experienced independent conservation organisations with over 6 million supporters and a global network active in more than 100 countries.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

WWF South Africa is a national office in the global WWF network. Started in South Africa in 1968, we are a local NGO with a vision of building a sustainable and equitable future in which humans and nature thrive. We work to champion the Earth's capacity to provide a source of inspiration, sustainable food, freshwater and clean energy for all. For Nature. For You.

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Funders: Corteva Agriscience, the Fynbos Trust, Nedbank, Sanlam and Woolworths.

Corteva Agriscience, through its local subsidiaries, has introduced environmentally accepted herbicides in South Africa since the early 1980s. As global market leader in Green Chemistry Principles, Corteva is committed to new innovations for the control of introduced invader plants that threaten the biodiversity and functioning of our forests, wetlands and especially the species diversity of the Cape Floral Kingdom, without negative impacts to the environment.

The Fynbos Trust is an NGO that promotes and supports landscape-scale conservation (primarily in the Overberg). Conservation leadership and innovation, partnerships with communities, technical support and collaboration with land users, decision-makers and other stakeholders are key areas of focus to ensure that natural diversity and processes persist across the landscape. Integrated invasive alien plant and fire management are key elements of the Fynbos Trust's landscape-scale conservation approach.

Nedbank is proud to fund the production of this guide as part of its support for WWF as we work together to safeguard South Africa's water source areas, improve rural livelihoods and promote land stewardship. WWF and Nedbank have been working together in various forms for almost 30 years – a long-term NGO/business partnership that continues to evolve and innovate to find solutions to complex sustainability challenges in South Africa.

WWF South Africa's partnership with Sanlam works to conserve and ensure the healthy functioning of South Africa's important freshwater ecosystems and, in so doing, the well-being of people that depend on this natural resource. This practical guideline to managing invasive alien plants is one of the tools contributing towards this purpose.

The WWF–Woolworths partnership seeks to improve the stewardship of water resources nationally, explore low-carbon pathways, reduce potential negative impacts of agriculture, improve seafood production and reduce food waste throughout the supply chain. The management of invasive alien plants contributes towards this mission. Therefore, Woolworths is proud to be part of this publication that summarises the lessons and tips for land users who want to join the practice of keeping alien plants at bay.

Indigenous common pagoda (*Mimetes spp*) after a fire in Luiperdskloof, Betty's Bay. © Tessa Oliver

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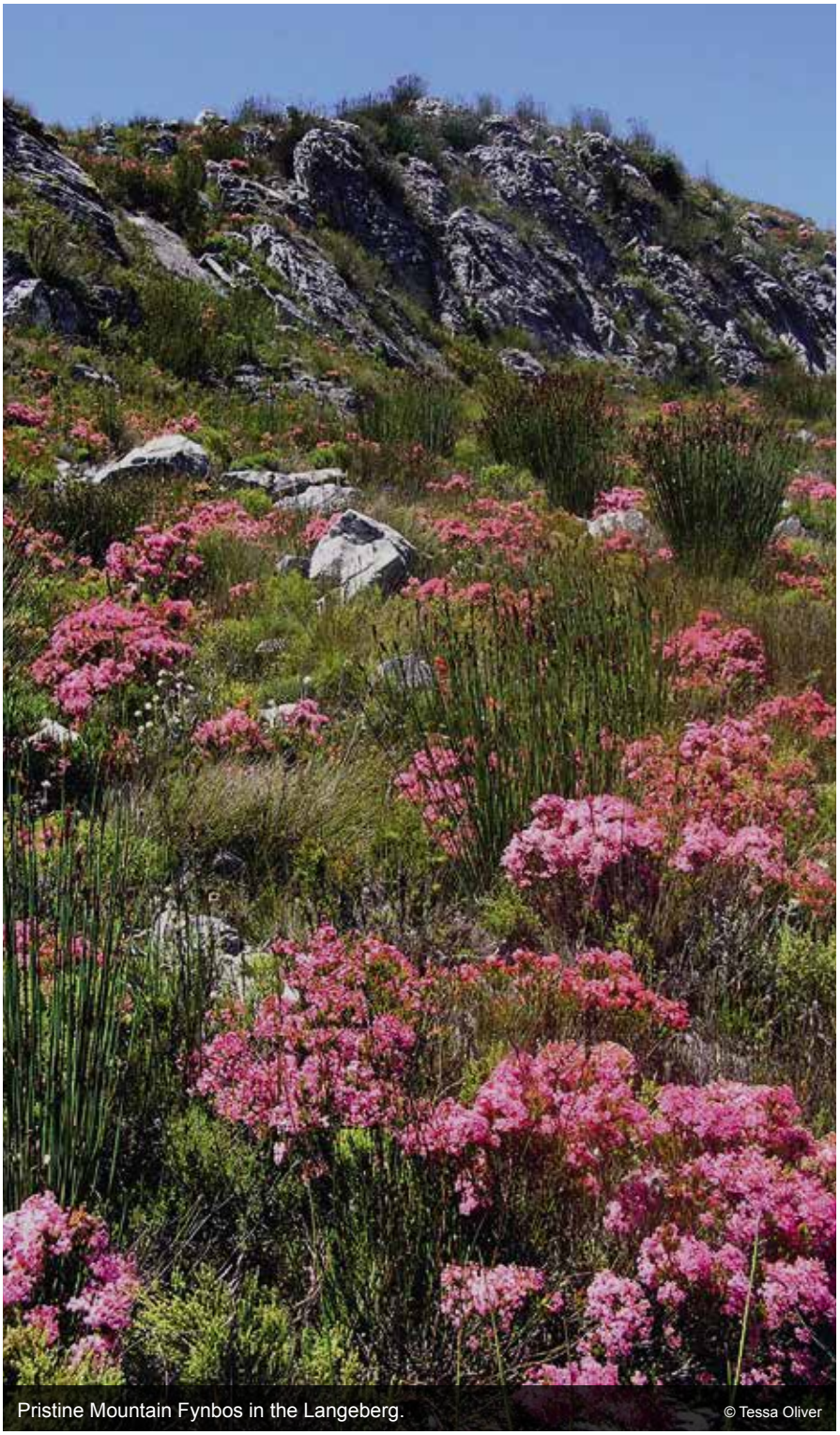
INTRODUCTION

This practical guide aims to empower land users (landowners, land managers and contractors) in the Cape Floral Region to understand the threat of invasive alien plants (IAPs) and manage the IAPs on their land.



Pristine Mountain Fynbos in the Langeberg. © Tessa Oliver

The guide was developed by WWF South Africa in collaboration with the Agricultural Research Council; the City of Cape Town; Corteva Agriscience; the Department of Environment, Forestry and Fisheries; LANDWORKS; the Fynbos Trust; and NCC Environmental Services. It not only contains a detailed set of instructions on how to proceed when clearing IAPs (this often differs per context) but also aims to be a first-stop resource that can be adapted to local conditions, while giving useful pointers for where to find further information from numerous other sources.

Land users are given an overview of how to approach an IAP management programme: understanding what IAPs are, the relevant legislation, planning, the methods that are available, health and safety considerations, the safe use of herbicides, and successfully rehabilitating the cleared land, if that is the end goal. The authors' intentions are to update the necessary sections on an annual basis, and it is in the reader's best interest to use the latest version of the guide at www.wwf.org.za/report/invasive_plants_handbook and of the supporting Appendices at www.wwf.org.za/invasive_plants_appendices/.

Additional resources are noted throughout the guide in the "For more information (page xx)" sections, and options to source funding for IAP management are given.

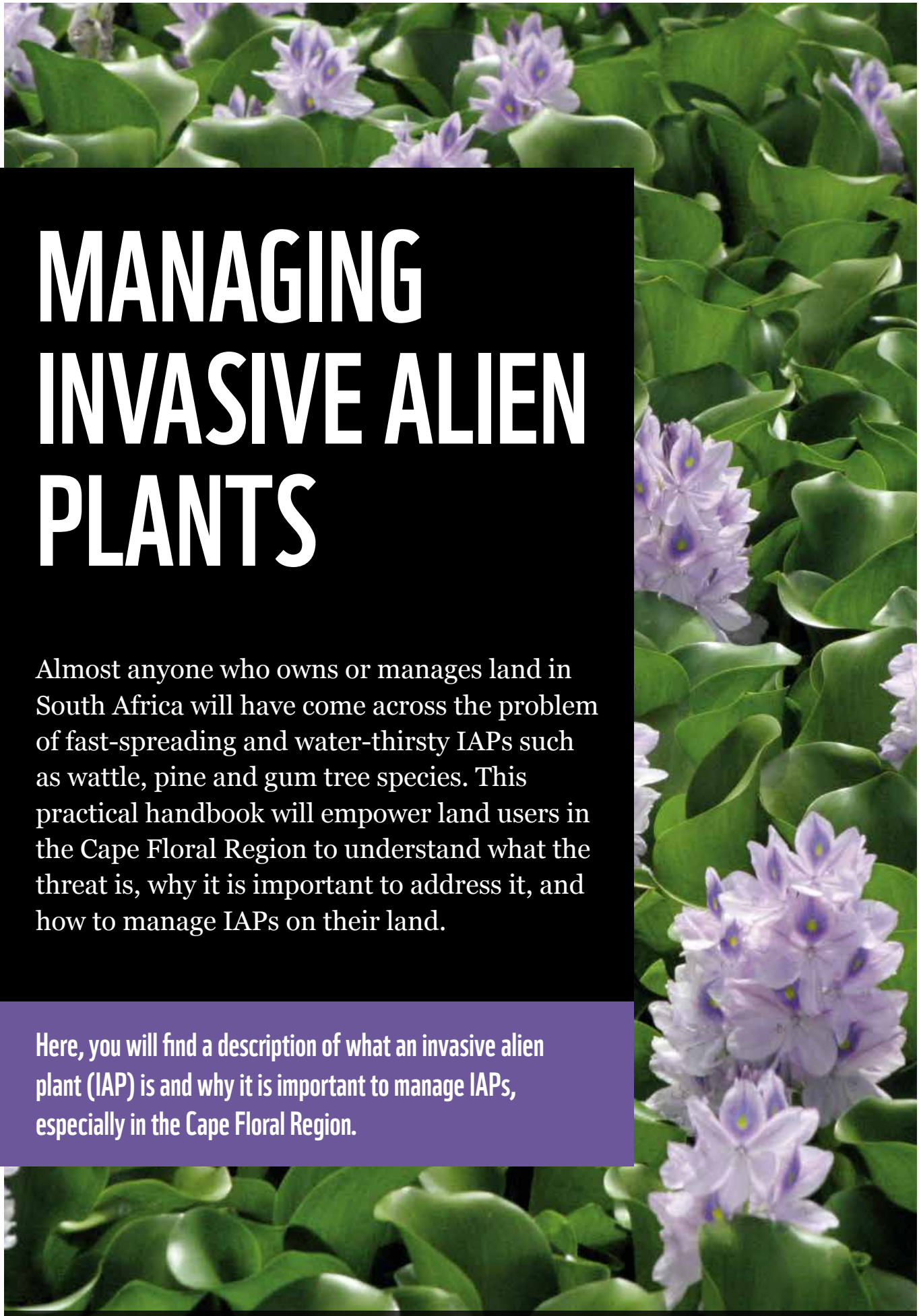
A land user can mean the legal owner of the land, or a land manager, someone leasing land or an IAP contractor.

Introduction	In this section, the origin and purpose of this guide is explained.
Managing IAPs	Here, you will find a description of what an invasive alien plant (IAP) is and why it is important to manage IAPs, especially in the Cape Floral Region.
Legal	The legal obligations of landowners with IAPs on their land are summarised in this section. You will find a brief explanation of the relevant laws and regulations relating to IAPs, including what actions are required for different categories of IAPs.
Planning	This section provides the main considerations to think about before beginning an IAP management operation, including steps to develop a management plan, how to prioritise IAP clearing, mapping management units, planning for wildfires, and the labour and budget requirements.
Methods	Here, you will find simple instructions for the four main methods of managing IAPs: manual, mechanical, chemical, and biological control. Further information is given on how to dispose of plant and waste material.
Health and Safety	This section covers the legal background for health and safety, as well as minimum safety requirements. You will also find information on safety in the field, fire preparedness and a list of personal protective equipment.
Herbicide safety	In this section, information is given on herbicide labels and the safe storage, mixing and disposal of herbicides. Following these precautions will help to reduce the risks associated with these dangerous chemicals.
Rehabilitation	Here, you will find an overview of the reasons for rehabilitating cleared land, the types of rehabilitation and the phases in a rehabilitation project. Useful resources with more detailed information on rehabilitation are suggested.
Funding	This section contains information about government and other funding opportunities for IAP management. Options include accessing government programmes, working cost effectively with neighbours, and finding resourceful ways to recoup funds from IAPs.

MANAGING INVASIVE ALIEN PLANTS

Almost anyone who owns or manages land in South Africa will have come across the problem of fast-spreading and water-thirsty IAPs such as wattle, pine and gum tree species. This practical handbook will empower land users in the Cape Floral Region to understand what the threat is, why it is important to address it, and how to manage IAPs on their land.

Here, you will find a description of what an invasive alien plant (IAP) is and why it is important to manage IAPs, especially in the Cape Floral Region.



Water hyacinth (*Eichhornia crassipes*), an aquatic invasive alien plant native to the Amazon basin, is widely spread throughout South Africa and is found in many of our water bodies.

THE CAPE FLORAL REGION – WHAT ARE WE CONSERVING?

The Cape Floral Region is an area of special and unique biodiversity. It is the smallest of only six floral kingdoms around the world and the only one found within a single country.

The Cape Floral Kingdom extends across the Western Cape and parts of the Northern and Eastern Cape provinces of South Africa, from Gqeberha (formerly Port Elizabeth) to Cape Town and north towards Nieuwoudtville. There are many ways in which the natural ecosystems in this area are recognised as extraordinary.

Cape Floral Region

Biodiversity and endemism

The Cape Floral Region is home to more than 9 000 different species. This is one of the highest concentrations of plant species anywhere in the world. Covering only 0,5% of Africa's area, the Cape Floral Region hosts more than 20% of the continent's plant species. About two-thirds of these plants are endemic, meaning they are not found anywhere else.

Fynbos, Renosterveld and Strandveld

The Fynbos biome comprises various Fynbos, Renosterveld and Strandveld vegetation types. These are the dominant vegetation communities of the Cape Floral Region. Fynbos is a type of shrubland adapted to a mild climate with winter rainfall, poor soils and regular wildfires. It is known for its unique proteas, ericas and restios. Renosterveld is also part of the Fynbos biome but occurs on more fertile soils. It has more grasses, annual plants and bulbs than typical Fynbos. All lowland types of Renosterveld are considered critically endangered, because only small fragments of natural vegetation remain. Strandveld vegetation grows in deep, well-drained alkaline sand along the West Coast and on the Cape Flats. Many Strandveld plants are succulent, so the vegetation does not burn as regularly as Fynbos and Renosterveld.

Biodiversity hotspot

The high biodiversity and endemism of the Cape Floral Region have led to it being considered a biodiversity hotspot. There are 36 recognised biodiversity hotspots around the world. These are areas with very high levels of biodiversity that are also under significant threat from human activities.

World Heritage Site

In 2004, the Cape Floral Region was designated as a World Heritage Site in recognition of its unique biodiversity. The World Heritage Site currently consists of 13 clusters of national parks, nature reserves and wilderness areas, covering more than a million hectares. It is considered of global value because of the unique ecological processes and high biodiversity associated with the Fynbos biome.

Water Source Area

The mountain catchments of the Cape Floral Region are part of South Africa's Strategic Water Source Areas. These are areas that cover only 10% of the country's land but contribute a disproportionate 50% of its water supply. The rainwater that fills the rivers of the Cape Floral Region is a vital water source for millions of people, farms and industries downstream.

Threats

Invasive alien plants are one of the biggest threats to the Cape Floral Region. Fynbos is a shrubland and is vulnerable to invasion by wildfire-adapted tree species. Pines, woody acacia and hakea have the most negative impacts, particularly on water supply, and are the most difficult to deal with. Infestation levels vary from areas that are completely infested to areas free of IAPs. If IAPs are not controlled, they will continue to be an ever-expanding threat to this remarkable biodiversity area and all the benefits provided by a functioning environment. It is therefore critical to maintain IAP-free land and prioritise low infestations for clearing.

INVASIVE ALIEN PLANTS – WHY ARE THEY A PROBLEM?

Invasive alien plants are problem plants. They are plants that are not native to an ecosystem. They spread rapidly and cause harm to the environment, the economy and even to human health.

Purple loosestrife (*Lythrum salicaria*), native to Eurasia, spreads easily and replaces indigenous vegetation, creating its own dense stands. © Debbie Muir / NRM

4 MAIN CHARACTERISTICS OF INVASIVE ALIEN PLANTS

1 Non-indigenous

Alien species are those that do not occur naturally in an area. They are brought in by people, either on purpose (as garden plants or plantation trees) or by accident (such as seeds in bags of animal feed).

2 From a similar climate

Many IAPs in South Africa come from Australia, Europe or North and South America. They are well adapted in their natural habitat to enjoy similar temperatures, rainfall patterns and fire regimes. This means they can spread easily and thrive in the place to which they have been introduced.

3 No natural enemies

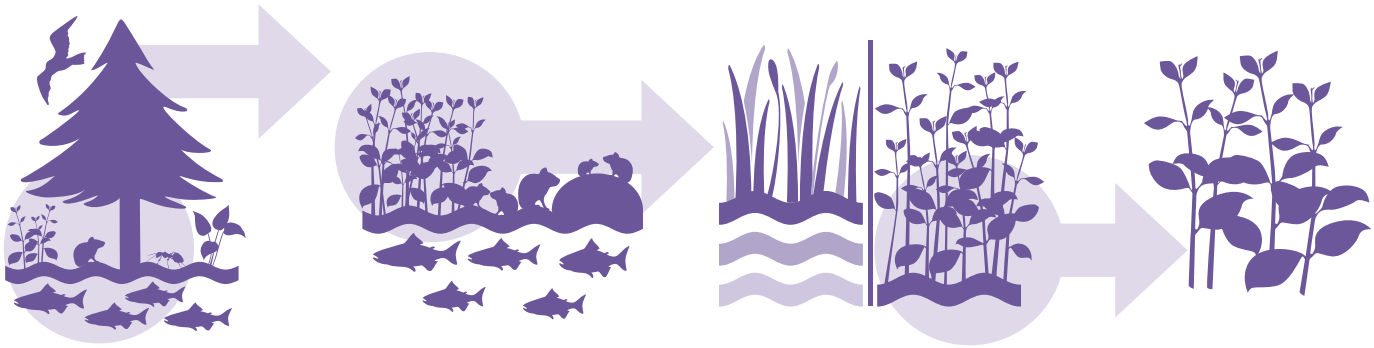
Because IAPs have been artificially introduced to an area by humans, they have not evolved to be a part of the local ecosystem. In their country of origin, they are kept in check by insects, diseases or fungi that feed on them and control their numbers. These natural enemies are often missing in the new environment, which means the IAPs can grow without anything to stop them.

