NSW NATIONAL PARKS & WILDLIFE SERVICE

# Aerial Spraying Guidelines

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# 1. Introduction

Weeds pose a serious threat to the environment and agricultural industry in New South Wales (NSW). They can impact on biodiversity and the balance of natural ecosystems, landscapes and water catchments. They can also influence rural economies, human health and recreational use of land.

Several weed species or groups of weed species have such an impact on the environment that they are recognised as key threatening processes (KTPs) under the NSW *Biodiversity Conservation Act 2016* (BC Act). These species have been assessed to have a particularly adverse impact on threatened species or ecological communities or could cause unlisted entities to become threatened. Species such as bitou bush, blackberry and ox-eye daisy are KTPs that have been successfully targeted with aerial spraying.

The NSW Department of Primary Industries is the lead government agency for weed management in NSW and administers the *Biosecurity Act 2015*. As a land manager, the National Parks and Wildlife Service (NPWS) has an obligation under that Act to control and manage pest animals and plants on land administered by the service. Collectively this land is referred to as ‘park’.

NPWS weed control programs are carried out in collaboration with a number of agencies and organisations such as Local Land Services, regional or local weeds authorities and local government through priority-based weed programs.

Weed control programs integrate a number of methods depending on the site-specific factors and the priority weeds. These methods may include physical removal, release of biological control agents, on-ground or aerial herbicide application. Aerial application or spraying, is an important tool, allowing the treatment of large-scale weed infestations with greater ease and effectiveness, as well as managing weeds in remote or inaccessible locations. Aerial spraying techniques are cost-effective mechanisms to implement statewide containment programs, such as for ox-eye daisy and bitou bush, to prevent their further spread and impacts to biodiversity.

Aerial spraying is not without risk, and the use of this control technique must incorporate robust planning and environmental risk assessment.

# 2. Scope

The NPWS Aerial Spraying Guidelines (the Guidelines) replace and expand on the *Best Practice Guidelines for Aerial Spraying of Bitou Bush* (Broese van Groenou and Downey 2006).

The Guidelines (including appendices), are referenced in 2 NPWS aerial spraying Minor Use Permits approved by the Australian Pesticides and Veterinary Medicines Authority (APVMA).

These Guidelines provide best practice information on the aerial spraying of herbicides by NPWS staff and contractors working on park. The principles described here may also be applied by any party wishing to utilise the current APVMA aerial spraying permits to facilitate aerial spraying operations in conservation settings (i.e. non-agricultural).

The Guidelines cover aerial spraying of herbicides:

- from manned rotary and fixed wing aircraft (referred to from hereon as helicopter or fixed wing)
- from remotely piloted aircraft, both fixed wing and rotary (referred to from hereon as RPA/RPAS)
- through use of boom and spot spraying techniques.

The Guidelines provide broad best practice information and guidance on complying with regulatory obligations. Detailed best practice aerial spraying guidance relating to priority weed species may be found in the appendices. These appendices may be added to with species-specific information or amended from time to time to accommodate additional weed species and control techniques. Content for appendices may be written by other agencies or parties and must be approved by NPWS prior to addition.

## 2.1 Application of these Guidelines

**All pesticide applications must comply with relevant New South Wales legislation. These Guidelines do not replace legislative requirements, including permit and label directions.**

These Guidelines, including the checklists, must be read and followed in conjunction with the use of the APVMA permits in which they are referenced (at the time of writing this includes Permit Number PER12251 and Permit Number PER12363).

The Guidelines may refer to other NPWS policy and procedural documents, including:

- NPWS Aerial Application – Aviation Standard Operating Procedure
- NPWS Aviation Safety Policy
- NPWS Pesticide use Standard Operating Procedure
- NPWS Appointment of Officer in Charge and Principal Officer – Aviation Standard Operating Procedure
- NPWS Pesticide Use Notification Plan (PUNP)
- *Remotely Piloted Aircraft Guidelines for NPWS Staff* (if using remotely piloted aircraft)
- NPWS Pesticide Compliance Policy.

Other useful external documents and resources include:

- Aerial Application Association of Australia (AAAA)
- *Monitoring Manual for Invasive and Native Flora: Guidance for field monitoring and reporting* (Watson et al. 2021)
- *Understanding pesticide chemical labels* (APVMA 2020)
- NSW Department of Primary Industries NSW WeedWise website
- APVMA public search portal (for label and permit searches): PubCris Portal.
- *Bitou Bush Management Manual: Current management and control options for bitou bush (*Chrysanthemoides monilifera *spp.* rotundata*) in Australia* (Winkler et al. 2008).

**Hyperlinks to all supporting documents, including NPWS policies and procedures, webpages and templates referred to in the Guidelines are provided in the *Online resources* and *References* sections at the end of the document.**

# 3. How to use these guidelines to plan an aerial spraying operation

Each section of the Guidelines provides information that should be considered during the planning of aerial spraying operations (with detailed guidance for specific species within the appendices). The checklists contained in Appendix A of these Guidelines, provide step by step guidance for program planning and implementation of an aerial spraying operation.

Documenting the considerations outlined through these Guidelines demonstrates best practice and due diligence and, in some cases, may provide legal defence against unintentional adverse impacts. Considerations may be demonstrated through any number of documentation methods, including:

- vegetation monitoring plans
- communication plans/ strategies (including stakeholder lists)
- review of environmental factors (environmental risk assessments)
- operational plans
- work health and safety records (Job Safety Analysis (JSA), etc.)
- pesticide application recording
- final program report/ debrief documentation.

Note: The aerial spraying program's scope and size will determine the complexity of these documents – from simple to complex and comprehensive. Documents may contain multiple sections; for example, the vegetation monitoring plan may be integrated within the overarching control program document. Templates provided in appendices are examples only and are not mandatory for use.

# 4. Should I aerially spray?

Where the use is appropriate, aerial spraying demonstrates huge benefits to control of certain widespread weeds. Boom spray with manned aircraft allows large and dense areas to be treated in a cost-effective manner in a short space of time, allowing for the integration of other control methods. Spot spray and spray using RPAS is ideal for spraying inaccessible areas and may also have cost benefits over traditional ground control.

Figure 1 illustrates some of the key considerations to determine if aerial spraying is an appropriate option where weed control has been identified as a priority.

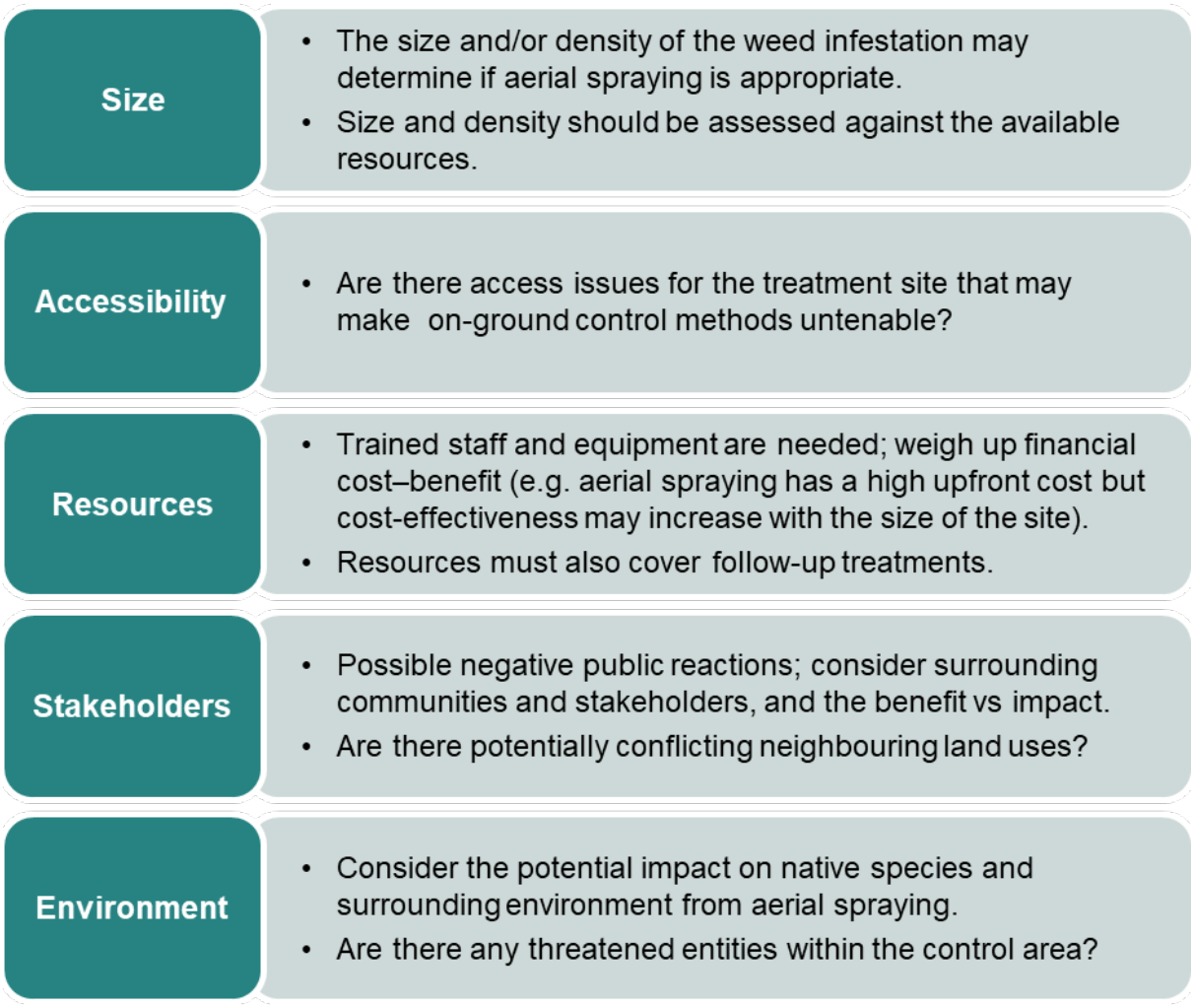


**Figure 1 Deciding if aerial spraying is the best option**

# 5. Legislation and regulations

## 5.1 Pesticides

In Australia, pesticides are assessed, approved and registered for use nationally through the APVMA. Only registered pesticides can be used unless approval has been granted by an APVMA permit.

At a state level, the following agencies regulate and manage pesticide use. The NSW Environment Protection Authority (EPA) administers the *Pesticides Act 1999* (the Pesticides Act) and Pesticides Regulation 2017 (the Pesticides Regulation). This Act and subordinate Regulation regulate the application of registered or permitted pesticides in NSW, including mandatory training, licensing requirements and record-keeping.

Pesticide pollution or waste incidents are also regulated by the EPA under the *Protection of the Environment Operations Act 1997* (POEO Act).

SafeWork NSW regulates the classification, packaging, labelling and storage of dangerous goods (including pesticides) and their transport on private roads under the *Work Health and Safety Act 2011* and Work Health and Safety Regulation 2017.

### 5.1.1 Labels and permits

Pesticide registration includes the approval of strict label directions. In every instance of pesticide application, the label directions must be read, understood and followed.

Note: The Pesticides Regulation provides allowable exemptions for using a pesticide contrary to its approved label; however, this exemption does not extend to permit directions (see clause 57 of the Regulation).

Aerial spraying is authorised only when explicitly stated within the label directions (i.e. apply by air) and is not contravened by label restraints.

**Labels may contain directions for use relating to aerial spraying in different sections of the label. Ensure the entire label is read and understood, and all conditions can be followed; for example, the following are excerpts from a single current pesticide label.**

*'Aerial Application (by helicopter only):* Use a properly calibrated helicopter using the half overlap opposite pass technique. Apply a minimum of 100 L/ha on blackberries and 60 L/ha on *Mimosa pigra* up to a maximum of 200 L prepared spray per hectare. Use a Volume Mean Diameter (VMD) of 300 microns. High temperatures and/or low humidity may cause excessive evaporation of droplets and may reduce results. Where bushes are large, or terrain is steep, higher water volumes are necessary to ensure adequate coverage. Avoid spraying in conditions which favour temperature inversions or in still conditions. Turn off boom when passing over creeks, dams or waterways. Avoid spraying where drift can move onto crop areas that are likely to be planted to crops and non-target pastures as injury may occur. Do not apply when temperatures exceed 30°C…'

*'Aerial application by helicopter restraints:* DO NOT apply if rainfall is expected within 2 hours of spraying. DO NOT store tank mixes with other products. DO NOT store the prepared spray for more than 2 days...'

*'Rate:* 160g/ha – Ensure all foliage is thoroughly covered including peripheral runners. Use at least 100 L of prepared spray per hectare...'

APVMA permits allow for the legal use of chemicals in ways different from those set out on the product label. In every instance of pesticide application where a permit is required, that permit and its conditions must be read, understood and followed **in addition to the label**.

Permits may provide for use in limited settings, for research purposes, or for unregistered products. Current permits and registered product labels may be found through the APVMA PubCris search portal. At the time of writing, NPWS holds 2 permits related to aerial spraying activities (to which these Guidelines refer): PER12251 and PER12363.

Failure to comply with label or permit directions may constitute a pesticide misuse offence under the Pesticides Act.

The APVMA has developed information and guidance, including *Understanding pesticide chemical labels* (APVMA 2020), to assist in reading, interpreting and understanding pesticide product labels. For further information, refer to the APVMA website.

