Biosecurity
in living plant collections in South Africa – guidelines for best practice

Editors:
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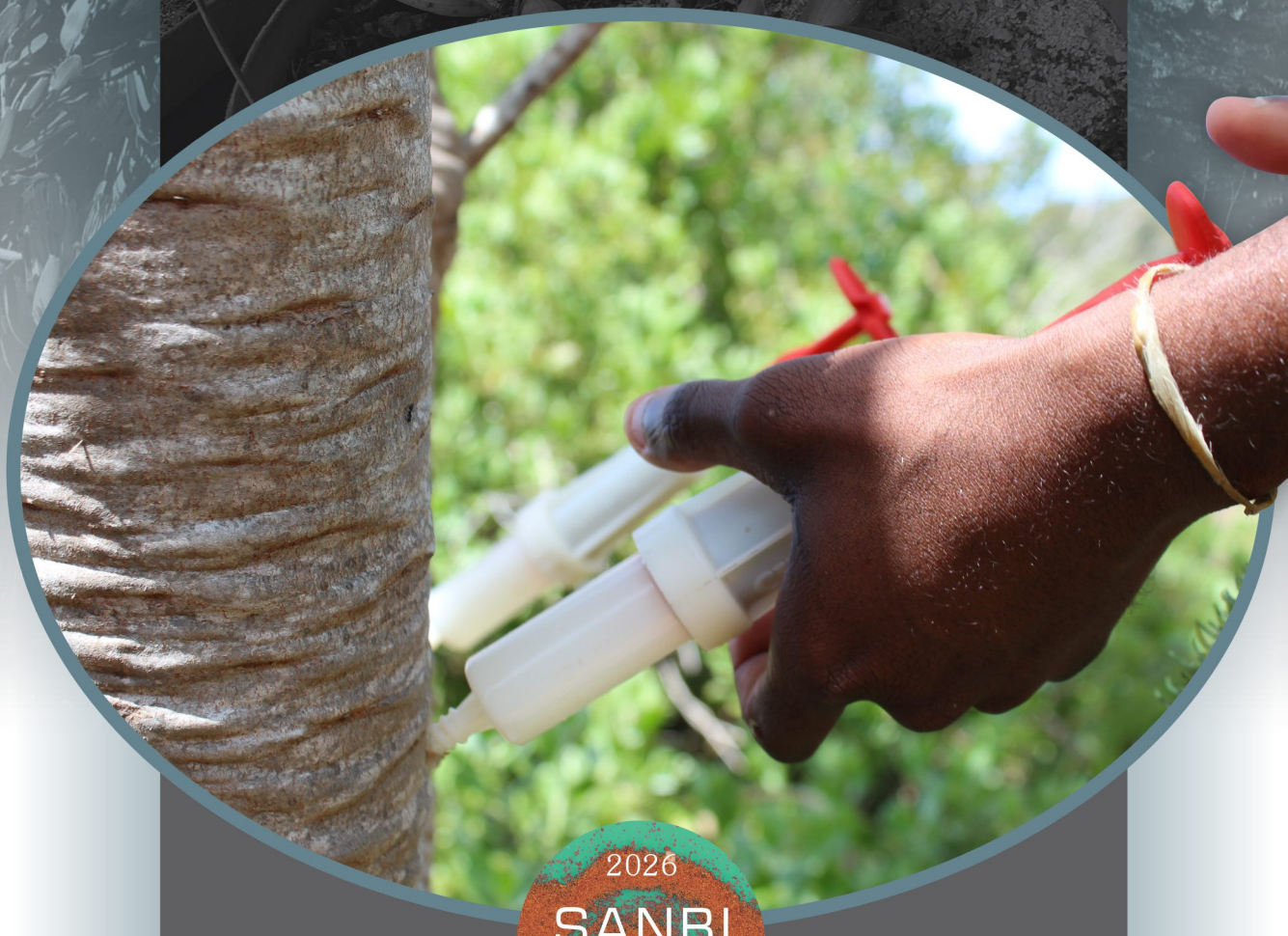

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Biosecurity in living plant collections in South Africa – guidelines for best practice

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The South African National Biodiversity Institute (SANBI) was established on 1 September 2004 through the signing into force of the National Environmental Management: Biodiversity Act (NEMBA) No. 10 of 2004 by President Thabo Mbeki. The Act expands the mandate of the former National Botanical Institute to include responsibilities relating to the full diversity of South Africa's fauna and flora, and builds on the internationally respected programmes in conservation, research, education and visitor services developed by the National Botanical Institute and its predecessors over the past century. The vision of SANBI: South Africa's biodiversity is conserved and enhanced to deliver sustainable benefits for all. SANBI's mission is to provide leadership in biodiversity research, policy advice, conservation and human capital development; and to promote the appreciation, sustainable use and equitable sharing of the benefits of South Africa's biodiversity. SANBI Biodiversity Series publishes occasional reports on projects, technologies, workshops, symposia and other activities initiated by or executed in partnership with SANBI.

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Broad-leaved coral tree (*Erythrina latissima*).
Photograph: Trudy Paap.

List of abbreviations

A&IS	Alien and Invasive Species
CBD	Convention on Biological Diversity (of the United Nations)
DoA	Department of Agriculture
DFFE	Department of Forestry, Fisheries and the Environment
FABI	Forestry and Agricultural Biotechnology Institute
HEF	Horticultural Enrichment Forum
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IPSN	International Plant Sentinel Network
ISPM	International Standard for Phytosanitary Measures
NBG(s)	National Botanical Garden(s)
NEMBA	National Environmental Management: Biodiversity Act (Act No. 10 of 2004)
NPPO	National Plant Protection Organisation
NPPOZA	South African National Plant Protection Organisation
PEQ	post-entry quarantine
SANBI	South African National Biodiversity Institute

Overberg pincushion (*Leucospermum oleifolium*).
Photograph: Trudy Paap.

Glossary*

Alien species: a species that is present in a site outside its natural range as a result of human action that has enabled it to overcome biogeographic barriers.

Biological invasions: the phenomenon of, and suite of processes that are involved in determining, the transport of organisms to sites outside their natural range by human activities and the fate of the organisms in their new ranges.

Biosecurity: measures that are taken to stop the introduction or dispersal of organisms harmful to human, animal or plant life.

Integrated Pest Management (IPM): an approach to pest control that integrates various methods, including biological, cultural, physical and chemical techniques, in a compatible, sustainable and environmentally friendly manner and aims to suppress pest populations below economic injury level.

Invasive alien species: alien species that sustain self-replacing populations over several life cycles, produce reproductive offspring, often in very large numbers at considerable distances from the parent and/or site of introduction, and have the potential to spread over long distances.

Living plant collection: a group of plants (including germplasm) grown, assembled and displayed, and curated for the purposes of biodiversity conservation, education and training, and scientific research.

Non-quarantine pest: a pest that is not a quarantine pest for an area.

Outbreak: a recently detected pest population, including an incursion, or a sudden significant increase of an established pest population in an area.

Pathogen: refers to a broad range of micro-organisms, including fungi, bacteria, oomycetes, viruses and nematodes, that cause disease.

Pathway: any means that allows the entry or spread of a pest.

Pest: a broad term that refers to any living thing, including arthropods, pathogens and plants, that causes damage to plant, animal or human health.

Phytophthora: a genus of plant-damaging oomycetes (water moulds), whose member species are capable of causing diseases to a diverse group of plants, including crops, ornamentals and natural vegetation.

Phytosanitary measure: any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests.

Phytosanitary procedure: any official method for implementing phytosanitary measures including the performance of inspections, tests, surveillance or treatments in connection with regulated pests.

Propagation: the process of growing new plants from different sources, including seeds, cuttings, tubers, corms, suckers, bulbs and rhizomes.

Quarantine: official confinement of regulated organisms for observation and research or for further inspection, testing or treatment.

Quarantine pest: a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled.

Sentinel arboreta: botanical gardens and arboreta where sentinel plants are located and used as sentinel plantations.

Sentinel nursery (synonym used in literature: '*in patria* planting'): site where indigenous plants are planted and grown without pest control measures in an exporting country to identify potential pests

*These definitions are based on those in relevant South African and international legislation and reports, specifically the NEM:BA A&IS Regulations, the CBD (https://www.cbd.int/invasive/terms.shtml), the IPPC (2017a) https:/www.ippc.int/en/publications/622/) and South Africa's national status reports on biological invasions (http://iasreport.sanbi.org.za/)

that could be associated with international trade of plants or derived plant products.

Sentinel plantation (synonym used in literature: '*ex patria* planting'): site where non-indigenous sentinel plants are grown and monitored for identification of potential pest risks for countries where these plants are indigenous or widespread.

Sentinel plants: plants used for identification of potential pest risks associated with international movement of plants and plant products.

Solarisation: a non-chemical method of controlling pests using solar power to increase the temperature of soil or plant parts to levels at which many pests are killed or greatly weakened.

Piketberg conebush (*Leucadendron discolor*).
Photograph: Trudy Paap.

Summary

Pests and pathogens pose significant risks to plant health across living collections, as well as natural ecosystems, commercial crops and ornamental gardens. While indigenous pests and pathogens typically coexist harmlessly with their plant hosts in natural settings, they can become problematic in cultivated environments. Additionally, these organisms can transfer to alien hosts in non-indigenous areas, underscoring the importance of monitoring plant health to anticipate future threats.

It is imperative that everyone with an interest in South Africa's indigenous plants, or any stake in commercial crops or ornamental gardens, understands the threat to plant health posed by pests and pathogens. The growing impact of these threats demands proactive biosecurity measures. There are several simple steps that every individual can take to play a part in reducing the risk of introducing or spreading plant pests and diseases.

The South African National Biodiversity Institute (SANBI), in collaboration with the Forestry and Agricultural Biotechnology Institute (FABI), has developed the guide to biosecurity best practice for living plant collections in line with their commitment to promoting the understanding and implementation of good biosecurity practices, with the aim of assisting in protecting the country's plants from the introduction and spread of harmful organisms. The best practice guide provides information that will assist in efforts to prevent a pest or pathogen outbreak. It contains recommended procedures for routine activities undertaken by staff working with living plant collections. We hope that you will find the guide useful, and that adopting the suggested measures will enhance your ability to manage the health of your plant collections. We hope that you too, in adopting the best practice guide, will become a champion of biosecurity to safeguard plant health.

The following summary provides an overview of the guidelines developed to safeguard living plant collections from the growing threats of pests and pathogens. The messages are grouped around eight themes, representing the various chapters of the document:

- threats
- pathways
- biosecurity measures
- quarantine
- cultural practices
- waste disposal
- monitoring
- staff roles

Kirstenbosch National Botanical Garden. Photograph: Trudy Paap.

Threats

- The proximity of living plant collections to high risk sites, e.g., seaports, airports and urban areas, together with the diverse range of plant species cultivated, increases their vulnerability to pests.
- The establishment and spread of pests can impact the aesthetic, conservation and research value of collections, as well as threaten natural ecosystems and commercial crops.

Pathways

- Alien pests and pathogens can be introduced through multiple pathways, including the movement of contaminated plant material, soil, vehicles, equipment and human activity.
- Indigenous and alien pests are spread by human activity within and between gardens.

Biosecurity measures

- Implementing the biosecurity best practices in this guide reduces the risk of pest introduction, build-up and spread.
- Recommended procedures for routine staff activities are provided, as are key messages for raising visitor awareness.
- These measures will assist in protecting plant collections and contribute to enhancing overall plant health in South Africa.

Quarantine

- Quarantine of incoming plant material is essential to ensure newly introduced collections do not carry harmful organisms.
- Different plant material types carry different levels of risk, higher risk material requires more stringent approaches.
- Distinctions are also made between collections sourced at local, regional, national or international levels.

Cultural practices

- Cultural practices optimise plant growth and health; healthy plants are more resistant to pests and diseases.
- Properly matching plants to their preferred conditions further enhances vitality.
- Nurseries can become hotspots for pests and pathogens, necessitating extra vigilance in all nursery environments.

Waste disposal

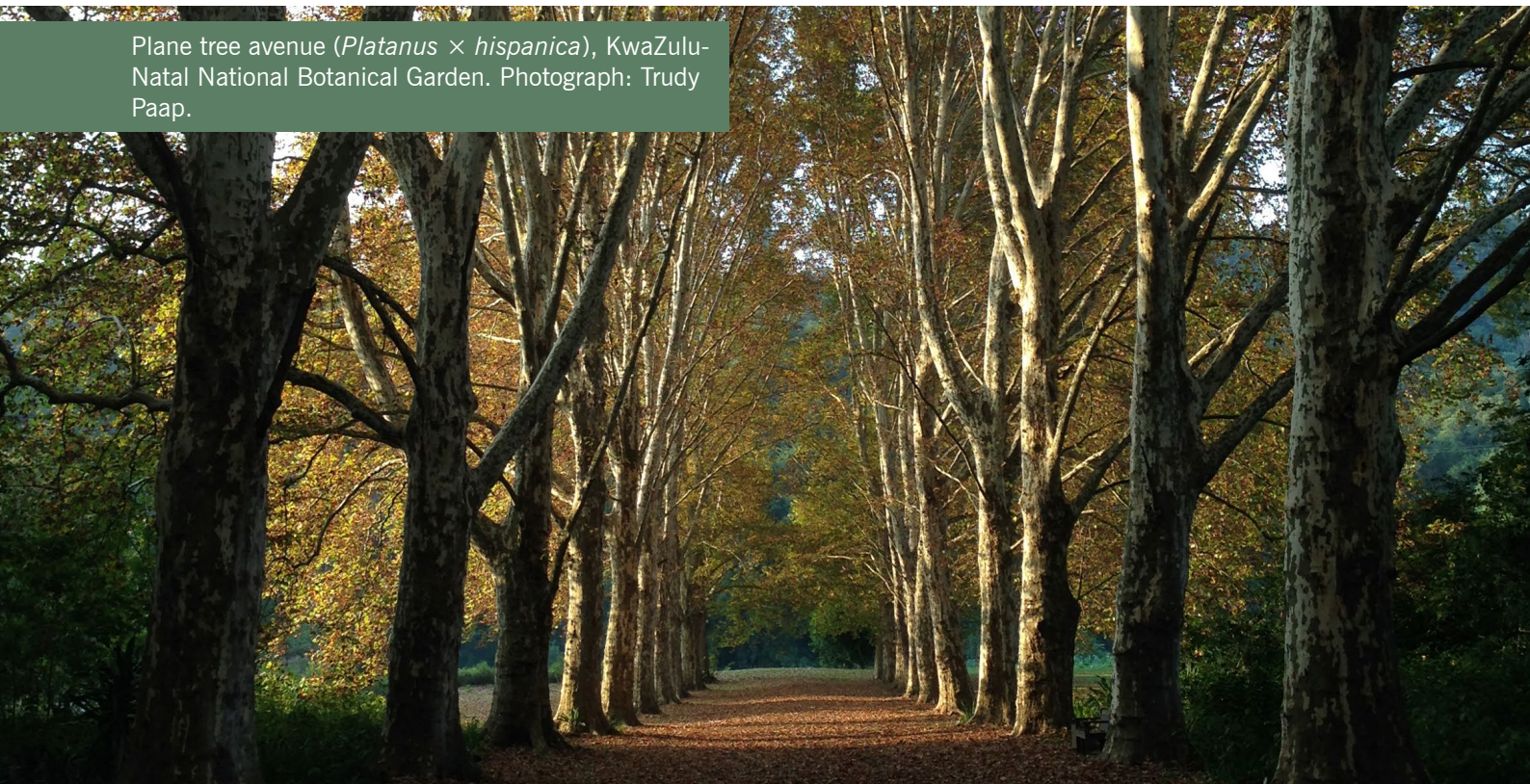
- Improperly managed discarded growing media and plant waste can facilitate pest and pathogen build-up.
- Effective waste disposal strategies are essential, with handling tailored to the associated risk level.
- Despite challenges in organic waste management, following the best practice guidelines will help mitigate pest transmission risks.