4 Invasive and competitive

Not all alien plants become invaders. But those that find themselves in a suitable climate where there are no natural enemies can quickly become a serious problem. Many IAPs can grow fast, produce large, long-lived seedbanks and disperse easily. IAPs, especially trees, tend to use more water than natural indigenous vegetation. Pines (*Pinus* species), wattle (*Acacia* species) and gum trees (*Eucalyptus* species) invade water courses and can form dense stands.

INVASIVE ALIEN SPECIES IN THE SOUTH AFRICAN CONTEXT

There are currently 2 033 listed alien species in South Africa, consisting of marine organisms, freshwater fish, insects and plants. Altogether 771 of these are invasive, while 107 of them are found to have a major impact on the environment. Of the 107 problem species, 80 of them are plants. This practical guide focuses only on the invasive alien plant species.



2 033
ALIEN SPECIES IN SOUTH AFRICA

771
OF THESE ARE INVASIVE

107
OF THESE CAUSE MAJOR IMPACTS

80
OF THESE ARE PLANTS

European blackberry (*Rubus fruticosus*) originates from the Mediterranean region of Europe. It outcompetes indigenous woody and grassland species.

MANAGING INVASIVE PLANTS – WHY IS IT NEEDED?

By disrupting natural ecosystems, taking up space and using natural freshwater resources – especially in a water-scarce country like South Africa – IAPs can cause serious damage to the natural environment. Clearing and controlling IAPs can help to prevent some of these negative impacts.

7 NEGATIVE IMPACTS OF INVASIVE ALIEN PLANTS

1 Overuse of water

A single large invasive alien tree can use between 100 and 1 000 litres of water per day, significantly more than the average indigenous plant. They use so much water that they decrease the flow of streams and reduce the amount of water that reaches dams. South Africa loses as much as 2 500 million m^3 of water to IAPs every year. This is a significant amount in a country that is already suffering from water shortages. Some of the worst-affected river catchments are in the Western Cape.

2 Decreased agricultural production

IAPs that spread through agricultural land reduce the space available for crops or livestock and this can decrease agricultural production. Managing IAPs is an added expense for farmers. The consequence is that these plants have a negative impact on the agricultural economy and ultimately affect food security.

3 Increased impact of wildfires

IAPs increase the risk of wildfires by increasing the amount of fuel available. Woody IAPs grow in dense stands that increase the biomass available to burn. Some species also contain flammable compounds. Wildfires in IAP-infested areas burn hotter and more intensely than wildfires in natural vegetation, and are more difficult to contain, increasing the danger to lives, livelihoods and the environment.

4 Reduced ecosystem services

IAP-infested habitats have a reduced capacity to deliver ecosystem services – such as providing clean water and healthy soils – that support a healthy living environment for people and animals. They can also cause a decrease in the availability of natural products such as medicinal plants, fodder and building materials.

5 Lower land values

IAP invasions have a significant impact on the sale value of land because the land has lower agricultural production value or the new owner will not want the expense of dealing with the problem.

6 Impacts of climate change

Many IAPs can easily adapt to take advantage of the changing climate and global warming. The Western Cape is predicted to get hotter, drier and have more extreme weather events, leading to significant shifts in biomes like the Fynbos. These changes favour the growth of IAPs. This means that some IAPs will become more aggressive and spread faster. There may also be new and emerging ones that benefit from a changing climate. Some species, like the Acacia, are legumes that can fix nitrogen, changing the chemical composition of the soil. This can make the natural ecosystems less resilient to climate change and more susceptible to secondary invasive species.

7 Biodiversity loss

Biodiversity is the variety of natural species living in an area and the relationship between them. IAPs outcompete and replace indigenous plants, causing a decline or even disappearance of biodiversity. Because IAPs tend to form dense stands where very little else can survive, they can have a devastating impact on local biodiversity. IAPs are one of the biggest causes of biodiversity loss worldwide. This is especially severe in places with unique and rich biodiversity, like the Cape Floral Region (see The Cape Floral Region – What are we conserving? page 7).

To address these negative impacts of IAPs, the government has put in place laws and regulations. The regulations identify which IAPs need to be eradicated or controlled based on their degree of impact. There are also measures to detect and prevent new invasions (see Legal requirements, page 14).

MANAGING IAPS – WHAT ARE THE KEY PRINCIPLES?

The management of IAPs is driven by two fundamental principles: **acting early and following up**.

1 Act early

Taking action to manage IAPs when they first appear is much easier and cheaper than addressing severe infestations. Younger IAPs that cover smaller areas of land can be controlled with less time, labour and equipment. So, making an investment in IAP management at an early stage will save costs over the long term. Monitoring land for new IAP infestations will help to combat them in good time.

2 Follow-up

Follow-up and ongoing maintenance are essential to protect the investment made in IAP management. Regular follow-up treatment will stop any regrowth and prevent secondary infestation.

Any IAP management programme should follow three phases:

Phase 1 – Initial control

Drastically reducing the existing population (potentially including biocontrol)

Phase 2 – Follow-up

Controlling seedlings, root suckers and regrowth

Phase 3 – Maintenance

Sustaining low and decreasing IAP numbers with annual control

A clearing team in the Vyeboom Wetland near Theewaterskloof Dam in the Western Cape stacking cut black wattle. © WWF

TYPES OF IAPS – HOW DO THEY DIFFER?

Invasive alien plants are often grouped into different types. The management methods for each type can be more or less effective depending on where the IAPs grow, how they grow or how they reproduce. The types of seeds will influence how they need to be managed.

Water hyacinth (*Eichhornia crassipes*) is often labelled as the world's worst aquatic weed because of its invasive potential, negative impact on aquatic ecosystems and the costs involved in controlling it. © Debbie Muir / NRM

WHERE THEY GROW

In water

These IAPs are known as aquatic IAPs, live mainly in water and can tolerate very wet conditions. Aquatic species invade rivers, dams and wetlands. Water Hyacinth (*Eichhornia crassipes*), for example, is a floating plant that is highly invasive in South Africa.

On land

These IAPs are known as terrestrial IAPs and grow on land. Silky hakea (*Hakea sericea*) is an example. Because so many IAPs fall into this type, they are usually further categorised according to other growth forms.

On riverbanks

These IAPs are plants that grow on the land along the edge of a river, also known as riverbanks or riparian areas. Black wattle (*Acacia mearnsii*) is an example. This can be viewed as a subset of the terrestrial grouping. The interface between land (terrestrial) and water (aquatic) areas are particularly susceptible to severe infestations that cause serious impacts.

HOW THEY GROW

Root systems

Some IAPs have long, deep taproots that make pulling out the plant difficult. Port Jackson (*Acacia saligna*), for example, has a tap root system. If pulled it can break off at the base and the plant will resprout. IAPs with shallow root systems can be pulled out more easily. Some plants grow from root suckers or rhizomes (underground stems) that connect plants below the ground. Saplings of invasive poplars (*Populus* species), for example, are connected to the parent tree. Both need to be treated during clearing operations.

Dormancy

Some IAPs may go through periods of dormancy, which is when growth stops for a while and the plant may lose its leaves. *Populus* species, for example, are widely invasive in South Africa and are deciduous. Some control methods are more effective when the plant is actively growing or has leaves, so it is important to know which IAPs have a dormant period, and when it is.

Bark types

Some IAPs have very thick bark. This will influence the method of control that should be used. The bark of *Eucalyptus*, for example, is thick, so tougher ring-barking methods will be needed.

Climbers

Some climbing plants are particularly serious invaders, like the Madeira vine (*Anredera cordifolia*). Invasive climbers can grow over and overwhelm natural plants. They spread rapidly and can be difficult to control.

An invasive alien weed: pampas grass (*Cortaderia jubata*), which is native to South America. © Ed February

Other ways of grouping IAPs

Emerging IAPs

Some plants with invasive tendencies are already present outside of their natural distribution, but have not become widely established as yet. They often have horticultural value, but can have a negative impact on natural ecosystems, biodiversity, livelihoods and human health if allowed to continue to expand outside of their natural range. It is important to be on the lookout for new invasive species.

Indigenous invasive plants

A few native species can become invasive due to human-made changes to the environment, such as altered wildfire regimes or pollution. The indigenous bitou (*Osteospermum moniliferum*), for example, can become dominant and cover large areas, reducing the species diversity in smaller isolated remnants in Fynbos systems. Nutrient enrichment (eutrophication) of wetlands also leads to indigenous reeds such as bulrush (*Typha capensis*) becoming dominant.

HOW THEY REPRODUCE

Reseeders

These are plants that reproduce by producing lots of seeds. The parent plant may be killed, but new plants will grow from the seedbank in the soil or from seeds released from cones which had stored the seeds in the canopy. Different species have various methods of spreading their seeds, such as wind or water dispersal. Many species also exhibit fire-activated seed germination. Hakea, for example, is a serious invasive plant in South Africa. It produces seed pods that split open after a wildfire to release winged seeds that disperse in the wind.

Resprouters

These types of plants can grow back after they have been damaged by wildfire or cut down. New shoots grow from the base after the top of the plant has been removed. This is also known as coppicing. Invasive eucalypts in South Africa, for example, will grow new stems if the main trunk is felled. Resprouting may mean that more than one control method, including herbicide, will be required for follow-up treatment.

Vegetative regrowth

Some plants do not only rely on their seeds for survival. Some IAPs can grow from a piece of the parent plant, like a leaf or stem. This is called vegetative regrowth. In some invasive cactus species, for example, each leaf has the potential to grow into a new plant if it comes into contact with the ground.

LEGAL REQUIREMENTS

Landowners have certain legal responsibilities relating to invasive alien plants on their land. These are specified in laws about environmental management, agriculture, water, heritage, health and safety, and the application of herbicides.

The legal obligations of landowners with IAPs on their land are summarised in this section. You will find a brief explanation of the relevant laws and regulations relating to IAPs, including what actions are required for different categories of IAPs.

The headwaters of the Jonkershoek / Eerste River in the Jonkershoek Nature Reserve near Stellenbosch in the Western Cape.

BIODIVERSITY LAWS – WHAT ARE THE LEGAL OBLIGATIONS?

As invasive alien plants can have a negative impact on biodiversity, laws protecting biodiversity include regulations to control the spread of IAPs. The owner of land where IAPs occur carries responsibilities under these laws.

BIODIVERSITY ACT

The National Environmental Management: Biodiversity Act 10 of 2004 is administered by the Department of Environment, Forestry and Fisheries. Its purpose is to conserve South Africa's biodiversity. The Alien and Invasive Species Regulations are published under the Act. These regulations go together with a national list of invasive species that puts IAPs into categories.

Duty of care

Certain sections of the Biodiversity Act impose a 'duty of care' that applies to landowners. A duty of care means that people must take reasonable action to prevent harm to the environment. A person who owns land where IAPs occur needs to take steps to control them, prevent them from spreading and minimise harm to biodiversity.

Categories

The list of invasive species under the Biodiversity Act has four different categories. Different obligations apply to each of these categories (Table 1).

Table 1: Categories of IAPs under the Biodiversity Act

	Category 1a	Category 1b	Category 2	Category 3
Definition	A species that must be combated or eradicated	A species that must be controlled	A species that requires a permit	A species that is subject to certain prohibitions
Actions required	• Take immediate steps to eradicate the invasive species using appropriate methods.	• Take steps to control the invasive species using appropriate methods.	• Apply for, and comply with, a permit to conduct restricted activities (e.g. import, possess, grow, move, trade, dispose of or spread the species).	• Control the species if it spreads to riverbanks. • Planting, propagating, and trading in the species are not allowed.

Obligations

Landowners are required to do the following:

- Notify the responsible provincial agricultural authority in writing if a Category 1 invasive species occurs on their land.
- Comply with any relevant Invasive Species Management Programme.
- Allow an official onto the land to monitor, assist with, or implement control of a listed invasive species.
- Take measures to control the invasive species, depending on the category it is listed under.
- Conduct control activities cautiously to cause the least harm to biodiversity and the environment.
- Inform the buyer in writing of invasive species on the land, if the land is to be sold.

Offences

If a landowner does not obtain the necessary permit or does not take the required steps to control an invasive species, they can be found guilty of an offence. They may be sentenced to a fine of up to R10 million, or imprisonment for up to 10 years, or both.

AGRICULTURAL LAWS – WHAT ARE THE LEGAL OBLIGATIONS?

Invasive alien plants can have a negative impact on agriculture, so agricultural laws include regulations to prevent their spread. Requirements under agricultural laws may apply to a landowner, or to a land user who has a right to use the land for a certain purpose.

CARA

The Conservation of Agricultural Resources Act 43 of 1983 (CARA) is administered by the Department of Agriculture, Land Reform and Rural Development. Its purpose is to look after South Africa's agricultural resources. The CARA does not use the term IAPs but refers to "declared weeds" or "declared invader plants".

Methods

The CARA places a general ban on any conduct that would disperse a declared weed (e.g. selling, advertising, keeping, delivering). It can also require land users to use specific methods to control weeds, depending on what is most appropriate for the species and ecosystem concerned (see IAP management methods, page 32). Methods include:

- Uprooting, felling, cutting or burning
- Treatment with a registered herbicide
- Biological control
- Any other method of treatment
- A combination of one or more methods.

Categories

The actions required depend on which category the plant falls under in the CARA regulations (which might differ from province to province) (Table 2).

Table 2: Categories of IAPs under the CARA

	Category 1	Category 2	Category 3
Definition	Alien plants that are absolutely prohibited and will no longer be tolerated. Their harmfulness outweighs any useful properties they might have.	Alien plants with proven potential to become invasive, but which have some beneficial properties that warrant their continued presence in some circumstances.	Alien plants with proven potential to become invasive but that are popular ornamentals or shade trees that will take a long time to replace.
Actions required	• Take steps to prevent the occurrence of these plants on any land or water surface. • These plants may no longer be planted, and all trade in them is prohibited. • They may not be transported or allowed to disperse.	• Take steps to prevent the occurrence of these plants on any land or water surface. • An exemption can be obtained. • These plants may be kept in special areas, demarcated for that purpose. • Growing these plants is a "water use" in terms of the National Water Act 36 of 1998.	• These plants are allowed to remain where they are, as long as they do not grow in watercourses and steps are taken to prevent them from spreading.

Offences

Failure to comply with any measure in terms of the CARA regulations can attract a fine of up to R5 000 or up to two years in prison (or double for a second conviction).

WHICH OTHER LAWS REFER TO IAPS?

Several other national laws may have some relevance to invasive alien plants. These are listed below. There may also be some regional requirements, like municipal by-laws, but those are not covered here.

Environmental laws

The National Environmental Management Act 107 of 1998 (NEMA) is the main law governing environmental management in South Africa, including environmental impact assessments. It too contains a "duty of care": every person must take reasonable care to prevent harm to the environment. Importantly for IAP management, it allows employers or company directors to be held responsible for offences under the Biodiversity Act or the CARA. If a person is convicted, the court can also ask them to pay the costs to deal with environmental damage that was caused.

Water laws

The National Water Act 36 of 1998 places all South Africa's water resources under the ownership and governance of the state. Anyone who wants to use water for certain purposes must apply for authorisation. There are some water uses that may be relevant to IAPs. Planting IAPs is considered a "stream flow reduction activity" that requires a water-use licence. Also, if mechanical removal of IAPs alters the banks of a river, or changes the flow, it can be considered a water use.

Forest laws

The National Forests Act 84 of 1998 can declare some trees, including IAPs, as "champion trees". The River Red Gum (*Eucalyptus camaldulensis*) that was planted in Bergzicht market square, Stellenbosch, in 1880 is an example of a "champion tree". These individual trees are protected and it is illegal to cut them down.

Agricultural remedies

The Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act 36 of 1947 regulates fertilisers, feeds and remedies used in agriculture. The chemicals used for IAP management are regarded as agricultural remedies. The Farm Feeds Act contains some requirements for the registration, proper use and handling of these chemicals (see Herbicide safety, page 52).

Health and safety laws

The Occupational Health and Safety Act 85 of 1993 promotes the health and safety of workers in the workplace. It contains information on the duties of employers and employees to ensure safe working conditions (see Health and safety, page 46). It also has some provisions that may be relevant for handling IAPs that are dangerous to human health.

Heritage laws

The National Heritage Resources Act 25 of 1999 protects South Africa's heritage resources. IAPs are sometimes protected under these laws, e.g. trees growing on heritage sites.

Fire management laws

The purpose of the National Veld and Forest Fire Act 101 of 1998 is to prevent and combat wildfires. It requires every owner of land where a fire may start, burn or spread to maintain a firebreak that is free from flammable material (see Integrated planning for fire and IAPs – Why is it important? page 24).