### 5.1.2 Pesticide Control Orders

Pesticide Control Orders (PCOs) are gazetted by the EPA under authority of the Pesticides Act. In many cases PCOs are developed in relation to high-risk pesticides (or Restricted Chemical Products); however, there is currently an aerial spraying PCO, which relates to the aerial spraying of herbicides near sensitive receivers.

This PCO, known as Air-1, provides notification and consent conditions where herbicide is to be applied aerially within 150 m of sensitive receivers (sensitive receivers are defined in the PCO). Programs in which these sensitive receivers are present within the spray application zone (given as a distance of 150 m horizontally from the boundary of the sensitive receiver), must adhere to the conditions of the Air-1 PCO.

Note: PCOs are amended from time to time; ensure the most current PCO (obtained from the EPA website) is used.

## 5.2 Aviation

Aviation activities, including the aerial spraying of pesticides, are further governed under the *Civil Aviation Act 1988* including the requirements of relevant Parts of the Civil Aviation Safety Regulations 1998. Key parts include (but are not limited to):

- Part 61 – flight crew licensing
- Part 67 – medical
- Part 91 – general operating rules
- Part 99 – drug and alcohol management plans and testing
- Part 137 – aerial application
- Part 138 – aerial work operations.

### 5.2.1 Remotely piloted aircraft

The use of RPA/ RPAS is also governed by the Civil Aviation Act and Civil Aviation Safety Regulations 1998 (specifically Part 101). The following Civil Aviation Safety Authority (CASA) advisory circulars also contain relevant RPA requirements and restrictions:

- Advisory Circular 101-01
- Advisory Circular 101-10.

Note: This area of application technology is under constant change. Prior to using any RPA ensure you are familiar with current regulations on calibration, use and piloting of these devices.

# 6. Training and licensing

Evidence of appropriate and current training and qualifications / licence details must be confirmed and recorded prior to aerial spraying. For NPWS operations, these details must be retained (e.g. in Content Manager 9 – CM9, with appropriate access controls/ restrictions) in accordance with NPWS policy.

In addition to pesticide related training, all NPWS staff working in and around aircraft during aerial spraying programs must have current Work Safely Around Aircraft (WSAA) accreditation.

Specific training and licensing requirements for various roles are outlined below.

Note: The following information is correct at the time of writing. Regulations pertaining to these requirements may change; check the relevant regulatory agency's website for the most up-to-date information.

## 6.1 Pesticides users generally

The Pesticides Regulation identifies that where a person is using pesticides as part of their work, they must meet minimum qualification (training) requirements. This training, known as chemical accreditation training (or more commonly as AQF3) comprises successful completion of 3 units of competency, prescribed by the EPA. To maintain currency of this training, a refresher course must be completed every 5 years. In addition to AQF3 currency, NPWS staff using/ handling pesticides must also be current in their NPWS pesticide awareness training (either face-to-face or online).

## 6.2 Loaders and mixers

Where a person uses pesticides in a loader or mixer role supporting aerial application, they must also meet one or more of the qualification requirements outlined in section 31 of the Pesticides Regulation. In most cases this would be either a current AQF3 or certificate of completion for the Spraysafe Loader/ Mixer Program issued by the AAAA.

## 6.3 Pilots

The pilot in command (PIC) must hold current licences issued both by CASA under the Civil Aviation Act the NSW EPA under the Pesticides Act. These include:

- a commercial pilot (aeroplane or helicopter) licence issued by CASA with an aerial application rating
- an air operator certificate (AOC) with approval to conduct aerial application, issued by CASA (pilots may hold, be engaged by or employed by the holder of an AOC)
- an aerial applicator pilot licence issued by the EPA
- an aerial applicator business licence issued by the EPA (pilots may hold, be engaged by or employed by the holder of a business licence).

Note: Mutual recognition of interstate pesticide application licences may apply; contact the NSW EPA for more information.

For all NPWS operations involving manned aircraft, the PIC must also have the required experience, flight hours and any additional training requirements as set out in the Aerial application – Aviation Standard Operating Procedure (ParkAir or contracted operators).

## 6.4 Remotely piloted aircraft and operators

RPA involve the use of drone technology to apply herbicides aerially or for weed and vegetation monitoring. To use RPAS for aerial application of herbicides in NSW, the operator must hold:

- an RPA Applicator Pilot licence, issued by the EPA
- a Remote Pilot Licence issued by CASA

  and

- must hold or be employed by a holder of a Remotely Piloted Aircraft Operators Certificate (ReOC), issued by CASA.

To use RPAS for weed or vegetation monitoring (i.e. without the application of pesticides), the operator must hold:

- a Remote Pilot Licence issued by CASA

  and

- must hold or be employed by a holder of an ReOC, issued by CASA.

*Note some exemptions apply to licensing requirements where the RPA is used over the operator's own property. For more information, see the NSW EPA and CASA websites.

All remotely piloted aircraft must be registered with CASA and all programs on park must be approved by the respective area manager and comply with the NPWS Drones in National Parks Policy and NPWS Remotely Piloted Aircraft Guidelines.

# 7. Environmental considerations

## 7.1 Non-target harm

The Pesticides Act defines non-target harm as occurring where pesticide use has resulted in:

- the harm or death of a plant or animal that was not the intended target species of the pesticide application
- injury to a person
- damage of a neighbouring property.

The primary defence for a non-target harm misuse offence under the Pesticides Act is to demonstrate that all reasonable precautions were taken, and due diligence was exercised.

In demonstrating due diligence, key factors include:

- evidence that label and permit (where applicable) directions were followed (e.g. application methods, mixing and application rates)
- program planning documentation to:
  - justify the program's critical need
  - clearly identify areas that have been excluded from spraying, which may include for example, sensitive receivers (places or species locations) or waterways
  - demonstrate appropriate environmental impact or risk assessments have been completed prior to application (and that these risks are addressed by specific, documented/ evidenced mitigation measures)

- evidence of statutory consultation with relevant land mangers including threatened species officers within the Department of Planning and Environment
- evidence that the risk of spray drift was managed through the implementation of best practice principles and label directions
- evidence that appropriate stop work triggers are in place (e.g. recommended parameters around weather conditions – wind speed, direction, relative humidity/ Delta T conditions)
- evidence of current required training and licences held at the time of application
- evidence that notifications and signage (as applicable) were used – including compliance with an NPWS Pesticide Use Notification Plan (PUNP) for work on park
- compulsory and accurate record-keeping, made at the time of or within 48 hours of application (for all NPWS operations, record-keeping must be completed in line with the requirements of the Pesticide Use Standard Operating Procedure)
- consultation with and management of the general public in spray areas.

## 7.2 Spray drift management

Spray drift can pose a significant risk and must be considered during the operational planning of all pesticide application operations. Spray drift has the potential to harm human and animal health, damage surrounding environments, as well as impact on neighbouring agricultural crops and livestock.

Pilots holding aerial application rating and AAAA Spraysafe accreditation, have undertaken substantial training in the management and reduction of spray drift. The aerial spraying program's PIC will determine whether additional spray drift management measures are required **in addition to the label directions** (e.g. by altering the gap between spray runs and hence avoiding misses and overlaps; altering flying height and speed, banking, as well as stopping and starting the release valve; all may influence spray drift).

Considerations for managing spray drift may differ between application techniques; however, generally, key considerations include:

- weather conditions:
  - wind direction – especially when wind is blowing towards susceptible areas
  - unstable weather patterns – variable/blustery wind (e.g. wind gusts), a changing weather front
- thermal inversion:
  - highly stable conditions – leading to still air masses (no wind)
  - wind speed – the best conditions for spraying are when wind speed is between 4 and 15 km/hr
  - relative humidity/ Delta T – affects evaporation and hence droplet size
  - accessing the western NSW mesonet to determine inversion conditions is useful as a decision-making tool when conditions are uncertain
- application methods – ensure the most appropriate method is selected for the landscape, weed infestation size and density
- spray equipment and appropriate settings– use appropriate nozzle sizes that produce droplets in accordance with label requirements and use them in accordance with the manufacturer's specifications. For example, median droplet sizes of <250 µm (microns) are more likely to drift, while larger median droplet sizes of >250 µm are less likely to drift. The potential drift produced from the equipment and settings used can be measured (with spray pattern or nozzle atomisation testing available).

**The spray volume required to cover a defined area is a function of the droplet size. A doubling of the median droplet size will require an increase in the spray volume to cover the same area.**

**Therefore, increasing droplet size to reduce drift will require more payloads and greater flying time. This will add to the cost of the operation and is an important factor to consider.**

- for boom spraying, the boom height – flight heights while spraying should be minimised where possible. Higher speeds may also significantly increase potential for drift
- the surrounding environment – identifying (and mapping where appropriate), susceptible non-target species in the area, including any sensitivities associated with the specific herbicide planned for use may assist in determining appropriate spray drift management measures (e.g. see NSW threatened species lists)
- the neighbouring land uses – identify the possible impacts associated with neighbouring land uses (e.g. agricultural and organic crops or pollinators), as well as providing notifications to neighbours and obtaining consent where required.

Spray drift management must form part of your program planning and should be discussed with the PIC. The identification of additional measures or stop work triggers must also be discussed with the PIC on the day of spraying.

The Department of Primary Industries webpage *Reducing herbicide spray drift* also provides valuable information on minimising spray drift.

## 7.3 Herbicide selection

The selection of an appropriate herbicide is highly species and situation-specific and is driven by the ability to target the desired weed with current label or permit directions. Key principles in selecting the most appropriate herbicide include:

- ensuring the target species can be appropriately controlled with the intended herbicide – including compliance with all label / permit conditions
- determining how effective the treatment is likely to be, including the likely timeframes involved (i.e. long-term treatments), and which other control methods will be integrated to enable the most effective control
- determining which (or if any) additives may be required (e.g. anti-foaming agents).

  Various chemicals can be combined with a herbicide to modify its activity; however, such modifications may reduce herbicide selectivity and alter non-target harm risks. Additives are included in formulated products or may be added to a tank-mix prior to application. Always consult the herbicide label prior to the addition of an additive (note however that information on the additives in formulated products is not always provided)
- assessing the receiving environment – this must include assessment of factors such as herbicide persistence and the possible impacts to sensitive species within the target area
- assessing the mobility of the intended herbicide within the receiving environment
- evaluating the potential public concerns regarding the intended herbicide, particularly if spraying in proximity to urban areas (e.g. public concerns over the use of glyphosate), as well as human health considerations that may require additional notification or restrictions (e.g. extended re-entry periods).

**It is important to remember that product labels may differ in their directions for use, even where the active ingredient remains the same. You must read and understand all label directions (and permit conditions) and ensure all requirements can be met.**

## 7.4 Spray timing

The timing of spraying should be considered in relation to the target weed (to increase control efficacy), and to the co-occurring native species. Spray timing is often detailed in label directions. Considerations may include:

- season of application – for example, when aerial spraying bitou bush, during winter many native plant species are dormant and thus may be less susceptible to herbicides than at other times when they are actively growing
- seasonal conditions and plant growth stage – weeds are generally most susceptible to herbicides when they are young and actively growing. Aim to spray young weeds where possible and avoid spraying stressed weeds as applications to stressed weeds are likely to be ineffective
- flowering – herbicide control may be most effective after flowering (e.g. as for bitou bush). The timing of peak flowering may vary within the state and may be affected by other environmental factors (e.g. fire, drought)
- interval between herbicide applications – the optimal interval between herbicide applications differs across NSW and inappropriate intervals between applications may result in adverse impacts to some native species. The likelihood of such impacts should be assessed prior to any repeated aerial spraying program
- choice of herbicide – different herbicides may influence the re-treatment interval; for example, use of metsulfuron methyl may require longer intervals between applications due to the residual effect of this herbicide
- stage of the current program within your long-term control program. The interval between spraying events should increase with time as weeds are effectively controlled.

## 7.5 Environmental impact assessments

Environmental impact and risk assessments are a necessary step in demonstrating environmental due diligence.

Pesticide application as a singular action (*at the time of writing*), is not defined as an activity for the purposes of the *Environmental Planning and Assessment Act 1979*; however, there remains potential for off-target damage. Undertaking an environmental impact assessment provides, in some cases, a planning approval that is a defence to prosecution against off-target impacts to natural values under the BC Act and *Fisheries Management Act 1994*. For this reason, a Review of Environmental Factors (REF) under Part 5, Division 5.1 of the Environmental Planning and Assessment Act is required.

Note: Where existing approved environmental impact and risk assessments developed under the previous best practice aerial spraying guidelines (Broese van Groenou and Downey 2006) are in place, these may be used for the 2022 spray season. The requirement to prepare an REF for all future aerial spraying programs is now in place.

The REF must contain the relevant information specific to the spraying activity, including consideration of native species that may be susceptible or sensitive to the herbicides being used (e.g. for bitou bush control this should include consideration of the sensitive species list provided in Appendix D), with particular focus on food and other wild resources utilised by

the local Aboriginal community. Social or economic impacts (including community interest and concerns, and possible economic losses due to park closures, etc.) must also be considered.

The NPWS REF template (linked below), has built-in requirements to justify and assess the program against the environmental matters listed in clause 171 of the Environmental Planning and Assessment Regulation 2021, and the adopted guideline as published on the NSW Planning Portal subject to clause 170. This includes consideration of alternatives to the spray program, and a 'do nothing' scenario.