Monitoring

- Regular monitoring can facilitate early detection of pest issues and allow prompt remedial action.
- Be familiar with the main plant health issues likely to be encountered in the collections and submit samples for diagnostics where new problems are suspected.
- Report new pest incursions.

Staff roles and training

- All staff should have basic training in hygiene best practices and plant health issues.
- Staff in quarantine or isolation facilities require more specialised knowledge to effectively identify and manage pests and diseases.
- Staff must understand the importance of plant health procedures to avoid shortcuts; familiarity with biosecurity best practices promotes long-term protection of plant health.



Plane tree avenue (*Platanus* × *hispanica*), KwaZulu-Natal National Botanical Garden. Photograph: Trudy Paap.

1 Introduction

South Africa has an incredible floristic diversity, with over 21 000 plant species occurring across many unique vegetation types. The country has an exceptionally high level of endemism, with 67% of these plant species occurring only in South Africa. The South African National Biodiversity Institute (SANBI) is mandated with undertaking and promoting biodiversity research and collecting, generating, processing, coordinating and disseminating biodiversity information. This includes managing 11 National Botanical Gardens (NBGs), as well as the National Zoological Garden and Mokopane Biodiversity Centre, as 'windows' to South Africa's biodiversity.

The focus of the SANBI NBGs is to grow, display and conserve South Africa's indigenous plants. Over 7 400 ha of natural vegetation and associated biodiversity is maintained within the NBGs' boundaries, as well as over 200 ha of landscaped areas consisting of documented collections of living plants, which are managed for conservation, research, display and education.

Pests (both microbial pathogens and arthropods) have the potential to cause significant damage to living plant collections. Pests may also spread from these collections, threatening the health of indigenous plants in natural areas, commercial crops and ornamental plantings. Indigenous pests have coevolved with their plant hosts over very long time frames and do not generally result in significant damage under natural conditions. In cultivated or garden settings, or under monoculture conditions, plants are often more stressed. As such, pest numbers may build up to a point where they become problematic. These organisms may also jump to alien hosts planted in non-indigenous environments, thereby creating problems. Monitoring the health of these plants can help forewarn of future threats to plant health, should the pest arrive in the country of origin of the alien plant.

Alien pests have led to significant damage, following their arrival and establishment in novel environments, as they encounter 'naïve' hosts that lack any coevolved resistance. Globally, there are many examples of disastrous pest outbreaks that have caused devastating environmental damage and associated economic impacts. South Africa is no different from other countries, and is experiencing an increasing rate of introductions of damaging plant pests. A notable invasive species that is predicted to have massive impacts in South Africa is the polyphagous shot hole

The tree canopy walkway known as the Boomslang, Kirstenbosch National Botanical Garden. Photograph: Trudy Paap.

Common coral tree (*Erythrina lysistemon*) mortality caused by the invasive polyphagous shot hole borer (*Euwallacea fornicatus*) Photograph: Trudy Paap.

borer (PSHB). With few exceptions, invasions by alien pests are the result of unintentional introductions. This threat continues to grow, with globalisation and increasing trade and transport presenting increased risks for the unintentional introduction of alien pests.

While international and national legislative measures have been established, these control measures cannot entirely eliminate the risk of introduction of new alien pests to South Africa, nor can existing alien pests be completely prevented from spreading. In addition, indigenous pests will likely continue to pose existing threats and, in some cases, cause new problems. Climate change is expected to enhance the likelihood and extent of invasions by alien pests, while also intensifying impacts and enabling host range expansion by indigenous pest species.

As a result of a number of routine activities conducted in botanical gardens, these (and living plant

Durban Botanic Garden orchid display house. Photograph: Trudy Paap.

collections in general) can be hotspots for the introduction and spread of pests. These activities include the movement of live plants and plant material, as well as the mobility of staff and visits by millions of people each year. It is, therefore, essential that those involved with botanical gardens include biosecurity considerations in all their activities.

By undertaking biosecurity best practice measures, garden staff can help protect botanical gardens from the risk of introducing or spreading pests, thereby protecting valuable plant collections and, in addition, benefiting broader plant health in South Africa. Botanical gardens provide a unique opportunity to conduct surveillance and detect incursions of new pest problems. With staff working in these collections on a daily basis, careful monitoring of plant health presents a significant opportunity to quickly identify pest issues. This offers an opportunity to improve South Africa's biosecurity system. Alien plant specimens in these collections can also act as sentinels, to help predict organisms that may pose a threat in their indigenous range, and which may pose a risk to related indigenous plant species.

This project was initiated in 2019 by the SANBI's annual Horticultural Enrichment Forum (HEF), as part of streamlining and standardising horticultural practices in SANBI's National Botanical Gardens (NBGs). A task team was established by the HEF to initiate and implement the project in collaboration with the Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria. The protocols in this guide have been drafted by a small team of SANBI horticulturists, and plant health researchers based at FABI, through a SANBI–FABI sentinel plant project collaboration. The biosecurity guidelines have been reviewed by HEF members and presented to the garden managers nationally. The document has been reviewed and endorsed by SANBI's Director of National Botanical Gardens. The biosecurity best practices in this guide have been developed with the intention to be taken up by SANBI NBGs. However, the guidelines should broadly apply to other living plant collections, and we would encourage those involved in municipal and private gardens to consider the measures outlined in this document. These guidelines are to be revised and published by the HEF every five years.

2 Aims and objectives of the guidelines

This document aims to help reduce the damage caused by pests and pathogens to living plant collections by:

- Providing practical and helpful measures to assist the gardens in minimising the risk of introducing or spreading pests.
- Providing guidance on routine monitoring strategies to enhance detection of pest outbreaks.
- Identifying standardised practices to improve biosecurity across SANBI's NBGs.

Implementation of the guidelines will assist staff in gardens to:

- Identify plant health threats.
- Establish protocols to deal with major pest threats in public areas, botanical gardens and nurseries.
- Produce an inventory of pests detected in SANBI NBGs.
- Facilitate biosecurity training, public awareness, information access and dissemination.
- Promote collaborative interventions to reduce and mitigate pest problems based on scientific evidence.
- Standardise plant health protocols in all SANBI NBGs.

Broad-leaved sugarbush (*Protea eximia*), Harold Porter National Botanical Garden. Photograph: Trudy Paap.

Ganoderma sp. fruiting bodies on *Fagus sylvatica*. Photograph: Trudy Paap.

3 The threats

Several factors contribute to the vulnerability of botanical gardens to pests:

- Due to their proximity to high-risk sites, such as seaports, airports and urban areas, plants in botanical gardens are frequently the first point of contact for introduced alien pests.
- The broad range of indigenous and alien plant species cultivated in botanical gardens increases the likelihood of introduced pests finding a suitable host on which to establish.
- Indigenous pests may cause greater damage to indigenous plants in cultivated settings than in natural environments (cultivated plants are often more stressed as the growing conditions do not exactly match those that they naturally thrive in).
- As plants are grown in close proximity, indigenous pests may also jump host to alien plant species present in the gardens.

Pests established in botanical gardens can cause significant socioeconomic and environmental impacts. The resulting damage may:

- Kill plants in the collection or prevent new plants from being successfully established, creating replacement costs.
- Reduce the aesthetic value of the gardens.
- Require intensive and costly management interventions.
- Lead to the spread of pests from gardens to natural ecosystems. This is likely to happen in South Africa where many botanical gardens have natural vegetation either within or adjacent to their boundaries.
- Spread to commercial crops, resulting in decreased yields, increased pest management costs and potential loss of marketability for affected produce.

4 Pathways of pest movement and recommended biosecurity measures

Pathways refer to the means of movement of pests. This includes introduction into a site, e.g., a botanical garden. Once established, pests may build up and spread within the site. From here, pests may go on to spread from the site to the surrounding environment.

The major pathways relevant for the introduction and spread of pests are presented in Table 1. For each of these, details of the activity and the associated risk are provided, together with best practice recommendations.

Mulch ready to be distributed onto garden beds, Kirstenbosch National Botanical Garden. Photograph: Trudy Paap.

Table 1: Threats and best practice recommended actions to eliminate movement of pests

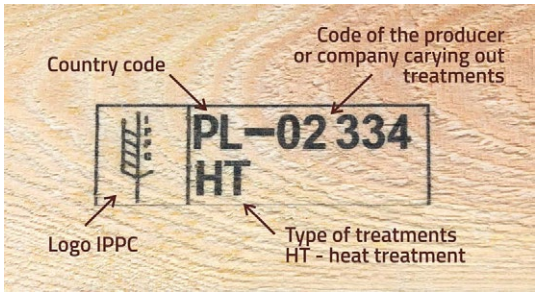
Threat	Description	Recommendations	Links
Plants and propagation material	Botanical gardens obtain whole plants and propagation materials such as seeds, corms, tubers and cuttings from plant collections, donations, or from external suppliers for sale in NBG shops. Plants and propagation material may harbour pests, including insects, mites and nematodes, and microbial pathogens including bacteria, fungi, oomycetes and viruses. The probability of establishment of such pests in the gardens can be high, as they arrive together with their hosts, and successful establishment of the host may confer successful establishment of the pest.	• Source material from trusted suppliers and reputable sources. • When collecting material from wild populations, prioritise collection from healthy plants that appear free of pests and disease. • Conduct visual inspection for signs and symptoms of pests on arrival, noting that not all pests show symptoms in all hosts. • Maintain and monitor mother stock plants. • High risk material (plants, especially large specimens) should undergo quarantine. • Keep records of incoming materials and their sources. In the event of a pest problem, this documentation can facilitate tracing the origin of the issue.	Table 2 shows varying risk levels associated with plant size and type of propagation material. See Appendix 1 for documenting incoming materials. See Chapter 5 for quarantine procedures.
Wood, timber and bark supplies	Wood and wood products may be brought into botanical gardens for firewood, infrastructure development, e.g., garden paths and raised beds, or as wood packaging material, e.g., pallets. Untreated wood can harbour nematodes, wood boring insects and pathogens. Wood with bark attached is considered of particularly high risk.	• Adhere to existing policies on the introduction of wood and wood products (where available). • Visually inspect all material entering the collection for signs of pests, including insect tunnelling (holes and frass), and evidence of decay, discolouration or fungi. • Only allow wood from tree species that are of low risk of polyphagous shot hole borer, e.g., *Pinus* and *Eucalyptus* species. • Check that all wood packaging material (including pallets) has a mark showing ISPM 15 compliance. Kiln-dried timber (when reaching lethal temperatures) does not present a risk. 	See IPPC (2017b, 2021b) for further details on wood packaging.

Table 1: Threats and best practice recommended actions to eliminate movement of pests (continued)

Threat	Description	Recommendations	Links
Organic matter	Botanical gardens source organic matter such as compost, soil, growing media and wood chip from external suppliers. Unless prepared following standard procedures, this can serve as a pathway of pest introduction into gardens. Soil and growing media can carry insects, nematodes and microbes such as bacteria, fungi and oomycetes, while wood chips may carry insects, nematodes, and canker and decay fungi. Different materials carry different levels of risk, with perlite, peat, coir, vermiculite and properly composted and correctly stored pine bark generally considered to be free of the major plant pathogens. Sand, soil and potting mixes present a higher risk. In addition to the potential to be a source of pest introductions, organic matter (especially growing media) can become infested on site if not stored or handled appropriately.	• Use reputable suppliers. • Keep records of incoming materials and their sources. In the event of a problem, this documentation can facilitate tracing the origin of the issue. • If pathogen issues are suspected, submit samples for diagnostics. • Steam pasteurise higher risk growing media. Industry standards recommend 30–45 minutes at 60–80 °C.	See Appendix 1 for documenting incoming materials. See Appendix 2 for diagnostics sample submission. See Table 4 in Chapter 7 for handling and storage.
Water	Several sources of water may be utilised for the maintenance of living plant collections. While mains (municipal) water is treated and therefore free from pathogens, it can be expensive and subject to restrictions on use. Borehole water, if available, is generally pathogen-free. Other sources of water, including reservoirs, rivers and tanks, may contain oomycetes (*Phytophthora* and *Pythium* species) and fungal pathogens.	• Use of mains and borehole water is encouraged as these pose a lower pathogen risk than other sources of water. • Water from higher risk sources, including reservoirs, rivers and tanks, should be tested annually for the presence of pathogens by diagnostic laboratories (ideally in late spring or early summer when the likelihood of detection is greater). • Water from high-risk sources or water testing positive for pathogens should be disinfested. • Share information with other water users.	See Appendix 2 for diagnostics sample submission. See Appendix 3 for disinfestation methods. See Chapter 7 for cultural practices.

Table 1: Threats and best practice recommended actions to eliminate movement of pests (continued)

Threat	Description	Recommendations	Links
Staff and contractors	Pests can be introduced to and spread within sites on staff and contractors' boots, clothing, vehicles and equipment (especially when moving between regions). Pathogens in particular are often carried on soil and plant debris stuck to footwear. Staff who regularly travel between sites (e.g., between gardens, into natural estate and collecting from wild populations) should follow biosecurity measures to minimise the risk of transmitting plant pests and pathogens.	• Footwear and clothing should be free of soil and plant material before entering or leaving sites. • Scrubbing brushes, footbaths, boot covers, rubber boots and protective clothing, such as disposable overalls, should be provided for people entering or leaving production areas, such as the nursery, or moving from contaminated to clean areas of the site. • Expectations must be communicated to all staff and contractors.	See Appendix 4 for standard disinfection kit and procedure.
Tools, machinery and vehicles	Botanical gardens regularly use various tools, machinery and vehicles for their activities. Some of these tools and machinery are hired or brought into the gardens by contractors and taken out upon completion of tasks, where they are often used in other places such as sport fields, home gardens and parks. Tools, machinery and vehicles can carry and spread pests between and within gardens and the surrounding environment unless cleaned properly. Pests can be transported in soil or organic matter adhering to vehicles and equipment, including trucks, earth-moving equipment and tools. Stopping all vehicle and equipment movement is impractical. However, following the recommendations can help reduce the risk of introducing and spreading pests through this pathway.	• To reduce traversing of contractors, service providers and delivery trucks across the estate, locate drop-off areas at easily accessible points. • Contractors should ensure vehicles and equipment are free from soil or plant debris before they enter or leave the site. • Inspect incoming vehicles and equipment for the presence of pests and plant material. • Keep records of site visits by contractors and the status of their vehicles and equipment. • Where possible, use the estate's own vehicles to transport visitors around the site. • Keep vehicle movement to a minimum, stick to pathways where possible. • Ensure borrowed and second-hand equipment and machinery are cleaned prior to use. • Expectations must be communicated to all staff and contractors; they should be made aware that access may not be granted if machinery is dirty. • Establishing wash-down facilities at all sites may not be feasible, but having a designated wash-down area can significantly reduce the risk associated with machinery and vehicles.	See Appendix 5 for record-keeping. See Appendix 6 for guidance on establishing a wash-down facility.