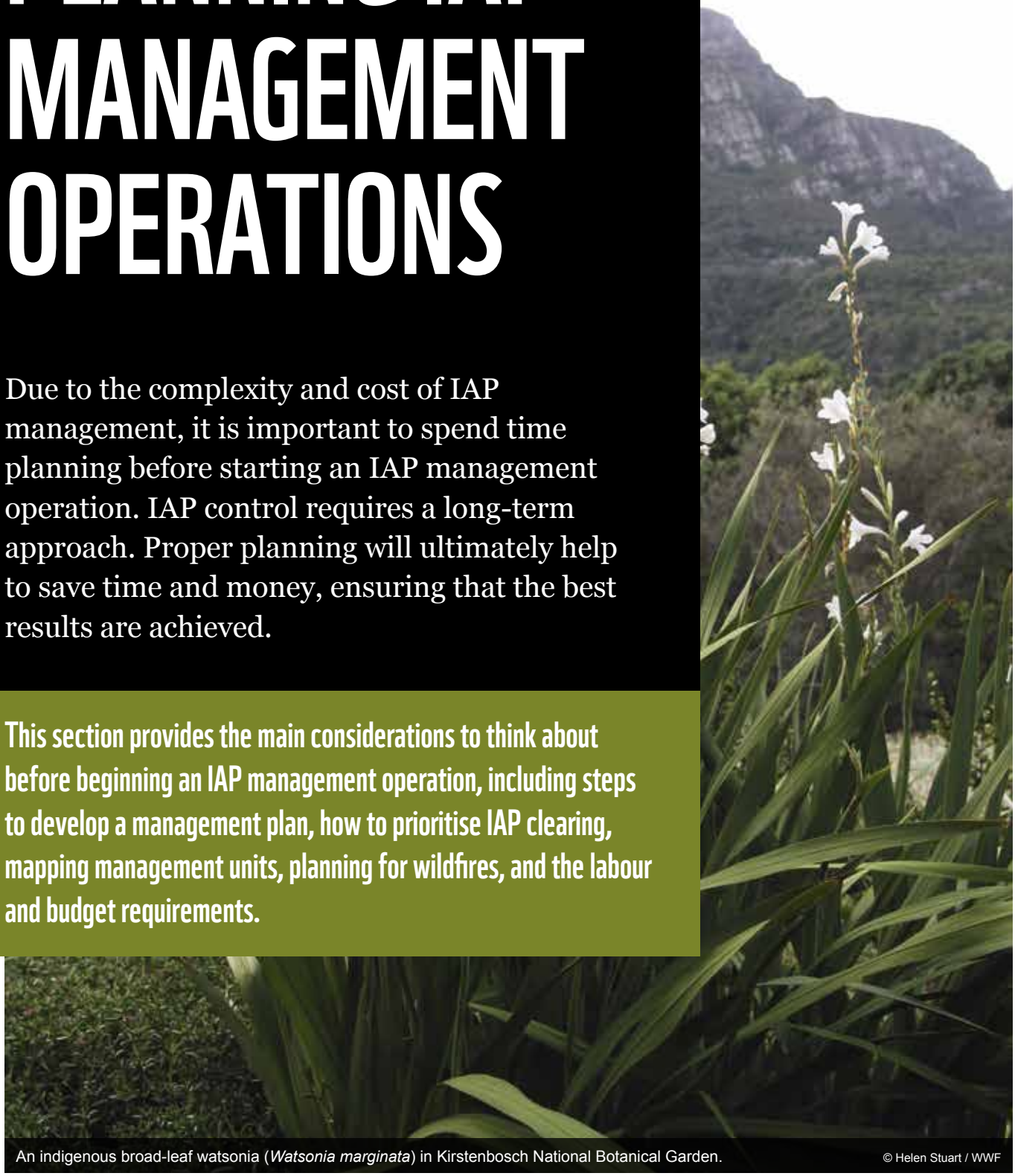
For more information, see Appendix 1: Legislation guideline for invasive alien species (page 66).

Houses in Lakeside, Cape Town, coming under threat from a wildfire above Boyes Drive during 2005. © Bruce Sutherland

PLANNING IAP MANAGEMENT OPERATIONS

Due to the complexity and cost of IAP management, it is important to spend time planning before starting an IAP management operation. IAP control requires a long-term approach. Proper planning will ultimately help to save time and money, ensuring that the best results are achieved.

This section provides the main considerations to think about before beginning an IAP management operation, including steps to develop a management plan, how to prioritise IAP clearing, mapping management units, planning for wildfires, and the labour and budget requirements.



An indigenous broad-leaf watsonia (*Watsonia marginata*) in Kirstenbosch National Botanical Garden. © Helen Stuart / WWF

IAP MANAGEMENT APPROACH – WHAT SHOULD A LAND USER CONSIDER?

The context within which IAP management is planned will determine the approach taken to the management programme.

CONSIDER THE CONTEXT

Goals

Much depends on your goals for the future management of the invaded area. Clearing IAPs for immediate development of the land, for example, will require different methods compared to managing IAPs to restore functioning of the natural environment.

Environment

The type and condition of natural vegetation in the area may determine the IAP control methods so as to limit a negative impact on the surrounding environment.

Season

The season of the year may influence accessibility to the site, visual identification of species through flowering, the safe and effective use of herbicide and fire, and the ecological impact of IAP management. All these factors will have an impact on the number of available work days for clearing.

A Genadendal community member collecting firewood along the densely invaded Riviersonderend River. © Helen Stuart / WWF

4 STEPS TO DEVELOPING A LOGICAL IAP MANAGEMENT PLAN

As important as considering the context within which one is planning IAP management, is considering the steps to develop a logical plan and set priorities for the IAP clearing process. By following a few basic steps, it is relatively easy to put together a simple but effective IAP management plan for a property.

1. SURVEY THE AREA

- Walk the area
- Take photographs
- Review aerial photographs
- Identify IAPs

2. IDENTIFY UNITS

- Uniform areas
- Similar IAPs
- Topography
- Manageable size
- Fire history

3. PLAN ACTIONS

- IAP control methods
- Burning schedule
- Optimal sequence
- Seasons

4. CALCULATE COSTS

- Equipment needed
- Labour required
- Areas and norms
- Keep records

1 Survey the area

A suitably experienced person should survey the areas to be cleared and identify the IAPs that occur there. For very large areas, mapping of IAP coverage is essential, but for small sites it may not be necessary. It is best to walk the area to be mapped, and not just to rely on viewing the area from a distance or via an aerial photo. Photographs of the site should be taken to assist the process of monitoring the impact of the IAP management programme (see Mapping management units – What does this involve? page 23).

2 Identify units

Break the property down into sensible management units. A management unit is a uniform block of land, with similar soil, slope, history, etc. that will respond in a similar way to a management action. For IAP management, a management unit may be an area of uniform species, age classes and densities (and the potential for the use of fire as an IAP management method, if appropriate) (see Mapping management units – What does this involve? page 23).

Give each management unit a unique identification number. Compile an inventory for each management unit, including the density and age of IAPs.

3 Plan actions

Identify what management actions are needed in each management unit, taking into account the integration of fire and IAP management, if appropriate. Determine the sequence and which methods or combination of methods is best for the site and target species. Consider what field equipment and herbicides are required. Plan the order in which management actions should be implemented, taking into account the effect or advantage of implementing actions in a particular season (see 9 priorities when clearing IAPs, page 21).

Check with your local Fire Protection Association (FPA) to ensure that your operation has received approval from the relevant authorities.

4 Calculate costs

Using the information gathered on the size of the management units, the density of IAPs and selected control methods, calculate the labour required and the costs (see How much labour and budget will a land user need? page 26).

Land users should keep a note of all expenses incurred from IAP management as these are tax deductible.

For more information, see Appendix 5: Template for a farm-level alien plant control plan (page 66).

9 PRIORITIES WHEN CLEARING IAPs

It is often not possible to tackle all stands of IAPs at once. It is also important not to take on too much at one time, remembering that each area will require follow-up treatments. For this reason, it is useful to plan where to start by setting priorities.

1 Prevent new invasions

Target emerging or new species before they have a chance to set seed and spread.

2 Follow-up first

Areas that require follow-up treatment should be prioritised over areas that still require initial clearing. Follow-up treatment is essential to curb the further growth and spread of IAPs. Follow-up reinforces previous efforts in which you have already invested time and money, so it is important not to waste this investment. This also applies to an area that has recently been burnt: the fire acts as an initial clearing mechanism, so if these areas are prioritised, it will cost less to clear while the growth is young.

3 Limit wildfire risk

Areas of IAPs that pose a wildfire risk to houses or infrastructure should be targeted as a priority. Effective firebreaks should be created where woody or fire-prone IAPs are located in dense stands near settlements, power lines, etc.

4 Start with less dense stands

Treatment of low-density, young invasions should be a priority to halt the invasion and prevent the build-up of IAP seedbanks. This is especially important in fast-maturing, wind-dispersed species such as hakea and pine (*Pinus* species). Less dense areas will also require fewer resources and easier follow-up treatment. Dense mature stands should be left for last, as they probably will not increase in density or pose a greater threat than they do at present. Clearing very dense areas requires a commitment to expensive, long-term follow-up treatments.

5 Start upslope

Consider the natural gradient of the area being cleared. All operations should ideally follow the slope or drainage lines. Clearing needs to start from the highest point and move downstream and downslope. This ensures that potential sources of IAPs – seeds and other regenerative material – are eliminated upstream of the working area to avoid reinfestation.

6 Work from the outside inwards

On gentle gradients, clearing should start from the outside of a work block and move inwards towards the centre, to contain IAPs within a confined area.

7 Follow contours

To avoid the threat of soil erosion when clearing dense infestations of IAPs on steep slopes, work should progress horizontally along the contours. IAPs should be cut in bands of 3 m wide along the slope contour and the cut material should then be rolled back so that it forms a “frill” along the band. Openings between contoured stacks should be staggered to further reduce water run-off.

8 Focus on riparian areas

Rivers, streams and wetlands are a priority when planning the clearing of IAPs. IAPs often use a lot of water and can reduce water flow and quality if water systems are heavily invaded. Waterways also provide a way for IAPs to spread rapidly downstream.

9 Collaborate with neighbours

Collective management and planning with neighbours allow for more cost-effective clearing and maintenance. This reduces reinfestation. It also allows a more integrated approach with respect to fire and fuel-load management.

Cleared material stacked along contour lines. © Saskia Fourie / WWF

MAPPING – WHY IS IT ESSENTIAL?

Mapping skills are useful for anyone undertaking the management of IAPs. Maps such as topographical and aerial maps can help land users to understand the location of the area, its boundaries and the layout of the landscape to successfully plan and carry out the IAP management work.

Maps can be used to show where the IAP infestations are, and how management operations should be approached. They can also be used to schedule IAP control treatments and calculate costs.

TYPES OF MAPS NEEDED FOR PLANNING IAP MANAGEMENT

1:50 000 topographical map of the Berg River Dam, one of Cape Town's six water supply dams.

1:10 000 aerial photograph used for mapping invasive alien plants.

Topographical maps

A topographical map shows the layout (or the topography) of the land. It shows the height above sea level using contour lines, which also gives an indication of the slope of the land. This type of map is useful for assessing accessibility and walking time to an area. Rivers, roads and compass bearings are shown on these maps.[1]

It is advisable that a contractor has a topographical map of the area where the work is to be conducted.

Aerial maps

Aerial maps are made from photographs taken from aeroplanes, drones or satellites. These types of maps are easy to understand because they provide a picture and not just a line drawing of the area. But they give less detail than topographical maps. It is important to remember that you need to get the most up-to-date aerial map, as landscapes change over time due to fires, development, etc.

Free open source GIS software is available to anyone to view and manipulate spatial information, e.g. Quantum GIS, Google Earth.

For more information, topographical and aerial maps are available from the National Geospatial Information (NGI) agency (Appendix 9) (page 66).

[1] Deacon, G. and Harding, G. 2007. *Worksite Management Manual.*

MAPPING MANAGEMENT UNITS – WHAT DOES THIS INVOLVE?

Walk the area

Before starting the clearing work, it is essential to walk through the whole area in a set pattern. Walking the area will help to gather information about the IAPs on the land. This information can be used to map out management units.

Information will need to be gathered about:

Species

Managing IAPs cannot be done if the IAP species have not been identified. Only once the species has been identified can the appropriate IAP control methods be selected.

Growth form

How the IAP grows is known as its growth form or habit (see Types of IAPs – How do they differ? page 12). There are many different growth forms for plants, each with different control strategies.

Age classes

The age, stem thickness and height of the IAPs will determine the type of control method. The age of a plant is usually divided into the following classes:

- Seedling (diameter at ankle height: 0–15 mm)
- Young (diameter at ankle height: 16–50 mm)
- Adult (diameter at ankle height: > 50 mm)

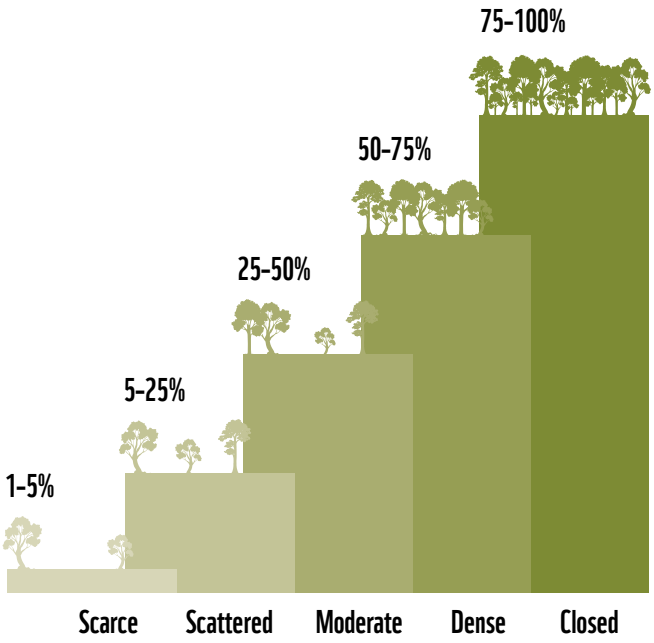
See IAP management methods (page 32).

Remember, height does not equate to age. Some mature plants do not grow very tall. Generally, anything lower than hip height is classified as a seedling.

Density class

The density of IAPs refers to how closely packed they are. It is measured by estimating the ground cover or the number of stems in an area. Density is usually expressed in percentage, ranging from 0% (no IAPs) to 100% (fully covered with IAPs). It is commonly estimated using simple visual methods to assess the coverage of each IAP species within a set area. The categories generally used are shown in Figure 1. Densities will be a significant determinant of how much time and money it will take to clear the area.

Figure 1: Density class categories for IAPs



Size of area

The size of the area, measured in hectares, will affect the number of working days needed to complete the treatment area. Integrated fire and IAP management may include smaller IAP management units within larger fire management units. In these cases, a fire management unit is an area that can be burnt in a prescribed burn. The rule of thumb is that the unit size is determined by what can be burnt in one day.

Ensure that the boundaries of the area to be cleared are visibly marked to orientate the team.

The information gathered on the species, growth form, age and density across the land will help to decide on management units. A useful management unit is one where the IAPs are of the same species, age and density. Then the most appropriate control treatment can be applied to each unit (see 4 steps to developing an IAP management plan, page 20). Also consider appropriate units for Integrated planning for fire and IAPs – Why is it important? (page 24).

For more information, see Appendix 6: Basic mapping skills (page 66).

INTEGRATED PLANNING FOR FIRE AND IAPS – WHY IS IT IMPORTANT?

Fire management and the management of IAPs are inextricably linked. The role of wildfire is central to planning IAP control as it presents both a threat to IAP management operations and an opportunity for IAP control.

Threat

Wildfire management is necessary to reduce fire hazards and control unscheduled wildfires that threaten property, crops, infrastructure and IAP management investments already made. In the absence of IAP control, successive wildfires in areas invaded by IAPs lead to densification and further invasion. This in turn increases fuel loads and rate of spread, fuelling a vicious cycle. Uncontrolled wildfires often defeat the purpose of mechanical and biological control. Only once a sound level of wildfire management is in place should alternate IAP control strategies be implemented and integrated.

Opportunity

Fire, with appropriate management, is a cost-effective IAP control method. Fire can be used to control IAPs and maintain optimal water yield in catchments. It is critical to understand the effect of fire as a driver in Fynbos and other fire-driven systems and recognise that fire may be used as an effective management tool.

Integrated planning is required to coordinate the management of fire and IAPs to take advantage of the opportunities and limit the threats. Planning firebreaks (fuel breaks) and treatment blocks, and being adequately prepared are essential for successful fire management. Land users should devise a joint strategy guided by both legal and practical management requirements. An understanding of fire ecology and the natural processes will further enhance land users' wildfire management capabilities. There are significant benefits to membership of a Fire Protection Association, which promotes and supports fuel-load management.

For more information, see Appendix 7: Fire Protection Associations in the Western Cape (page 66).

To set up integrated fire and IAP management, it is necessary to identify management units that can be subjected to planned burns. Management actions can then be scheduled in these units to optimise both ecological burning and IAP management at the right time. It is important to note that too frequent or unseasonal fires can have a significant negative ecological impact. It is also crucial to strive for a mosaic of different veld ages across the greater landscape.

For more information, see CapeNature's fact sheet Appendix 10: What a landowner needs to know about fire management (page 67).

A member of a fire management team in action. © Tessa Oliver

HOW TO PREPARE FOR AND MANAGE WILDFIRES

Landowners should take measures to prevent wildfires from starting and spreading to neighbouring land. They should be ready to manage any wildfire that occurs on the property.

Legislation

The requirements for fire prevention and preparedness are covered in the National Veld and Forest Fire Act 101 of 1998. There are penalties if landowners fail to follow these provisions (e.g. firebreaks, notification of intention to burn).

Invasive alien plants

Bringing IAP infestations under control is an important step towards preventing wildfires, as these fires burn hotter than Fynbos fires. Wildfires on IAP-infested land are very difficult to control, especially under dry, windy and hot conditions.

Firebreaks

A firebreak (fuel break) should be prepared and maintained around the property, or firebreak exemption should be sought. It should be wide and long enough to assist in managing a wildfire. It should also be reasonably free of flammable material that might carry a fire across it. The firebreak should not cause soil erosion.

Fire Protection Association (FPA)

The landowner should join the local FPA. Landowners should notify the FPA and neighbouring landowners about fires. Landowners should be ready to fight fires by acquiring equipment and having competent personnel available to fight fires, or appoint an agent to do so. In an emergency, fire services and FPA officials should be given permission to enter the land to fight fires.

For more infomation, see Appendix 7: Fire Protection Associations in the Western Cape (page 66).

A member of a fire management team using a drip torch to set fire to the veld. © Tessa Oliver

HOW MUCH LABOUR AND BUDGET WILL A LAND USER NEED?

The amount of labour (in person days) and the budget a land user will need will depend on the size of the area to be cleared of IAPs, the nature of the terrain, the species present and the age and density of the IAPs.

By mapping out management units, the area can be worked out in hectares (see Mapping management units – What does this involve? page 23). This information can be used to estimate labour (see Funding opportunities, page 64) and herbicide costs. Also see Figure 2.

Person days

Labour required for IAP management is measured in person days (Pd). A person day is the amount of work that one person can do in one day. The number of person days needed for certain species, ages and densities of IAPs have already been worked out and these norms are available on norm sheets.

> Norm sheets are available from the Department of Environment, Forestry and Fisheries Natural Resource Management Programmes offices.

To calculate person days, the area to be cleared (ha) is multiplied by the "norms". If working in a riparian area, add 50% to the total person days to include time for carrying out the material from the natural flood zone. If cutting and stacking is required, add an additional 20%.

The cost of labour can be calculated by multiplying the total person days by the cost per person per day. Every team's dynamics are different, so it is advisable to eventually work out one's own norms over time. Keep records of production against the norms and adapt the norms to local conditions.