For all NPWS operations, the Aerial Spraying REF must be prepared using the approved NPWS template and determined by the relevant NPWS branch director in accordance with the NPWS REF guidelines.

**The REF guidelines and template documents can be found on the Department of Planning and Environment webpage titled *Development guidelines*.**

## 7.6 Buffer zones

Buffer zones (or buffers) are herbicide application exclusion areas, such as those bordering environmentally sensitive areas or receivers such as waterways, species, cultural values or other locations as identified in the REF.

In many cases buffer zone sizes and locations are determined by the product label, permit, or other legislative instrument (such as the Air-1 PCO). In instances where buffer zones are not pre-determined by label/ permit directions, buffer zone sizes must consider (but are not be limited to) the:

- potential for spray drift
- ability of the chosen herbicide to move through the environment
- sensitivity of surrounding native species or other identified assets to be protected.

Once determined, buffers must be clearly marked on accompanying spray program maps (preferably digitised for use on tablet and/or GPS in the aircraft) and communicated to all involved in the spray program.

Where possible, buffer zones may also be marked to be visible from the air (e.g. with orange para-webbing).

Note: Reconnaissance flights prior to spraying are important to check and assess flight paths in relation to marked buffers.

Where automatic RPA are used (i.e. autonomously operated but still under full operator control), 'no spray zones' should be programmed into the flight plan to prevent accidental pilot errors.

### 7.6.1 Sensitive species

In some circumstances and as an alternative to no spray zones, sensitive plant species can be covered with hessian, sand or tarpaulins prior to spraying, instead of using buffers. Such covers should be numbered and marked with a GPS and removed within 24 hours of herbicide application. This may also apply to threatened species. The use of anti-transpirants (compounds applied to leaves to reduce transpiration) such as Envy, may also be effective in protecting sensitive species if applied the day prior to aerial spraying (demonstrated through field trials conducted in Wyong, NSW during the late 1990s).

A list of herbicide sensitive species related to the aerial boom spraying of bitou bush can be found in Appendix D. This list has been compiled from field observations and should be considered during the environmental impact assessment and operational planning for aerial bitou bush control. It is important to note that some of the effects attributed to herbicide sensitivity may have been caused by other environmental factors such as drought, salt damage, water stress, etc.

### Assessing herbicide sensitivity during aerial bitou spraying programs

Where possible during aerial control of bitou bush, information should continue to be collected on the condition of individual native species to determine herbicide sensitivity or any adverse impacts (i.e. non-acute impacts such as reduction in flowering/ fruiting/ growth and/ or increased mortality) following aerial spraying. Information should also be collected on species that show no signs of sensitivity. It is important to note the herbicide formulation and adjuvants used when monitoring for herbicide impacts. For example, during previous assessments during bitou bush aerial spraying the following codes were used:

**OK** = no effect on foliage, **SL** = some foliage burn, **M** =25% foliage burn, **SD** = some dead, **MD** = most dead, **A** = more observations required, **NF** = no more observations required.

While the data collected to date (provided in Appendix D), has concentrated on perennials and adults of species impacted by bitou bush, information on the fate of native species that co-occur with other aerially sprayed weeds, in particular seedlings, ephemeral annuals, parasitic plants, and geophytes is needed and should be included where possible. If time and funding permit, selected plants in sprayed and nearby unsprayed areas should be tagged and assessed. Post-spray monitoring should be undertaken at 2 months and 6 months after spraying, and thereafter annually depending on the herbicide action time.

## 7.6.2 Aquatic areas

It is an offence to pollute waters under the POEO Act. To ensure pesticides do not enter waterways either directly or indirectly, buffer zones must account for the potential for spray drift or runoff. Buffers should be placed along creeks and around water bodies, including intertidal rock pools. Any herbicide, surfactant or adjuvant that may have adverse effects on aquatic organisms (i.e. as per label comments and instructions) should be avoided in any terrestrial situation bordering an aquatic ecosystem.

**‘Protection of Wildlife, Fish, Crustacea and Environment:**

**DO NOT contaminate dams, rivers or streams with the product or used containers.’**

The above statement, which appears on all product labels, including those designed for aquatic use, creates some confusion regarding use of pesticides near or in waters or sensitive habitats.

To ‘contaminate’ or ‘pollute’ is clarified in detail in the POEO Act dictionary. The act of pollution in its essence is an act that results in **degradation** or **harm** to a **habitat**.

It is this question that the APVMA considers when it establishes product label buffer zones for the protection of sensitive areas. In accordance with the POEO Act, these buffer zones are made on the basis of acceptable pollution, not on the basis of zero pollution. Whilst these buffer zones must be observed when spraying, they should not be relied upon for the protection of areas of valuable or high sensitivity. The most effective way to prevent impact to these areas is to conduct an assessment and determine the most appropriate methods, chemical, equipment and conditions during which to spray near these areas.

### 7.6.3 Public places and dwellings

At the time of writing, the Air-1 PCO requires that a 150 m buffer be provided from any dwelling or public place as defined within the Order (this rule is in addition to any additional label buffer zone). Where spraying may occur within that buffer, written consent must be obtained from the occupier of the dwelling for the aerial spraying to occur. For NPWS, visitor precincts such as campgrounds may be considered dwellings; however, partial park closures should be implemented for areas in the immediate vicinity of spray operations.

# 8. Vegetation monitoring

Vegetation monitoring is an essential part of weed management and must be considered in the planning stages of any pesticide application or weed management program. It involves the collection of quantitative and/or qualitative data about the response of native species, target weeds and other weeds to the spray program. Vegetation monitoring provides information to inform future spraying programs, helps to identify non-target effects, builds knowledge, contributes to the development of best practice guidelines, and allows you to determine if your control is working effectively.

The development of a monitoring program / monitoring plan should be based on the type of information required (i.e. the questions you want answered), program scope and complexity, and the resources available. Monitoring should be undertaken **both before and after** the spray programs (i.e. pre and post-spray monitoring), with monitoring sites clearly mapped, and GPS marked. There are several monitoring options; to select the best method for the program you should consider (but are not be limited to):

- what your monitoring question is
- what your available resources are
- what to measure
- what sampling units (quadrats, transects, etc.) and design to use
- how best and how often to measure
- how to record those observations
- how to analyse the data
- how long to continue the monitoring.

While sometimes costly or resource intensive, monitoring requirements are dependent upon several factors (such as program objective and monitoring questions, weed infestation, landscape and location), and may range from simple qualitative assessments to more advanced sampling methods. Some common examples include:

- **Photographs or photopoints** – these are the easiest method of monitoring. Fixed photopoints should be marked on a map and with a marker on the ground. Photos should be taken from the same direction and angle using the same focal length (for SLR cameras) and taken at the same time of day or season (for annual reporting). If capturing aerial photographs, they should be taken of the same location and at the same altitude for comparison with subsequent photos.
- **Quadrats and transects** – these can be used for qualitative or quantitative monitoring. Quadrats can be used to measure density, cover–abundance, plant life stages, plant damage, and other metrics like plant height or diameter at breast height, using a defined area. Transects can be used to collect similar data across a linear area, line-intercept transects are a good method to collect quantitative plant cover data (as opposed to estimating cover). Other information can also be collected using these methods; for example, vegetation condition.

The *Monitoring Manual for Invasive and Native Flora* (Watson et al. 2021) provides detailed explanations of monitoring methods and worked examples of monitoring designs for differing landscapes or program purposes. RPAS may also provide a useful tool for monitoring weed extent and density from the air in remote or inaccessible areas or along waterways. Whichever monitoring method is selected, ensure the same method is used over the entire monitoring period to allow for valid comparisons between samples.

# 9. Notification and communications

Stakeholder lists must be developed and reassessed annually for ongoing programs. Major stakeholders are likely to include the Department of Planning and Environment, NSW Department of Primary Industries, CSIRO, local government, private landholders, Indigenous communities, community groups, volunteers, and other concerned parties (e.g. members of the local community who are sensitive to chemicals).

Communication methods may include meetings, phone calls, letters or emails and should aim to inform stakeholders of progress or major events and seek feedback on the aerial spray program.

Where community interest is likely to be high, early engagement and communication in the planning stages is important to increase understanding of program objectives and reduce public concern or the spread of misinformation.

## 9.1 Notifications

Notification means informing the people who live, work or visit in or near the intended spray area about the planned aerial spray operation. This enables people to take action to avoid the areas if they wish and reduces misunderstanding and conflict.

NPWS is required to provide notification of pesticide use under the Pesticide Regulation. The NPWS *Pesticide Use Notification Plan* (PUNP) provides details on how and when the public must be notified of pesticide applications. In all instances of pesticide application on NPWS estate, by staff or contractors, the PUNP requirements must be met.

There may be additional or specific notifications required; for example, some local councils use notification registries to identify those people in the community requiring notification with respect to pesticides use (e.g. people with chemical sensitivities).

## 9.2 Communications plan

Documentation of the intended and required communications, or a more formal communication plan must be developed, as appropriate to the scale and complexity of the aerial spraying operation. This will outline the means for facilitating the two-way flow of information throughout the aerial spraying program (i.e. from the planning stages to the operational phase), and for dissemination of program outcomes to relevant stakeholders and the public.

The level of community interest and the neighbouring stakeholders will determine the size and scope of the communications documentation (i.e. a simple strategy detailing stakeholders and messages or a comprehensive plan for larger operations with high community interest – an example communications plan is provided at Appendix B). The documentation should address:

- key messages to be conveyed
- key community groups and stakeholders to communicate with/ through
- alternative communication channels (e.g. social media)

- how to manage public communications on the day of operation (i.e. questions from members of the public during aerial spraying)
- park/ road or public area closures
- post-program communication requirements – to address program effectiveness and future program plans.

Key community messaging should aim to educate the public and stakeholders, and may include:

- the program objectives/ the need for and benefits of the program, to provide a good understanding of the intended/ desired conservation outcomes
- legislative obligations on land managers to control weed species
- environmental risks posed by the targeted weed, and the likely benefits to biodiversity of control
- where relevant, integrated and cooperative programs and the benefits of these (i.e. NPWS and other land managers – local councils, regional and/ or local weeds committees working together to achieve better conservation outcomes)
- environmental assessments undertaken to consider and address the range of environmental matters covering the park's natural and cultural values
- other risk management actions taken to prevent pesticide products affecting (non-target) plants, animals or people – including the regulatory framework in which the program operates (i.e. the pesticides legislation/ labels and permit conditions – including these Guidelines, and NPWS policies including the publicly available PUNP)
- the choice of herbicide and the reasons it was chosen
- the timing of spraying with regard to minimising impacts on the public and stakeholders; for example, where possible, avoid weekends and school/ public holidays to minimise disruption and the likelihood of members of the public being in the spraying area.

## 9.3 Signage

The PUNP also provides details on site signage requirements, including mandatory signage locations. Where the closure of public areas is required, protocols are needed to notify the public who use the areas to be sprayed (e.g. beaches and reserves). For NPWS operations, the PUNP requires that signs will be placed on all roads, trails and tracks that give access to the treatment area advising of the planned spraying operation (and the closure of the reserve where applicable), at least 3 days prior to the spraying operation wherever possible (a traffic control plan may be required).

The Pesticides Regulation requires that signs contain:

- the full product name of the herbicide(s)
- the purpose of the application (e.g. to control bitou bush)
- the name/ description of the place at which the herbicide is to be applied
- proposed start and finish date/s and times
- the contact details for enquiries (name and telephone number)
- any warnings from the product label or permit about re-entry to the place of application.

Signs may also contain additional information as per PUNP requirements, including:

- a warning and description of the planned activity (e.g. 'Warning – No Entry. Park closed to public. Aerial spraying of <specific weed species> will occur in this area sometime during <date range>')
- who is undertaking the operation (e.g. for work on park, NPWS is the agency coordinating the spray program, not the contractor)
- a map of the proposed area to be treated.

# 10. Aerial spraying options

## 10.1 Determining suitable aircraft and technique

The most suitable aircraft for the type of aerial spraying should be selected based on the aircraft's ability to carry out the aerial spraying to meet all label and permit requirements. The treatment area topography, application method, payloads, altitude, accessibility, landing area requirements and number of personnel required for each flight must also be considered (e.g. helicopters are highly manoeuvrable and well suited for use in remote or mountainous areas, steep terrain/ cliff lines, etc.). RPAS do not have the endurance or payload of manned aircraft but are also much less expensive, particularly for control over small areas; whereas, manned aircraft are expensive initially but the larger the area treated the greater the cost-efficiency.

The Pesticides Act prohibits the attachment of pesticide spray equipment to any aircraft that is not endorsed for agricultural operations.

Table 1 overleaf, which has been adapted from the *Bitou Bush Management Manual: Current management and control options for bitou bush in Australia* (Winkler et al. 2008), provides some considerations of bitou bush aerial spraying techniques for a range of coastal habitat types and management issues, as well as other control techniques that may be considered for follow-up or integrated control.

## 10.2 Boom spraying

Boom spraying can be a cost-effective way of treating large, dense infestations in areas that are either inaccessible by ground or not cost-effective to control using ground spraying. Boom spraying involves aircraft flying at a set height and speed while spraying herbicide from a boom spray unit (Figure 2). The size and location of the infestation determines the size of the machine and spray unit required. Over time aerial boom spraying should be incorporated into intergrated weed management programs and not be used in isolation.