Table 1: Threats and best practice recommended actions to eliminate movement of pests (continued)

Threat	Description	Recommendations	Links
Visitors	Botanical gardens are frequently visited by local and international visitors due to their diverse collection of plant species, beautiful landscaping and ecotherapeutic value. Visitors can unintentionally spread pests between gardens and the surrounding environment, sometimes even between countries. Some pests hitchhike on luggage, clothes and hair. Others may be present in soil and plant debris attached to footwear. The recommendations in this section can mitigate the risk of visitors introducing pests, while also raising awareness about plant health and biosecurity.	• Encourage and implement the 'arrive clean, leave clean' principle to minimise pest introduction and spread by visitors. • Key messages should be communicated to a wider audience through: ▪ SANBI and satellite gardens' websites and other online platforms, including social media. ▪ Interpretive signage. ▪ Hosting plant health and biosecurity-themed workshops, presentations and seminars. ▪ Biosecurity information pamphlets for visitors. • Security staff should be trained and aware of existing policies to ensure implementation. • SANBI has the option to establish footbaths or squelch mats at public entrances.	See Box 1 for important messages to be communicated. See Appendix 7 for guidance on setting up and maintaining footbaths.
Plant sale	Several NBGs regularly sell plants. There is a risk of this action facilitating the spread of pests into home gardens, natural ecosystems and commercial settings.	• Follow strict phytosanitary practices to ensure clean stock.	Cultural practices are detailed in Chapter 7.
Disposal of plant waste	Botanical gardens regularly dispose of plants and plant parts to maintain hygiene and safety in their estates. This includes pruned material, weeds, broken branches or trees uprooted by winds and plant parts damaged by pests. Any plant or plant part that is removed from the garden has the potential to spread pests established in the gardens to the surrounding environment.	• Implement effective waste disposal strategies and handle waste according to its associated risk level.	Waste disposal methods are detailed in Chapter 8.

Processing samples for diagnostics. Photograph: Trudy Paap.

Box 1: Key messages to communicate with garden visitors

- **Wear clean footwear**
  Pathogens can hitchhike on your shoes. You can help reduce the risk of spreading invasive pathogens by cleaning your footwear before visiting.
- **Keep to the paths**
  We strive to maintain our paths to ensure your safety and preserve the health of our garden. By staying on designated paths, you help minimise the risk of picking up soil and plant debris on your footwear. This simple action plays a vital role in reducing the spread of pathogens within our garden and beyond.
- **Observe any notices**
  Please observe any notices, as these may indicate areas undergoing repair or replanting. Adhering to these helps minimise the risk of picking up soil on your footwear. This simple action plays a vital role in reducing the spread of pathogens within our garden and beyond.
- **Protect our garden, leave biological material outside**
  To safeguard the health of our garden, please refrain from bringing in any biological materials, such as soil, cuttings, seeds, bark, branches, leaves, wood or pets. These items may harbour pests that could harm our delicate horticultural environment.
- **Resist the temptation to take cuttings**
  Whilst we aim to keep our plants healthy, we ask that you buy a carefully selected plant from our shop rather than removing any plant material from the garden. There is potential for you to transmit diseases onto our critical conservation collections.

Example of interpretive signage. Photograph: Mpendulo Gabayi.

Table 2: Risk levels (black to light grey = high to low) associated with plant material (adapted from the International Plant Sentinel Network [IPSN]'s *Guide to Plant Biosecurity in Botanic Gardens and Arboreta*)

Plant material	Description	Specific risks	Potential mitigation	Risk
Large plant specimens	Large, live plants from any source, including wild-collected, commercial or other organisations.	• Can harbour many pests and pathogens. • Challenging to inspect.	• Know the origin of the material, keep records. • Conduct risk assessments. • Inspect, quarantine.	
Plants	Live plants from any source, including wild-collected, commercial or other organisations.	• Can harbour many pests and pathogens.	• Keep records. • Inspect carefully on arrival. • Quarantine.	
Wild-sourced seeds	Collected from natural populations rather than cultivated plants.	• May carry pests and pathogens.	• Clean to remove debris and contaminants. • Treat with appropriate disinfectants. • Quarantine and monitor.	
Wood, timber and bark	Any wood, timber or bark product or material.	• Can carry nematodes, wood boring insects and pathogens. • Wood with bark is of particularly high risk.	• Inspect on arrival. • Check wood for mark of ISPM 15 compliance.	
Soil and growing media	Organic matter, compost, soil and other growing media.	• Can carry arthropods, nematodes and pathogens.	• Keep records of inputs. • Use reputable suppliers. • Where possible, pasteurise.	
Reproductive material or storage organs	E.g., bulbs, corms, tubers and fruits.	• Common pathway for pests and pathogens.	• Thoroughly inspect on arrival. • Source carefully.	

Table 2: Risk levels (black to light grey = high to low) associated with plant material (adapted from the International Plant Sentinel Network [IPSN]'s *Guide to Plant Biosecurity in Botanic Gardens and Arboreta*) (continued)

Plant material	Description	Specific risks	Potential mitigation	Risk
Non-certified seed	Seeds from cultivated settings, which have not been subjected to certification process.	• May carry pests and pathogens.	• Source carefully. • Inspect seeds, seedlings and (later) young plants.	
Tissue cultures	Plants propagated from small sections of plant tissue under sterile conditions.	• May carry viruses.	• Inspect on arrival. • Source carefully.	
Cut flowers	Flowers or flower buds cut from the main plant for decorative use.	• Can harbour pests including aphids, leaf miners, thrips and whiteflies.	• Inspect on arrival. • Source carefully.	
Dried artefacts	Plant materials desiccated to preserve them for scientific study, display or archival purposes.	• Low risk to live plants but can cause problems for herbaria, libraries and galleries.	• Treat appropriately, e.g., fumigation, heat treatment or rapid freezing.	
Dried flowers	Dried flowers for the purpose of decoration, education or research.	• Low risk to live plants but can cause problems for herbaria, libraries and galleries.	• Source carefully. • Inspect on arrival.	
Certified seed	Meet standards for genetic purity, germination rate and freedom from pests and pathogens through quality assurance processes.	• Unlikely to be completely pest and pathogen free, but lower risk than other sources.	• Careful planting (away from susceptible/ unhealthy specimens).	

Bald cypress (*Taxodium distichum*), KwaZulu-Natal National Botanical Garden. Photograph: Trudy Paap.

5 Quarantine procedure for incoming plants

As detailed in Chapter 4, incoming plants can pose significant threats to living plant collections. Therefore, they need to be handled appropriately to reduce the risk of pest introduction. As indicated in previous chapters, different plant material types carry differing levels of risk, with higher risk material (such as large specimen plants and live plants in soil) requiring more stringent approaches. Distinctions are also made between plant material originating from overseas, and collections sourced at local, regional or national levels.

Plant material coming from overseas must be handled following the procedures outlined by the South African National Plant Protection Organisation (NPPOZA) (within the Department of Agriculture [DoA]), which is the national body responsible for regulating international agricultural trade and enacting biosecurity regulations. Any imported plant material is considered a 'controlled good' under the Agricultural Pests Act, 1983 (Act No. 36 of 1983) (APA). To import plants or plant products to South Africa you must apply for an import permit issued by the NPPOZA. For the permit to be approved, you must meet the phytosanitary import conditions of the APA and the NPPOZA. If approved, you must send a copy of the import permit to the exporter/supplier. The National Plant Protection Organisation (NPPO) of the exporting country must

Plant exchange. Photograph: Trudy Paap.

Inspecting incoming plant material for the presence of pests and pathogens. Photograph: Trudy Paap.

check if the products meet the import requirements of South Africa. If import requirements are met, the NPPO will issue a phytosanitary certificate.

The exporter must send the original phytosanitary certificate with the goods to South Africa. On arrival in South Africa, the material will be visually inspected at the port of entry. Plant propagation material (e.g., in vitro plantlets, seedlings, budwood) for any commercial plant species are shipped in sealed packages and transported directly to the DoA's agricultural quarantine facilities for post-entry quarantine. Plants considered as non-commercial ornamentals generally do not undergo post-entry quarantine at the DoA's facility. However, if the border inspector finds or suspects a pest or pathogen in the consignment, a sample will be sent to one of the DoA's diagnostic laboratories. Samples may also be sent for diagnostics if quarantine organisms have been detected on previous imports of that plant species. Detection of a listed phytosanitary pest or pathogen results in the rejection of the consignment. However, complications arise where non-listed pests are detected, or identification is incomplete, e.g., only to genus or family level. Generally, in these cases either full risk assessments are then required, or consignments may be treated with fumigants in the case of non-listed arthropods.

It is very important to note that visual inspections have significant limitations. Many plant species can be asymptomatically infected with pathogens that might not cause disease on that host but could affect other plant species. Additionally, infections can be latent, with symptoms yet to emerge. Furthermore, the use of fungicides in the exporting country may suppress disease development, also resulting in asymptomatic infections. Similarly, visual inspections, especially of large specimen plants, may miss cryptic arthropod pests. Trees and woody plants can harbour wood-boring beetles with long life cycles, which may not become apparent for several months or even years after arrival. It is therefore recommended that material originating from overseas undergo quarantine, as detailed here. The following recommendations are also relevant for high-risk plant material originating from other biomes in South Africa:

- All incoming plant material should be assigned a risk category based on origin and material type (see

Holding bay for incoming plant material. Photograph: Trudy Paap.

Table 2 for guidance), with all details of the consignment recorded (see Appendix 1 for record-keeping guidance). This enables trace back should a pest problem arise.

- A single point of entry should be established, with incoming plant material to be visually inspected on arrival (see Chapter 9 for guidance on monitoring), ideally in a designated quarantine facility (see Chapter 6 for requirements).
- Samples of any suspected pests or pathogens should be sent for diagnostics and further recommendations (see Appendix 2).
- High-risk material should be isolated, ideally in a quarantine facility, for a suitable period after arrival. This allows for the detection of latent pathogen infections or cryptic pests with long life cycles. Guidance on holding times is provided in Section 5.1.
- Do not conduct fungicide or insecticide treatment on arrival or during the holding time, as this can mask pest and pathogen symptoms. Pests may then emerge after the quarantine period, when plants have been moved out into the general collections.

5.1. Duration of isolation

The duration for which plants should be held in isolation will vary depending on the level of risk assigned. The following are suggested minimum periods:

- All medium- to high-risk plant material should remain in isolation for a minimum period of three months.
- Large specimen plants pose a greater risk and, therefore, should remain in isolation for a minimum of six months.
- For dormant plants, the required isolation period should only commence once active growth has begun. This allows any potential cryptic pests to become visible or active before the end of the isolation period.
- If risk assessments indicate that certain pests may be encountered on imports, the plant material should be isolated for the full life cycle of the pest.

Certain pests, such as *Anoplophora* species, have cryptic stages and can remain hidden within plant tissues for years. Their larvae, for instance, can bore

into tree trunks and stay there for up to three years. If a risk assessment indicates the potential presence of such pests with desired plants, it's wise to source from countries without these pests, or consider alternative plant species.

5.2. Procedures during isolation

The following procedures should be adhered to during isolation of plant material:

- All general hygiene and cultural best practice measures should be adhered to, as presented in Chapter 7.
- In addition, be extra aware of people as vectors. Wash hands or wear gloves between handling new batches of material and other collections. Further recommendations to reduce the risks associated with people working with this material are provided in Chapter 6 where the design of a quarantine facility is explained.
- Continue to monitor plants throughout the isolation period, to promptly identify and address any issues that arise. Send samples for diagnostics as soon as any potential problems are observed (see Appendix 2).
- Place yellow and blue sticky traps or sticky rolls among new batches of plant material to trap and monitor any emerging pests. Be sure to replace these as required (usually around every 8–12 weeks) (visit www.insectscience.co.za for available products).

5.3. Treatment methods

If a pest or pathogen issue has been confirmed via diagnostic sample submission, appropriate treatments or disposal methods should be initiated as soon as possible. The treatment method is dependent on the nature of the infestation. In any instance of infestation by a quarantine pest or alien pest not reported as present in South Africa, all affected plant material should be destroyed (see Chapter 8 for correct procedures). This should be done in consultation with plant health experts to prevent escape risks.

Even pests that are known to be present in South Africa (including alien pests that have successfully established in the country, and indigenous pests that originate from other biomes) may not be present in all regions. Therefore, care should be taken to eliminate infestations before moving plant material out of isolation or propagating from it. For arthropod pests, plants may be treated with insecticides. Systemic insecticides are preferred over contact insecticides for comprehensive treatment. However, be aware that few insecticides are effective against eggs, so a sufficient waiting period should be maintained to ensure pest-free status.

Cypress pine aphid (*Cinara tujafilina*) infesting Clanwilliam cedar (*Widdringtonia cedarbergensis*). Photograph: Trudy Paap.