Person days	=	area (ha) × norm
Cost	=	total person days × cost per person day

Herbicide cost

Herbicide norms appear on the herbicide norm sheets, which are included when the product is purchased, and are used to calculate herbicide requirements and costs. Herbicide cost is calculated by multiplying the area (ha), the density of IAPs, the litres of herbicide required according to the norm sheet, and the cost per litre.

Herbicide required	=	area (ha) × density (proportion) × dilution factor (ha/litre)
Cost	=	total litres required × cost per litre

Figure 2: Aspects that may influence the costing of an IAP management operation

Vegetation
- Species
- Density (coverage % or stems/ha)
- Area (ha)
- Height (m)
- Growth stage

Terrain
- Slope
- Access
- Transport costs

Herbicide
- Herbicide type
- Rate spray volume (per ha or %)
- Knapsacks/sprayers/nozzles
- Herbicide costs

Equipment
- Slashers/brush cutters
- Maintenance
- Equipment costs and depreciation

Labour
- Type (skilled/unskilled)
- Task rate (person days/ha)
- Number of labourers
- Availability
- Salaries/wages
- Benefits/bonuses
- Training costs

Programme
- Duration
- Number of treatments

For more information, see:
Appendix 3: Work sheet for field verification (page 66).
Appendix 4: Guidelines for clearing time (Person days/ha norms) (page 66).

An indigenous pincushion protea (*Leucospermum spp*.) in Kirstenbosch National Botanical Garden. © Helen Stuart / WWF

WHAT OTHER FACTORS SHOULD ONE CONSIDER FOR IAP MANAGEMENT?

In addition to the context, methodology and priorities, other factors may influence the methods, extent and location of an initial IAP management operation, and warrant consideration.

A chainsaw operator undertaking alien clearing in the Kouga River in the Eastern Cape, an important catchment for water supply to the Nelson Mandela Metro. © Rodney February / WWF

Combinations of control methods

An IAP control plan should integrate the various control methods to optimise effectiveness and limit environmental impact. Moderate to low IAP infestations in wetland areas, for example, can be treated by implementing controlled burning at the beginning of autumn, followed by mechanical removal or herbicide application in mid-spring (see IAP management methods, page 32).

Infestations in wetlands

Note that wetlands are protected by the National Water Act 36 of 1998 and the National Environmental Management Act 107 of 1998. No heavy machinery may be used to remove IAPs in wetland areas without prior authorisation from the relevant government departments.

Disposal of material

Disposal of the cut IAP material needs to be carefully considered. Whatever disposal method is selected must meet all the legal requirements and must not create a risk for residents and infrastructure (see How can one responsibly manage plant material? page 45).

Biomass potential

Dense stands of IAPs may have the potential to be harvested for additional value, e.g. timber, firewood, briquettes or biochar, or even fuel for boilers. Using biomass provides additional benefits, as reducing fuel loads improves fire safety and rehabilitation potential.

Indigenous vegetation

Natural vegetation – including individual indigenous trees located among stands of IAPs – must be protected from damage during the clearing process. Indigenous trees and vegetation can be cordoned off or marked using danger tape to make sure workers know what must be protected. This approach will reduce the long-term cost of managing invasive alien plants by reducing the need for active rehabilitation, and protecting the cleared area from erosion and regrowth. In very sensitive ecosystems, IAP clearing interventions should ideally be done during the dry season when the vegetation is less sensitive to disturbance.

Rehabilitation potential

If the intention is to rehabilitate the area, further restoration methods may be needed. If appropriate in terms of locality and wildfire risk, stands of alien trees can be used to create nursery stands for forest species. This may be managed by selective removal of alien trees to allow indigenous forest to emerge over time (see Long-term rehabilitation, page 58).

Labour considerations

Consider the possible seasonal availability of human resources (e.g. personnel shortage in spring and summer due to irrigation, harvesting and other activities). Also consider the level of skills required.

Practical considerations

Think about the location of the site, the distances to travel and the accessibility for machinery. Plan to use existing access roads.

Threat to pastures and planted crops

Think about how the IAP management operation may enhance the essential economic activity on the property.

Ability to follow up

Follow-up treatments will be needed to maintain the initial investment. Do not start clearing an area if you will be unable to follow up as this can make infestations worse. IAPs are quick to regrow in disturbed areas and often out-compete indigenous vegetation. Different follow-up schedules (e.g. in terms of timing, frequency and approach to follow-up treatments) may be required for different species.

Management history

Previous management actions in the area that you intend to clear could play a role. Understanding the fire and IAP management history of the site will help to choose the appropriate methods and sequence of treatments. Wildfires, for example, may stimulate Acacia seedbanks in areas where seed-limiting biocontrol methods are not yet present. This will determine the appropriate follow-up methodology and costs (see What is biocontrol? page 41).

Ongoing evaluation

Land users will need to continually evaluate the success of the IAP management operations and potentially adjust the methods used. Other species may invade after initial clearing – this is known as secondary invasion – which may require different management methods.

For more information, see CapeNature's fact file Appendix 8: A landowner's guide to planning alien control (page 66).

An active restoration site on the Meul River, a tributary of the Riviersonderend near Greyton in the Western Cape. © Rodney February / WWF

WHAT BASIC TOOLS ARE REQUIRED FOR IAP MANAGEMENT OPERATIONS?

Conducting an IAP management operation will require a basic set of tools and equipment. Further requirements may depend on the specific control methods used.

Table 3: Tools and equipment for IAP management operations

(also see Personal protective equipment – What does it include?, page 50)

Item	Supervisor	Machine operator	General workers	Herbicide applicator
First-aid kit (and maintenance)	✔			
Fire beaters	✔			
Wajax can[2]	✔			
Chainsaw		✔		
Chainsaw maintenance items Chain lube Fuel mix Chain Bar Sprocket Sparkplug Round files Flat files		✔		
Combi-can		✔		
Fire extinguisher[3]		✔		
Sharpening kit		✔		
Sharpening kit tool pouch		✔		
Axe Axe handles Sharpening stones			✔	
Bow-saw/pruning saw Blades			✔	
Lopping shears			✔	
Spray can hand-held			✔	
Drip tray or sheet		✔		✔
Measuring jug, bucket, container				✔
Knapsack maintenance Parts				✔
Knapsack sprayer				✔
Stopwatch				✔
Tape measure (> 30 m)				✔

[2] A specially designed, rugged knapsack with a pump action that has been developed to squirt water on a fire. Very effective in extinguishing small fires.

[3] A fire extinguisher must be kept at the refuelling area to extinguish fires that can start when petrol lands on the exhaust of a hot chainsaw.

CHECKLIST FOR AN IAP MANAGEMENT OPERATION

When embarking on an IAP clearing programme, land users should bear in mind certain general principles. This will help them to choose the appropriate clearing method, be it manual, mechanical, chemical, biological or a combination thereof.

10 POINTS TO REMEMBER WHEN CONDUCTING AN IAP MANAGEMENT OPERATION

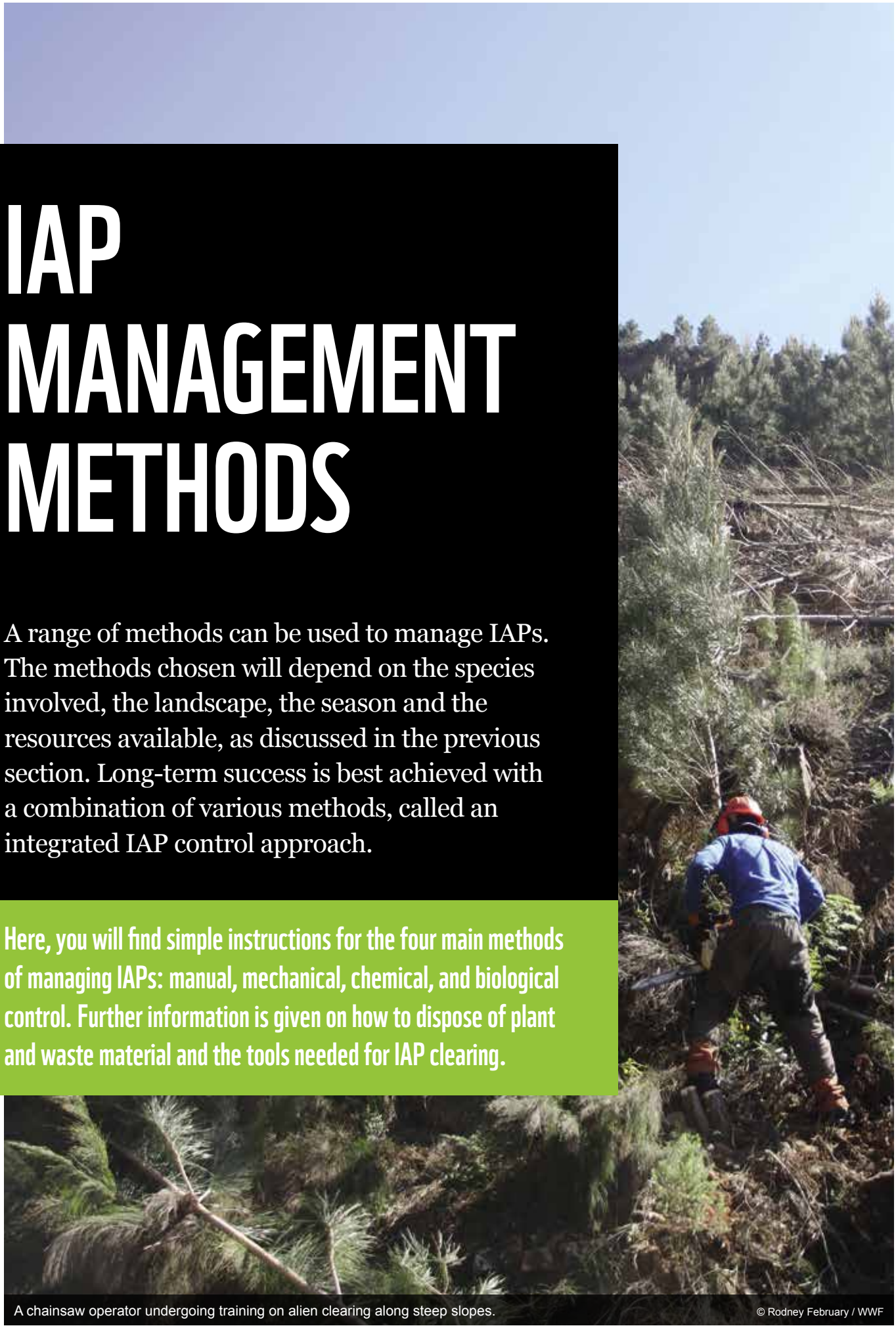
1. Always start at the highest point and work downwards, downhill or downstream.
2. Start from the edge of the infestation and work towards the centre.
3. Take care to prevent the spread of cuttings, which could take root further downstream.
4. Once plants have been removed, unstable slopes should be stabilised by erosion protection measures (such as geotextiles or other suitable material).
5. Keep accurate records of actions and costs to assist with future planning.
6. Control IAPs when the plants are young, rather than waiting until they are woody and difficult to remove by hand.
7. Manage IAPs before a wildfire burns the area, as the mechanical control thereafter is substantially more expensive (see Mapping – Why is it essential? page 22).
8. Set up an integrated fire and IAP management plan (see Integrated planning for fire and IAPs – Why is it important? page 24).
9. Take care to distinguish between young invasive species and Fynbos species (this could be difficult). Keurboom seedlings are remarkably similar to that of many acacia species seedlings.
10. Select the quickest and most effective way to efficiently kill a plant – time is money.

A Working for Water team untertaking slashing and stacking of the invasive weed lantana (*Lantana camara*). © LANDWORKS

IAP MANAGEMENT METHODS

A range of methods can be used to manage IAPs. The methods chosen will depend on the species involved, the landscape, the season and the resources available, as discussed in the previous section. Long-term success is best achieved with a combination of various methods, called an integrated IAP control approach.

Here, you will find simple instructions for the four main methods of managing IAPs: manual, mechanical, chemical, and biological control. Further information is given on how to dispose of plant and waste material and the tools needed for IAP clearing.



A chainsaw operator undergoing training on alien clearing along steep slopes.

MANUAL CONTROL OF IAPS – WHAT DOES IT ENTAIL?

Manual control is when a worker removes or kills each IAP through hand pulling, cutting, digging out, ring barking or bark stripping. Because it is so labour intensive, it is best used for lighter infestations, seedlings, single plants, plants that have shallow roots, or in very sensitive areas.

Hand pulling

Hand pulling is most effective when plants are small (30 cm), immature or shallow-rooted, and after rain.

- Use a pair of gloves and grip the plant firmly around the stem just above the root.
- Pull hard and remove the plant, roots and all.
- Kicking around the root area of the plant may help to loosen the root system, making it easier to pull out the plant.
- Shake the excess sandy material from the plant to ensure a higher mortality rate and make the plant easier to stockpile and lighter to transport.

Cutting

Chopping or slashing is most effective for young plants that are too large to pull out by hand, or for plants that have woody stems. It is best used on plants that are not resprouters. In the case of resprouters (coppicing), chopping must be combined with chemical treatment of the cut stumps.

- Use implements such as pangas (slashers/machetes), handsaws, bow-saws and axes to cut plants down as low as possible.
- Remember to wear protective clothing and keep team members at least two arm-lengths apart (see Health and safety, page 46).
- Stack removed material into piles of 2 m high and 3 m wide.

A team using the technique of cutting close to the ground combined with bark stripping, which eliminates the use of herbicide.

Digging out

Digging out IAPs involves the use of tools like hoes, sticks, tree poppers or spades. The entire plant and root must be removed.

- Dig around the plant, making sure the sand is loosened around the root system.
- Dig down under the roots, applying pressure, and wrench the entire plant out.
- Kicking the plant may help to dislodge it; however, care should be taken if the plant is seeding as dry seeds may be dislodged.
- Stack removed material into piles of 2 m high and 3 m wide.

Ring barking

Since this method means the tree is left standing, it is recommended only for single trees or very low-density invasions, not for stands. Ring barking on smaller diameter stems is ineffective and it would be quicker to just cut the tree down. Ring barking should be used on trees with stem diameters greater than 150 mm, where the time taken to fell, de-branch and stack would be excessive. Basal bark treatment could be considered as an alternative in some cases (see Chemical control of IAPs – What does it involve? page 36).

- Slashers or axes should be used for debarking.
- Remove the bark and cambium (outer rings where the trunk grows) in a continuous band around the trunk of the tree at least 25 cm wide, starting as low as possible.
- Where clean debarking is not possible due to crevices in the stem or where exposed roots are present, a combination of bark removal and basal stem treatments should be carried out.
- For better control of aggressively coppicing species, combine with bark stripping (right).

Bark stripping

Bark stripping is the removal of bark from the trunk between ground level and up to 1 m above ground. A suitable herbicide can be applied along with this method. Applications should be by means of a low-pressure, coarse-droplet spray from a narrow-angle solid-cone nozzle or by using a paint brush.

Bark stripping, ring barking and frilling should not be used as methods on any trees located next to rivers or infrastructure. Treated trees that are either dying or dead could fall into rivers and block the flow of water, or cause damage to infrastructure such as roads, fences, buildings and power lines.

Bark stripping removes the phloem layer of the plant, which will cause the tree to die over time. © Rodney February / WWF

Ring barking is used for larger trees. © Saskia Fourie / WWF

MECHANICAL CONTROL OF IAPS – WHAT ARE THE OPTIONS?

Mechanical control involves the use of machinery to clear IAPs and is often the most effective for larger individual plants. Cost effectiveness, personnel competency and safety remain important considerations.

Bulldozers

Although machines like bulldozers can bring additional strength to clearing more stubborn infestations, the use of heavy machinery has serious limitations:

- The disturbance to the soil and vegetation will lead to loss of natural biodiversity.
- Bulldozers create a fresh seedbed for germination of more invasive species.
- There are also unforeseen impacts caused by compacting the soil.

Because of these limitations, laws protecting natural veld, riparian areas and wetlands only allow heavy machinery to be used in areas that are already disturbed (e.g. cultivated lands, firebreaks and road verges).

Bulldozers have been used for IAP clearing with varied results.

- Use of machinery for IAP clearing must be compliant with the relevant legislation.
- The blade should be kept 15 to 20 cm above the ground to catch and push plants without gathering too much soil.
- The mix of soil and plants that is created makes disposal of plant material difficult and costly. Stacking into rows is the best option (see How can one responsibly manage plant material? page 45).

Felling equipment

Felling is appropriate where trees can be cut down and removed using chainsaws, bow-saws, brush cutters or slashers. Where trees cannot be removed (on steep slopes), it is better not to fell trees, but rather to control them where they stand. Where possible, large trees should be felled so that they fall uphill. Cut trees should be debranched.

Take wind direction into account when felling large trees with chainsaws. Always start downwind.

Heavy rollers

Heavy-duty forestry rollers are used to mulch plantation waste after clear-felling. They have been usefully applied to IAP clearing as part of a combined programme where fire is also used. The heavy roller can be used after fires on medium to dense stands of young saplings (saplings up to 2 m in height and < 30 cm in diameter). Fire can also be used to remove the flattened material.

Heavy machinery can be used in various ways to help dispose of plant waste from IAP clearing, such as by chipping or stacking (see How can one responsibly manage plant material? page 45).

A chainsaw operator felling a pine tree in the Vyeboom Wetland in the Theewaterskloof catchment. © Rodney February / WWF

CHEMICAL CONTROL OF IAPS – WHAT DOES IT INVOLVE?

Chemical control makes use of herbicides to kill target IAPs by foliar application, blanket spraying, aerial application or cut stump treatment. Other chemical methods are chemical frilling, basal bark treatment and stem injection.

A herbicide is a substance that is toxic to plants, either killing the plant or interfering with its growth. Several effective herbicides are available. Herbicides are usually applied to IAPs using special equipment such as knapsacks with spraying nozzles.

Chemical methods are a good choice when the IAPs are still seedlings or young. At this stage of a plant's life it is growing fast, so herbicides will be quickly translocated through the plant to reach the roots. The leaves and stem are young and green with a large surface area, allowing for good absorption of the herbicide.

Chemical control should not be applied when it is raining. It is important to note that herbicide can also harm many non-target species and must always be used with the greatest of care. Wetlands require special care and only herbicide appropriate for wetlands should be used.

Foliar application of herbcide using the correct PPE. © Peter Emsile

Foliar application of herbicide. © Peter Emsile

Foliar treatment

Foliar treatment is when herbicide is applied to the leaves of the plant, usually by spraying.

- Spray herbicide with a knapsack sprayer, mist-blower or high-pressure sprayer firefighting unit, e.g. a bakkie-sakkie.
- The correct choice of nozzle is important to achieve an even spray cover.
- The best results can be expected in the active growing season (but some species are more susceptible to chemical absorption when they are sprayed in summer).