Due to the broadcast nature, boom spraying can be a significant risk and mitigation plans to prevent spray drift should be put in place. Ideally, boom spraying should be conducted in areas where weed infestations are heavy or dense, and there is limited risk of non-target damage. There is also significant planning involved in boom spraying operations and extensive community consultation may be required.

Boom spraying is advantageous however, in that large areas may be treated in a single event, the cost per unit area is low, and plants in otherwise inaccessible areas can be controlled (Winkler et al. 2008).

**Table 1 Suitability of bitou bush control methods for various habitat types and management issues**

| | | Control method | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hand weeding | Crowning | Cut-and- paint | Stem injection/ scrape-and-paint | Foliar spraying | Splatter gun | Aerial boom spraying | Aerial spot spraying | Mechanical methods | Fire | Biological control |
| Habitat type | Foredunes | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X | X | ✓ |
| | Dune crests | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X | X | ✓ |
| | Hind dunes | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | O | ✓ | O | O | ✓ |
| | Coastal heath and scrub | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | O | ✓ | O | O | ✓ |
| | Littoral rainforest | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X* | X* | X | X | ✓ |
| | Woodlands | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | O | O | O | O | ✓ |
| | Headlands | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | O | O | ✓ |
| | Steep slopes | O | O | O | O | ✓ | ✓ | ✓ | ✓ | X | X | ✓ |
| | Riparian areas (incl. tidal rivers and estuaries) | ✓ | ✓ | ✓ | ✓ | O | ✓ | X | O | X | X | ✓ |
| Management issue | Outlier, small or isolated | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X | ✓ | X | X | ✓ |
| | Heavy infestations | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | O | O | ✓ |
| | Unstable soils | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X | X | ✓ |
| | Native species at threat from bitou bush | ✓ | ✓ | ✓ | ✓ | O | O | O | O | X | O | ✓ |
| | Depleted native seed bank | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | O | ✓ |
| | Culturally sensitive areas | O | O | O | O | O | O | O | O | X | O | ✓ |

✓ Suitable control method.

X Control method **not recommended**.

O Further consideration required – refer to the Bitou Bush Management Manual for a description of the method and its advantages/ disadvantages before using it.

* Aerial boom or spot spraying of littoral rainforest is **not legally permitted** in NSW because it is a threatened ecological community under the BC Act (formerly an endangered ecological community under the NSW *Threatened Species Conservation Act 1995*).

## Case study: Bundjalung National Park – successful broad-scale control of bitou bush

Bundjalung National Park is a large coastal reserve on the north coast of NSW, north of the Clarence River. The park contains a variety of coastal vegetation communities including wet and dry heathland, littoral rainforest, mangrove, eucalypt forests and melaleuca woodlands, as well as freshwater and estuarine wetlands, headland grasslands and dune communities. Mapping prior to 2002 identified that approximately 75% of the foredunes in the park contained heavy bitou bush infestations (greater than 40% vegetation cover).

In December 2001/ January 2002 a significant wildfire impacted 75% of the reserve, burning to the seaward side of the dune and killing large areas of mature bitou bush. Fire is known to promote mass bitou bush germination and be a catalyst for significant vegetation change due to bitou bush's ability to outcompete native species. For this reason, the fire was used opportunistically to control bitou bush across a large area, as part of an integrated long-term control program to create conditions suitable for the regeneration and restoration of the native coastal vegetation.

### Aerial boom spraying

The technique of low concentration aerial boom spraying of bitou bush had recently been developed and was selected as the lowest cost option to knock down dense emergent bitou bush post fire. Initial aerial boom spraying took place over a 400 ha area in 2002. At the time, the costs of aerial bitou bush spraying were approximately $100/ha compared with the ground-based high-volume spraying cost of up to $1200/ha. From 2003, ground-based control in more accessible areas was combined with aerial boom spraying of the frontal dune crests, selective spot spraying and aerial and manual seeding in selected areas. At the end of 2001, initial bitou bush cover averaged 55%, which was reduced to 5% after the third aerial spraying in 2004. In 2005, post-spray monitoring showed bitou bush was reduced to about 1% cover in burnt and unburnt vegetation and at last monitoring in 2014 bitou bush cover averaged 1.1%.

**Figure 2** **Aerial boom spraying**
Photo credit: NPWS.

Control programs involving aerial and/or ground-based spraying have occurred each subsequent year. Over time, as bitou bush extent and density declined, aerial spray area and frequency declined with ground control methods dominating. The area controlled by both methods varied each year, with aerial spray requirements being determined by aerial reconnaissance prior to control. Annual reductions in the size of aerially control areas were determined by the success of the previous year's control; for example:

- 2002 – an area of 400+ ha was treated for bitou bush control with aerial boom spray over a lineal distance of 34 km
- 2008 – an area of 251 ha was treated for bitou bush control with aerial boom spray over a lineal distance of 21 km.

Overall, this program is an example of successful deployment of bitou bush aerial spraying, where a wildfire was opportunistically used to initiate the program that successfully integrated aerial and ground-based methods. The dune landscape has been transformed from one dominated by bitou bush to one dominated by locally indigenous species. Today, limited bitou bush control in Bundjalung is continuing using ground control methods only.

## 10.3 Spot spraying

For isolated pockets of weeds or those growing on cliffs or steep terrain, spot spraying may be more effective. Spot spray methods target specific infestations and allow directed application to control weeds in remote or inaccessible sites. This method uses the ground-based spot spray technique but with a modified spray rig and hose and nozzle assembly protected by a cone suspended beneath the helicopter (Figure 3). Aerial spot spraying enables treatment of individual plants or small clumps that may not otherwise be treatable due to limited or difficult access. This technique is highly weather dependant and off-target damage in the immediate area may be a higher risk due to hose sway. Pilot experience in this application technique is essential.

The current permit (PER12363) utilises ground-based spray rates as opposed to the specific aerial spray rates applied during aerial boom spraying.

Lance spraying is another spot spray method, where the nozzle is forward mounted on the helicopter (see case study below). While these methods allow for more controlled application, potentially reducing the risk of non-target applications, they may be less cost-effective and efficient for use over large-scale infestations.

**Figure 3** **Ox-eye daisy aerial spot spraying**
Photo credit: Elouise Peach/ NPWS.

## Case study: Lord Howe Island – lance spraying

Parts of Lord Howe Island (LHI) are characterised by oceanic and mountainous cliff lines, where weeds have invaded. The LHI Board is implementing a program to eradicate priority weeds to protect the island's unique terrestrial ecology from their damaging effects. To achieve eradication, an all-terrain approach is required, which poses access challenges.

The use of a helicopter with a forward mounted lance spray apparatus has provided a critical breakthrough in being able to target control of weeds across a broad expanse of cliff lines. Four lance spray programs have been undertaken, which have significantly depleted extensive infestations of ground asparagus and bitou bush from elevated locations.

### The benefits

Although costly, helicopters provide effective weed surveillance and control across a large area of otherwise inaccessible terrain, within a short period of time.

The program enables surveillance and immediate control of detected weeds from seedlings to mature plants that are readily observed from the helicopter cab.

The lance allows access to weeds on sheer cliffs, crests and benches. The lance and spray output are beyond the extent of the rotor blades, and the spray output is targeted.

**Figure 4** **Cliff line lance spraying on LHI**
Photo credit: Sue Bower/ LHIB.

Aerial spraying provides improved safety as opposed to gaining access via ropes/ abseiling to control infestations. It allows access to places only birds can reach, from sea level to 840 m elevation.

It also adds another critical utility to the weed management tool kit, complementing rope access and on-ground control measures. In future, with less weed load, spot spraying with drones may be applied but due to the extent of cliffs this is unlikely to replace helicopter operations at present.

## Critical factors for success

Cliff lines provide a weed dispersal pathway with bird movements often following cliff edges; hence they are vulnerable to weed invasion. Having equipment to access cliff lines is critical for success.

LHI is a remote location and mobilising equipment, monitoring weather conditions and protecting seabirds makes operations logistically complex. Improved planning and resourcing to allow operations across a broader weather window to accommodate downtime will improve success.

## Restrictions

- Weather conditions
- Scheduling – application must occur before the arrival of thousands of seabirds that breed in the Northern Hills in mid to late September. Surveillance must also be undertaken outside of seabird breeding periods (i.e. skies must be clear, as birds mass on dusk or during overcast conditions).

## Ecological benefits

On LHI cliff lines provide important breeding habitat for migratory and nomadic seabirds, and in the southern mountains, cliffs support rare cliff line waterfall plant communities and the endangered rock shield fern. Without the helicopter lance spray program these habitat features would be at risk from the smothering impacts of ground asparagus and bitou bush.

## 10.4 RPA spraying

RPA technology is rapidly evolving. The use of these aircraft for herbicide application may be beneficial in certain circumstances, particularly where small areas of otherwise inaccessible weeds can be targeted.

**Figure 5 RPA spraying around inaccessible cliff line areas**
Photo credit: Garth Short/ Hunter Precision Agriculture.

The use of RPAS for spraying is generally permitted where the label (or permit) allows for aerial spraying (i.e. through boom or spot spraying). However, it must be noted that all aspects of the label directions must be able to be met; for example, prescribed water volumes and droplet sizes. Where conditions cannot be met, an APVMA permit may be required.

There are several considerations when determining if RPA use is suitable; for example, the payload limit and the treatment area size. Aerial herbicide drones are inherently larger and heavier, typically exceeding 35–50 kg (while remote sensing drones used for vegetation monitoring may be below 10 kg). A risk assessment should be done when utilising larger drones near high-risk areas such as public beaches, tourist spots and walking tracks.

All RPA work on park, whether by NPWS staff or contractors, must comply with the requirements of the Remotely Piloted Aircraft Guidelines.

All RPA operations must comply with the conditions of the Air-1 PCO (where relevant), and the following CASA requirements (unless special approval has been granted by CASA):

- must be operated by visual line of sight (i.e. the operator must be able to continually see, orient and navigate the aircraft to meet distance restrictions)
- must be operated no higher than 120 m above ground level

- must not be operated closer than 30 m to people associated with the flight (or 15 m to people who have consented to the RPA operating closer to them)
- must not be operated autonomously (must be under the control of a remote pilot/ operator)
- must not be operated within 3 nautical miles (5.5 km) of a controlled aerodrome or in a prohibited area
- must not be operated at night or in cloud
- must not be operated over a populous area
- must not be operated over the movement area or in the approach and departure paths of an aerodrome.

CASA maintains strict rules regarding the flying of RPAS in certain situations. In addition to the training and licensing requirements listed in Section 6.4 of these Guidelines, licence holders must also have a current Aeronautical Radio Operators Licence issued by CASA if flying in or around controlled airspace.

**Figure 6 Results of targeted application of herbicide to bitou bush using an RPA**
Photo credit: Garth Short/ Hunter Precision Agriculture.

# 11. Aircraft planning and permissions

NPWS ParkAir is the preferred operator for works on NPWS estate. All external operators and aircraft used must be listed within the Land Management Approved Operators List (AOL), in accordance with the NPWS Aviation Safety Policy.

Procedures for NPWS staff on how to book an aircraft are available on the NPWS intranet.

The engagement of external RPA operators must be done in accordance with the NPWS Remotely Piloted Aircraft Guidelines (note the NPWS RPA intranet page provides fact sheets and more detailed information on engaging external RPA operators). NPWS internal RPA operators can be verified through the chief remote pilot.

## 11.1 Minimum aircraft requirements

All aerial spraying operations must have effective flight-following and recording/ tracking systems in place. The minimum requirements for helicopter and fixed wing aircraft (not including RPAS) for work on park, are set out in the NPWS Aerial Application – Aviation Standard Operating Procedure.

Minimum aircraft requirements for aerial spraying operations may include:

- a GPS with grid reference, Universal Transverse Mercator (UTM) and latitude /longitude capability
- an appropriate tracking system
- a data logging system suitable for aerial spraying
- an emergency locator transmitter (ELT) (406 MHz), first aid kit and survival kit
- aviation band VHF radios
- strobe lighting
- appropriate pesticide application equipment
- a wire strike protection system (WSPS) for helicopters.

## 11.2 Restricted airspace

The management and requirements for operating within, or nearby to, restricted or controlled airspace must be discussed with the PIC/ unmanned aircraft vehicle operator.

## 11.3 Determining an appropriate landing site

All landing sites must consider:

- public exclusion zones/ access by the public
- proximity to control work sites
- ground staff access including the transport and storage of pesticides
- water supply or ability to transport and store adequate water (i.e. for mixing, wash down, etc.)
- distance from water and drainage lines
- the presence of wildlife and domestic stock
- aviation hazards; for example, the landing site should be free of transmission wires, however if wires are present, this must be communicated to the PIC. Hazards may also include foreign objects such as unsecured items, loose sheets of roofing metal, unsecured star pickets.

When operating on remote landing runways or helicopter landing sites a risk assessment must be undertaken by or in consultation with, the PIC. On the day of operation, if possible, reconnaissance of remote runways or helicopter landing sites (HLSs) should be done prior to landing. This can mean the entire length of the runway being driven or inspected by ground crews prior to landing to prevent collisions with wildlife and to ensure a safe surface.