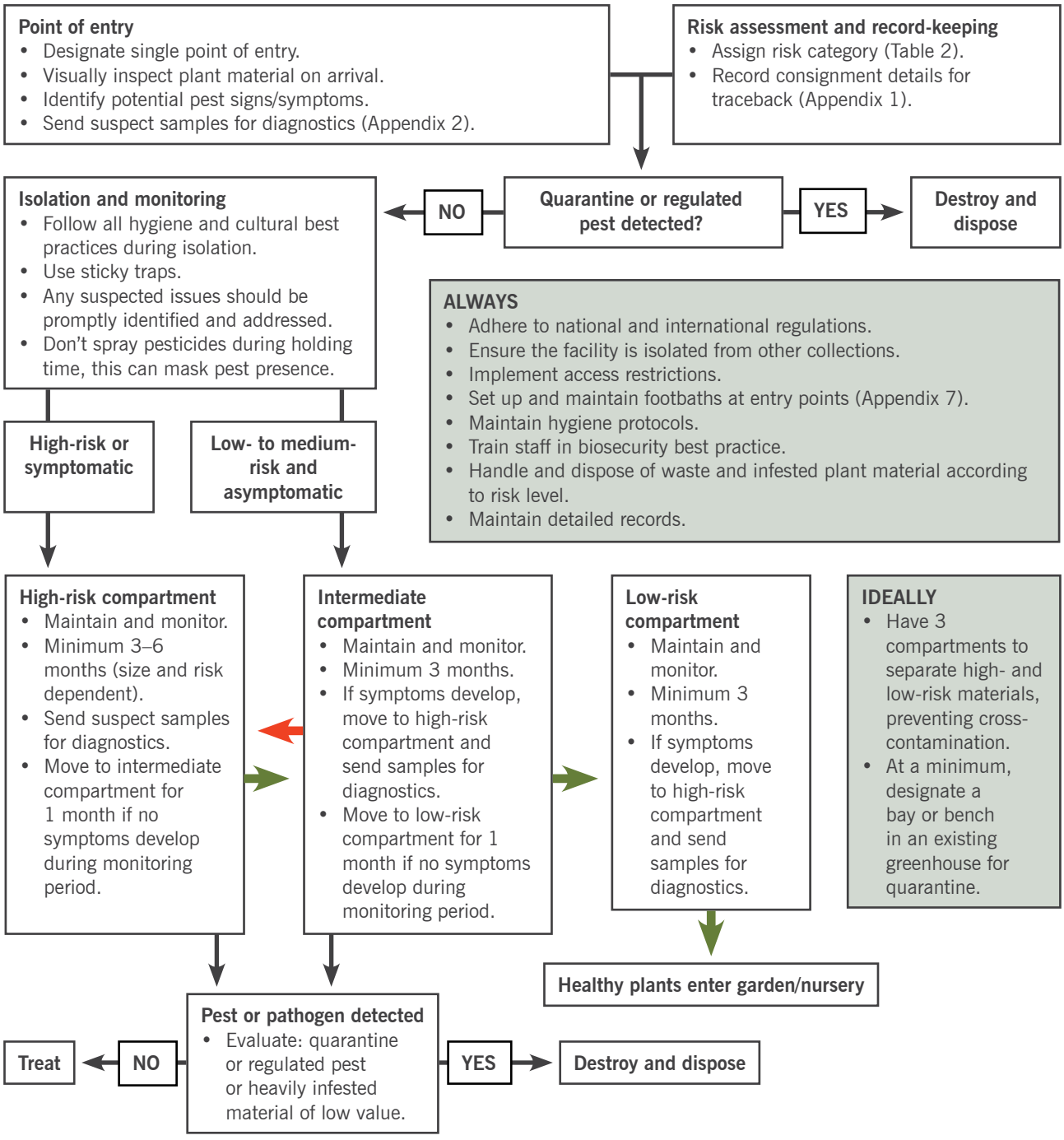
Assess heavily infested plants or batches to determine whether the material is of sufficient value to warrant treatment, or whether it should be destroyed to mitigate risks to wider collections or the environment.

Complete elimination of pathogens from live plants is seldom achievable. The appropriate response to pathogen detection depends on its presence in the country, region and collection, as well as the associated risks.

Biocontrol is not an option for dealing with alien pests and pathogens. Unfortunately, the risk is too great to take chances and a zero-tolerance policy should be enforced.

The details provided in this chapter, together with recommendations for the design of a quarantine facility, are condensed into the single quarantine flow chart presented here.

Quarantine flow chart for incoming plant material.



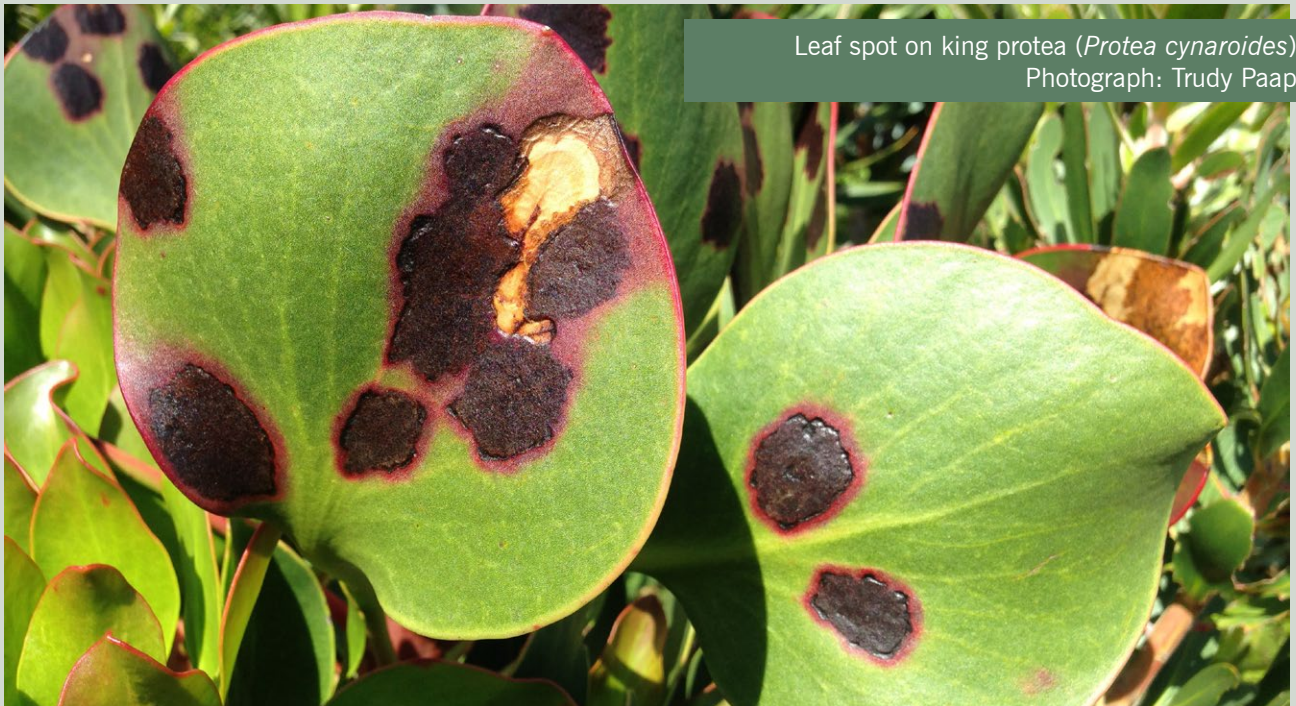
6 Design of a quarantine facility

Establishing a quarantine or isolation facility for incoming plants and plant materials is essential to prevent the introduction of pests and pathogens into new environments. Such an area allows for plants to be monitored for pest and disease development before they are moved to other existing collections or planted out. While creating a purpose-built facility may not always be feasible, many of the recommendations in this chapter can still be implemented to ensure effective quarantine practices. At a minimum, a bench or bay in an existing greenhouse can be designated specifically for this purpose. It's important to note that high-risk plant material (as outlined in Table 2), should be treated with extra care to mitigate risks. This is particularly relevant for material originating from other countries or different biomes. Staff responsible for maintaining living plant collections should assess their capacity to effectively detect and manage any potential pests or pathogen escapes. If a facility or staff capacity falls short in this regard, staff should be cautious about accepting any material that may pose higher levels of risk.

6.1. Location and design

The International Standard for Phytosanitary Measures (ISPM) 34 of the International Plant Protection Convention (IPPC) (2010) describes general guidelines for the design and operation of post-entry quarantine (PEQ) stations. These stations are used for holding imported consignments of plants to verify whether or not they are infested with quarantine pests. The Stellenbosch Quarantine Station has a PEQ facility, which is managed by the DoA's Division Plant Quarantine Services. All imported propagation material of quarantine crops will be established and maintained at either the Stellenbosch station or other approved external quarantine facilities and outsourced institutions. Should resources be available to build a designated facility, ISPM 34 should be consulted to ensure the facility is built to the highest specifications possible. At a minimum, however, the following recommendations should be followed to safely manage incoming plant material:

- The facility should be isolated from the rest of the garden, general plant production areas and retail areas.
- Where this isolation cannot be achieved geographically, give extra emphasis to access restrictions.
- There should be no public access.
- Staff access should be limited to those needing to conduct required tasks.
- There should be clear signage to prevent unauthorised access.
- Access should be limited to a single entry point, ideally with locked doors. There should be adequate safeguards to ensure plants cannot be accessed or removed without authorisation.



Leaf spot on king protea (*Protea cynaroides*).
Photograph: Trudy Paap.

- Floors should be of a surface that can be easily cleaned and disinfected (e.g., concrete).
- Floors should be designed to prevent the accumulation of standing water, and to prevent water running out to, or entering from, other parts of the garden.

6.2 Facility infrastructure

- Ideally, the facility should consist of at least three separate compartments, which can be designated for plant material of varying risk levels, to prevent contamination of low-risk material by high-risk material (see quarantine flow chart in Chapter 5).
- As different plant species have different environmental requirements, it's advisable to group plants with similar needs together. Efforts should be made to maintain suitable conditions (e.g., temperature, water levels, sunlight exposure). Ideally compartments should have a sunny side and a shady side. If natural shade is lacking, shade cloth, sails or whitewash can be used to modify conditions.
- Footbaths or squelch mats should be set up and maintained at entry points (see Appendix 7).
- Ventilation systems should be in place to regulate airflow.
- The facility should contain separate tools and equipment that are dedicated to that area only, and not to be taken out for use in other areas of the collection. These should be cleaned and disinfected regularly.

6.3. Monitoring and record-keeping

Quarantined plants should be inspected regularly and monitored for any signs of pests or pathogens. Detailed records should be kept of all plant movements, inspections, treatments and observations. Further guidance on monitoring and record-keeping is provided in Chapter 9.

6.4. Staff training

Staff working in the facility should undergo training in biosecurity best practices and should be capable of recognising plant health issues. Should any pest issues be encountered, these should be managed in consultation with plant health specialists, starting

Stripping and cleaning a chainsaw, hygiene best practice. Photograph: Kamogelo Modimola.

with identification of the causal agent by submission of samples for diagnostics (see Appendix 2).

6.5. Waste management

Proper waste management protocols should be followed to contain any waste generated within the facility, to prevent contamination of the surrounding environment. Waste should be placed in biohazard bins or sealed bags, before being properly disposed of (see Chapter 8).

In addition to the recommendations highlighted in this chapter, all general hygiene best practice measures, as detailed in cultural practices (Chapter 7) should be strictly adhered to. A summary of the basic requirements for a quarantine or isolation facility, together with the quarantine procedure details provided in Chapter 5, are condensed into a quarantine flow chart (see p. 18).

7 Cultural practices

Cultural practices encompass a wide range of activities that are essential for the management of plant collections. These practices aim to optimise plant growth, health and productivity, while minimising negative environmental impacts. A healthy plant is typically more resistant to disease and pest infestation. Matching a plant to its preferred location, soil type and water requirements can enhance its vitality. If a plant species consistently struggles in a specific area, consider replacing it with another species better suited to the location's conditions.

Nurseries in particular have the potential to become hotbeds of pests and pathogens, as conditions are often highly conducive to pest build up. This has far-reaching implications, considering that plants will be moved from the nursery to the garden or potentially sold to the public. Therefore, extra care and vigilance are required in the nursery environment. It's important to note that the following recommendations apply, not only to nurseries managed for plant production within the estate, but also to isolation or quarantine facilities and nursery shops selling plants to the public.

Table 3 details general cultural practices applicable to all environments within the living plant collections. Table 4 includes cultural practices that may also be specifically relevant to nursery or garden settings.

Nursery with yellow sticky traps installed. Photograph: Trudy Paap.

Agapanthus in a garden. Photograph: Trudy Paap.

Table 3: General cultural practices applicable to all environments within living plant collections

Nutrition	Plants should be monitored for nutrient deficiencies. Appropriate fertilisers or foliar feeds should be applied to correct significant deficiencies. Exercise caution to avoid over-feeding, as this can result in excessive soft growth, which is more susceptible to infection.
Spacing	Insufficient spacing between plants can create ideal conditions for pests and pathogens. When plants are overcrowded, air circulation is restricted, humidity levels rise and sunlight penetration decreases. Crowded plants may compete for nutrients, weakening their overall health and resilience. Wherever practical, space plants adequately to allow air movement between the plants to reduce humidity.
Weed management	Regardless of the environment (nursery, quarantine facility or garden area), weeds should be controlled using methods such as mulching, hand weeding or the use of herbicides. Weed management is crucial to prevent competition for nutrients, water and sunlight. Importantly, weeds may serve as alternative hosts for pests, enabling their populations to thrive and intensifying pest and pathogen pressure on plants in the collection.
Integrated pest management (IPM)	A recommendation that emerged during the development of the current biosecurity best practice document is to create a comprehensive document outlining the principles, processes and practices of IPM within living plant collections. This document should be developed by a task team appointed by the HEF. Additionally, it should aim to compile effective IPM strategies for managing the pests most commonly encountered within these collections.

Table 4: Specific cultural practices relevant to nursery or garden conditions

	Nursery	Garden
Hygiene	The following general practices should be standard. Emphasising their importance is vital as they can significantly improve overall health of collections. These fundamentals can be neglected when workloads increase or staff turnover is high. Nevertheless, they are easy to implement, require minimal time and resources, and offer substantial benefits: • Regularly clean footwear by removing organic matter and disinfecting, e.g., at the end of each day. • Disinfect tools (secateurs, pruning knives and saws) between cuts and especially when moving between plants. Use 70% ethanol, methylated spirits, or a commercial sterilant like 'Terminator'. Standard disinfection kit and cleaning procedures are provided in Appendix 4.	
	The following practices should be standard: • Set up footbaths or squelch mats at nursery entrance points (Appendix 7). • Have separate tools exclusively for nursery use, not to be used in other garden areas. • If reusing trays or pots, brush free from organic matter, wash and disinfect with chemical disinfectant or by steam sterilisation. • Wooden canes can harbour pests and pathogens and are challenging to sterilise, so reuse should be avoided. • Benches should be brushed clean and disinfected between jobs. • Regularly collect and discard spilt media and plant waste. • Dispose of soil, media and debris appropriately (see Chapter 8). Extra vigilance is required for quarantine or isolation areas (see Chapters 5 and 6).	The following practices should be standard: • Footwear and tools (including spades, shovels, forks, etc.) should be cleaned to remove soil particles (using a stiff brush) and disinfected when moving between beds (see Appendix 4). • All equipment (tools and machinery) should be cleaned regularly, ideally using a pressure sprayer at a wash-down facility (see Appendix 6). • Instruct contractors to clean their vehicles and equipment before entering and/or leaving the garden (see Appendix 5).
Water	Provide plants with adequate water using efficient irrigation methods (drip irrigation, sprinkler systems or hand watering). Avoid over- or under-watering as both can stress plants. In addition, over-watering is wasteful of water, energy, labour and resources.	
	Poor water management can accelerate the spread of *Phytophthora* and *Pythium*. Manage water use to prevent standing water: • Avoid over-watering to prevent run-off. Group plants by water needs to reduce inputs. • Use drip irrigation where possible. If overhead is the only option, avoid evening watering to minimise leaf wetness duration. • Regularly inspect and maintain irrigation systems for leaks or clogs that affect water quality or distribution. • Periodically disinfect irrigation lines. • Regularly check drainage areas. See Chapter 6 for additional water management notes for quarantine facilities.	Poor drainage or flooding can result in infection and plant death. Address drainage issues: • Regularly maintain drainage systems to ensure they work effectively. • For gardens prone to inundation, explore methods to keep flood water from reaching valued plants, e.g., diverting flood water along gullies. • Address soil compaction issues to improve drainage.