Blanket spraying

Blanket spraying, or broadcast spraying, is when herbicide is sprayed across an entire area of over 70% infestation. While this method is recognised, it should be used with a high level of caution due to the significant environmental risk. It is the most cost-effective way to eradicate young, dense, uniform stands of IAPs. Some IAPs, like introduced acacias, germinate by the thousands after fire. The first line of attack to reduce these numbers is the use of broadcast spraying. Calibration is crucial to ensure even distribution of herbicide over the target area (see What you need to know when calibrating your equipment, page 40, and Herbicide safety, page 52).

For more information, see Appendix 11: Choice of nozzles for invader plant control (page 67).

Aerial application

Aerial application is spraying either large-scale infestations or targeted inaccessible plants from an aircraft. While aerial application is a recognised method of IAP control, it is still under development and should be used with a high level of caution due to the significant environmental risk. Aerial spraying can only be done by registered and certified operators according to strict regulations. The pilot must ensure that the spray mixture is distributed evenly over the target area and that the wastage of herbicide, as well as drift onto indigenous species, is kept to a minimum. It is essential that the following criteria be met:

- Inform your neighbours well in advance before spraying commences.
- Use only an aerial registered product. Port Jackson (*Acacia saligna*) and rooikrans (*Acacia cyclops)* have herbicides registered for aerial application.
- Adult Port Jackson and rooikrans must be sprayed in summer (i.e. November–March) for optimum results.

Applying herbicide from a helicopter using the wand method is the most targeted, although it is still under development. © Andrew Turner

Any aerial application of herbicide needs to be certified for in-field use. © Andrew Turner

Cut stump treatment

Applying herbicide to cut stumps is a highly effective method for larger woody IAPs.

- Fell the target tree horizontally and as low as possible to the ground.
- Ensure a smooth cut surface to expose the cambium (outer rings where the trunk grows).
- Clear around the cut stump to expose side branches that also need to be cut and treated.
- Spray the herbicide mixture at a very low pressure on the freshly cut surface.
- Treat only the outside cambium layer for stumps with a diameter larger than 10 cm.
- Apply the herbicide mixture as soon as possible after the tree has been felled.
- When using a product that is mixed with penetrant oil, the entire stump and exposed roots must be treated.

The correct application of herbicide for cut stump treatment. © Peter Emsile

The correct method for the chemical frilling of trees. © Peter Emsile

Application of herbicide once the frill has been completed. © Peter Emsile

Chemical frilling

The frill method can be used to kill standing trees where felling is too difficult. Frilling refers to a series of downward cuts made in the bark around the tree.

- Use an axe to frill trees smaller than 10 cm in diameter. A chainsaw can be used for larger diameter trees, but take care to ensure that the chain is sharp because cauterising the cambium layer can prevent absorption of the herbicide.
- The cut must penetrate the bark and must be deep enough to reach the cambium layer.
- The cuts must be made horizontally and as close to the ground as possible.
- Enough herbicide must be sprayed into the cut to ensure that it runs down to the cambium layer.
- The entire circumference of the tree must be treated.

Basal bark treatment

Basal bark application can only be carried out with an oil miscible product. Oil miscible products are formulated with penetrant oil, which acts as a carrier that moves the herbicide through the bark to the cambium and eventually to the roots. Young trees and shrubs with green bark can be treated while standing with no need for felling.

- Spray the herbicide onto the stem.
- Ensure wetting of the root crown, exposed roots and stem up to a height of 0,5 m.
- Low-pressure spraying or stem paint is required to minimise spillage onto the soil.
- The entire circumference of the trunk must be treated.

Basal bark application of herbicide. © Peter Emsile

Stem injection

This treatment, whereby the chemical is directly injected into the base of the plant, is only used for prickly pear (*Opuntia* species), but is still under development. Methods suitable for use on woody species are being investigated.

9 THINGS YOU NEED TO KNOW WHEN APPLYING HERBICIDES

1 Registration

Only herbicide products registered for the particular IAP species being treated must be used.

2 Safety

Appropriate protective clothing must be worn and should be changed and washed regularly. Clothing should be removed immediately if grossly contaminated. Hygiene aids – clean water, soap, towels and eyewash – must always be available to spray operators (see Herbicide safety, page 52).

3 Weather

Application should not be carried out during unfavourable weather such as rain, wind or hot, dry conditions. Weather conditions could affect the ability to control the spread of herbicide and endanger desirable vegetation, water bodies or personnel. Poor results may be achieved if the target plants are not in a suitable condition for treatment – this includes plants that are either water stressed or waterlogged.

4 Drift

Caution must be observed to limit wind drift when using minimum output nozzles.

5 Inspection

Equipment should be inspected regularly between and during applications. Ensure that the correct nozzles are fitted and that pressure settings are checked regularly.

6 Filling

Always ensure that knapsacks are filled to the desired level (generally only 95% of the tank volume). Ensure that there is a sufficient quantity of water on site to prevent operators from running out of spray water.

An example of a herbicide camp in the field. © Rodney February / WWF

7 Spillage

Spillage must be attended to immediately and appropriately disposed of. Where spillage occurs in a storage facility with a hard surface, the following steps should be followed:

- If available, an appropriate spill kit should be used to clear up the spill.
- Alternatively, contain the spillage with lime sand or a suitable material. Never use sawdust, as this could lead to spontaneous combustion.
- Bag and dispose of the material using a reputable hazardous waste disposal company.

If a spill occurs at a clearing site:

- Bag the spill material in thick plastic bags and take it off-site.
- Dispose of the bagged material in the same way as for a spill in the storage facility.

8 Repairs

Leaking sprayers or sprayers not applying correctly should be withdrawn until repairs have been carried out. Spare applicators and parts should always be available so as not to impede operations.

9 Cleaning

Equipment must be emptied and cleaned thoroughly after spraying. The spray mixture must not be left in the apparatus overnight.

Do not under any circumstances use metal objects to clean clogged spray nozzles, as this will cause damage, affecting the flow rate, spray pattern and droplet size. Use a soft bristled brush or compressed air to clean.

Spray water that is left over after cleaning the sprayers can be sprayed out on dense stands of IAPs, but remember to respray the area the next day with the correct concentration.

Important tips to remember

- Herbicide mixing and refuelling must be conducted on a spill blanket.
- A spade must be on-site to deal with any accidental spillage.
- Keep spill kits at hand when working with hydrocarbons.
- Do not decant or mix herbicide near water bodies.
- Do not rinse herbicide equipment in water courses.
- Do not use metal objects to clean clogged spray nozzles.

THE DOS AND DON'TS OF CHEMICAL CONTROL

WHAT TO DO

- ✔ Plan the use of herbicides before the operation starts.
- ✔ Wear the appropriate safety clothing (see Personal protective equipment – What does it include? page 50).
- ✔ Use only approved herbicides.
- ✔ Only use designated knapsacks or spray bottles.
- ✔ Follow the manufacturer's instructions.
- ✔ Mix herbicide according to the label.
- ✔ For some species, an adjuvant (wetter, spreader, sticker) will be added to the spray mixture to increase the efficacy of the herbicide.
- ✔ Spray when plants are actively growing.
- ✔ Spray when the leaves are dry.
- ✔ Apply spray mixture to the entire leaf surface including green stems and branches.
- ✔ Add dye to the spray mixture to prevent over-spraying.
- ✔ Keep herbicide in a demarcated area at the spraying site, out of direct sunlight.

WHAT NOT TO DO

- ✘ Do not spray without the appropriate personal protective clothing and the correct equipment.
- ✘ Do not spray during wind, or when there is a likelihood of spray drift.
- ✘ Do not apply herbicide in the rain or on wet, damp leaves.
- ✘ Do not spray when the temperature exceeds 30 ^{0}C.
- ✘ Do not spray plants that have signs of drought stress, frost damage or have not fully developed after winter dormancy.
- ✘ Do not spray plants that are above hip height.

Cut stump herbicide application using the correct PPE.
© Rodney February / WWF

The correct set-up of a herbicide storage camp in the field.
© Guy Deacon

WHAT YOU NEED TO KNOW WHEN CALIBRATING YOUR EQUIPMENT

Calibration is the adjustment of spray equipment in order to deliver the recommended volumes of water and herbicide, taking into account the operator or machine speed across the terrain to be treated. All spraying equipment must be correctly calibrated to obtain best results and prevent wastage. Calibration is needed for every knapsack since equipment and nozzles differ. The calibration results from one knapsack cannot be used for other knapsacks.

Calibration should be carried out on site and checked frequently during application. The following should be checked:

- Correct spray pressure
- Correct nozzle size and spray pattern
- Correct nozzle output (delivery rate in litres per hectare, suggested in the herbicide label)
- Volume of application over a specific area.

WHAT IS BIOCONTROL?

Biological control, or biocontrol, is bringing in natural enemies of an IAP from their country of origin. The natural enemies will feed on and damage the IAPs, making them easier to manage and reduce the rate of spread.

Biocontrol is a good management option for several reasons:

- It is environmentally responsible as it does not cause pollution and only affects the target plant.
- It does not disturb the soil or create large empty areas where other IAPs could invade.
- Biocontrol can be self-sustaining without the need for ongoing management.
- It is a cost-effective option that is often a key part of an integrated control plan.

BIOCONTROL AGENTS

The natural enemies used in biocontrol are called biocontrol agents. They are usually plant-feeding insects, mites or plant diseases. Biocontrol agents may control an IAP in different ways, e.g. by damaging vegetative growth, or by lowering the number of seeds produced.

More than 700 biocontrol agents have been tested and released around the world. Biocontrol agents are host specific. This means they only feed on the target IAP, and cannot survive by switching to indigenous plants or crops.

If the target IAP population eventually dies out, the introduced biocontrol agents will die out with it. It is sometimes necessary to establish small reserves of healthy, mature IAPs on which the agents can survive and spread to IAPs that may have escaped the clearing process.

Galls formed as a result of *Dasineura rubiformis*, the biological control agent for black wattle (*Acacia mearnsii*). Female midges lay their eggs in the flowers and the flowers become galled rather than going on to produce bunches of seed pods.

SAFETY REGARDING THE USE OF BIOCONTROL

The use of living organisms is never entirely risk free, but modern methods of biocontrol are very safe. Biocontrol has been used for over 100 years in South Africa. It has become an accepted and common practice in many countries. There are safety measures in place to ensure that biocontrol does not harm natural ecosystems.

Scientific research

There is a lot of scientific research on biocontrol. Biocontrol scientists are constantly working to expand and build on the current knowledge. They publish their research in reputable scientific journals and share their results at international conferences. Biocontrol scientists are careful to maintain their excellent safety record.

Choice of agents

Biocontrol agents are very carefully selected before release. They are usually chosen to be specific to the target IAP, so they cannot harm any other plants. There have been advances in molecular techniques that have made host-specificity testing more accurate and less time consuming.

Testing

Before any biocontrol is carried out, rigorous scientific safety tests are conducted under strict quarantine. It may take several years to test a single biocontrol agent before it is released.

Regulation

Different countries have different regulatory processes for biocontrol. Regulations are used to decide whether or not a biocontrol agent is safe for release in a particular country. Scientists and regulators are getting better at weighing up the risks and benefits. Usually, approval from the relevant authority is required before biocontrol agents are released.

THE BENEFITS OF BIOCONTROL

Around the world, the benefits of biocontrol are impressive. Biocontrol has been responsible for ending some very damaging IAP invasions. It is also more cost effective than many other IAP control methods. It was estimated in 1998 that biocontrol programmes had already saved South Africa R1,38 billion in IAP control costs. However, biocontrol agents can have varying degrees of effectiveness.

Complete control

Some biocontrol agents have been very successful at suppressing the target IAPs. When biocontrol is successful, it can sustain this benefit for decades, without any further investment or management.

Management aid

Biocontrol agents can help to reduce the density or spread of IAPs to a more easily managed level. These invasions can then be addressed using other control methods. The land user must then consider how best to integrate the use of the biocontrol agents with other control methods.

Limited effect

There are some instances where a biocontrol agent does inflict damage on the IAPs, but it is not enough to bring the invasion under control. In a few cases, biocontrol agents fail to become established in the introduced environment. A suitable biocontrol agent may not be available for some IAPs.

Long term

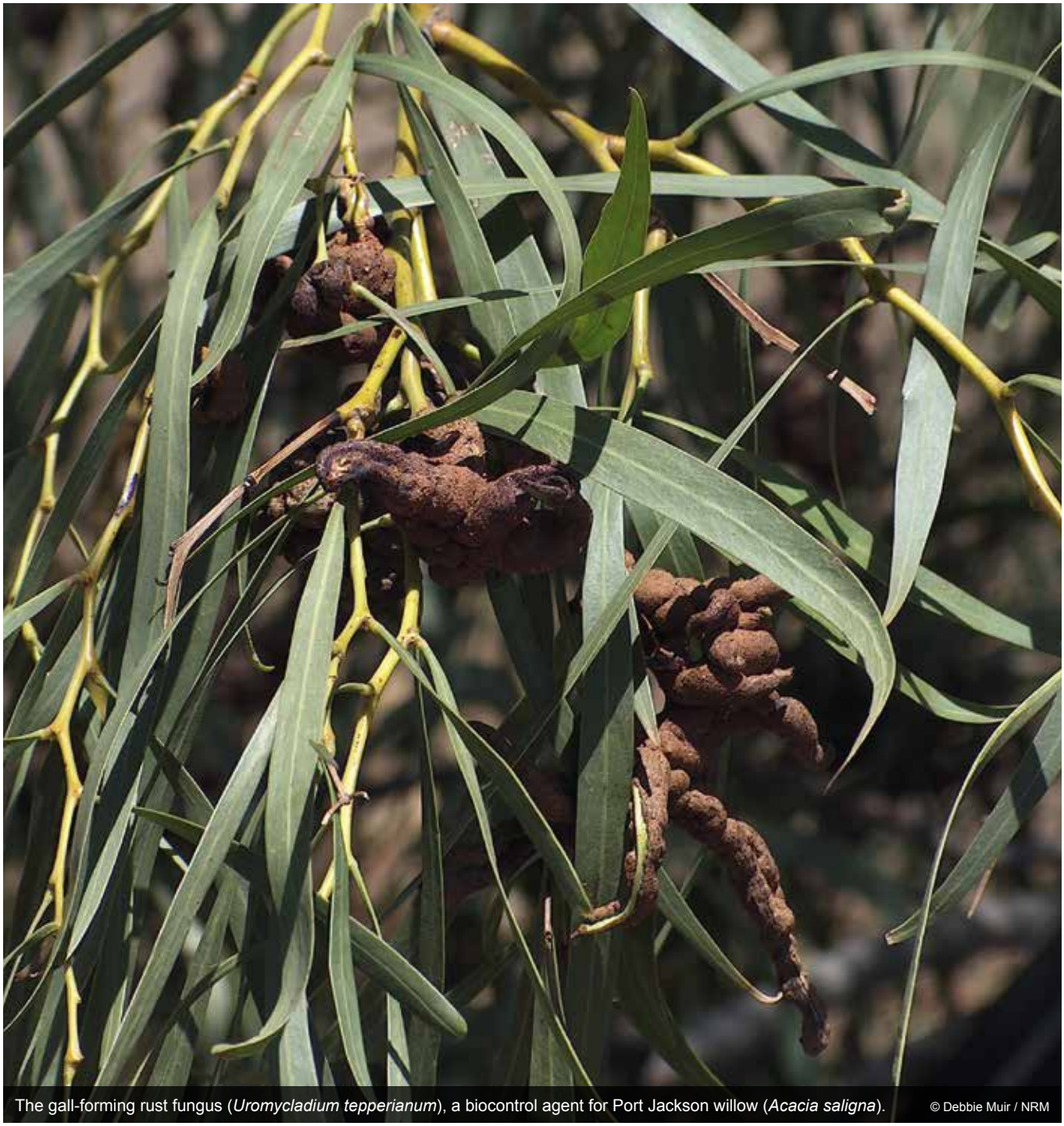
It is important to understand that biocontrol is often a long-term strategy. It is usual for biocontrol agents to take 10 to 20 years to build up large enough numbers to control the target IAPs. Often, biocontrol has been discounted too early because the IAP problem is not solved within a few months or years.

Dr Alan Wood of the Agricultural Research Council applying the biocontrol stink bean fungus spores to stink bean plants in the field.

EXAMPLES OF BIOCONTROL AGENTS IN SOUTH AFRICA

Over the years, several biocontrol agents have been approved and released for IAPs in South Africa (Table 4 on the next page). Some invasive alien plants are at present under effective biological control. In these instances, further time and money need not be wasted on additional clearing methods. Examples are:

- Silky hakea (*Hakea sericea*) in areas where the climate enhances gummosis disease and other agents;
- Sesbania (*Sesbania punicea*) after the introduction of all three insect agents;
- Red water fern (*Azolla filiculoides*) which has been brought under control by a frond-feeding weevil;
- Harrisia cactus (*Harrisia martinii*) after the establishment of the mealy bug;
- Australian pest pear (*Opuntia stricta*) after the establishment of cochineal.