For NPWS operations, where a landing site is intended to be off park, written permission for landing must be obtained from the property owner (this should consider/ acknowledge preferred flight paths to avoid assets and hazards including stock, and acknowledge any operational risks specific to the site advised by the property owner).

The following information details specific landing site considerations that should be assessed in consultation with the PIC.

### For fixed wing operations:

- the length of the runway must meet the aircraft's requirements. The minimum strip length must be discussed with the PIC prior to use to determine suitability
- all potential aviation hazards at the end of strips need to be considered when selecting sites
- always assess and consider surface conditions in consultation with the PIC.

### For helicopter operations ensure:

- the HLS is flat with no more than a 5° slope
- the surface of the site is suitable and does not contain any items that could be moved by the downdraft of the rotors, such as loose sheets of roofing metal, unsecured star pickets, dust, dirt, mown grass (preferably the site should be free of culverts, drains and ditches)
- the HLS can be approached from multiple directions
- the shape of the HLS will allow operations to be conducted in varying weather conditions and wind directions
- ground crew place flagging tape in an appropriate location to indicate wind direction.

### For RPA operations:

The RPA operator must conduct a site reconnaissance prior to works to establish an appropriate landing site (note that multiple landing zones/ sites may be appropriate for RPA operations). This will consider aspects such as:

- the presence of wildlife, stock or domestic animals
- predatory or threatened bird life (interruption to, and damage from)
- objects and hazards
- access
- the ability to maintain line of sight and comply with any other specific RPA use requirements.

## 11.4 Refuelling

When refuelling manned aircraft, distances should be more than:

- 5 m from any sealed building
- 8 m from other aircraft
- 15 m from any exposed public area
- 15 m from any unsealed building.

# 12. Developing an operational plan

An operational plan provides detailed information on the actions to be undertaken prior to, during and after the aerial spraying program. Appropriate roles and responsibilities must be established and assigned for aerial spraying operations and detailed within the operational plan. Roles and responsibilities should suit the operational needs of the program to allow for effective command and control structures. An example pesticide operation plan (POP) is provided as a template at Appendix C. Note that the example POP is provided in A4 format; an incident action plan (IAP) style A3 format POP is available on the NPWS intranet.

The operational plan should:

- summarise the operational objectives, regulatory and work health and safety requirements for the program
- contain a map of the operational location
- provide details of the means of communication to be used on site between ground crew, the PIC and the program manager
- detail incident notification processes and stop work triggers
- be used during briefings (in conjunction with the JSA) and be available to all personnel during the operation.

## 12.1 Officer in Charge

For every NPWS aerial spraying program an Officer in Charge (OIC) must be appointed (in accordance with the Appointment of Officer in Charge and Principal Officer – Aviation Standard Operating Procedure).

The OIC aerial application checklist must be completed prior to spraying (see intranet link in Section 17 below).

# 13. Work health and safety

## 13.1 Job Safety Analysis

The health and safety aspects of the aerial spraying program must be assessed through one or more JSAs. The JSA must be specific to the operation (i.e. it must identify and provide risk mitigative measures for the specific aircraft type, herbicide used, etc.) and contain considerations relating to mixing and site storage of chemicals. A separate JSA may be required to establish and maintain closure areas.

Contractors must develop JSAs (or Safe Work Method Statements – SWMS) for themselves and their employees and provide these to NPWS prior to the spraying operations.

JSAs and their contents (or SWMS) must be discussed during briefings, with a record kept each time (i.e. a Job Safety Brief Record – JSB record). Any issues raised or alterations required to mitigative measures listed in the JSA must be accurately documented in the JSB record, with all personnel present during the briefing also required to sign the JSB record.

## 13.2 Operational briefings

Operational briefings are required to ensure all personnel involved in the spraying program are aware of risks, risk mitigations and the operational workflow. All staff operationally involved in the aerial spraying program must attend briefings.

**The PIC retains control of aviation decisions. This includes but is not limited to: whether an air observer/ navigator or other persons are permitted during flights; safety and assessment of landing/ loading sites; payloads; safety considerations; whether spraying should occur or not; and if the operation needs to be stopped during spraying.**

### 13.2.1 Initial program briefing

The initial briefing should be delivered by the OIC, program manager or suitably qualified person (i.e. a person with suitable knowledge and oversight of the program). The operational planning document (e.g. POP) and JSAs should be used at this briefing to:

- clearly explain the objective, intended areas to be sprayed and delivery method over a set timeframe
- clearly assign and define roles and responsibilities and detail resources available
- detail the communication plan as well as community and stakeholder notification requirements for daily operations
- detail procedures for spray zone closure management and spraying operation
- describe protocols for the aircraft
- detail how the program is to be executed including the sorties/loads, loading of the aircraft, aerial observer maps, roles, application technique, personal protective equipment (PPE)
- detail required weather parameters for spraying operations, weather recording procedures and stop work triggers
- detail the flight following procedures
- discuss protocols for responding to community questions and potential non-compliance during the operation
- discuss the JSA (with JSB record signed by all in attendance)
- discuss emergency procedures in case of an incident.

### 13.2.2 Daily operational briefing

In addition to the initial briefing, for multi-day operations the OIC and PIC must also undertake daily briefings. Evidence of these briefings must be recorded (i.e. within the JSB or a communications log).

Daily briefings must ensure all operational staff understand key program objectives and may include, but are not limited to:

- the mission statement for the day
- the sorties/ loads and order to be completed
- relevant maps showing target areas and no spray zones/ buffer zones, etc.
- flight paths
- known and potential safety hazards/ risks and mitigative measures as outlined in the JSA
- regulatory compliance requirements
- roles and responsibilities if working in or around the aircraft (briefed by the PIC in line with CASA requirements).

### 13.2.3 Debrief

As soon as possible after the spray operation, a debrief or after-action review (AAR) must be held with all operational staff and flight crew. The debrief should assess the spraying operation and record all positive and negative feedback. Consider documenting the outcomes of the debrief to inform and improve future spray operations.

Where identified in the communication plan/ strategy, information from the debrief (e.g. any post-program reports, etc.) may be provided to stakeholders and the local community.

## 13.3 Personal protective equipment

Appropriate PPE as detailed on the pesticide product label and safety data sheet must be available and used during pesticide handling and use.

NSW legislation requires that full pesticide product labels are attached to pesticide containers and that product-specific safety data sheets are available on site.

Persons on board an aircraft or working in the vicinity of an aircraft must wear appropriate PPE as detailed in the NPWS Aerial Application – Aviation Standard Operating Procedure and program JSA.

## 13.4 Emergency equipment

The following emergency equipment must be available at all landing sites:

- appropriate chemical spill kit (as per the safety data sheet and label requirements)
- appropriate fire extinguisher
- appropriate first aid kit (aviation appropriate for manned aircraft).

## 13.5 Stop work triggers

At the discretion of the OIC or the PIC, the operation may be stopped in the following situations (but is not limited to):

- it is deemed unsafe to proceed
- the weather will not allow the operation to be completed within the label/ permit requirements
- any requirements under the Pesticides Regulation, other relevant legislation or this Guideline cannot be fulfilled (e.g. due to faulty equipment).

# 14. Record-keeping

The Pesticides Regulation requires that a record of each pesticide application is made; the Regulation provides specific record requirements that must be kept for aerial spraying (i.e. there are different requirements for record-keeping for ground and aerial pesticide spraying). At the time of writing the required aerial spraying records to be kept are listed in clause 26 of the Pesticides Regulation. These records:

- must be legible and in English
- must be made at the time of application or within 48 hours and must be retained for a minimum of 3 years

- can be made in hard copy or electronically (e.g. Field Manager application); duplication is not necessary
- may be integrated with other records but must be available to produce on request in a reasonable period of time (e.g. within 24–48 hours).

For NPWS operations, records must be made in line with the Pesticide Use Standard Operating Procedure (i.e. entered into the Pest and Weed Information System (PWIS)). Contractors must supply NPWS with completed pesticide application records.

# 15. Incidents

For NPWS operations, pesticide related incident responses must be in line with the Pesticide Compliance Policy. Any aviation related incidents must be managed in accordance with the Aviation Safety Policy and NPWS work health and safety risk management system.

# 16. Program review and future planning

Appropriate follow-up control is essential to the long-term success of any aerial spray program. If follow-up treatments are not carefully planned and undertaken, the areas treated may return to pre-treatment condition. Contingency plans should be developed to ensure follow-up controls can be completed.

Post-spray monitoring, consistent with the vegetation monitoring plan, and informal site survey will assist in determining the type and extent of follow-up control. Ongoing aerial spraying programs should see a decrease in aerial spray area and frequency as weeds are effectively controlled over time, and other control methods become more useable or cost-effective. The integration of alternative/ additional control methods should be developed into the subsequent program plans and should be based on comparisons of pre and post-spray vegetation monitoring, to determine the spraying effectiveness, herbicide resistance, as well as the ongoing resource and cost requirements. A threshold should be determined, below which aerial spraying is no longer necessary, and ground control should be used for follow-up.

Integrated control techniques to consider may include:

- Ground spraying – as for aerial spraying, ground spraying must comply with the directions on the label and permit.
- Manual control and bush regeneration – note that in situations where bush regeneration activities may impact on the habitat of threatened species, endangered populations or endangered ecological communities, a scientific licence may be required under Part 2 of the BC Act.
- Biological control – the NSW Department of Primary Industries website contains information on current biological control agents.
- Revegetation – by ground techniques or aerial seeding.

# 17. Online resources

- Aerial Application Association of Australia (AAAA)
- Air-1 Pesticide Control Order (PDF 8KB)
- Aircraft booking procedures (NPWS intranet)
- APVMA Permit Number PER12251 (PDF 109KB) (bitou bush control products)
- APVMA Permit Number PER12363 (PDF 146KB) (other environmental weed products)
- APVMA Understanding pesticide chemical labels (PDF 992KB)
- Biodiversity Conservation Act 2016
- Biological control of weeds: A practitioner's guide for south-east Australia
- Bitou Bush Management Manual: Current management and control options for bitou bush (Chrysanthemoides monilifera spp. rotundata) in Australia
- Development guidelines (Department of Planning and Environment)
- Environmental Planning and Assessment Act 1979
- Environmental Planning and Assessment Regulation 2021
- FloraBank website
- Greening Australia website
- Land Management Approved Operators List (AOL) (NPWS intranet)
- Monitoring Manual for Invasive and Native Flora: Guidance for field monitoring and reporting
- NPWS Aerial Application – Aviation Standard Operating Procedure (NPWS intranet)
- NPWS Appointment of Officer in Charge and Principal Officer – Aviation Standard Operating Procedure (NPWS intranet)
- NPWS Aviation Safety Policy (NPWS intranet)
- NPWS Drones in National Parks Policy
- NPWS Pesticide Compliance Policy (NPWS intranet)
- NPWS Pesticide Management webpage (NPWS intranet)
- NPWS Pesticide Use Notification Plan (PDF 319KB) (PUNP)
- NPWS Pesticide Use Standard Operating Procedure (NPWS intranet)
- NSW threatened species lists
- NSW WeedWise website (NSW Department of Primary Industries)
- Officer in Charge aerial application checklist (NPWS intranet)
- Pesticides Act 1999
- Pesticides Regulation 2017
- POEO Act dictionary
- Protection of the Environment Operations Act 1997 (POEO Act)
- PubCris Portal (for label and permit searches)
- Reducing herbicide spray drift (NSW Department of Primary Industries)
- Remotely Piloted Aircraft Guidelines for NPWS Staff (NPWS intranet)
- Review of the NSW Threat Abatement Plan: Invasion of native plant communities by Chrysanthemoides monilifera (bitou bush and boneseed) 2006–2011 (PDF 1.8MB)
- Work Health and Safety Act 2011
- Work Health and Safety Regulation 2017

# 18. References

APVMA (Australian Pesticides and Veterinary Medicines Authority) (2020) *Understanding pesticide chemical labels*, Australian Pesticides and Veterinary Medicines Authority, Sydney.

APVMA (Australian Pesticides and Veterinary Medicines Authority) Permit Number PER12251, *Product for control of bitou bush and boneseed in sand dunes, bushland and grassland*, Australian Pesticides and Veterinary Medicines Authority, Sydney. https://permits.apvma.gov.au/PER12251.PDF (PDF 109KB)

APVMA (Australian Pesticides and Veterinary Medicines Authority) Permit Number PER12363, *Product for control of various environmental weeds in natural ecosystems using helicopter and unmanned aircraft vehicles (UAVS) spot-spraying equipment*, Australian Pesticides and Veterinary Medicines Authority, Sydney. https://permits.apvma.gov.au/PER12363.PDF (PDF 146KB)

Broese van Groenou EA and Downey PO (2006) *Best Practice Guidelines for Aerial Spraying of Bitou Bush in New South Wales*, NSW Department of Environment and Conservation, Hurstville. www.environment.nsw.gov.au/research-and-publications/publications-search/best-practice-guidelines-for-aerial-spraying-of-bitou-bush-in-new-south-wales

DEC (Department of Environment and Conservation) (2006) *Invasion of native plant communities by Chrysanthemoides monilifera (bitou bush and boneseed): NSW Threat Abatement Plan*, NSW Department of Environment and Conservation, Hurstville. www.environment.nsw.gov.au/research-and-publications/publications-search/invasion-of-native-plant-communities-by-chrysanthemoides-monilifera-bitou-bush-and-boneseed

DPI (Department of Primary Industries) (2021) *Biological control of weeds: A practitioner's guide for south-east Australia*, NSW Department of Primary Industries. www.dpi.nsw.gov.au/biosecurity/weeds/weed-control/biological-control/biological-control-of-weeds-manual

French K, Ens E, Gosper CR, Lindsay E, Mason T, Owers B and Sullivan N (2008) *Management implications of recent research into the effect of bitou bush invasion*, *Plant Protection Quarterly*, 23:24–28.