Table 4: Specific cultural practices relevant to nursery or garden conditions (continued)

	Nursery	Garden
Infrastructure	All infrastructure, including glasshouses and polytunnels, and benches and workspaces within, should be well maintained, and kept clean and tidy. In addition: • Concrete or gravel floors are preferable, as weeds and pathogens can establish more easily on bare ground. • Keep work surfaces and floors weed free and clean to minimise opportunities for pest accumulation. • Spaces should be maintained to be free of dead plants and plant debris, as these can also facilitate pest accumulation. • Avoid having plants in direct contact with the ground. • Raised benches are preferred, but if this is not possible, having plants raised on steel mesh on bricks can still reduce the risk of pathogen outbreaks. • Ensure spaces have adequate and functional drainage to prevent water accumulation. • Maintain good ventilation to reduce humidity and discourage fungal growth. • Designate specific areas for different stages of plant production to prevent cross-contamination between healthy and potentially diseased plants. Additional requirements for quarantine infrastructure are presented in Chapter 6.	Wet, muddy areas can harbour pathogens like *Phytophthora*, and people walking through such areas can pick up the pathogens on their footwear. To prevent this: • Keep the surface of paths in good repair and prevent ponding of water. If this is not possible, restrict access to affected areas during wet conditions. • Ensure that path cambers divert water to gullies and drains, and regularly inspect to ensure they remain clear. • Regularly remove leaves, other plant debris and soil from paths. Where necessary, erect signs and fencing to restrict access to high-risk areas, including those with a known pest or pathogen problem, areas under development or waterlogged areas.
Plant debris	Plant debris can facilitate pest build up, so nursery spaces should be maintained to be free of any plant debris. This includes regularly rogueing out dead or dying cuttings.	As well as looking unsightly, having dead or dying plants in the garden can promote the accumulation of pests and pathogens. Therefore, they should be promptly removed and disposed of appropriately (see Chapter 8). This also applies to any other plant materials, including prunings and weeds, which have been removed from garden beds.
Labelling	Correct labelling of plants, including accession numbers and planting or last potting date, is essential to minimise mixing of accessions in nurseries. See also recommendations on record-keeping (Chapter 9, Appendix 1).	Keep comprehensive records of plants in the garden and develop management plans for conserving important (rare or threatened) species.

Table 4: Specific cultural practices relevant to nursery or garden conditions (continued)

	Nursery	Garden
Growing media	To ensure good plant growth and development, choose growing media with optimum air-filled porosity, water-holding capacity and nutrient availability. Improper storage or handling can lead to on-site infestation, allowing pests to spread when plants are planted out or sold. To mitigate this risk: • Store growing media on a concrete pad away from high traffic areas. • Growing media should never be reused. The risks of contamination by pests and pathogens, nutrient depletion, poor drainage, pH imbalance and weed infestation far outweigh cost savings.	
Soil health		Good soil health can be achieved by alleviating compaction, implementing appropriate watering regimes and ensuring adequate nutrient levels. This can include the addition of organic matter (e.g., compost), though precautions should be taken to mitigate associated risks (see Chapter 4).
Pruning		Pruning improves plant shape, structure and health by removing unwanted parts, increasing air movement and reducing humidity. However, poor pruning can harm plants: • Use the right tool for the task and keep tools sharp and clean. Blunt tools make pruning more laborious, increase injury risk and can damage plants. • Prune at the right time to encourage rapid wound closure and reduce pest entry – usually after leaves harden, in late spring to summer, though some plants benefit from winter pruning. • For large branches, use the ternary pruning method (undercut, top cut, stub cut). Avoid rip cuts, flush cuts and stub cuts, as these hinder quick healing and can become sites for pathogen infection or decay. • Wound paints are not recommended as they can trap moisture and impede natural healing.

Testing water sources for the presence of pathogens. Photograph: Trudy Paap.

Baiting for *Phytophthora*. Photograph: Trudy Paap.

8 Disposal methods for plants and organic waste

Without proper management, discarded growing media and plant waste can end up dumped in random heaps. This creates opportunities for pest and pathogen populations to build and spread to nearby plants, both within living collections and the surrounding environment. Therefore, implementing effective waste disposal strategies and handling waste according to its associated risk level is crucial. We recognise that managing organic waste can present challenges, especially in locations with limited disposal options. However, adhering to the guidelines presented in this chapter can help mitigate the risk of pest transmission associated with plant waste, regardless of site limitations.

8.1. Determining risk level

As a first step, it is important to differentiate between disposal requirements for general (non-diseased/non-quarantine) organic waste, and waste material originating from quarantine facilities or symptomatic/infested plants. The biosecurity risk associated with waste material generated during quarantine or isolation procedures is high, therefore, such waste should be treated as potentially biohazardous and should be handled using stringent procedures, as outlined in Section 8.4.

The presence of several significant pest and pathogen species has been confirmed at a number of NBGs, including *Phytophthora* species, *Armillaria mellea* and the polyphagous shot hole borer (PSHB). Plants infested by these species should be treated as high-risk material, as reusing organic matter from these plants (e.g., uncomposted woodchips), can facilitate further spread. It's important to note that *P. cinnamomi* is listed as a Category 1b species under the National Environmental Management: Biodiversity Act (NEMBA, Act No. 10 of 2004) Alien and Invasive Species (A&IS) regulations (invasive species which must be controlled and, wherever possible, removed and destroyed). Eradication of this soil-borne pathogen is nearly impossible, so precautions should be taken to minimise the risk of further spread. Regular monitoring for detection of plant health issues in the estate (as detailed in Chapter 9) is closely tied to understanding the risk level associated with waste plant material. Staff should be familiar with the symptoms and signs associated with damaging pests and pathogens known to be present on the estate. Where there is uncertainty about the cause of plant health issues, samples should be submitted for diagnostics (see Appendix 2).

Prunings from healthy plants, fallen leaves, weeds and media waste resulting from repotting (outside of quarantine context) can be classified as general waste. These materials can be disposed using the general methods outlined in Section 8.3.

8.2. Site location

Waste disposal sites (including composting areas and points where high-risk waste is held) should be situated away from production areas and plant collections. These sites should be isolated from public access and located in low-traffic areas. Ideally, they should be positioned downwind and downhill from production areas and collections to mitigate the risk of wind- or water-borne debris spreading back to these areas. Additionally, waste sites should be located well away from water sources such as streams, rivers and reservoirs.

8.3. General waste disposal

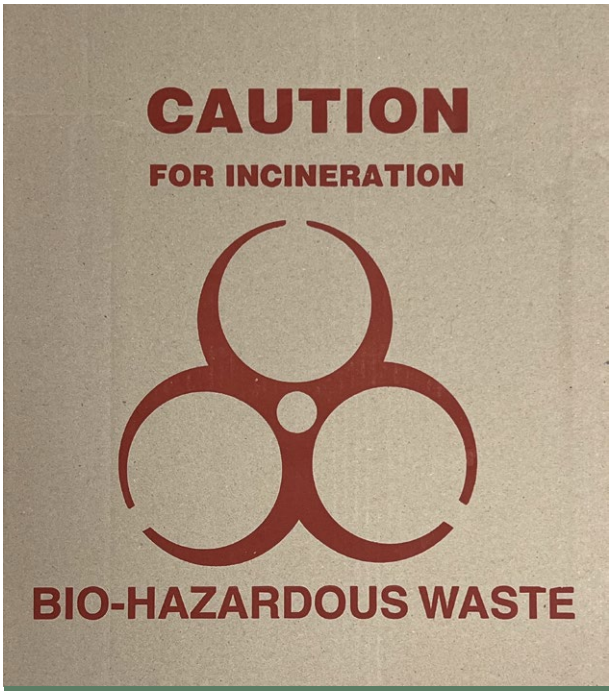
General waste material can be disposed of through on-site composting, incineration, landfill or removal.

- **On-site composting:** this method offers significant benefits. If only low-risk materials are incorporated, and adequate temperatures are reached, the end product can be used as a soil additive in garden beds to improve soil structure, or as a surface mulch. Note that temperatures should reach at least 55 °C for a continuous period of two weeks, or 65 °C for a continuous period of one week. Water content during this period should be a minimum of 40%. These conditions are sufficient to kill many

On-site green waste disposal by chipping and composting. Photograph: Trudy Paap.

weed seeds and pest and pathogen propagules. However, some pathogens produce very resilient resting structures that can survive the composting process (e.g., *Armillaria mellea*), hence considerable care should be taken when determining the risk level of the material to be composted. Bulky items will take longer to compost than macerated or shredded material. Larger woody prunings can be chipped before being added.

- **Incineration:** where facilities and permits are in place, incineration can be a good way of disposing of plant waste, either by burning in an incinerator, or burning in the open. However, there are limits on the amount of material that can be processed in these ways or at any one time. As incineration is well suited for the disposal of biohazardous waste, it is discussed in more detail in Section 8.4.
- **Landfill:** if on-site composting is not feasible, general green waste may be disposed of at landfill facilities.
- **Removal:** removal of green waste to a commercial composting facility (usually by a waste management company) may be an alternative disposal method.



Biohazardous waste disposal box. Photograph: Trudy Paap.

8.4 Biohazardous waste disposal

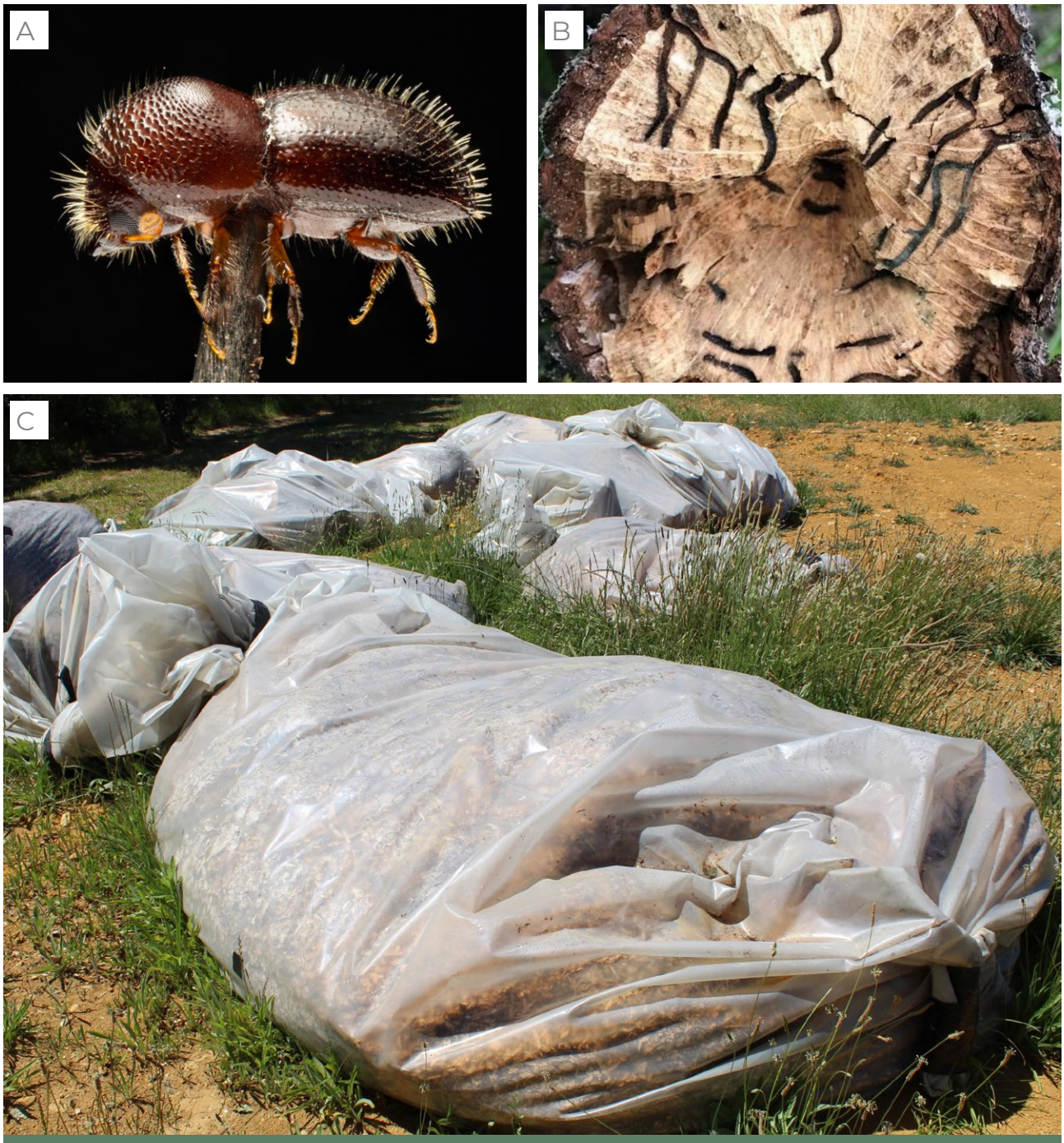
Any organic waste originating from quarantine or isolation facilities, as well as plant material that is obviously diseased or infested, poses a risk to living plant collections. Proper disposal methods are crucial to prevent further spread of pests and pathogens. Staff should be trained in biohazardous waste management, including recognition of biohazardous materials, waste disposal procedures and proper handling techniques. As noted in Section 5.3, destruction of high-risk plant material infested by a quarantine pest or alien pest not reported as present in South Africa, should be done in consultation with plant health experts to prevent escape risks. Appropriate disposal methods for biohazardous waste include incineration or steam sterilisation.

If incineration or sterilisation options are not available, bagging and solarising the waste may be used as an alternative prior to disposal, however, all care should be taken to ensure sufficient temperatures are reached and sustained to kill pest and pathogen propagules.

For larger material, including wood infested with PSHB beetles, *Armillaria* or *Phytophthora* species, burning, chip and compost or solarisation is recommended.

- **Incineration or steam sterilisation**: use biohazard bins in isolation facilities to contain potentially infectious material prior to disposal. Be sure to follow the hygiene measures outlined in Chapter 7, especially with regards to cleaning hands, footwear and any tools that may have been used during the process. This is only suitable for smaller quantities of waste (e.g., originating from quarantine or isolation facilities).
- **Burning:** where site conditions allow, open burning of material is an appropriate disposal method. Material should be collected, covered and transported to the dedicated disposal site and burned as soon as conditions allow.
- **Chip and compost or solarise:** this should be done on-site or at a designated dump site, to prevent further spread. As previously noted, some pathogens have very resilient resting structures that can survive the composting process. Therefore, it is not advisable for this material to go back into garden beds. Once composted or solarised, landfill may be the most suitable destination for this material. In the instance where quarantine pests may be involved, however, off-site disposal should be avoided, to reduce the risk of spread.