The gall-forming rust fungus (*Uromycladium tepperianum*), a biocontrol agent for Port Jackson willow (*Acacia saligna*). © Debbie Muir / NRM

Table 4: Biocontrol agents and their effectiveness

Biocontrol agent	Year introduced	Damage to plant	Comments
Silky hakea (*Hakea sericea*)			
Erytenna consputa (seed-feeding weevil)	1970	Extensive	
Carposina autologa (seed-feeding moth)	1970	Moderate	
Cydmaea binotata (leaf/shoot-boring weevil)	1979	Trivial	
Aphanasium australe (stem-boring beetle)	2001	Moderate	Limited in distribution and destroyed in areas prone to wildfires
Dicomada rufa (flower bud-feeding weevil)	2006	Moderate	Established only in the southern Cape to date
Colletotrichum acutatum (gummosis fungus)	Indigenous	Considerable	Performs best in wet cold conditions
Rock hakea (*Hakea gibbosa*)			
Erytenna consputa (seed-feeding weevil)	1979	Trivial	Negligible, but priority species for future biocontrol
Carposina autologa (seed-feeding moth)	1979	Trivial	
Port Jackson willow (*Acacia saligna*)			
Uromycladium morrisii (gall rust fungus)	1987	Extensive	Control almost complete; around 85% of adult plants killed
Melanterius castanaeus (seed-feeding weevil)	2001	Considerable	Seedling regrowth problems
Long-leaved wattle (*Acacia longifolia*)			
Trichilogaster acaciaelongifoliae (bud-galling wasp)	1982	Extensive	Almost complete control achieved
Melanterius ventralis (seed-feeding weevil)	1985	Extensive	
Golden wattle (*Acacia pycnantha*)			
Trichilogaster signiventris (bud-galling wasp)	1987	Extensive	Almost complete control achieved
Melanterius maculatus (seed feeding weevil)	2005	Moderate	
Baileys wattle (*Acacia baileyana*)			
Melanterius maculatus (seed-feeding weevil)	2006	Trivial	*D. pilifera* first released and established in 2016
Dasineura pilifera (bud-galling midge fly)	2016	Too early to tell	Site destroyed by fire; new releases in 2019
Pearl acacia (*Acacia podalyriifolia*)			
Melanterius maculatus (seed-feeding weevil)	2008	Trivial	
Black wattle (*Acacia mearnsii*)			
Melanterius maculatus (seed-feeding weevil)	1995	Moderate	Both agents have most impact in winter rainfall regions
Dasineura rubiformis (flower-galling fly)	2001–06	Extensive	Establishment and impact far less successful in summer rainfall regions
Silver wattle (*Acacia dealbata*)			
Melanterius maculatus (seed-feeding weevil)	2001	Moderate	Moderate in the Western Cape, trivial elsewhere
Dasineura pilifera (flower-galling fly)	2018	Unknown	The fly is a new introduction
Green wattle (*Acacia decurrens*)			
Melanterius maculatus (seed-feeding weevil)	2001	Moderate	Moderate in the Western Cape, trivial elsewhere
Australian black wood (*Acacia melanoxylon*)			
Melanterius maculatus (seed-feeding weevil)	1986	Extensive	Majority of seeds destroyed
Rooikrans (*Acacia cyclops*)			
Melanterius servulus (seed-feeding weevil)	1994	Extensive	High proportion of seeds destroyed (96% or more at many sites)
Dasineura dielsi (podlet-galling midge fly)	2002	Considerable	
Australian myrtle (*Leptospermum laevigatum*)			
Aristaea thalassias (leaf-mining moth)	1996	Trivial	Both agents are abundant but control is negligible
Dasineura strobila (bud-galling midge fly)	1994	Trivial	
Red sesbania (*Sesbania punicea*)			
Trichapion lativentre (bud-feeding weevil)	1970	Extensive	Complete control in most areas
Rhyssomatus marginatus (seed-feeding weevil)	1984	Extensive	Some isolated patches need weevils introduced
Neodiplogrammus quadrivittatus (stem-boring weevil)	1984	Extensive	
Stink bean (*Paraserianthes lophantha*)			
Melanterius servulus (seed-feeding weevil)	1989	Considerable	High levels of seeds destroyed at many sites
Uromycladium woodii (gall-forming rust fungus)	2016	Unknown	
Mesquite (various hybrids of *Prosopis* species)			
Algarobius prosopis (seed-feeding weevil)	1987	Considerable	High levels of seeds destroyed by *A. prosopis* but control is negligible
Neltumius arizonensis (seed-feeding weevil)	1993	Unknown	

HOW CAN ONE RESPONSIBLY MANAGE PLANT MATERIAL?

Invasive alien plant clearing produces large amounts of dead and dying plant material. An excessive amount of plant material can present a fire hazard and, if washed down rivers, can damage infrastructure and riverbanks. This plant waste needs to be responsibly disposed of.

Make use of the waste

Plant material should be used beneficially wherever possible. This includes a wide range of options like charcoal, timber, or even using the cut material to generate electricity where facilities are available. It may be possible to use some material for basket making or animal feed. Wood can be made available to the local community for firewood. This use can offset the costs of IAP management or create a local economic opportunity. However, care must be taken not to distribute seeds or vegetatively growing material (e.g. *Cactus cladodes*) as it could give rise to new infestations.

Chipping and composting

Woody and dry material can be chipped and used as mulch, but beware of the risks of using chips that may contain IAP seed. Wet material and aquatic weeds should be combined with other organic matter and composted. Composting is not appropriate if the material contains seeds. Chipping can also be used to make a range of products, such as pellets for animal feed or fertiliser.

Burning on site

Burning the material on site presents risks that need to be managed appropriately. Burning should only be attempted by suitably (in terms of the relevant legislation) equipped and competent personnel. Material can be stacked in several ways before being burnt (see Integrated planning for fires and IAPs – Why is it important? page 24).

Landfill

Material that cannot be used, stacked or burnt must be disposed of at a registered and approved disposal site. Plant material can take up valuable space in a landfill, so other disposal options are preferable first. When removing material, take care to remove all debris, including shoots and seeds.

Stacking

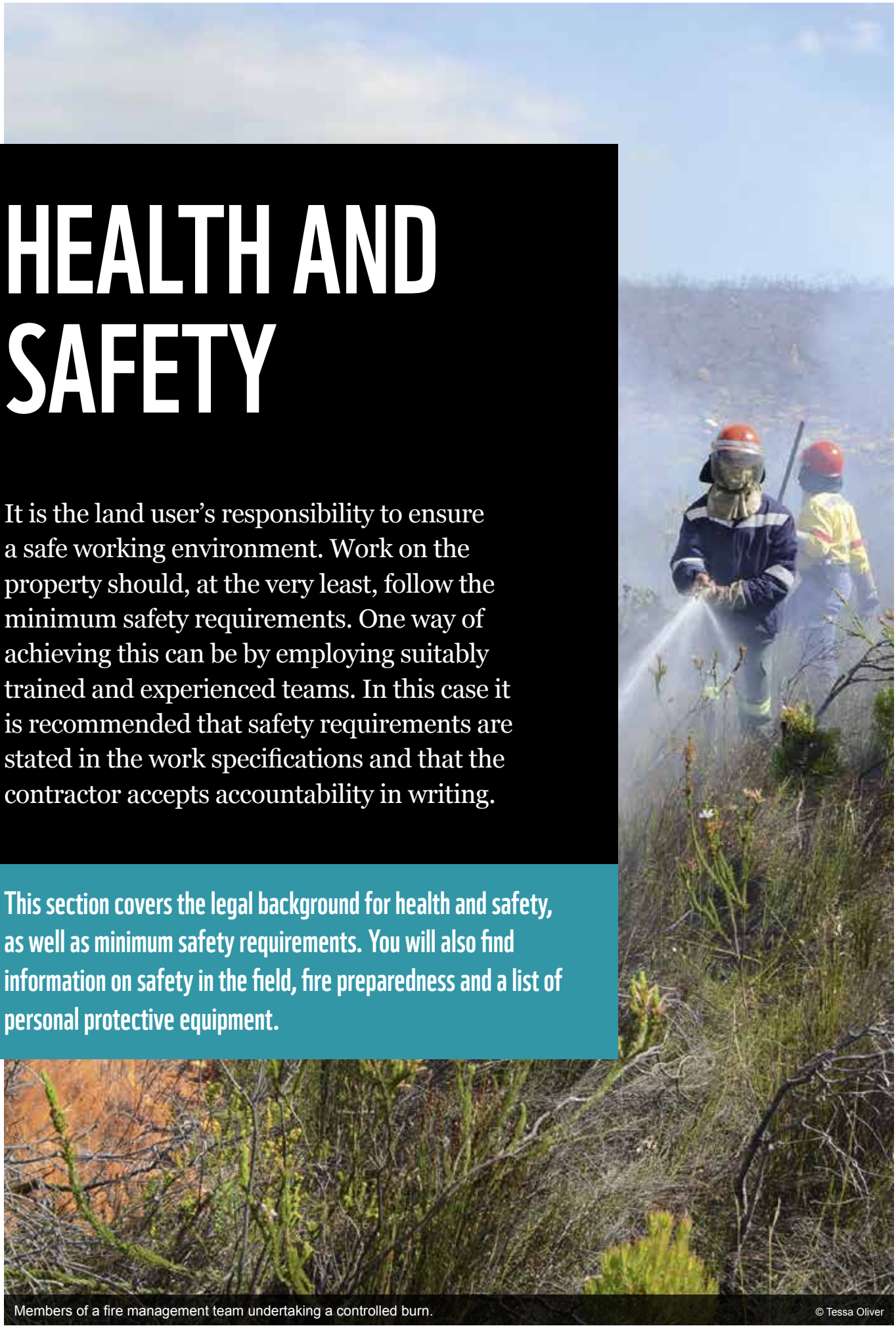
Stacking the cut material in heaps or windrows along mountain contours can help to reduce erosion. This also facilitates easy access for follow-up, and assists in containing the fuel load and reducing the risk of uncontrolled wildfires. The stacking method will depend on the IAP species, the clearing methods used, the habitat and the fire history of the invaded area.

- Stack removed material into piles of 2 m high and 3 m wide.
- Keep stacks well apart to prevent fires from crossing, not less than 10 m apart – this is naturally dependent on the size of the stack and the resulting fire intensity when the stacks burn.
- Stack light branches separately from heavy timber (diameter of 150 mm and more) – this helps if communities are dismantling stacks for firewood.
- Preferably remove heavy branches to reduce long-burning fuel loads that can result in soil scars from intensely hot fire, and the need for increased fire surveillance after burning.
- Stack brushwood rows along the contour if on a slope.
- Do not make stacks under trees, power and telephone lines, within 30 m of a firebreak or near water courses, houses and other infrastructure.
- Distribute the team along natural open areas for stacking as productivity will be improved if workers are not working too close to one another. In this way they will not get in one another's way and will be able to stack more freely and safely.

HEALTH AND SAFETY

It is the land user's responsibility to ensure a safe working environment. Work on the property should, at the very least, follow the minimum safety requirements. One way of achieving this can be by employing suitably trained and experienced teams. In this case it is recommended that safety requirements are stated in the work specifications and that the contractor accepts accountability in writing.

This section covers the legal background for health and safety, as well as minimum safety requirements. You will also find information on safety in the field, fire preparedness and a list of personal protective equipment.



Members of a fire management team undertaking a controlled burn. © Tessa Oliver

WHAT ARE THE MAIN PILLARS OF HEALTH AND SAFETY LEGISLATION?

IAP management involves manual labour with dangerous machinery and hazardous chemicals. It is important that everyone understands the risks and responsibilities. Taking the necessary measures to ensure health and safety makes the difference between a high-risk and a risk-free work environment.

In South Africa, the most important legislation for health and safety is the Occupational Health and Safety Act 85 of 1993 (OHSA). The two main pillars of this Act are:

1 Employer duties and responsibilities

Employers are responsible for making sure that all employees understand the risks and hazards in the workplace. Communication is critical under the OHSA, so workers must be informed of dangers at the workplace. Health and safety information must be communicated to all employees.

2 Employee duties and responsibilities

Employees are responsible for their own health and safety. They should also take reasonable care of those around them. Employees must cooperate with any health and safety rules by obeying all lawful instructions.

A Working for Water clearing team in the field, using the correct PPE. © Rodney February / WWF

WHAT ARE THE MINIMUM SAFETY REQUIREMENTS?

The landowner should check with the contractor or the contractor's staff to make sure the minimum health and safety requirements are met.

Safety representatives

Due to the risks (or the nature of the work) involved in IAP clearing, the employer should appoint a safety representative. The employer must explain to the workers' organisation what responsibilities the safety representatives will have. The safety representative should be available on site.

Safety committees

In every workplace where there are two or more safety representatives, there must also be a safety committee. This committee must meet at least every three months. The committee must deal with all health and safety issues that affect workers. Safety committees have certain functions and powers. You can find out more about these by contacting the Department of Labour.

Emergency contacts

All teams should be aware of the correct emergency contact details for the ambulance service, South African Police Service, Poisons Information Helpline, COVID-19 public helpline, as well as directions to the nearest hospital, clinic or doctor. Detailed procedures should be drawn up for dealing with emergencies, including fuel, oil and herbicide spills.

Water

Clean water must be available in suitable, clearly marked containers for drinking and mixing herbicides.

Toilet facilities

The contractor or land user should provide a mobile toilet on site for the duration of the work.

Training

Only correctly trained staff can perform quality work. If the land user or contractor is unaware of what training is required, they should consult the local Department of Labour office. It is the employer's duty to give training to workers who use dangerous machinery and materials, and to make sure they know the safety precautions.

Team skills

Chainsaw operators should have valid certificates and members of the team who apply the herbicide should be certified.

Work methods and equipment

Equipment must be suitable for the work and in good working order. All work methods set out in the project specifications should be followed. Dangerous machinery must carry warnings and notices. Workers should be prevented from using dangerous machinery and materials unless all safety rules have been followed.

Compensation for Occupational Injuries and Diseases (COID)

The contractor must have a valid certificate of good standing from the Compensation Commissioner. An indemnity form must be signed stating that the contractor accepts full liability for any COID-related matters and that the land user will not be held liable should the contractor not comply with the minimum health and safety standards.

Accident and incident register

Any incident must be reported to the land user. A register of near misses, incidents and accidents must be kept. If an accident occurs, evidence must not be moved until a Department of Labour inspector has given permission, unless someone has been badly injured and needs treatment.

Insurance

The contractor must be insured for vehicles and equipment, and must provide proof of third-party and liability insurance.

It is important to:

- Ensure that all Covid-19 safety protocols are adhered to.
- Sign an agreement whereby the contractor accepts liability for damages in case of negligence.

HOW CAN A LAND USER ENSURE SAFETY IN THE FIELD?

Safety is all important in the field. There are two areas of safety that the land user must be aware of: staff safety and environmental safety.

Staff safety is only possible if the team has the correct mental attitude and have had appropriate training. Only then is personal protective equipment (see Personal protective equipment – What does it include?, page 50) and first aid effective. Supervision by someone who knows the work will help to ensure the safety of workers.

Environmental safety is achieved through correct choice of IAP control methods and herbicides, proper field storage and waste disposal (in a waste bin or a refuse bag on site for the collection of waste material and to prevent littering), and good team training. It is important to keep the workplace open so that workers can escape from danger if necessary, and to have adequate field-safety measures in place.

Toolbox talks

A "toolbox talk" is a safety meeting that focuses on safety topics related to the specific job. Meetings are short and conducted at the job site before a job or work shift begins. They are an effective way to refresh workers' knowledge, cover last-minute safety checks, and exchange information with workers. Toolbox talks help to open up discussions about safety at the job site and to promote a culture of safety.

First aid

The regulations state that an employer should take reasonable steps to make sure that someone who is injured at work gets prompt first-aid treatment. If there are more than 10 employees at a workplace, the employer needs to appoint a first aider. This is a compulsory legal appointment, and the first aider should be readily available during normal working hours. The first aider should have a valid first-aid certificate, issued by a person or organisation approved by the chief inspector. Where pesticides, hazardous chemical substances or hazardous activities are involved, the first-aid worker should also be trained to treat the types of injuries that may result. A fully stocked first-aid kit must be available on site.

Camps

Camps and equipment should not be placed in environmentally sensitive areas, but in a shady spot that has been demarcated before activities commence on site. All rubbish should be collected and disposed of off site. Waste bins should have lids that shut firmly. No waste should be burnt.

Storage of herbicides and fuel

Fuel and herbicides must be left in a shady area, away from the resting/eating area. The area must be clearly marked with danger tape, which must be removed on completion of the job. Herbicide mixing must be conducted on a spill blanket. A spade must be on site to deal with any accidental spillage. Keep spill kits at hand when working with hydrocarbons. Do not decant or mix herbicide near water bodies and do not rinse herbicide equipment in water courses.

Herbicide equipment can be cleaned back at the herbicide store (shed) where there is running water. It should not be cleaned in the field, especially not near water courses. Collect the water still containing herbicide and apply it to dense stands of IAPs, which can be resprayed with the correct concentration later.

No oil, petrol or diesel should be allowed to spill onto the ground or into a stream or river. Drip trays should be used when refuelling, parking overnight or carrying out repairs to machinery. When refuelling on site (e.g. using 200 litre drums), the proper dispensing equipment must be used and the drum should not be tipped in order to dispense fuel.

Transport

The National Road Traffic Act 93 of 1996 is very clear on what is required for safe transport. It is the employer's responsibility to see that all transport meets these requirements. Some of the basic requirements include the following:

- Vehicles must be roadworthy
- Drivers must be in possession of a valid professional driving permit (PrDP)
- Passengers must be seated and have safety belts
- No hazardous substances should be carried in the same compartments as passengers or food and water
- Tools must be transported in a trailer, separately from the workers.

Preventing fires

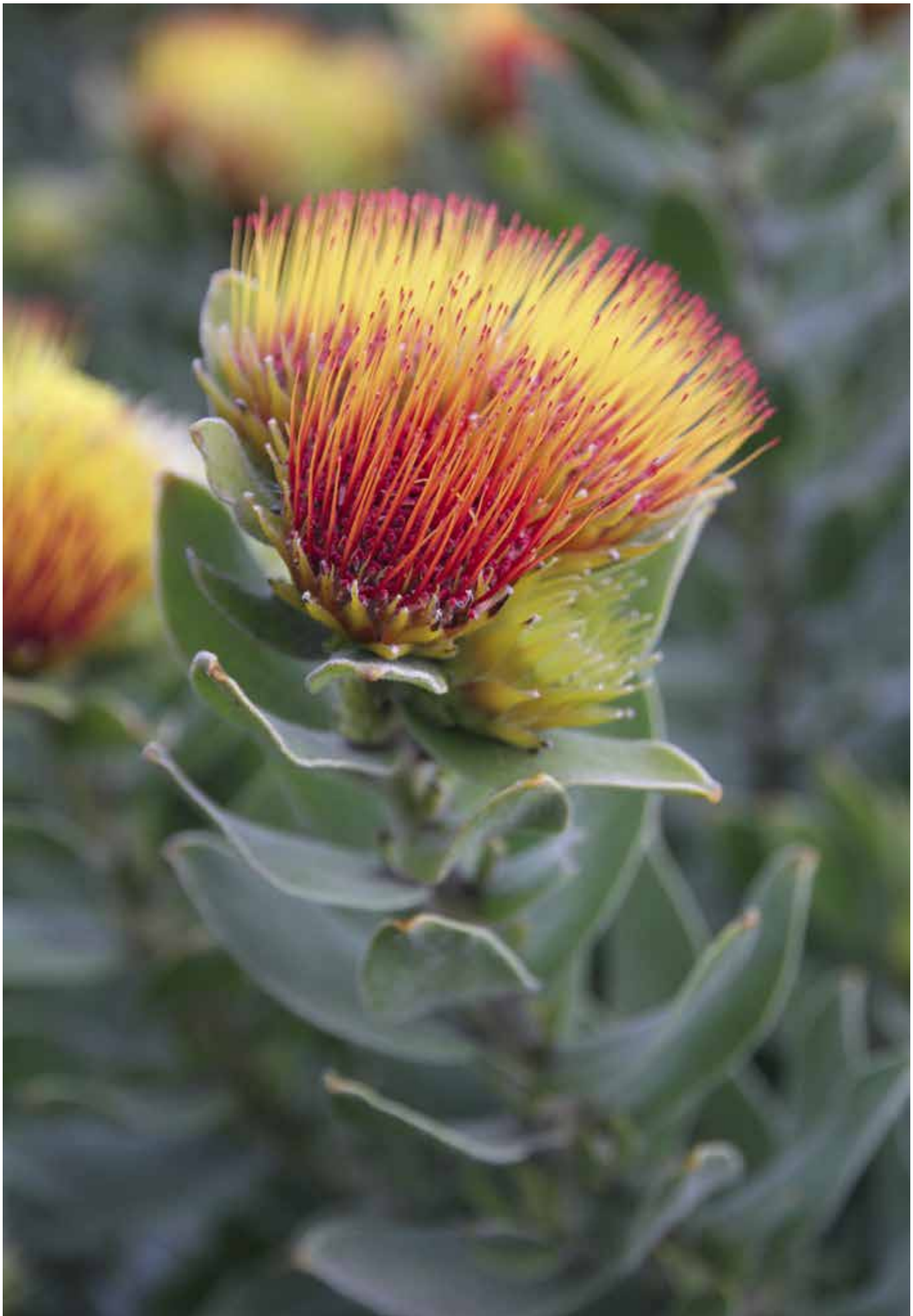
No smoking should be allowed while working. Assign a designated smoking area, remove cigarette butts, and prohibit smoking during windy conditions. No chainsaw work should be done during Code Orange and Red days (Fire Danger Indices are obtainable from the Fire Protection Association). Keep one fire beater for every team member within reach of the workers. A serviced and functional fire extinguisher must be kept at the fuel refilling area (see How to prepare for and manage wildfires, page 25).