Hamilton MA, Winkler MA and Downey PO (2008) *Native plant species at risk from bitou bush invasion: a field guide for New South Wales*, NSW Department of Environment and Climate Change, Hurstville. www.environment.nsw.gov.au/research-and-publications/publications-search/native-plant-species-at-risk-from-bitou-bush-invasion.

Hamilton M and Tuner P (2013) *Review of the NSW Threat Abatement Plan: Invasion of native plant communities by Chrysanthemoides monilifera (bitou bush and boneseed) 2006–2011*, NSW Office of Environment and Heritage, Sydney. www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Pests-and-weeds/invasion-of-native-plant-communities-by-chrysanthemoides-monilifera-130350.pdf (PDF 1.8MB)

Thomas J, Hofmeyer D and Benwell AS (2006) *Bitou Bush control (after fire) in Bundjalung National Park on the New South Wales North Coast*.

Watson GM, French KO, Burley AL, Brading MB and Hamilton MA (2021) *Monitoring Manual for Invasive and Native Flora: Guidance for field monitoring and reporting*, NSW Department of Planning, Industry and Environment, Sydney. www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/weeds/monitoring-native-plant-recovery.

Winkler MA, Cherry H and Downey PO (eds) (2008) *Bitou Bush Management Manual: Current management and control options for bitou bush (*Chrysanthemoides monilifera *ssp.* rotundata*) in Australia*, NSW Department of Environment and Climate Change, Sydney. www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Pests-and-weeds/bitou-bush-management-manual-080465.pdf (PDF 6.2MB).

# Appendix A: Aerial spray program checklist

The following checklist contains 5 sections:

1. pre-planning
2. communication and notifications
3. operational planning
4. aerial spraying application (on the day of application)
5. program evaluation.

The checklist comprises key considerations detailed within this Guideline to support the planning and implementation of an aerial spraying operation (i.e. using various aerial application techniques and target weed species).

| Yes/ No | Key consideration | Explanation |
|---|---|---|
| **1. Pre-planning checklist** | | |
| Yes ☐ No ☐ | The site has been thoroughly assessed and is suitable for aerial spraying (**base line study**). | Assess the characteristics of the site to be sprayed. Assessments may include size and shape of area; weed density; accessibility; topography; soil type and pH; type and range of vegetation present; proximity to sensitive and cultural heritage places, sites or items (including food resources). |
| Yes ☐ No ☐ | Appropriate / adequate **resources** are available for aerial spraying. | An assessment of resources must also include the need for long-term control. |
| Yes ☐ No ☐ | Potential adverse consequences from the weed control program have been assessed. | In some situations, weed control may promote an increase in the density of other weed species. Assessment of such potential consequences should be made before selecting a control method. |
| Yes ☐ No ☐ | An **appropriate herbicide** has been selected. | Herbicide selection must consider label/ permit requirements and the receiving environment, e.g. sensitive species, waterways or other sensitive locations in proximity to the planned spray area (as determined through site assessment), as well as efficacy on the target weed. |
| Yes ☐ No ☐ | All NSW legal requirements (and NPWS policy requirements for work on park) can be met. | In determining the most suitable technique, application method and herbicide product, ensure in the planning stages that all label and permit requirements can be met. |
| Yes ☐ No ☐ | Where required and resources allow, a vegetation **monitoring** plan or program is established. | The vegetation monitoring methods, frequency and success factors are developed. |
| Yes ☐ No ☐ | A **Review of Environmental Factors (REF)** has been completed and determined.<br>Note: The following pre-planning checklist items will generally be contained within the REF but are provided here for completeness. | An REF must be completed and determined.<br>For NPWS operations you must use the current template version on the DPE webpage. |

| Yes/ No | Key consideration | Explanation |
|---|---|---|
| Yes ☐ No ☐ | The need for control has been justified. | Depending on the target weed, biosecurity obligations may drive the control of the target weed. Driving factors for control may also contribute to determining the resources available. |
| Yes ☐ No ☐ | **Treatment options** have been reviewed, including non-chemical methods. | Integrated approaches to control must be considered. Weed management techniques, application technology and pesticide products change over time. Historical approaches to control may not always be the right choice. The Department of Primary Industry's WeedWise website can provide valuable information on control techniques, including current permits available for use. |
| Yes ☐ No ☐ | **Buffer zones** have been determined (and marked clearly on maps attached to the risk assessment/ POP/ operational plans). | Determination of buffer zones will be dependent on the directions provided in the label or permit, or where the Air-1 PCO applies. Additional buffer zones may be required where walking tracks, cultural heritage locations or other sensitive receivers/ locations may be present as identified through the REF. |
| Yes ☐ No ☐ | Reputational risk has been adequately addressed within the risk assessment. | Risk assessments must also address and consider reputational risk to the agency or entities involved in the aerial spraying operations. |
| **2. Communication and notification checklist** | | |
| Yes ☐ No ☐ | Community/ public interest has been assessed and a **communications strategy/ plan (or other relevant communications documentation)** has been developed and a **stakeholder lis**t created. | Highly visible aerial spraying (e.g. coastal/ adjacent to populated areas) may result in increased community interest in herbicides used and choice of application technique. Community awareness and public scrutiny regarding herbicide application has increased over time, with social media playing a large part in the spread of information (or misinformation) regarding aerial spraying programs. Determining the level of likely community interest and concern will assist in developing appropriate communication strategies.<br>Development of a communications plan / appropriate documentation to detail the communication channels and key messaging will ensure clear and consistent information is provided regarding program goals, how the program is addressing risks and meeting regulatory obligations. This should include communication requirements, pre, during and post-spraying. |
| Yes ☐ No ☐ | **Stakeholders** have been consulted, including identification of integrated/ collaborative programs. | Where possible, the integration of other land tenure into the aerial spraying programs should be encouraged. Identification of, and discussions with stakeholders such as local councils, local or regional weeds committees or specialist threatened species officers may identify how programs may complement or be run together and share program aspects (such as community engagement or notifications).<br>Neighbouring land occupiers must also be considered and consulted, particularly where sensitive receivers, dwellings or potential conflicting land uses are in place. |

| Yes/ No | Key consideration | Explanation |
|---|---|---|
| Yes ☐ No ☐ | For works on park, the NPWS **Pesticide Use Notification Plan** (PUNP) has been considered (or any other relevant PUNP for works off park) and notification requirements assessed. | Operations on NPWS estate must comply with the PUNP; where a contractor is undertaking the application on NPWS estate, they must agree to abide by the PUNP requirements. |
| Yes ☐ No ☐ | **Signage** requirements (location of signs, timeframes and signage contents) are understood and documented. | Signage placement and contents must comply with the PUNP and Pesticides Regulation. |
| **3. Operational planning checklist** | | |
| Yes ☐ No ☐ | A pesticide **operation plan** (POP) or equivalent operational planning document has been developed, containing all relevant information to be used during operations. | This document provides an effective written summary of operational planning, including roles, responsibilities and command structure, work health and safety/ stop work triggers and key environmental considerations to ensure safe, compliant and efficient program delivery. An appropriate map with hazards and buffer zones must be attached to the POP/ planning document. |
| Yes ☐ No ☐ | A **qualified operator** is selected, appropriate and required licensing and training currency is documented. | For NPWS operations, ParkAir is the preferred operator, or where unavailable, select an operator from the Land Management Approved Operators List. |
| Yes ☐ No ☐ | Aerial spray **technique**/ method and **application equipment** discussed and agreed on with the PIC. | Appropriate technique and application equipment confirmed based on program planning and risk assessments – operator confirms they can carry out the application. |
| Yes ☐ No ☐ | Roles and **responsibilities** agreed upon. | In consultation with the PIC/ operator, ensure the specific roles and responsibilities of all parties are understood and agreed upon. For NPWS operations this must include the appointment of an **Officer in Charge** (OIC) and completion of the OIC checklist.<br>Responsibilities and decisions must include herbicide transport and storage at the landing site, mixing and loading and record-keeping. |
| Yes ☐ No ☐ | Field **communication processes** during operations have been established. | Methods of communication between aerial applicators (pilots and crew) and ground staff must be established prior to works. These communication methods and the responsibilities of those involved should be detailed within the POP or equivalent operational planning documentation. |
| Yes ☐ No ☐ | All staff/ employees involved have current required **training** (or **licences** where contractors are used). | Confirm training and licensing details for all staff/ contractors and employees involved in the operation. |

| Yes/ No | Key consideration | Explanation |
|---|---|---|
| Yes ☐ No ☐ | Appropriate **landing site**(s) determined and documented (and permissions obtained where off park) | Landing site must be determined in consultation with the PIC/ RPA operator and a layout plan for landing site prepared.<br>Note: Multiple landing zones (sites) may be appropriate for RPA operations. |
| Yes ☐ No ☐ | Spray **timings** have been determined and agreed. | In consultation with the PIC/ operator establish a timeline for the period when spraying is to occur (i.e. avoid weekends and school/ public holidays; also consider the growth stages of the target weed in relation to herbicide effectiveness). |
| Yes ☐ No ☐ | Work health and safety risks have been assessed (a **Job Safety Analysis** (JSA) is completed). | A JSA must be completed and approved for each aerial spray program. The JSA must include site/ technique/ methodology-specific risks and mitigation measures. Note that NPWS operations must use the aerial spraying JSA template from the NPWS intranet and contextualise for the program specifics.<br>It may be necessary to prepare a separate JSA for establishing and maintaining spraying zone closures including management of public access and vehicle traffic. A traffic control plan may be required.<br>Contract operators must develop their own JSA / Safe Work Method Statement and provide this to NPWS for discussion and review.<br>Note: A Job Safety Briefing record (JSB record) must be signed by all operational staff/ contractors prior to commencement of the program, with signatures required to confirm attendance. |
| Yes ☐ No ☐ | **Water source** for the landing site is identified. | Adequate water of appropriate quality (enough for mixing as well as tank rinsing, etc.) must be available at the landing site. Determine an appropriate source including transport and onsite storage. |
| **4. Aerial spray application checklist** | | |
| Yes ☐ No ☐ | **Landing site**(s) assessed and confirmed. | Reconnaissance on agreed landing site(s) to confirm site suitability.<br>Landing sites set up appropriately. |
| Yes ☐ No ☐ | Appropriate and adequate **personal protective and emergency equipment** on site. | All required PPE is on site to be used by all relevant staff/ operators.<br>Location of emergency equipment and procedures for use is known to all on site. |
| Yes ☐ No ☐ | **Buffers** marked. | All buffer zones as identified during planning and environmental risk assessments must be clearly marked (either on-ground or on maps). Ensure the locations of buffers are discussed and understood by the PIC.<br>Reconnaissance flights may check buffers and spray areas/ flight paths. |

| Yes/ No | Key consideration | Explanation |
|---|---|---|
| Yes ☐ No ☐ | **Resources** are available to implement spraying operations. | Personnel, equipment and other resources required are available on the day to ensure the spraying operation can be undertaken in accordance with the POP/ operational planning document. |
| Yes ☐ No ☐ | **Signs** and **public closure structures** are in place and spray zones are confirmed closed and clear of people. | Confirmation that signs are in place as per the operational plan (including timings for sign removal).<br>Confirmation that public closure structures and ground personnel are in place and spray areas are effectively closed/ clear of people must be obtained before commencement of spraying. |
| Yes ☐ No ☐ | **Weather** forecast assessed and observed as ok to spray. | Weather forecast has been checked. Weather must be monitored prior to take off, and during spray operations throughout the day. To manage spray drift, changes in weather must be monitored, recorded and communicated to key operational staff. Weather related stop work triggers must be clearly understood prior to spraying and monitored throughout the operation. |
| Yes ☐ No ☐ | **Safety data sheets** (SDS), full **product labels** (and **permits** where applicable) for all chemical products on site and available to all involved. | All chemical products must have a full label attached. SDS may be available in hard copy or electronic versions (electronic versions must be easily accessible and readable). |
| Yes ☐ No ☐ | **Briefings** are completed. | Required briefings are undertaken with the PIC and OIC and operational staff.<br>Roles, responsibilities and communication processes confirmed.<br>PIC confirms areas to be sprayed/ buffers, etc. are clear on maps and determines ok to spray. |
| Yes ☐ No ☐ | Spraying undertaken/ **logged and recorded**. | Spraying is undertaken with appropriate data logging, GPS recording and flight-following.<br>Weather and spray drift are monitored throughout spraying. |
| Yes ☐ No ☐ | **Pesticide use records** are created. | All records required by the Pesticides Regulation are created. NPWS records must be entered into the Pest and Weed Information System (PWIS); contractors must provide a copy of records to NPWS.<br>Records must be made within 48 hours of application and kept for 3 years. |
| Yes ☐ No ☐ | Site **clean-up** | All rubbish, chemical containers, etc. removed from site. Unused pesticide spray mix to be disposed of as per label/ SDS directions. |
| **5. Program review checklist** | | |
| Yes ☐ No ☐ | Post-spraying **debrief** | Debrief/ after-action review with PIC/ operator and staff involved to discuss program delivery/ any issues encountered (should be held on day of operation or as close as possible to the end of the operation). |

| Yes/ No | Key consideration | Explanation |
|---|---|---|
| Yes ☐ No ☐ | Treatment **effectiveness assessed**. | Post-spraying monitoring (consistent with pre-spray monitoring and as outlined in the monitoring plan), is be undertaken to assess the effectiveness of, and weed response to the treatment.<br>Monitoring should also assess any additional negative impacts such as off-target damage, to inform future management. |
| Yes ☐ No ☐ | Need for **subsequent** aerial spraying determined and/ or assessment of **alternative treatment options**. | Depending on the assessed effectiveness of the treatment, re-evaluate the program in terms of reapplication with aerial spraying, integrated control methods or alternative options. |
| Yes ☐ No ☐ | Ongoing or **follow-up** program identified and implemented. | Develop a follow-up control program based on the assessments of effectiveness and alternative treatment methods. |