Controlled open burning for safe disposal of infested plant material. Photograph: Alice Notten.



Waste disposal: A, the invasive polyphagous shot hole borer (*Euwallacea fornicatus*); B, infested oak (*Quercus robur*) wood; C, chipped and bagged infested wood undergoing solarisation. Photographs: A, Garyn Townsend; B, C, Trudy Paap.

Quercus sp. Photograph: Trudy Paap.

9 Monitoring and record-keeping

Monitoring and record-keeping are essential components of biosecurity best practices and play a crucial role in maintaining the health of living plant collections. By systematically observing and documenting plant health, institutions can detect potential issues early, track changes over time and implement timely interventions.

9.1. Regular inspections

Implement a schedule for regular visual inspections of all plants in the collection. Inspections should occur weekly, monthly or bimonthly, depending on capacity, though checks should be more frequent during critical periods, such as after introducing new plant material or during peak pest seasons.

Appendix 1 provides a check sheet for inspecting incoming plant material. In addition, the IPSN has produced Plant Health Checker guides to provide a standard format to record symptoms, so that damage can be tracked and monitored. These forms (see Appendix 8) assist in identifying when a problem needs to be escalated to more experienced staff or when samples need to be submitted for diagnostics (see Appendix 2).

9.2. Establish baseline health

Where capacity allows, develop a baseline assessment of plant health for each species in the collection. This includes noting typical growth patterns, leaf coloration and any signs of stress or damage. Capturing

baseline data provides a reference point for comparison over time, allowing staff to track changes in plant health and detect deviations from normal conditions. This proactive approach facilitates early identification of potential problems and can allow staff to take preventive measures before problems escalate.

9.3. Record-keeping and reporting

Maintain detailed records of plant health observations, including inspection dates, specific observations and any actions taken. Guidance on the data fields to capture is provided in Appendices 1 and 8, with Appendix 2 detailing the process for submitting samples for diagnostics. Results of pests or pathogens identified during diagnostics will be shared with the responsible horticulturist. Establishing a centralised database to maintain all monitoring and diagnostics records will be hugely beneficial and is highly recommended.

Under the NEMBA A&IS Regulations, SANBI is tasked with compiling a National Status Report on Biological Invasions every three years. Therefore, it is vital to relay any detections of alien species not currently reported as present in South Africa to the team responsible for the status report. The team can be contacted at invasives@sanbi.org.za and the SANBI lead is Dr Tsungai Zengeya (e-mail: T.Zengeya@sanbi.org.za). New incursions of plant pests should also be reported to the NPPO, under the DoA's Directorate Plant Health (e-mail: phytomatters@dalrrd.gov.za). Support for reporting will be provided through the SANBI-FABI sentinel plant project.

9.4. Use of technology

Utilise technology such as digital cameras or smartphone apps to document plant health observations visually. This can aid in tracking changes over time and sharing information with relevant stakeholders.

9.5. Pest trapping and monitoring

Set up pest traps and monitoring devices to detect the presence of pests in the collection. This is particularly relevant for nurseries and quarantine facilities. Regularly check traps and monitors for signs of pest activity and adjust management strategies accordingly. See Section 5.2 for further details.

9.6. Collaboration and information sharing

Foster collaboration with other botanical institutions and experts in the field to share information and best

SANBI horticulturalist staff engaging in biosecurity best practice discussions. Photograph: Felipe Balocchi.

practices. Participate in networks or forums dedicated to plant health to stay updated on emerging issues and solutions. A list of diagnostic service providers is presented in Appendix 2, and further information on current pest issues in the NBGs is available via the SANBI–FABI Sentinel Project website (www.fabinet.up.ac.za/index.php/sentinel-plant-network).

9.7. Early intervention

Develop protocols for early intervention in the case of pest outbreaks or other plant health issues. Measures such as quarantine, biological control or targeted pesticide applications should be implemented as needed to prevent further spread and minimise damage to the collection. As noted in Chapter 7, there is a need for a comprehensive IPM document to be developed. Such a document will be a valuable resource in compiling effective IPM strategies for managing the pests commonly encountered within the collections.

9.8. Review and evaluation

Regularly review and evaluate the effectiveness of plant health monitoring protocols and adjust as necessary. Incorporate feedback from staff and stakeholders to continuously improve practices and ensure the long-term health of the plant collections.

10 Staff roles and training

Unless staff feel connected to plant health procedures and understand their importance, they're likely to take shortcuts. Therefore, management should provide support to ensure everyone grasps the significance of these procedures.

Currently, plant health support is provided through the SANBI-FABI sentinel plant project. However, given the incredible value of the living plant collections maintained by SANBI, it is strongly recommended that SANBI appoint a dedicated plant health specialist.

The responsibilities of such an appointee would include:

- Coordinating plant health assessments and monitoring.
- Overseeing the development of an IPM document detailing management strategies for common pests.
- Facilitating diagnostics support.
- Assisting with centralised record-keeping and reporting.
- Implementing quarantine protocols for incoming plant material.
- Coordinating staff training in plant health monitoring and best management practices.
- Collaborating with other botanical institutions, universities and research organisations to contribute to the advancement of plant health knowledge.
- Ensuring compliance with relevant policies and regulatory requirements.
- Engaging with the public to raise awareness about plant health.

All staff working with the living plant collections should have a basic awareness of plant health issues and, at the very least, be trained in hygiene best practices.

Staff working in quarantine or isolation facilities will require a deeper understanding of plant health issues. In addition to following biosecurity best practice guidelines, they should have sufficient knowledge to accurately identify symptoms and signs of pests, diseases and other health issues, and take appropriate action.

By ensuring that staff are familiar with the biosecurity best practice measures presented in this document, we hope to greatly enhance the capacity to manage the health of these valuable plant collections. We encourage you to adopt the best practice guide and become champions of biosecurity, to safeguard plant health for generations to come.

In-field demonstration on diagnosing plant health issues. Photograph: Felipe Balocchi.

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Participants, including members of the drafting team, of the biosecurity best practice training workshop held at Kirstenbosch National Botanical Garden in October 2022. Photograph: Kamogelo Modimola.

12 References and further reading

CERRITOS, R., WEGIER, A. & ALAVEZ, V. 2012. Toward the Development of Novel Long-Term Pest Control Strategies Based on Insect Ecological and Evolutionary Dynamics. In: M.L. Larramendy & S. Soloneski (eds), *Integrated Pest Management and Pest Control – Current and Future* Tactics: 35–62. InTech, Rijeka. Available at: https://www.intechopen.com/chapters/29599.

COETZEE, M.P.A., MUSASIRA, N.Y., ROUX, J., ROETS, F., VAN DER MERWE, N.A. & WINGFIELD, M.J. 2018. *Armillaria* root rot spreading into a natural woody ecosystem in South Africa. *Plant Pathology* 67: 883–891. Available at: https://doi.org/10.1111/ppa.12804.

CROPLIFE INTERNATIONAL. 2004. Integrated Pest Management. The way forward for the plant science industry. Available at: https://croplife.org/wp-content/uploads/2014/04/IPM-The-way-forward-for-the-plant-science-industry.pdf.

DEPARTMENT OF ENVIRONMENT, FORESTRY AND FISHERIES. 2020. South African National Environmental Management: Biodiversity Act [NEM:BA, Act 10 of 2004] Alien and Invasive Species Regulations. *Government Gazette*, notice 1020 of 2020, no. 43735: 14–44. Available at: https://invasives.org.za/nemba-alien-and-invasive-species-regulations-and-lists.

FERA. 2012. *Parks and gardens – Biosecurity best practice protocol*. Available at: https://www.planthealthcentre.scot/sites/www.planthealthcentre.scot/files/inline-files/parksbiosecuritysmall_0.pdf.

HAYDEN, K. 2020. Botanic gardens and plant pathogens: a risk-based approach at the Royal Botanic Garden Edinburgh. *Sibbaldia* 18:

Durban Botanic Garden. Photograph: Trudy Paap.

127–139. Available at: https://doi.org/10.24823/Sibbaldia.2020.293.

INTERNATIONAL PLANT SENTINEL NETWORK (IPSN). [undated]. Guide to plant biosecurity in botanical gardens and arboreta. Available at: https://www.bgci.org/wp/wp-content/uploads/2022/08/BGCI-Guide-to-Biosecurity-in-Botanic-Gardens-and-Arboreta.pdf.

IPPC SECRETARIAT. 2010. Design and operation of post-entry quarantine stations for plants. *International Standard for Phytosanitary Measures* 34. Available at: https://www.ippc.int/en/publications/617.

IPPC SECRETARIAT. 2017a. Glossary of phytosanitary terms. *International Standard for Phytosanitary Measures* 5. Available at: https://www.ippc.int/en/publications/622.

IPPC SECRETARIAT. 2017b. International movement of wood. *International Standard for Phytosanitary Measures* 39. Available at: https://www.ippc.int/en/publications/84341/.

IPPC SECRETARIAT. 2021a. Strategic framework for the International Plant Protection Convention (IPPC) 2020–2030. Protecting global plant resources and facilitating safe trade. Available at: https://www.ippc.int/en/strategic-objectives/ippc-strategic-framework.

IPPC SECRETARIAT. 2021b. Regulation of wood packaging material in international trade. *International Standard for Phytosanitary Measures* 15. Available at: https://www.ippc.int/en/core-activities/standards-setting/ispms.

REPUBLIC OF SOUTH AFRICA. 1983. Agricultural Pests Act No. 36 of 1983 (Act No. 36 of 1983) as amended. Pretoria. Available at: https://www.gov.za/documents/agricultural-pests-act-30-mar-2015-1202.

SANBI & CIB. 2023. *The status of biological invasions and their management in South Africa in 2022*. South African National Biodiversity Institute, Kirstenbosch and DSI-NRF Centre of Excellence for Invasion Biology, Stellenbosch. Available at: http://dx.doi.org/10.5281/zenodo.8217182.

STAPLETON, J.J. & DEVAY, J.E.1986. Soil solarisation: a non-chemical approach for management of plant pathogens and pests. *Crop Protection* 5: 190–198. Available at: https://doi.org/10.1016/0261-2194(86)90101-8.

SUMMERELL, B.A. & LIEW, E.C.Y. 2020. *Phytophthora* root rot: its impact in botanic gardens and on threatened species conservation. *Sibbaldia* 18: 90–104. Available at: https://doi.org/10.24823/Sibbaldia.2020.290.

THOMAS, M.B. 1999. Ecological approaches and the development of “truly integrated” pest management. *Proceedings of the National Academy of Sciences* 96: 5944–5951.

WONDAFRASH, M., WINGFIELD, M.J., WILSON, J.R.U., HURLEY, B.P., SLIPPERS, B. & PAAP, T. 2021. Botanical gardens as key resources and hazards for biosecurity. *Biodiversity and Conservation* 30: 1929–1946. Available at: https://doi.org/10.1007/s10531-021-02180-0.

Appendices

- Appendix 1: Keeping records of inputs
- Appendix 2: Sample submission for diagnostics
- Appendix 3: Water disinfestation
- Appendix 4: Standard disinfection kit
- Appendix 5: Vehicle/equipment inspection record-keeping
- Appendix 6: Wash-down facility
- Appendix 7: Footbaths/squelch mats
- Appendix 8: Plant Health Checker forms
- Appendix 9: Relevant legislation and regulations

Appendix 1: Keeping records of inputs

Date received	Supplier (name)	Material type and quantity (e.g., media, timber, etc.)	Invoice, batch number or other identification	Material inspection (signs of pests or diseases)	Action (e.g., reject, treat)	Signature of inspector

Appendix 2: Sample submission for diagnostics

SANBI-FABI project:
'Monitoring tree health at sentinel sites: botanical gardens and arboreta'

SANBI Biodiversity for Life South African National Biodiversity Institute FABI

PLANT AERIALS

above ground organs

a. **What to collect?** – The samples need most crucially to include the plant parts **where tissues transition from being healthy to diseased**, most often evident by changes in their colour. Samples can include:
   i. **Seedlings**: Can be sent complete (including some soil) – if too large, make sure to send the relevant parts of the plant. Ideally each seedling should be packaged and labelled individually in plastic bags. If sending a large number of seedlings, these can be grouped in subsamples of 2–3 plants/bag.
   ii. **Stem/branch segments or trunk pieces**: Young stems/branches can be cut using secateurs/handsaw, or trunk pieces can be shaved with a pocket knife or collected with a chisel and hammer. These can be placed into paper or plastic bags.
   iii. **Leaves**: These can be collected in paper bags or paper envelopes. Leaves tend to rot easily when transported in plastic bags. For small-leafed plants whole twigs can be sent. Larger leaf pieces may be cut with secateurs.

b. **Dead plants or plant parts are often undesirable** – only include (as a separate subsample) if there is a limited amount of living symptomatic tissues. Dead tissues are colonized by numerous decomposing microorganisms that often interfere with sample processing.


Stem/Trunk pieces


Complete seedlings


Leaves: Full or pieces

ROOTS AND SOIL

below ground including soil

a- **What to collect?** **250–400 g of soil** should suffice for most purposes. Remove the top 5-10 cm of soil and collect underneath using a spade/shovel. For diagnosis purposes, soil must be collected from underneath the symptomatic tree, and **should include fine roots**.

b- **Collect samples in plastic bags or containers**. Paper bags break easily resulting in cross contamination.


Remove top 5-10 cm before collection Include roots

INSECTS FOR IDENTIFICATION

Insects may be sent in the form these are encountered (e.g., adults, larvae, attached to leaves). The inclusion of adults should be prioritized, as larvae and pupae are in many cases insufficient for identification purposes.

Loose insects should be stored in ethanol 70% or similar (**commercial hand sanitiser** is recommended), and sent in closed containers (tubes, vials, flasks).

For **Leaf samples**, these can be sent in plastic or paper bags.


Vials with 70% ethanol Leaf samples

SAMPLE PACKAGING AND LABELLING

1) **What to use?** – Samples may be collected in **plastic bags**, **paper bags**, **paper envelopes**, **plastic containers**, or **vials**. This will depend on the type of sample (specified below), its size and condition, and the estimated time that it will take to be shipped.

Samples can rot or can dry out – both interfere with processing. Paper bags usually decrease moisture, while plastic bags can do the opposite – to reduce this effect, keep samples in a cool place with no direct sunlight.

Paper bag | Plastic bags | Paper envelopes | Plastic vials | Carton box

2) **Labelling** – All samples and subsamples must be **labelled** so these are recognizable (matching the information provided in the sample sheet). Labels should include: <collectors initials-date (mmdd)-sample number>, e.g., **FB0405-1**.

3) One sample can be composed of a group of **subsamples** (*n* plants of a same species with similar symptoms), however, these need to be packaged and labelled individually (e.g., FB0405-1a, FB0405-1b…). Avoid mixing materials that originate from/contain:
   a. different **plant species**
   b. different **symptoms**
   c. different **locations**

4) **How many?** This is usually given by the context of each sample (e.g., the number of 'diseased' plants/trees observed). Where possible, sending material from **3–10 plants** showing similar symptoms improves the chances of accurate diagnosis.