PERSONAL PROTECTIVE EQUIPMENT – WHAT DOES IT INCLUDE?

Personal protective equipment (PPE) or personal protective clothing, such as chemical resistant plastic aprons, gloves and eye protection, is worn to protect workers from injury or harm when conducting IAP control. PPE should be of the correct standard (approved by the South African Bureau of Standards) for the task.

Table 5: Examples of personal protective equipment worn during IAP clearing operations

Item	Supervisor	Machine operator	General workers	Herbicide applicator
Conti suit (overall)	✔	✔	✔	✔
Gloves	✔	✔	✔	✔
Gumboots (when working in wet areas)	✔	✔	✔	✔
Rain suit (during rainy conditions)	✔	✔	✔	✔
Safety boots	✔	✔	✔	✔
Safety goggles	✔	✔	✔	✔
Sunhat	✔	✔	✔	✔
T-shirt	✔	✔	✔	✔
Hard hat	✔		✔	✔
Whistle	✔	✔		
Chainsaw operators' gloves		✔		
Chainsaw safety boots		✔		
Chainsaw safety pants (11 layers) with broad belt or braces		✔		
Safety helmet (EU standard)		✔		
Shin-guards for brush cutters		✔		
Cape (when using a knapsack)				✔
Mask (when applying herbicides)				✔
Rubber apron (for mixing herbicides)				✔
Rubber gloves (for mixing herbicides)				✔



Indigenous Overberg pincushion (*Leucospermum oleifolium*) in Kirstenbosch National Botanical Garden. © Helen Stuart / WWF

HERBICIDE SAFETY

Herbicides are chemicals used to kill unwanted plants. Herbicides can be very effective for controlling some types of IAPs. However, they can be hazardous or toxic, and cause harm to people, animals, other plants and the environment.

In this section, information is given on herbicide labels and the safe storage, mixing and disposal of herbicides. Following these precautions will help to reduce the risks associated with these chemicals.

A blue dye mixed with herbicide (which is often colourless) clearly identifies stumps that had been treated.

WHAT IS ON THE HERBICIDE LABEL?

The herbicide label will give details about how the herbicide should be prepared and applied. The Material Safety Data Sheet (MSDS) gives information on the hazardous ingredients, health risks, fire risk, emergency procedures, and more. MSDSs can be found on the Internet or from the dealer.

Concentration

The concentration gives the amount of herbicide that should be diluted in water for use in foliar spray. It is expressed as a percentage (%) or as a volume per volume (v/v). For example: 0,75% in 100 litres of water means you need 75 ml in 10 ℓ of water, or 7,5 ml in 1 ℓ.

Dosage

Dosage tells you the volume of herbicide that needs to be used per area for blanket spraying, e.g. 1,5 ℓ per hectare.

Rate of application

The rate of application gives the volume of mixture that needs to be used per area for blanket spraying, e.g. 1,5 ℓ of product to be applied in 400 ℓ of water per hectare.

For more information, see Appendix 12: Example of a herbicide mixing rate table (page 67).

An in-field herbicide mixing station with the correct safety precautions in place. © Carlo de Kock / SANParks

HOW TO STORE HERBICIDES

Herbicides should be stored correctly to prevent leakage and contamination.

Isolation

The herbicide store (shed) should be a separate building, more than 5 m from the dwelling house, livestock buildings or where fodder, fuel or flammable materials are stored. The store must be totally sealed off, with no free movement of air between the storage area and other areas. The location of the store must minimise possible pollution risk from spilt chemicals. It should be situated away from water sources, rivers, dams, boreholes and areas likely to be flooded. It should be in a location that can be supervised.

Accessibility

The store should have easy access for delivery and dispatch. In an emergency, it should be possible to approach the building from all sides.

Floor

Smooth, screeded concrete is the ideal flooring. Sealed steel-container floors are also acceptable. Earth, timber, bitumen, PVC, linoleum and coarse unscreeded or disintegrating concrete is not acceptable. The floor surrounding the doorway should be bunded (a ridge to contain spillage) to a height of 200 mm. The bunded area should be able to store 110% of the liquids kept in the store. All floor joints and doorways should be watertight.

Walls

Walls should be made of bricks or concrete blocks with vents 200 mm from the floor and near roof level. Repurposed shipping containers are acceptable if there is adequate ventilation. The container should be placed in a shaded area.

Roof

The roof should be leak-free and insulated to keep temperatures at a reasonable level. A vent in the roof will allow hot air to escape during the summer months. If possible, an extractor fan should be installed.

Doors

Steel doors with an effective locking system are preferred. Wooden doors should have security gates to reduce the risk of forced entry. Containers with fitted security gates can be left open to cool the contents during the heat of the day. Only authorised personnel should have access to keys and be allowed in the store.

Windows

Windows should allow enough light into the store to be able to read product labels. All windows should be weather proof, burglar barred and preferably at head height for security reasons.

Lighting

There should be sufficient lighting to allow for the reading of product labels. If electric lighting is required, it must be secure to reduce the risk of fire. The mains control should be outside the store itself.

Sanitation

Staff should have immediate access to washing facilities with running water, soap and towels. They should be encouraged to use these facilities frequently. An eyewash bottle or similar must always be available for the flushing of contamination from the eyes, should it occur. A shower facility is also recommended.

Equipment

The room should be equipped with a suitable table for the reading of labels and decanting and measuring of herbicides. Measuring jugs, funnels, pumps and buckets must be kept on hand. These items must be kept specifically for use with herbicides – do not use household items. Have on hand a broom, spade and a supply of dry, fine soil or spill-absorbing material (not sawdust) that is fire resistant to contain and absorb spills.

Fire extinguisher

A fire extinguisher should be mounted on the outside of the storage facility.

Emergency numbers

The store should have well-displayed emergency contact numbers, e.g. ambulance, medical doctor, Poisons Information Helpline, fire brigade, etc.

Labels

All containers should be labelled accordingly. The Material Safety Data Sheets should be placed on the wall behind the product.

For more information, see Appendix 13: AVCASA's Storing agrochemicals and stock remedies (page 67).

HOW TO MIX HERBICIDES

Many herbicides require mixing with water to dilute them, or with other additives to improve their effectiveness. Products should be mixed according to instructions on the label.

Water

Only clean water should be used for spray mixtures. The product label should be consulted regarding the quality of water suitable for a particular herbicide. Where particulate matter occurs in water (e.g. water from rivers), the water must be filtered to avoid nozzle blockages. When large volumes of water are transported over rough or uneven terrain, which causes the water to move from side to side, tanks should be fitted with tank baffles because the vehicle can be easily overturned by the pure weight of the water.

Adjuvants

There are several types of surfactants[4] that may need to be added to spray mixtures to increase the efficacy of the herbicide. Each product label will specify which adjuvant/surfactant is recommended with the product to optimise its performance. Contact the manufacturer or distributor for advice on the use of these agents. The contact numbers will be printed on the product label.

- Wetting and spreading agents should be mixed in accordance with label recommendations.
- Dye must be added where the product has no built-in dye. Dye helps to show where target species may have been missed or herbicide spilled.
- In areas where water is alkaline, a buffering agent may be necessary. Buffers should be added to water before the herbicide.
- In sensitive areas where drift must be controlled, the use of drift-control agents may be necessary.

Containers

All containers into which herbicides are decanted must be clearly marked with the contents and the dilution. A copy of the original label must be secured to the container. Mixtures should never be decanted into drinking bottles or food containers, as this is a serious safety risk. Suitable equipment must be available to prepare spray mixtures. These include plastic measuring cylinders and beakers, mixing containers (buckets) and funnels.

See What is on the herbicide label? (page 53) for more information.

Safety

The person responsible for mixing must take extra precaution since they are working with an undiluted product that can burn or irritate the skin and eyes.

- Wear suitable protective clothing when handling concentrates (see Personal protective equipment – What does it include? page 50).
- Mix the herbicide according to the label instructions, on a spill blanket.
- Add liquid concentrates to a half-full tank, and then top up the tank.
- Do not mix concentrates together before adding them to the tank.
- Follow the label instruction about when to add adjuvants – before or after mixing the herbicide.
- When a buffer is needed to stabilise the water at the desired pH, first add the buffer, measure the pH of the water to ensure that the correct pH has been reached, and only then add the herbicide to the spray water.
- Proper mixing in knapsacks and hand-held applicators is difficult; mix spray mixtures in bulk containers before pouring into the knapsacks or applicators.
- Agitate spray mixtures continuously, especially after they have been standing for a while.
- Do not wash or rinse spray equipment or containers in or near natural water systems, but take them back to the herbicide store (shed) where wash water can be safely stored in drums for future use as mixing water, without the risk of contaminating the natural environment.

[4] Surfactants lower the surface tension between substances and may act as wetting agents, emulsifiers, foaming agents or dispersants.

PRECAUTIONARY MEASURES WHEN HANDLING HERBICIDES

The handling of herbicides requires strict precautions to protect people, animals, non-target plants and the environment.

Clothing

Suitable protective clothing should be worn. These include chemical resistant plastic aprons, gloves and eye protection (see Personal protective equipment – What does it include? page 50).

In the field

Special care must be taken when handling herbicides in the field.

- Herbicides should only be kept on site in appropriate, clearly demarcated storage areas (see How can a land user ensure safety in the field? page 49).
- Care must be taken to prevent damage to desirable vegetation.
- Application equipment and containers should not be cleaned on site.
- Spray mixtures and equipment must not be left unattended where there is a danger of theft or misuse.
- Products should not be left uncovered in the sun.
- Plans must be in place to prevent spillage, and clean up and dispose of any spilled material.

Spillage

In the case of accidental spillage, the spill must be contained immediately. Suitable absorbent material, such as fine, dry soil, must be available to clean up spillage. Contaminated material should then be disposed of at an approved hazardous waste site. Adequate hygiene aids such as plentiful clean water, soap, towels and eyewash must be readily available.

Transporting

Herbicides and application equipment must be transported separately from people, food and clothing. Herbicides and equipment must be secured to prevent spillage and damage. Vehicles should carry absorbent material to absorb any spillage (see How can a land user ensure safety in the field? page 49).

For more information, see Appendix 14: CropLife International's Responsible Use Manual (page 67).

Since herbicides are hazardous to people and the environment, precautions must be taken to limit risks.

Public safety

Bystanders in the vicinity of herbicide storage and application areas must be well informed and protected from harm.

- The public should be kept out of operational areas where hazards exist.
- The public should be informed of control operations in their area by means of verbal communication, notices, pamphlets, the press, etc.
- Warning notices should be displayed where necessary.
- Product and spray mixtures should be stored so that they are inaccessible to the public.
- Treatment of areas within 50 m of homes and public areas (e.g. parks) should be avoided or only carried out in consultation with the parties affected.

Environmental safety

Steps must be taken to minimise the impact of herbicide use in IAP clearing operations on the natural environment.

- Area contamination must be minimised by careful, accurate application with the lowest amount of herbicide to achieve control of IAPs.
- To avoid damage to indigenous or other desirable vegetation (like crops), herbicides should be selected that will have the least effect on non-target vegetation.
- Coarse-droplet nozzles should be fitted to avoid drift onto neighbouring vegetation and crops.
- All care must be taken to prevent contamination of water bodies. This includes due care in storage, application, cleaning of equipment and disposal of containers, products and spray mixtures (see Safely disposing of empty containers and leftover spray mixtures, page 57).

SAFELY DISPOSING OF EMPTY CONTAINERS AND LEFTOVER SPRAY MIXTURES

In addition to taking care that the cleaning of equipment does not contaminate the environment, used containers and leftover spray mixtures should be disposed of with great care.

Used containers

Used herbicide containers must not be used for any other purpose and must be destroyed after use.

- A designated person should be responsible for safely disposing of used containers.
- Under no circumstances should containers be taken home for personal use.
- Empty herbicide containers will not be accepted back by the supplier. It is the purchaser of the product's responsibility to deal with empty herbicide containers according to the CropLife regulations.
- All empty containers must be returned to the herbicide store (shed) from where they were issued. The designated storeman will then triple rinse the containers, puncture and flatten them and send them away for recycling or destruction by an authorised organisation.

Leftover spray mixture

Only sufficient herbicide spray mixture that can be used in a day should be prepared. However, if it starts to rain and spraying cannot continue, leftover spray mixtures must be handled appropriately.

- Leftover mixed herbicide should be returned to the herbicide store (shed) for safe storage and reuse, if appropriate. Containers must be clearly labelled with the herbicide name and dilution.
- The spray mixture (or washings) can be kept in drums and used for 'spray water' when the same herbicide is required for the same species. In this case, the herbicide needs to be added to the spray mix again to compensate for chemical breakdown.
- Certain spray mixtures should not be left standing overnight and should be safely disposed of. Consult the product label.

Refilling herbicide spray bottles at a herbicide camp.

For more information, see Appendix 15: CropLife's Resources on Container Management (page 67).

LONG-TERM REHABILITATION

Clearing IAPs is an important part of rehabilitating infested land, and often a first step in any rehabilitation project. Rehabilitation work needs to be carried out by people with adequate skills to avoid damage to the remaining natural ecosystems.

Here, you will find an overview of the reasons for rehabilitating cleared land, the types of rehabilitation and the phases in a rehabilitation project. Useful resources with more detailed information on rehabilitation are suggested.

Regrowth of indigenous vegetation at an active restoration site in the Kouga catchment in the Eastern Cape. © Saskia Fourie / WWF

WHY REHABILITATE?

The need to tackle the threat of IAPs has been recognised for many years. But it is only more recently that we have started to realise what an important role rehabilitation can and should play in the process.

The removal of IAPs is the first step in addressing their negative impacts, but in some situations the natural area, such as rivers, have degraded to such a degree that they are not able to self-restore and their ability to deliver basic functions, e.g. flow and filtration, has been compromised. In these cases, additional interventions in the form of active restoration, such as seeding or planting, are required to return the area's natural functions and prevent further degradation. The establishment of an indigenous vegetation cover also suppresses alien regrowth and is a prerequisite for the long-term control of IAPs.

Intact, functioning natural ecosystems, which are called our "natural infrastructure", provide society with a number of goods and services (Figure 3).

Figure 3: Ecosystem services

CLEAN AIR	Ecosystems produce oxygen and also purify and detoxify the air
CLEAN WATER	Ecosystems provide us with clean water and store and cycle fresh water
CLIMATE	Ecosystems regulate the climate and provide resilience against the impacts of climate change
HEALTHY SOIL	Ecosystems form topsoil and prevent erosion and flood damage
RAW MATERIALS	Ecosystems produce raw materials, foods and medicines

Rehabilitating the cleared land will ensure that natural infrastructure can keep producing the benefits that people derive from nature. By planting back lost or endangered species, we can prevent extinction, maintain biodiversity, reverse the loss of species and help restore the way the natural environment functions.

WHAT ARE THE BASIC PRINCIPLES OF REHABILITATION?

Although one should always strive to avoid degradation in the first place, this is not always possible and rehabilitation might be necessary. Rehabilitation can differ from area to area, depending on the situation. However, all rehabilitation projects follow the same four basic principles.

4 BASIC PRINCIPLES OF REHABILITATION

1 Halt degradation

Identify what is causing degradation to the natural ecosystem and take measures to stop it. IAPs can be very damaging to natural ecosystems, so managing IAPs can help to prevent further destruction. Be careful not to inadvertently increase degradation through rehabilitation actions, either on or off site.

2 Address missing ecosystem processes

Ecosystem processes are processes that link organisms to their environment. These processes include things like nutrient cycles and food webs. Often, degraded systems are missing key ecosystem processes. Identifying and addressing these missing processes can help with rehabilitation. Local conservation offices or rehabilitation specialists could be consulted in this regard.

3 Conserve what remains

It is important to prevent the loss of remaining natural ecosystems, including seedbanks and soils. In this way, rehabilitation costs may be kept to a minimum.

4 Prioritise

Resources are usually limited, so it is important to carefully prioritise which areas should be rehabilitated. Studies in Brazil have shown that a well-prioritised approach is five times more effective than an unplanned approach. After clearing IAPs, areas most prone to further degradation should be prioritised for rehabilitation.

Cleared material at a restoration site that has been stacked along the contours to pervent erosion. © Saskia Fourie / WWF

WHAT METHODS CAN BE USED FOR REHABILITATION?

The type of rehabilitation will depend on the setting and the IAP management methods that were used. The extent, density, age and species of IAPs cleared will affect what type of rehabilitation – passive, active or manipulated succession – should be implemented.

Passive rehabilitation

After IAPs have been cleared or activities damaging the ecosystem stopped, the area is left to recover naturally. The causes of degradation are removed from the system and the system can repair itself over time. If the IAP infestation was minimal or if plenty of indigenous vegetation still exists around the IAP infestation and was not damaged during the clearing process, then one may rely on passive rehabilitation taking place. This will provide adequate ground cover to supress the regrowth of IAPs and prevent erosion.