# Appendix B: Aerial spraying communications plan template/ example

## Introduction

*Insert key program information – what are the objectives and justifications for the program? List the relevant legislation and guiding policies/ procedures, etc. the program must abide by.*

## Objectives

*What are the objectives of the communications plan? Objectives should be specific, measurable, achievable, realistic, time-bound (SMART) and able to be recorded and assessed.*

## Key issues of consideration

*Identify regional/ local issues that may affect the program or impact on the key messages or communication methods to be used.*

## Key messages

*List the key messages to be conveyed.*

*Key messages should aim to be one or 2 sentences, without jargon or acronyms and should include where to go for further details and information.*

*Key messages may be broken into subsections such as:*

- *key information to reinforce/ provide on the day of operation*
- *key information specific to certain stakeholder interests.*

*Example key messages:*

- *Weeds pose a serious threat to the NSW environment and farming industries – harming native plants and animals, natural landscapes, water catchments and agriculture.*
- *The National Parks and Wildlife Service (NPWS) has obligations under biosecurity legislation, to control and manage pest animals and weeds within the state's national parks system.*
- *All aerial spraying programs are carried out in accordance with NSW pesticide legislation, including the Aerial Spraying Guidelines, NPWS pesticide policies and procedures.*
- *Aerial spraying is one of several integrated control methods used to target weeds over larger areas or dense infestations.*
- *Thorough environmental risk assessments are carried out prior to aerial spraying.*

## Communication methods

Any number of communication methods may be used to engage and communicate with internal and external stakeholders and the general public, both prior, during and after the program.

Note, the Pesticide Use Notification Plan may also detail specific methods of communication that must be used.

Methods may include, but are not be limited to:

- letters, emails
- phone calls/ mobile phone/ VHF radio
- meetings/ briefings (staff and stakeholders)
- publicly available fact sheets
- NPWS website alerts and updates
- media releases (optional)
- maps
- signage
- social media.

## Media release

*If a media release is planned, detail:*

- *key staff/ roles to consult with and to approve media releases and key messages (e.g. branch directors, Public Affairs, etc.)*
- *planned media outlets (e.g. local newspapers, radio stations)*
- *key media messages*
- *timings of planned media releases*
- *approved NPWS spokespeople/ contacts.*

## Stakeholder list and communication

Stakeholder lists must be **reviewed and updated** prior to every spraying operation (i.e. for ongoing programs).

Local councils maintain lists of residents with chemical sensitivities; ensure these persons are adequately addressed within the communications plan.

| Stakeholder | Interest | Impact | Key message(s) | Communication method and frequency | Responsibilities |
|---|---|---|---|---|---|
| (Organisation name, group, etc.) | (What is the stakeholder's interest in the project?) | (How is the stakeholder affected by the project?) | (What are some key messages for this stakeholder?) | (What channels or formats will be used to communicate to the stakeholder and who is responsible? e.g. status reports, newsletters, phone) | (List persons responsible for ensuring stakeholder contact and communication is carried out as per this plan) |
| e.g. Commercial fishers | Aquatic fauna/ waterway health | Potential access closures | Timing/ location of program<br>Environmental assessment requirements<br>Project justifications and herbicide choice | Standard email/ letter prior to commencement<br>Invitation to face-to-face briefing and discussions (prior and after program)<br>Daily notification when spraying if required for operation | Project manager |
| e.g. NPWS staff | | | | | |
| | | | | | |
| | | | | | |

# Appendix C: Pesticide operation plan (POP) template/ example

| **Branch Aerial Spraying Program** | **CM9:** | DOCXX/XXXX |
|---|---|---|
| **NPWS Branch/es:** XXXX<br>**NPWS Area/s:** XXXX | **Proposed dates:** | Date range |
| ☐ Fixed Wing ☐ Helicopter ☐ Mixed deliver (both)<br>Cooperative program: Yes/No. If Yes responsible agency: NPWS/Other | **NPWS OIC:** | Name and phone no |
| ☐ ParkAir (provide aircraft identifier)<br>☐ Contractor (provide details) | **Pilot in charge:** | Name and phone no |
| ☐ Approved ☐ Not Approved<br>Park Operations Area Manager | **BPMS program:** | Program name<br>Number |

| **Objective** | Detail |
|---|---|
| **Situation** | |
| **Target weed(s)** | |
| **Treatment site** | |
| **Reason for treatment** | |
| **Consultation** | |
| **Risk Assessment, JSAs** | ☐ Approved environmental risk assessment (DOCXX/XXXX)<br>☐ JSAs: Aerial Spraying (DOCXX/XXXX) |
| **Compliance with NPWS policy including** | ☐ Aviation Standard Operating Procedures<br>☐ Pesticide Standard Operating Procedures<br>☐ Pesticide Use Notification Plan |
| **Recent related programs:** | Describe recent and/ or related programs (e.g. integrated control programs/ additional ground controls, etc.) |

**Mission**

Detail (including pesticide mixing and application rates)

**Execution**

To spray target weed in XXXX sorties/loads.

| **Total quantity herbicide** | |
|---|---|

**Tasks:** ***1. e.g.: Mixing and loading***
***2. Logistical support****/ on ground comms*
***3. Flight team*****: Deliver designated sortie/s in a safe and efficient manner within designated spray location*
** PIC, AOB/navigator*

**Sortie table**, see attached map. Note: Sorties should be denoted alphabetically, and aviation maps numbered.

| Sortie | POB | Est flight time | Fuel location | AOB Map |
|---|---|---|---|---|
| A | | | | |
| B | | | | |
| C | | | | |
| D | | | | |
| TOTAL | | | | |

**Pesticide use and logistics**
**Mixing and loading**: To be undertaken by flight team (or suitably trained on ground logistics team)
**Full product name of chemical to be used (including names of any additives):**
**Notifications:** Notifications provided as per PUNP and any other label/permit requirements. Signs in place.
**Record of chemical use**: NPWS PWIS record must be completed daily.
**Pesticide transport:** As per risk assessment and JSAs. Do not transport concentrate in cab of vehicle. Carry appropriate spill kit, ensure adequate water supply. Carry product SDS and ensure full labels are attached.

| **Safety and hazards** |
|---|
| **Approvals/ notifications:** For example, if in proximity to restricted/ controlled airspace.<br>**Stop works triggers:** Inappropriate weather, notification and signage issues, map failure causing uncertainty of where to spray, AQF3 out of date or there is risk of impacts to human health.<br>**Weather** forecast to be checked by OIC/PIC prior to fight. Exercise caution when pending forecast indicates winds exceeding 25 knots (fixed wing), low cloud levels or raining.<br>**PPE** as per the label and SDS requirements.<br>**Flight crew**: Fire pants and jacket and fire boots.<br>**Heavy lifting:** 2-person lifting of heavy objects or as per JSA<br>**Briefings:** initial safety briefing prior to commencement for all participating staff. Documented daily briefings on following days. |
| **Emergency procedures & medivac** |
| While **mixing/ loading**, if pesticide spillage occurs, clear the immediate area, contain spill using appropriate spill kit. Notify OIC and Branch Pest Officer.<br>Where pesticide contact occurs, consider contacting local doctor, transport to hospital, contact poisons information line 13 11 26. Take SDS.<br>If a vehicle accident happens in transit, if possible, stay with the vehicle, if injury does not prevent. Notify OIC.<br>**Nearest hospital:** Name phone number, address, google pin: XXXX.<br>**Ambulance meeting point:** Name phone number, address, google pin: XXXX. |
| **Administration & logistics** |

| | | |
|---|---|---|
| **WBS**: XXXX | **Equipment no:** XXXX | **Work order no:** XXXX |

| |
|---|
| **Mapping**: Spray map attached.<br>**Buffers**: Buffers/ exclusion zones clearly marked (detail how these are shown)<br><br>**Landing site/s**: **Airports**: Name, address, Google Pin: XXXX Coordinates: XXº XX' XX.XX" S XXXº XX' XX.XX" E with possible alternate fuel locations at XXXX.<br>**Alternate fuel locations:** Name, address, Google Pin: XXXX Coordinates: XXº XX' XX.XX" S XXXº XX' XX.XX" E<br><br>**NPWS Depot Address:** Address. Google pin: XXXX<br><br>**AQF3**: Chem certification to be confirmed prior to program participation.<br>**JSA/JSB**: Signed copies to be held by OIC. Daily brief to be documented in JSB or communications log.<br>**Paperwork available to team:** Product label, relevant APVMA Permits, NPWS SOPs, Product SDS, PWIS form, JSAs and Environmental Risk Assessment/s.<br>**Notifications:** Completed via NPWS web page, PUNP, communications plan (DOCXX/XXXX for program specific information).<br>**Signage**: in place as per the PUNP requirements (DOCXX/XXXX for program specific information.) |
| **Communications** |
| **Date of initial NPWS briefing held for program (all participating staff to attend)**: 0X00hrs on date at XXXX NPWS depot.<br>**Officer responsible for flight-following**: |

| | |
|---|---|
| **NPWS office:**<br>Phone No: XXXX<br>Radio tower: ChXXXX<br>CTAF: 123.45 | Agreed time of **flight-following**:<br>Top & bottom of hour by 2 means of communication. Tested prior to take off.<br>Aircraft location to be tracked by TracPlus. Flight manifest & endurance to be noted prior to take off.<br>**Uncertain Phase – 5 mins no response:** Continue to contact & track aircraft. Notify OIC. Use Overdue Aircraft Checklist.<br>**Alert – 15 mins no response:** Contact State Air Desk 1300 677 723.<br>**Distress (aircraft believed in danger/out of endurance range):** Contact 000, AM and Director. Collect paperwork. |

Insert map

# Appendix D: Aerial spraying of bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*)

## Introduction

This appendix should be read in conjunction with the National Parks and Wildlife Service (NPWS) Aerial Spraying Guidelines (the Guidelines). It provides additional guidance specific to bitou bush aerial spraying, above and beyond that provided in the checklist in Appendix A of the Guidelines.

A brief overview of the best practice integrated control methods is provided below, together with useful resources to support planning, implementation and monitoring of bitou bush control programs. Table 2 follows the format of the checklist in Appendix A of the Guidelines and provides additional guidance specific to bitou bush.

Several additional resources are available to land managers to support integrated control of bitou bush in NSW, including the *Bitou Bush Management Manual: Current management and control options for bitou bush (*Chrysanthemoides monilifera *ssp.* rotundata*) in Australia* (Winkler et al. 2008).The *Review of the NSW Threat Abatement Plan: Invasion of native plant communities by* Chrysanthemoides monilifera *(bitou bush and boneseed) 2006–2011* (PDF 1.8MB) (Hamilton and Turner 2013) details some case studies and other monitoring results from bitou bush aerial spray programs These resources should be reviewed prior to implementing an aerial spray program for bitou bush.

Practitioners wishing to undertake aerial spray programs for bitou bush must read both the Guidelines and this appendix to ensure compliance with current minor use permits PER12363 and PER12251 issued by the APVMA.

**The information provided here does not replace label or permit directions.**

Bitou bush, *Chrysanthemoides monilifera* subsp. *rotundata* is a perennial alien coastal shrub in the Asteraceae family, native to South Africa. Invasion by bitou bush has had severe impacts on the diversity of native coastal plant communities, leading to the species being listed as a KTP under Schedule 4 of the BC Act. There are 2 established containment lines for bitou bush in NSW, north from Cape Byron and south from Point Perpendicular. Outside these containment lines, the management objective for bitou bush is asset protection.

Aerial spraying programs for bitou bush have occurred since the early 1990s. During this time, many valuable lessons have been learned through both applied research and adaptive management. Thus, this appendix provides practitioners with targeted best practice information for aerial spraying bitou bush, both to mitigate environmental impacts and to maximise the effectiveness of aerial spray programs.

## Integrated weed management

Often the most successful and cost-effective approach to control weeds is to combine or integrate several control methods over time. An integrated approach should be used to support aerial spray programs because:

- control in buffer, exclusion and riparian/aquatic zones is also needed
- aerial control is not always needed every year due to insufficient bitou bush recruitment or density
- follow-up control may require additional techniques (e.g. bush regeneration)
- reliance on aerial control decreases with time, and thus other control techniques will be needed.