5) **Shipping**: Use preferably **carton boxes**. Delicate plant parts should be wrapped in extra paper to immobilize inside the box to reduce damage during transport.

DIAGNOSIS SERVICE PROVIDERS

A list of providers in South Africa is provided below. Each service provider may have their own collection guidelines and preferences, which may have differences to the method displayed in this document.

1) **FABI Diagnostic Clinic**
w: https://www.fabinet.up.ac.za/index.php/special-projects/diagnostic-clinic
e: diagnostic.clinic@fabi.up.ac.za
p: +27 12 420 3938

2) **Stellenbosch University Diagnostic Clinic:**
w: http://www.sun.ac.za/english/faculty/agri/plant-pathology/disease-clinic/more-information/staff-contact-info
e: sc2@sun.ac.za/ elaineb@sun.ac.za / dore@sun.ac.za
p: (021) 808 3221 / (021) 808 3222 / (021) 808 3222

3) **Agricultural Research Council:**
w: https://www.arc.agric.za/arc-infruitec-nietvoorbij/Pages/Cultivar%20Development/Plant-pathogen-diagnostic-service.aspx
e: smitl@arc.agric.za

4) **DALRRD Diagnostic services:**
w: https://www.nda.gov.za/index.php/publication/352-diagnostic-services
e: rinusk@dalrrd.gov.za
p: +27 21 8091621

Appendix 3: Water disinfestation

The following table summarises water disinfestation methods based on approved treatments as set out by the Nursery Industry Accreditation Scheme Australia (for more information: https://nurseryproductionfms.com.au/niasa-accreditation).

Treatment	Relative cost	Effective application	Advantages	Disadvantages
Chlorination (sodium or calcium hypochlorite)	Low	2–3 ppm for 20 min contact at pH 5.5–7.5	• effective, stable residual that keeps disinfesting • readily available and relatively cheap	• highly corrosive at high concentrations; requires careful handling • decreased efficacy at higher pH • reduced efficacy with high levels organic matter, iron or nitrogenous fertilisers
Chlorine dioxide	Moderate	3 ppm for 8 min contact at pH 5–10	• effective over a broad pH range • not affected by nitrogenous compounds • effective against broad range of pathogens	• human health and environmental hazards; requires careful handling and monitoring • higher initial costs and requires regular maintenance • high residual levels can be phytotoxic
Chloro-bromination	Low	3 ppm for 8 min contact at pH 5.5–9.0	• improved effectiveness over individual agents • testing of residual levels is relatively simple and inexpensive	• corrosive
Ozone	High	1.4 ppm for 16 min contact time	• effective against a wide range of pathogens, including viruses • can oxidise manganese and iron compounds and many pesticides • less affected by pH and temperature than chlorine	• affected by variations in water; demand increases with alkalinity and concentration of bicarbonate, iron and ammonium • not naturally dispersed in water column; requires complete mixing into water
Iodine	Moderate	5 ppm for 30 min contact time	• effective across various pH and organic loads • automatic dosing adjustment available	• potential phytotoxicity • carbon filters used to remove iodine residues also remove iron and copper leaving water deficient in these nutrients
Ultrafiltration (microfiltration)	Moderate	membrane pore sizes range between 0.01–1.0 micron	• no chemical use • effective against various pathogens including viruses	• requires pre-filtration • membranes need regular maintenance and replacement

Treatment	Relative cost	Effective application	Advantages	Disadvantages
Ultraviolet light	Low	60% transmittance (>80 mJ/cm^2)	• environmentally friendly • no chemical residues left in water	• water quality is critical • requires high level of pre-filtration
Slow flow filtration	Low	≤ 100L/h/m^2 flow rate	• environmentally friendly, no chemicals	• not available 'off the shelf' • must not be allowed to dry out or heat up • pre-filtering required to remove algae or silt • light transmission through tank walls allows algal accumulation across the biofilm layer causing system blockages • requires tanks that do not transmit light (e.g., metal)

Appendix 4: Standard disinfection kit

A recommended standard disinfection kit should contain:

- large washing bowl or plastic crate
- stiff bristled brush
- hoof pick
- water carrier and clean water
- disinfectant (Quaternary Ammonium Compound like 'Terminator', or 70% ethanol or methylated spirits)
- hand sanitiser foam or alcohol gel to disinfect hands
- associated consumables; paper towels, gloves

Standard disinfestation kit. A, water container for carrying clean water to mix with disinfectant in the bucket; B, disinfectant, e.g., approved Quaternary Ammonium Compound; C, bucket for preparing disinfectant solution and cleaning footwear, tools and equipment; D, hand sanitiser; E, associated consumables (paper towels, gloves, safety glasses and resealable plastic bags); F, hoof pick for removing soil and debris, especially from the tread of footwear; G,stiff brushes for scrubbing soil and debris from footwear, clothing and tools; H, spray bottle to apply disinfectant to shoes, clothes, tools and equipment. Photograph: Mpendulo Gabayi.

Appendix 5: Vehicle/equipment inspection record-keeping

Date	Vehicle identifier (e.g., registration number)	Organisation	Area visited	Vehicle inspected for foreign material/ organisms	Cleaned (Y/N)	Staff name

Appendix 6: Wash-down facility

Establishing wash-down facilities at all sites may not be feasible, but having a designated wash-down area can significantly reduce the risk associated with machinery and vehicles. This appendix outlines best practices for creating an effective vehicle and equipment wash-down facility to enhance biosecurity measures.

Location and specifications

- **Designated area:** select a specific area for the wash-down facility that is isolated from other operational zones to prevent cross-contamination.
- **Accessibility:** ensure the facility is easily accessible for all vehicles and equipment entering the site.
- **Drainage:** incorporate proper drainage systems to manage wastewater effectively, e.g., a sump, to prevent runoff that could contaminate surrounding areas.
- **Surface material:** use a sealed (concrete or bitumen) or packed gravel surface to facilitate cleaning and minimise contamination.
- **Water supply:** provide a reliable source of clean water, ideally with high pressure capabilities to effectively remove soil and debris.

Operational procedures

- **Wash procedure:**
  - Dismantle machinery as far as practically possible to give access to internal spaces.
  - Clean from top down to avoid contaminating already cleaned areas.
  - Pay special attention to wheel wells, undercarriages and other hard-to-reach areas.
- **Cleaning agents:** a detergent-based degreaser or disinfectant can be added for additional protection.

Post-wash protocols

- **Inspection after washing:** conduct a secondary inspection to ensure all contaminants have been removed.
- **Drying area:** designate a drying area where cleaned equipment can air dry before entering sensitive zones.

Training and compliance

- **Staff training:** train personnel on the importance of wash-down procedures and how to operate the facility effectively.
- **Record-keeping:** maintain records of wash-down activities, including dates, personnel involved and any issues encountered during the process (see Appendix 5).

Maintenance

- **Cleaning:** schedule routine cleaning of the wash-down area to prevent accumulation of contaminants.
- **Equipment maintenance:** regularly check and maintain wash-down equipment (hoses, nozzles, etc.) to ensure optimal performance.

Appendix 7: Footbaths/squelch mats

Establishing foot baths or squelch mats is an effective biosecurity measure to prevent the spread of pathogens in nursery environments. This appendix provides guidance on the setup, maintenance and best practices for using these facilities.

Setup

- **Location**: Place footbaths at all entry points to sensitive areas (quarantine, greenhouses, propagation zones, etc.).
- **Construction**: For footbaths, use durable, non-porous materials to facilitate cleaning and maintenance; ensure the bath is large enough to accommodate both feet comfortably. For squelch mats, use absorbent materials that can trap soil and contaminants effectively. Mats should be designed for easy cleaning and replacement.
- **Solution**: Fill footbaths with an appropriate disinfectant solution (e.g., Quaternary Ammonium Compound like 'Terminator') at the recommended concentration. The solution should be deep enough to ensure adequate contact with footwear. Soak mats in a disinfectant solution regularly. Ensure that the solution is effective against common pathogens found in the nursery environment.
- **Signage**: Clearly mark the footbath area with signs indicating mandatory use before entering sensitive zones.

Operational procedures

- **Daily checks**: Inspect footbaths and squelch mats daily for contamination and effectiveness of the disinfectant solution.
- **Refilling and changing solutions**: Refill/change the disinfectant solution in footbaths regularly (frequently if heavily used). Replace or clean squelch mats as needed to maintain their effectiveness.

Training and compliance

- **Staff training**: Train staff on the importance of using footbaths and squelch mats as part of biosecurity protocols.
- **Monitoring compliance**: Implement a monitoring system to ensure compliance with footbath usage, including periodic audits.

Basic footbath. Photograph: Felipe Balocchi.

International Plant Sentinel Network

Plant Health Checker - Step 1

Name of Botanic Garden / Arboretum:	
Country:	
Address:	
Name of IPSN contact:	
Survey details	
Survey carried out by:	
Date of survey:	
Best description of season:	
Main reason for surveying this particular individual:	
Plant details	
Species (Cultivar):	
Accession number:	
GPS	
Country/region species is native to:	
Age/amount of time plant has been present in gardens:	
General Comments:	

General description (please tick)

Generally healthy	✓	Some damage	✓
Dying	✓	Dead	✓

Any recent changes in health or overall look:

General description of environment
Any management issues (e.g. irrigation, soil pH, sun bleaching) or any recent use of pesticides/ fungicides/ herbicides:
Description of environment (focusing on recent changes and individuals in close proximity):

For each section of the plant give it a rating dependent on how healthy it appears:

Red (R) = In very poor health and of imminent concern due to significant damage potentially resulting in death of individual

Orange (O) = Not currently a concern but could develop; should be checked frequently to monitor progress

Green (G) = As would be expected on a 'healthy plant'

Black (X) = Absent/not applicable

Where an **orange or red** rating is given, ensure you give a description of why you've given it this rating in notes.

1.) Crown

R ✓ O ✓ G ✓ X ✓

2.) Cones

R ✓ O ✓ G ✓ X ✓

3.) New growth

R ✓ O ✓ G ✓ X ✓

4.) Needles / Leaves

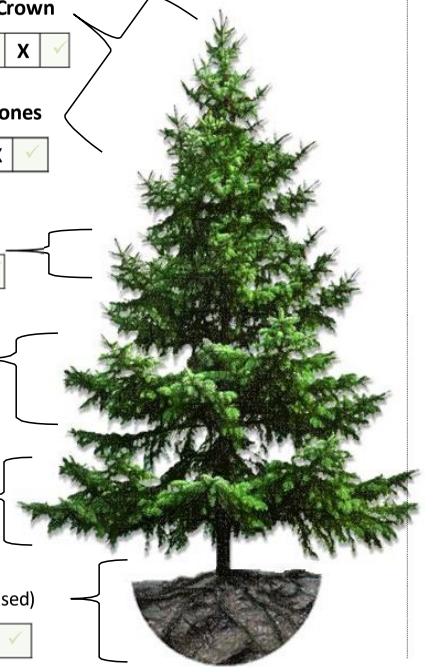
R ✓ O ✓ G ✓ X ✓

5.) Trunk & branches

R ✓ O ✓ G ✓ X ✓

6.) Base and Roots (if exposed)

R ✓ O ✓ G ✓ X ✓



Notes:

What do you think is wrong with this plant? *(give an indication of how sure you are of this diagnosis)*			Reference/file name of any photographs taken:	
1.) Is a re-survey required?	✓	2.) If yes, in what timeframe **(include a suggested date)**	3.) Should this be escalated to an appropriate staff member to carry out STEP 2?	✓
			4.) Name of person escalated to *(if applicable)*:	5.) Date:

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Accession number:_____ Survey completed by:_____ Date:_____

Plant Health Checker – Step 2

Please read: This section should be completed if escalation is specified by STEP 1. It should be carried out by an appropriately trained staff member who has the relevant knowledge concerning the plant's history and/or pest and pathogen identification skills.

Tick all signs/symptoms that are at abnormal levels or are unexpected for the individual, and are thus cause for concern (e.g. are out of the ordinary/new to the plant). Give a description and an indication of severity/abundance in the **notes**, plus note anything else of importance or interest.

1. Crown

Thin /sparse	✓	**Notes:**	
Yellow needles	✓		
Dead wood	✓		
Brown patches of needles/leaves			
Size: 1-2cm (½-1in)	✓	Single patch	✓
Size: 3-4m (10-14ft)	✓	Multiple patches	✓

2. Cones

Dead	✓	**Notes:**	
Malformed	✓		
Swollen	✓		

3. New Growth

Dead	✓	Dieback	✓
Wilted	✓	Malformed	✓

Notes:

4. Needles/leaves

Dead	✓	Malformed	✓
Discoloration	✓	Rust	✓

4. Needles

Dieback of needles along branch	✓		
Age of needles affected (year 1,2,3,4 etc.)			
Approx number of needles effected (%)			
Discoloration (spots/bands) on needles	✓		
Light green / yellow	✓	Single bands	✓
Brown / red	✓	Numerous	✓
Approx number of needles effected (%)			

Notes:

5. Trunk & Branches

Canker or lesion	✓	Approx. number	
Dry	✓	Gummy/sticky	✓
Approx. height of canker from ground (m)			
Galls	✓	Approx. size (m)	
Trunk bleeding ('weeping patches')	✓		
Approx. height of bleed from ground (m)			
Approx. number of bleeds over trunk (m)			
Vertical bleeds (in a line up the trunk)	✓	Horizontal bleeds (around the trunk)	✓
Loose Bark / bark flaking / comes off easily	✓		

Notes:

6. Base and Roots (if exposed)

Bootlaces/black strands *(1-2mm wide)*	✓		
Fungal mycelium/white strands	✓		
Mushrooms/toadstools on plant	✓		
Damage by mammals	✓	**Notes:**	
Decay / Rotting	✓		
Wet	✓	Dry	✓

7. General pest damage

		Location (e.g. leaf)
Insect galleries under loose bark	✓	
Insect eggs	✓	
Chewing damage	✓	
Insect webbing	✓	
Insect mines	✓	
Frass	✓	
Bore holes *(circle below)*	✓	
<5mm / 5-10mm / >15mm		

Notes:

8. Pest sightings

(give an indication of how sure you are of this identification)

		Location (e.g. leaf)	Photo (file name)
	✓		
	✓		
	✓		
	✓		
	✓		

9. General Observations and Additional Notes

Reference/file name of any photographs taken:

What do you think is wrong with this plant? *(give an indication of how sure you are of this diagnosis)*		1.) Is a re-survey required?	✓	2.) If yes, in what timeframe ***(include a suggested date)***	
3.) Should this be reported to the local diagnostic laboratory - a physical sample may be required *(this is only if symptoms are severe or if a pest of concern)*	✓	3.) Date reported:		4.) Should this be escalated to local National Plant Protection Organisation (NPPO)? *(as advised by local diagnostic laboratory)*	✓	5.) Date reported:	

Conifer trees

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International Plant Sentinel Network

Plant Health Checker - Step 1

Name of Botanic Garden / Arboretum:	
Country:	
Address:	
Name of IPSN contact:	

Survey details

Survey carried out by:	
Date of survey:	
Best description of season:	
Main reason for surveying this particular individual:	

Plant details

Species (Cultivar):	
Accession number:	
GPS	
Country/region species is native to:	
Age/amount of time plant has been present in gardens:	
General Comments:	

General description (please tick)

Generally healthy	✓	Some damage	✓
Dying	✓	Dead	✓

Any recent changes in health or overall look:

General description of environment

Any management issues (e.g. irrigation, soil pH, sun bleaching) or any recent use of pesticides/ fungicides/ herbicides:

Description of environment (focusing on recent changes and individuals in close proximity):

For each section of the plant give it a rating dependent on how healthy it appears:

Red (R) = In very poor health and of imminent concern due to significant damage potentially resulting in death of individual

Orange (O) = Not currently a concern but could develop; should be checked frequently to monitor progress

Green (G) = As would be expected on a 'healthy plant'

Black (X) = Absent/not applicable

Where an **orange or red** rating is given, ensure you give a description of why you've given it this rating in notes.