Active rehabilitation

When IAP clearing has resulted in large exposed areas, active rehabilitation activities may be required. These may include activities that stabilise the soil, the planting of seedlings or the sowing of seeds to reintroduce natural species. Obtain indigenous seed and seedlings from as nearby as possible to ensure correctly adapted plant populations. If IAP management is implemented properly, it can reduce the need for any active rehabilitation, thus reducing the long-term costs involved.

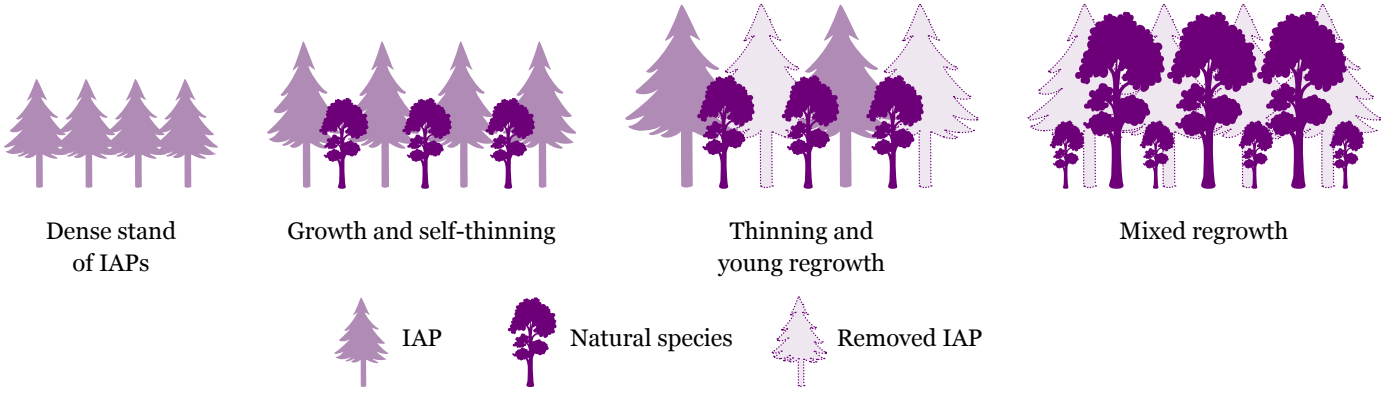
Manipulated succession

Complete clearing of an area can cause the growth of secondary IAPs (weedy species). Many IAPs fall into this category and will take advantage of newly cleared ground. To prevent this, IAPs can be thinned in stages to support the gradual regrowth of natural vegetation (Figure 4).

It is useful to plan IAP clearing and rehabilitation at the same time. There may be different rehabilitation methodologies for riparian or terrestrial areas. It should be noted that full restoration cannot always be achieved. This is often due to the severity of the degradation, or a lack of resources.

For more information, see:
Appendix 16: WWF: A practical guide for community-run nurseries (page 67).
Appendix 17: WWF: Restoration of alien-invaded riparian systems (page 67).
Appendix 18: Alien weeds and invasive plants (page 67).

Figure 4: Removing selected IAPs over time can support natural forest succession for rehabilitation [5]



[5] Geldenhuys, C.J. 2011. Most invasive plants facilitate natural forest recovery – how is that possible? *SAPIA News* 18: 2–5.

WHAT ARE THE PHASES OF A REHABILITATION PROJECT?

Rehabilitation projects invariably follow four distinct phases – a site assessment (getting an understanding of the site); planning (drawing up a detailed and cost-effective plan for the necessary interventions); executing the planned interventions; and monitoring the work (surveillance of the site and indicators of recovery, and identifying further interventions, as appropriate).

4 PHASES OF A REHABILITATION PROJECT

1 Site assessment

Before rehabilitation is even planned, a good background understanding of the site is needed. One should record the history of the site, look at its existing condition, and find out what has caused the degradation. They should collect baseline information over a period of time. Physical conditions such as slope, water quality, local climate and soils should be noted. A nearby natural ecosystem should be identified to understand what comprises the natural system, thus determining what rehabilitation efforts may be required. Information on plants and animals that make up the natural ecosystem should be gathered, including information about the reproduction and life cycles of key species. It may be necessary for a land user to consult experts on the above if they require additional assistance.

2 Planning

A rehabilitation management plan should be drawn up, building on the background information collected during the site assessment. Planning is essential to decide how feasible it is to carry out rehabilitation. The plan should clearly state the goal of the rehabilitation project. It should specify what rehabilitation activities will need to be undertaken over the course of the project. If necessary, trials should be carried out to test the rehabilitation methods. The plan should also identify the physical, human and financial resources that will be needed. It is also mandatory to get all the necessary approvals or permits, and to liaise with relevant organisations or government departments.

3 Implementation

Once planning is completed, staff can be hired to supervise and carry out the rehabilitation. Rehabilitation methods will vary depending on the situation. They will probably include the reintroduction of plants or animals, e.g. through collecting flower heads and mulch from surrounding areas to spread over the site. Beware of commercially available seed as it may contain other undesirable seed (especially alien species), which may compete with Fynbos seedlings or threaten the genetics of local plants. Other rehabilitation activities may include putting in place landscape restrictions, such as stopping land uses that reduce water quality.

4 Monitoring

Once active rehabilitation is complete, there are several follow-up tasks that should be done. These include protecting the site from vandals, pests or livestock, and performing ongoing maintenance, such as erosion repair and continued IAP control. Records should be kept of all rehabilitation sites. These records should include IAP management methods, dates, the results of IAP clearing and rehabilitation actions. Regular site inspections should be undertaken to address any threats to the recovering area.

For more information, see the resources listed under Rehabilitation and restoration (page 67).

Indigenous daisy (*S. elegans*) in Kirstenbosch National Botanical Garden. © Helen Stuart / WWF

FUNDING OPPORTUNITIES

Managing IAPs can be costly, but failing to manage IAPs before they get out of control can be even more costly. Land users do not need to wait until they have enough funds before starting with IAP management activities. There are many resources available to help them with their IAP management efforts.

This section contains information about government and other funding opportunities for IAP management. Options include accessing government programmes, working cost effectively with neighbours, and finding resourceful ways to recoup funds from IAPs.

An indigenous pincushion protea (*Leucospermum spp*).

AVAILABLE RESOURCES FOR IAP MANAGEMENT

To make the most of funding opportunities, it is vital that land users show that they are taking responsibility for the IAP problem that exists on their land. Funders often want to see what efforts the land user is already making towards IAP control.

Even if only limited funds are available, the management of IAPs still needs to be well planned (see Planning IAP management operations, page 18), with careful consideration of how activities can be sustained with the resources available.

The best way of finding potential co-funders is to think about where the property is situated in the landscape. Understanding who stands to gain from IAP clearing will help to determine who might be willing to provide funds. Is the area important for conservation, water production, or of high agricultural value? Linking up with other initiatives in the landscape can help to access funds from a variety of sources.

Neighbourhood initiatives and conservation stewardships

Often, extra resources can be found when IAP management is combined across neighbouring properties. It is best for land users to work together and develop a landscape or catchment approach to IAP management. This can be achieved by working through a Farmers' Association, Fire Protection Association or Water User Association, or by creating a new initiative like a conservancy, or by signing up with a conservation stewardship (see capenature.co.za/care-for-nature/stewardship). Conducting IAP management in this way is more cost effective because resources such as herbicide can be shared. A collaborative approach is also more likely to attract funding from outside sources.

LandCare Programme

Provincial departments of Agriculture sometimes fund IAP management through their LandCare Programme. If LandCare is active in an area, they may be willing to assist private land users by co-funding IAP clearing. However, in most instances they prefer to tackle large projects with many land users in priority areas.

Natural Resource Management (NRM) Programme

The Department of Environment, Forestry and Fisheries is another potential source of resources through its NRM provincial offices. Through the NRM Programme, a land user can get access to herbicide and IAP eradication assistance. Assistance will depend on various factors, including budget, the IAP management strategy in the catchment, and existing IAP control efforts. The land user and provincial office will negotiate contributions (financial and non-financial), and the land user will have to display a willingness to do their part. Due to the necessary checks and balances for disbursement of government funds, applying for and managing these resources may require a lot of administration.

Beneficiation

Additional funds can be gained by making use of the IAP biomass that is cut down (see What other factors should one consider for IAP management? page 28 and How can one responsibly manage plant material? page 45). The land user can get financial benefit if wood is processed into saleable products like charcoal, activated carbon, pellets, pallets, poles and many other wood products. The investment in these production processes can help to offset the costs of IAP management. However, this approach should always follow best practice for IAP management, as clearing only some IAPs may have no environmental benefit and could make the IAP problem worse.

Several green economy initiatives are emerging across the landscape, so it is wise to approach the government programmes mentioned above, local non-government organisations or local businesses to get involved.

FOR MORE INFORMATION

Supporting documentation and additional information have been compiled into a set of appendices, which are available at www.wwf.org.za/invasive_plants_appendices. All the documents are in PDF format, but the templates can be converted to MS Word using free PDF to MS Word conversion programs available on the internet.

LEGAL REQUIREMENTS

APPENDIX 1: LEGISLATION GUIDELINE FOR INVASIVE ALIEN SPECIES

A detailed guideline on the legislation relevant to landowners with invasive alien species on their land.

PLANNING IAP MANAGEMENT OPERATIONS

APPENDIX 2: GUIDELINES FOR THE PREPARATION OF AN IAP CONTROL PLAN

Guidelines for drawing up an IAP control plan for a farm, giving basic pointers on drawing up a plan, completing a field verification and determining working days for costing. A field verification worksheet (Appendix 3) and guidelines for clearing times (Appendix 4) are also included.

APPENDIX 3: WORK SHEET FOR FIELD VERIFICATION

A blank worksheet to fill in the species, age and density classes of IAPs and then calculate person days. The work sheet can be converted to MS Word using free PDF to Word conversion programs available on the internet. It is also available from the Department of Environment, Forestry and Fisheries Natural Resource Management (NRM) offices.

APPENDIX 4: GUIDELINES FOR CLEARING TIME (person days/ha NORMS)

The "norms" for person days required for different IAP types, ages and density classes. It is also available from Department of Environment, Forestry and Fisheries Natural Resource Management (NRM) offices.

APPENDIX 5: TEMPLATE FOR A FARM-LEVEL ALIEN CONTROL PLAN

A template to record listed alien species, distribution, objectives and actions, monitoring actions, planning and budget and a clearing schedule. It also provides a herbicide control sheet and useful checklists for landowners. The template can be converted to MS Word using free PDF to Word conversion programs available on the internet.

APPENDIX 6: BASIC MAPPING SKILLS

Some basics of map reading and mapping aids necessary to understand maps.

APPENDIX 7: FIRE PROTECTION ASSOCIATIONS IN THE WESTERN CAPE

Information about Fire Protection Associations are specific to the reader's location and can be found online. An example for the Western Cape is included here.

APPENDIX 8: CAPENATURE'S FACT FILE: A LANDOWNER'S GUIDE TO PLANNING ALIEN CONTROL

This two-page information sheet giving brief information on prioritisation, budget, clearing methods and common invasive alien species, in English and Afrikaans, is also available on CapeNature's website at www.capenature.co.za.

APPENDIX 9: NATIONAL GEOSPATIAL INFORMATION (NGI)

Topographical maps and aerial photos are available from the NGI at www.ngi.gov.za.

APPENDIX 10: CAPENATURE'S FACT SHEET: WHAT A LANDOWNER NEEDS TO KNOW ABOUT FIRE MANAGEMENT

A two-page information sheet on fire management for landowners, including principles of burning (frequency, intensity, season) and dos and don'ts, available in English at https://www.capenature.co.za/wp-content/uploads/2013/09/Landowners-Guide-to-Fire-Management-Fact-Sheet-English.pdf, and in Afrikaans at https://www.capenature.co.za/wp-content/uploads/2013/09/Landowners-Guide-to-Fire-Management-Fact-Sheet-Afrikaans.pdf.

IAP MANAGEMENT METHODS

APPENDIX 11: CHOICE OF NOZZLES FOR INVADER PLANT CONTROL

An introduction to the types of nozzles available and their uses. This information can be sourced from your herbicide provider.

HERBICIDE SAFETY

APPENDIX 12: EXAMPLE OF A HERBICIDE MIXING RATE TABLE

Most herbicide manufacturers supply a table of quantities for mixing common herbicides online. Additional information can be found on CropLife's website: https://croplife.co.za.

APPENDIX 13: AVCASA'S STORING AGROCHEMICALS AND STOCK REMEDIES

Guidance on the proper storage of chemicals to prevent the risk of agrochemicals being used to poison livestock, people and even to destroy crops is available at www.nda.agric.za/docs/peststore/storing.htm.

APPENDIX 14: CROPLIFE INTERNATIONAL'S RESPONSIBLE USE MANUAL

Comprehensive course material on the concepts and principles of the responsible use of pesticides is available at https://croplife.org/wp-content/uploads/2016/04/Responsible-Use-Manual.pdf.

APPENDIX 15: CROPLIFE'S RESOURCES ON CONTAINER MANAGEMENT

A set of resources on proper disposal of used herbicide containers is available at https://croplife.co.za/container-management.

REHABILITATION AND RESTORATION

APPENDIX 16: WWF: A PRACTICAL GUIDE FOR COMMUNITY-RUN NURSERIES

Wilman, V. 2019. *A Practical Guide for Community-run Nurseries: Growing Indigenous Plants for Restoration*. WWF South Africa, Cape Town, South Africa. This practical guide is available at https://www.wwf.org.za/our_research/publications/?29601/a-practical-guide-for-community-run-nurseries.

APPENDIX 17: WWF: RESTORATION OF ALIEN-INVADED RIPARIAN SYSTEMS

Fourie, S. and Wilman, V. n.d. *Restoration of Alien Invaded Riparian Systems*. Report ISBN 978-2-940443-06-2, WWF, Cape Town, South Africa.

APPENDIX 18: ALIEN WEEDS AND INVASIVE PLANTS

Henderson, L. 2001. *Alien weeds and invasive plants*. Plant Protection Research Institute Handbook No. 12. Plant Protection Research Institute, Agricultural Research Council, Pretoria, South Africa.

A complete guide to declared weeds and invaders in South Africa, including another 36 species invasive in that region, compiled by the Agricultural Research Council. This guide is available at www.wfw.org.za.

REFERENCES

Conservation of Agricultural Resources Act 43 of 1983

National Environmental Management: Biodiversity Act 10 of 2004

National Forest Act 84 of 1998

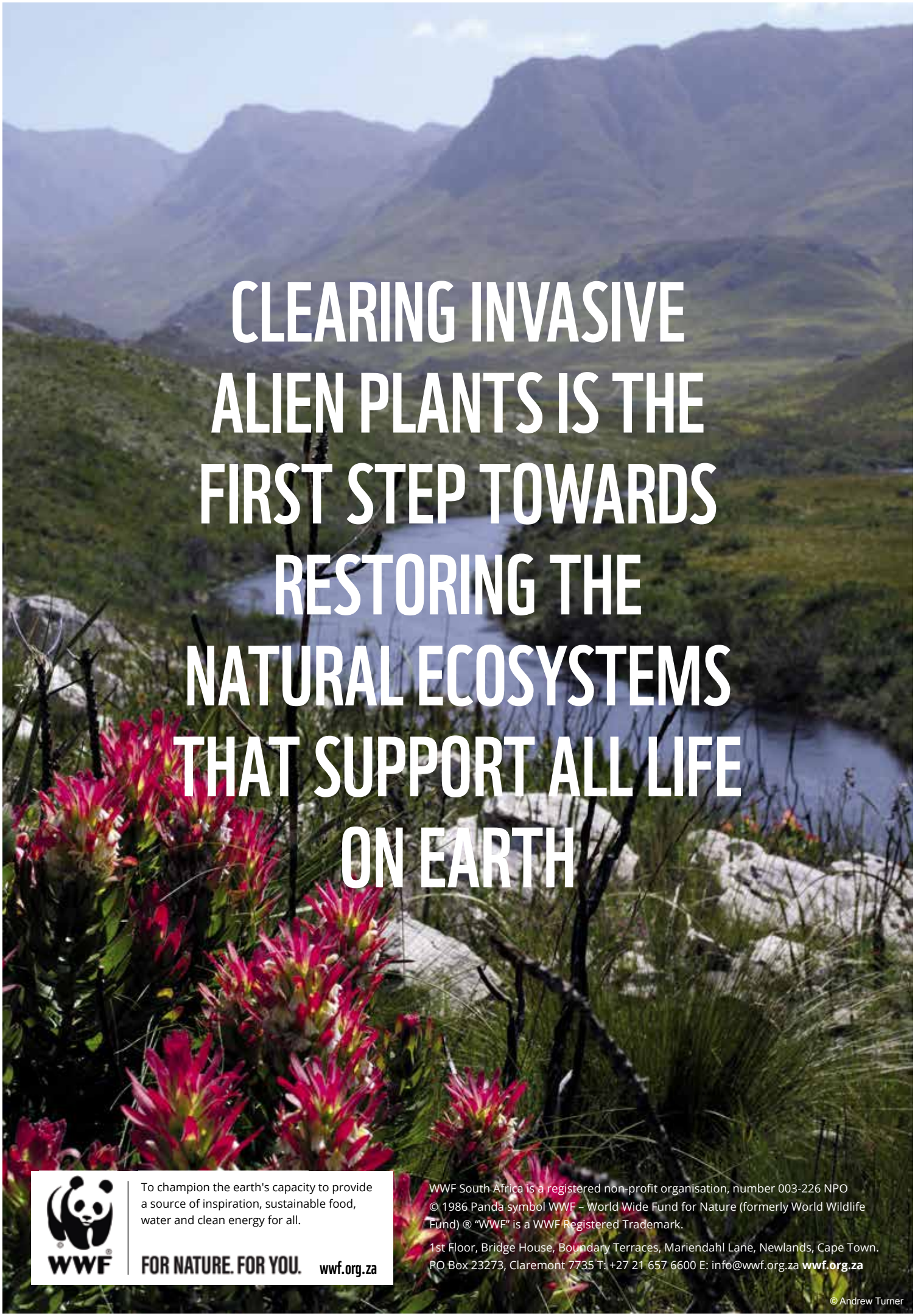
National Heritage Resources Act 25 of 1999

National Road Traffic Act 93 of 1996

National Veld and Forest Fire Act 101 of 1998

National Water Act 36 of 1998

Occupational Health and Safety Act 85 of 1993



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