1.) Crown

R ✓ O ✓ G ✓ X ✓

2.) Flowers / Fruits *(circle)*

R ✓ O ✓ G ✓ X ✓

3.) New growth

R ✓ O ✓ G ✓ X ✓

4.) Leaves

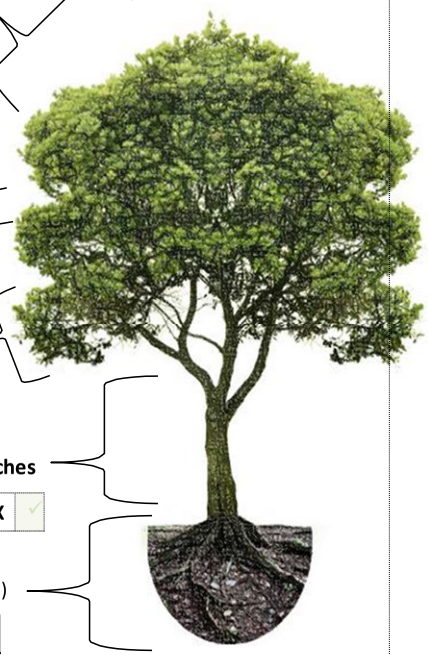
R ✓ O ✓ G ✓ X ✓

5.) Trunk & branches

R ✓ O ✓ G ✓ X ✓

6.) Base and Roots (if exposed)

R ✓ O ✓ G ✓ X ✓



Notes:

What do you think is wrong with this plant? *(give an indication of how sure you are of this diagnosis)*				Reference/file name of any photographs taken:	
1.) Is a re-survey required?	✓	2.) If yes, in what timeframe **(include a suggested date)**		3.) Should this be escalated to an appropriate staff member to carry out STEP 2?	✓
4.) Name of person escalated to *(if applicable)*:		5.) Date:			

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Accession number:_____ Survey completed by:_____ Date:_____

Plant Health Checker – Step 2

Please read: This section should be completed if escalation is specified by STEP 1. It should be carried out by an appropriately trained staff member who has the relevant knowledge concerning the plant's history and/or pest and pathogen identification skills.

Tick all signs/symptoms that are at abnormal levels or are unexpected for the individual, and are thus cause for concern (e.g. are out of the ordinary/new to the plant). Give a description and an indication of severity/abundance in the **notes**, plus note anything else of importance or interest.

1. Crown

Thin /sparse	✓	**Notes:**
Yellow leaves	✓	
Dead wood	✓	

2. Blossom/Flowers

Dead	✓	**Notes:**
Malformed	✓	
Swollen	✓	

3. New Growth (Shoots and Buds)

Dead	✓	Dieback	✓
Wilted	✓	Malformed	✓

Notes:

4. Leaves

Dead	✓	Malformed	✓
Smaller than expected (stunted)	✓	Mosiacs / mottled / variation in colour	✓
Sticky	✓	Galls	✓
Rust	✓	Mildew	✓

4. Leaves continued (leaf spots)

Single	✓	Numerous	✓
Present only at the edge	✓	All over leaf	✓
Only on old growth	✓	Only on new growth	✓
Yellowing (chlorotic leaves)	✓	Brown/blackeing (necrotic leaves)	✓

Notes:

5. Trunk & Branches

Canker or lesion	✓	Approx. number	
Dry	✓	Gummy/sticky	✓
Approx. height of canker from ground (m)			
Galls	✓	Approx. size (m)	
Trunk bleeding ('weeping patches')			✓
Approx. height of bleed from ground (m)			
Approx. number of bleeds over trunk			
Vertical bleeds (in a line up the trunk)	✓	Horizontal bleeds (around the trunk)	✓
Loose Bark / bark flaking / comes off easily			✓

Notes:

6. Base and Roots (if exposed)

Bootlaces/black strands *(1-2mm wide)*			✓
Fungal mycelium/white strands			✓
Mushrooms/toadstools on plant			✓
Damage by mammals	✓	**Notes:**	
Decay / Rotting	✓		
Wet ✓	Dry ✓		

7. General pest damage

		Location (e.g. leaf)
Insect galleries under loose bark	✓	
Insect eggs	✓	
Chewing damage	✓	
Insect webbing	✓	
Insect mines	✓	
Frass	✓	
Bore holes *(circle below)*	✓	
<5mm 5-10mm >15mm		

Notes:

8. Pest sightings

(give an indication of how sure you are of this identification)

		Location (e.g. leaf)	Photo (file name)
	✓		
	✓		
	✓		
	✓		
	✓		

9. General Observations and Additional Notes

Reference/file name of any photographs taken:

What do you think is wrong with this plant? *(give an indication of how sure you are of this diagnosis)*		1.) Is a re-survey required?	✓	2.) If yes, in what timeframe ***(include a suggested date)***	
3.) Should this be reported to the local diagnostic laboratory - a physical sample may be required *(this is only if symptoms are severe or if a pest of concern)*	✓	3.) Date reported:		4.) Should this be escalated to local National Plant Protection Organisation (NPPO)? *(as advised by local diagnostic laboratory)*	✓	5.) Date reported:	

Deciduous trees

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International Plant Sentinel Network

Plant Health Checker - Step 1

Name of Botanic Garden / Arboretum:	
Country:	
Address:	
Name of IPSN contact:	

Survey details

Survey carried out by:	
Date of survey:	
Best description of season:	
Main reason for surveying this particular individual:	

Plant details

Species (Cultivar):	
Accession number:	
GPS	
Country/region species is native to:	
Age/amount of time plant has been present in gardens:	
General Comments:	

General description (please tick)

Generally healthy	✓	Some damage	✓
Dying	✓	Dead	✓
Any recent changes in health or overall look:			

General description of environment

Any management issues (e.g. irrigation, soil pH, sun bleaching) or any recent use of pesticides/ fungicides/ herbicides:
Description of environment (focusing on recent changes and individuals in close proximity):

For each section of the plant give it a rating dependent on how healthy it appears:

Red (R) = In very poor health and of imminent concern due to significant damage potentially resulting in death of individual

Orange (O) = Not currently a concern but could develop; should be checked frequently to monitor progress

Green (G) = As would be expected on a 'healthy plant'

Black (X) = Absent/not applicable

Where an **orange or red** rating is given, ensure you give a description of why you've given it this rating in notes.

1. Flowers & buds

R ✓ O ✓ G ✓ X ✓

2. Leaves

R ✓ O ✓ G ✓ X ✓

3. Stem

R ✓ O ✓ G ✓ X ✓

4. Taproots and Branch Roots

R ✓ O ✓ G ✓ X ✓

Notes:

What do you think is wrong with this plant? *(give an indication of how sure you are of this diagnosis)*						Reference/file name of any photographs taken:	
1.) Is a re-survey required?	✓	2.) If yes, in what timeframe **(include a suggested date)**		3.) Should this be escalated to an appropriate staff member to carry out STEP 2?	✓	4.) Name of person escalated to *(if applicable)*:	5.) Date:

Herbaceous plants - uncovered

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Accession number:_____ Survey completed by:_____ Date:_____

Plant Health Checker – Step 2

Please read: This section should be completed if escalation is specified by STEP 1. It should be carried out by an appropriately trained staff member who has the relevant knowledge concerning the plant's history and/or pest and pathogen identification skills.

Tick all signs/symptoms that are at abnormal levels or are unexpected for the individual, and are thus cause for concern (e.g. are out of the ordinary/new to the plant). Give a description and an indication of severity/abundance in the **notes**, plus note anything else of importance or interest.

1. Flowers and buds

Dead	✓	**Notes:**
Buds failed to open		
Buds discoloured	✓	
Buds dry up or rot		
Buds/flowers deformed		
Buds/flowers swollen	✓	
Flowers discoloured	✓	
Flowers failed to develop	✓	
Flower heads collapsed		

2. Leaves

Dead	✓	Dieback	✓
Thin/sparse	✓	Pustules	
Smaller than expected (stunted	✓	Mosiacs / mottled / variation in colour	✓
Sticky	✓	Galls/swellings	✓
Rust	✓	Mildew	✓
Surface growth	✓	Blistering	✓

2. Leaf Spots

Single	✓	Numerous	
Present only at the edge	✓	All over leaf	
Only on old growth	✓	Only on new growth	✓
Yellowing (chlorotic leaves)	✓	Brown/blackeing (necrotic leaves)	✓

Notes:

3. Stem

Staining/discolouration	✓
Wilting	✓
Gummy/sticky residue	✓
Galls/swellings	✓

Notes:

4. Taproot and Branch Roots

Bootlaces/black strands *(1-2mm wide)*	✓
Galls/swellings	✓
Mushrooms/toadstools around plant	✓
Damage by mammals	✓
Staining	✓
Decay / rotting	✓

Notes:

5. General pest damage

		Location (e.g. leaf)
Insect eggs	✓	
Chewing damage	✓	
Insect webbing	✓	
Insect mines (leaves)	✓	
Frass	✓	
Mites seen	✓	

Notes:

6. Pest sightings

(give an indication of how sure you are of this identification or description if unknown)

		Location (e.g. leaf)	Photo (file name)
	✓		
	✓		
	✓		
	✓		
	✓		

7. General Observations and Additional Notes

Reference/file name of any photographs taken:

What do you think is wrong with this plant? *(give an indication of how sure you are of this diagnosis)*		1.) Is a re-survey required?	✓	2.) If yes, in what timeframe ***(include a suggested date)***	
3.) Should this be reported to the local diagnostic laboratory - a physical sample may be required *(this is only if symptoms are severe or if a pest of concern)*	✓	3.) Date reported:		4.) Should this be escalated to local National Plant Protection Organisation (NPPO)? *(as advised by local diagnostic laboratory)*	✓	5.) Date reported:	

Herbaceous plants - uncovered

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Appendix 9: Relevant legislation and regulations

South Africa is a signatory to the World Trade Organisation Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement), the International Plant Protection Convention (IPPC) and the Convention on Biological Diversity (CBD). All plant material coming into gardens from across borders must comply with the regulations detailed by the following international and national conventions and Acts. Management of living plant collections is also regulated in terms of biological invasions.

- **WTO-SPS Agreement**
  The Agreement gives members the right to apply sanitary and phytosanitary measures necessary for the protection of the life and health of humans, animals and plants, provided that such measures are not in contravention of the provisions of that Agreement. More information: http://www.wto.org/english/res_e/booksp_e/agrmnt-series4_sps_e.pdf.

- **International Plant Protection Convention (IPPC)**
  The IPPC is an international plant health treaty that aims to protect cultivated and wild plants by preventing the introduction and spread of pests. It provides a framework for the establishment and cooperation of national and regional regulatory authorities for plant import and export, and is responsible for developing International Standards for Phytosanitary Measures (ISPMs). More information: https://www.ippc.int/about/convention-text.

- **Convention on Biological Diversity of the United Nations (CBD)**
  Requires each contracting Party, as far as possible and as appropriate, to 'prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species'. More information: https://www.cbd.int/convention/text/.

In addition to the above international agreements, the following national regulations apply:

- **The National Environmental Management: Biodiversity Act (No. 10 of 2004) (NEM:BA) and its Alien and Invasive Species Regulations (A&IS Regulations) of 2014 as updated 2020**
  Provides for the regulation of the importation of alien species through the issuance of relevant permits; specifies invasive species that are subject to regulation in South Africa, including some of which through the issuance of relevant permits; and requires all land-owners (including national botanical gardens) to develop plans for managing biological invasions on their land. More information: https://invasives.org.za/nemba-alien-and-invasive-species-regulations-and-lists/.

- **Agricultural Pests Act, 1983 (Act No. 36 of 1983) (APA)**
  The national phytosanitary regulatory system is currently administered under the APA and its associated regulations. The aim of the current Act is to prevent and control the importation of agricultural and forestry pests, and to provide appropriate measures for their national control and matters connected therewith. In terms of its provisions, no person is allowed to import into South Africa any controlled goods, except under the authority of a permit or regulation and in compliance with the relevant import requirements. Legislation and regulations relating to Agricultural Pests Act can be found at: https://invasives.org.za/wp-content/uploads/Agricultural-Pests-Act.pdf.

- **Plant Health (Phytosanitary) Bill**
  The APA was promulgated in 1983, with its latest amendment promulgated in 1992. It was promulgated before the adoption of the IPPC's 1997 text and the WTO-SPS Agreement of 1995. The Plant Health (Phytosanitary) Bill seeks to address gaps and challenges in the current phytosanitary system. The proposed new phytosanitary legislation will replace the current APA when promulgated after completion of the required national processes. More information: www.gov.za/sites/default/files/gcis_document/202108/b14-2021planthealthphytosanitarya.pdf.

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34. Biosecurity in living plant collections in South Africa – guidelines for best practice. 2026. M. Gabayi & T. Paap (eds). ISBN 978-1-928224-79-2.

Enquiries

South African National Biodiversity Institute, 2 Cussonia Ave., Brummeria, Pretoria, 0184 South Africa.
Website: www.sanbi.org

Pests and pathogens pose significant risks to plant health and it is important for anyone with an interest in South Africa's indigenous plants, or who has a stake in commercial crops or ornamental gardens, to understand the threats involved. There are several simple steps to reduce the risk of introducing or spreading plant pests and diseases.

The South African National Biodiversity Institute (SANBI), in collaboration with the Forestry and Agricultural Biotechnology Institute (FABI), has developed this guide to biosecurity best practice for living plant collections, with the aim of assisting in protecting the country's plants from the introduction and spread of harmful organisms. This best practice guide provides information that will assist in efforts to prevent a pest or pathogen outbreak, with recommended procedures for routine activities undertaken by staff working with living plant collections.

Eight themes are represented in various chapters of the document: threats, pathways, biosecurity measures, quarantine, cultural practices, waste disposal, monitoring and staff roles.

SANBI
Biodiversity for Life
South African National Biodiversity Institute

FABI
Forestry and Agricultural Biotechnology Institute

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