Winkler et al. (2008) developed a decision matrix to assist land managers in identifying suitable control methods based on habitat type including aerial boom and spot spraying. The following subsections provide a brief overview of available control methods for bitou bush to support aerial spraying programs; for further details including the advantages and disadvantages of different methods, see the *Bitou Bush Management Manual* (Winkler et al. 2008).

## Manual methods

Manual control methods include the physical removal of the weed, with hand tools or by hand, and exclude herbicide. Methods include hand weeding and crowning. Such methods are useful where there may be community opposition to herbicide use in conservation settings or in highly sensitive situations. Hand weeding involves the manual removal of seedlings and juvenile plants without the need for tools by grasping the stems at the base. Crowning works by cutting the stem away from the roots below ground level or cutting out the ‘crown’ of the plant.

## Chemical (herbicide) methods

There are currently 6 herbicide methods available for bitou bush: cut and paint, stem injection/scrape and paint, foliar spraying, splatter gun, aerial boom and spot spraying. The WeedWise bitou bush profile provides a summary of currently available registered herbicides and appropriate application rates for bitou bush control. For aerial boom or spot spraying, only glyphosate and metsulfuron methyl are permitted for use.

- **Glyphosate** (N-phosphonomethyl glycine) is a broad-spectrum herbicide that can be used to control a wide range of broadleaf and grass weeds. It is translocated from the leaves to actively growing parts of the plant. Glyphosate works by disrupting an essential plant enzyme (5-enolpyruvylshikimic acid 3-phosphate synthase or EPSPS) in the shikimic acid pathway and inhibits production of essential aromatic amino acids. EPSPS and the shikimic acid pathway are present in plants, fungi and bacteria, but not in animals.

  Bitou bush is more susceptible to glyphosate during winter when it is taken up through the leaves and translocated to the roots; however, in summer glyphosate is less effective because translocation to the root system is reduced.

- **Metsulfuron methyl** is a sulfonylurea herbicide that provides selective pre- and post-emergence control of broadleaf weeds and some annual grasses. Metsulfuron methyl inhibits the enzyme acetolactate synthase (ALS), which is required for the synthesis of amino acids necessary for cell division. ALS is not present in animals. Metsulfuron methyl has residual activity in the soil. Bitou bush is susceptible to metsulfuron methyl throughout the year.

Winkler et al. (2008) provide comprehensive information on the 6 herbicide control methods, including advantages and disadvantages of each method.

### Fate of herbicides used in aerial bitou bush spraying

Due to the lower herbicide application rates used in aerial helicopter boom spraying, any herbicide residues will be lower than those associated with ground spraying.

- **Glyphosate** is rapidly deactivated in the soil because it binds to soil particles. It is broken down in the soil by microbial activity. The rate of decomposition depends on temperature and the organic matter content of the soil. Glyphosate is broken down into naturally occurring substances such as carbon dioxide, inorganic phosphate and a range of other compounds. The average half-life of glyphosate in soil is 32 days (half-life is the time taken for the concentration of herbicide to be halved).
- **Metsulfuron methyl's** residual activity varies with soil type, soil pH and organic matter. Metsulfuron methyl is broken down by microbial activity and chemical hydrolysis. The half-life of metsulfuron methyl in soil ranges from 5 days in acidic soils to 69 days in alkaline soils. Also, leaching of metsulfuron methyl is greater in alkaline soils.

  The presence of other compounds in the soil may reduce the soil activity of metsulfuron methyl (e.g. high carbon levels following fire).

## Spray timing

Decisions on when to spray herbicides should include assessment of:

- **season of application** – the use of glyphosate and metsulfuron methyl in winter is based on extensive trials that showed the impact on native species at this time was low, while effective control of bitou bush could be achieved. During winter, most native plant species are dormant and thus are less susceptible to herbicides than in summer when they are actively growing
- **flowering of bitou bush** – herbicide control is most effective after peak bitou bush flowering, which occurs in autumn to early winter (i.e. April to June). The timing of peak flowering varies from northern to southern NSW and may be affected by other environmental factors (e.g. fire, drought)
- **interval between herbicide applications** – the optimal interval between herbicide applications differs across NSW, often due to the differences in the time it takes bitou bush to flower for the first time. In the north, plants may flower within the first year after germination, and thus spraying every year may be required. In southern NSW, the spraying interval may be longer due to greater time from germination to first flowering. Inappropriate intervals between herbicide applications may result in adverse impacts to some native species. **The likelihood of such impacts should be assessed prior to any repeated aerial spraying program.**
  - **interval too short** – there may not be enough bitou bush regrowth to warrant treatment at the time, or native plants may not have recovered sufficiently to withstand a subsequent application, increasing the risk of cumulative herbicide injury. Alternatively, bitou bush seedlings may not be large enough to provide suitable shelter from the herbicide spray for native seedlings
  - **interval too long** – bitou bush may recover or re-invade, and plants may have time to mature and fruit and replenish the seed bank
- **choice of herbicide** – different herbicides may influence the re-treatment interval; for example, use of metsulfuron methyl may require longer intervals between applications due to the residual effect of this herbicide suppressing bitou bush germination
- **stage of current program within your long-term control program** – the interval between spraying events should increase with time, as bitou bush seed banks and plant densities are reduced.

## Biological control

There are 4 established biocontrol agents in NSW including the bitou tip moth (*Comostolopis germana*), bitou leaf-roller moth (*Tortrix* sp.), bitou seed fly (*Mesoclanis polana*), and bitou tortoise beetle (*Cassida* sp. 3). The tip moth and the seed fly are well established, with the seed fly existing across the range of bitou bush in NSW.

Effective control of bitou bush is best achieved using conventional control methods (as per below) in combination with biocontrol, particularly when complementary agents are present in the field. For example, the bitou leaf-roller moth, bitou tip moth and bitou seed fly coexist well in the field and their damage is complementary. In combination, their impact minimises seed production in bitou bush. For further information on biocontrol for bitou bush, see the NSW Department of Primary Industries *Biological control of weeds: A practitioner's guide for south-east Australia* (DPI 2021).

## Other control methods

Heavy machinery can be used to control bitou bush plants (by slashing or mulching standing biomass) or to create access paths into areas that are otherwise difficult to reach for spraying. However, the use of such machinery can have negative effects on native plant communities and may lead to erosion. With all vehicle movement there is a risk of transporting undesirable plant species via seed, so ensure correct hygiene measures are implemented prior to and directly after any control event.

Fire can be used to control bitou bush, but it must be part of an integrated control strategy. Fire may be very advantageous as it can kill bitou bush plants and seeds in the top 2–3 cm of soil. Fire may also stimulate germination of the soil seed bank, thus helping to deplete the seed bank more quickly. The success of fire to control bitou bush is highly dependent on commitment to treat the resulting germination before young plants flower and set seed. It is more efficient to spray regrowth after fire; however, research indicates that hand weeding or targeted spot spraying may cause less damage to regenerating native plant species (French et al. 2008). See Winkler et al. (2008) for further information on mechanical and fire control strategies.

## Revegetation

Revegetation should use locally indigenous species, and where possible such species should be sourced locally (i.e. of local provenance, see the FloraBank and Greening Australia websites). Allow sufficient time for natural regeneration to occur and assess the need for replanting before implementing a revegetation program.

Hand planting seedlings or sowing seeds can be an important part of the long-term rehabilitation of weed infested sites. The level of natural recruitment and native vegetation present should influence future spraying program planning; for example, revegetated sites may need to be excluded from subsequent aerial spraying programs until plants are sufficiently established to withstand herbicide exposure. Such sites may require manual control to keep weeds in check during such intervals.

Aerial seeding has been used to help revegetate sites following the control of bitou bush. Aerial seeding can be applied either at the time of herbicide application or at a later stage. Limited data suggest that in situations where large amounts of bitou bush detritus are present or when a residual herbicide has been used, aerial seeding should be delayed until the bitou bush detritus has broken down and the herbicide residue periods have elapsed. Seeds may need to be treated prior to application (e.g. with activated carbon) to stimulate germination. The addition of insecticide to the coating of pelleted seeds may prevent removal of seeds by ants, while fertilisers will help with germination. Do not scarify seeds unless rain is forecast, as germination under low soil moisture will mean many seedlings will die.

**Table 2 Further guidance for bitou bush aerial spraying**

| Yes/ No | Key consideration specific to bitou bush | Explanation |
|---|---|---|
| **1. Pre-planning checklist** | | |
| Yes ☐ No ☐ | The site has been thoroughly assessed and is suitable for aerial spraying (base line study). | Consideration should be given to the infestation size and density; for example:<br>a. infestations of bitou bush covering large areas may be more cost-effective to control with aerial spraying<br>b. small, isolated dense infestations, if accessible, may be more cost-effective to control using techniques other than aerial spraying (e.g. ground control or RPA spraying). If inaccessible, aerial spot spraying by helicopter may also be a cost-effective option.<br>Pre-planning activities such as **mapping weed densities** and **identifying integrated control methods** across your site should occur prior to treatment. See Watson et al. (2021) for information on how to map weed densities across a site. |
| Yes ☐ No ☐ | Potential adverse consequences from the weed control program have been assessed. | Large-scale aerial spraying of bitou bush may, in some circumstances, increase fire risk due to higher fuel loads from extensive dead stands of bitou bush remaining in the landscape.<br>Other weed species either co-occur with bitou bush or invade following bitou bush control, so it is essential to develop your bitou bush control strategy to prepare for control of co-occurring weeds or weeds that will invade following bitou bush control (see Winkler et al. 2008 for details of these weeds). |
| Yes ☐ No ☐ | An appropriate herbicide has been selected. | At the time of writing, only glyphosate and metsulfuron methyl can be used to control bitou bush from either helicopters or RPAS. Check permits for current requirements – PER12251 and PER12363. |
| Yes ☐ No ☐ | Treatment options have been reviewed, including non-chemical methods. | Ensure that either aerial boom or spot spraying methods are appropriate to your control area. Aerial boom spraying is suitable for **large and/ or dense** infestations, in particular in locations that are inaccessible and/or where it is not cost-effective to control using other methods. |
| Yes ☐ No ☐ | Are biocontrol release sites present within your intended aerial spray control area? | Consult with neighbours.<br>It is important to check if biocontrol agents have been released within your intended aerial control site. See DPI (2021) for more information on bitou bush biocontrol agents. |

| Yes/ No | Key consideration specific to bitou bush | Explanation |
|---|---|---|
| **2. Communication and notification checklist** | | |
| Yes ☐ No ☐ | Community/ public interest has been assessed and a **communications strategy/ plan (or other relevant communications documentation)** has been developed and a **stakeholder list** created. | Key message: There are 157 plant species, 3 plant populations and 24 ecological communities at risk from bitou bush invasion. Such information can be useful to include when developing communication strategies. See the Hamilton et al. (2008) to assist with identification of species at risk. |
| Yes ☐ No ☐ | Stakeholders have been consulted – including identification of integrated/ collaborative programs. | Weed practitioners must consult with relevant stakeholders, including threatened species managers; for example, contact the *Saving our Species* program to identify which staff are responsible for on-ground threatened species conservation projects (savingourspecies@environment.nsw.gov.au) |
| **3. Operational planning checklist** | | |
| Yes ☐ No ☐ | Spraying timings have been determined and agreed. | Aerial boom spraying is best undertaken in winter, when bitou bush plants can be killed while limiting off-target damage to native plants. The optimal interval between herbicide applications differs across NSW, often due to differences in bitou bush time to maturity (flowering). In the north, plants may flower within the first year after germination, and thus spraying every year may be required. In southern NSW, the spraying intervals between herbicide applications are longer, and may result in adverse impacts to some native species. Therefore, the likelihood of such impacts should be assessed prior to any aerial spraying program. |
| **Other considerations** | | |
| Yes ☐ No ☐ | Managing bitou bush in different habitats. | Bitou bush invades a range of native habitats. Habitat type will influence the control options available, as some methods may have negative impacts if used in some environments. See Winkler et al. (2008) for detailed information on habitats invaded by bitou bush. |

## Herbicide sensitive species

Information from controlled laboratory and field studies on the impacts of herbicides on native plants is limited. The following species sensitivity lists (Table 3 and Table 4), contain information gained during population-based visual assessment of herbicide injury during aerial spraying operations for bitou bush (John Toth, Management of Environmental Weeds Pty Ltd, personal communication) and contain 220 species examined for glyphosate and 83 species for metsulfuron methyl.

While the data collected to date (Table 3 and Table 4), has concentrated on perennials and adults of species impacted by bitou bush, information on the fate of native species that co-occur with other aerially sprayed weeds, in particular seedlings, ephemeral annuals, parasitic plants and geophytes is needed and should be included where possible. If time and funding permit, selected plants in sprayed and nearby unsprayed areas should be tagged

and assessed. Post-spray monitoring should be undertaken at 2 months and 6 months after spraying, and thereafter annually depending on the herbicide action time.

Where possible, information should be collected following aerial spraying on the condition of individual native species, to determine herbicide sensitivity or any adverse impacts (i.e. non-acute impacts such as reduction in flowering/ fruiting/ growth and/or increased mortality). Information should also be collected on species that show no signs of sensitivity. It is important to note the herbicide formulation and adjuvants used when monitoring for herbicide impacts.

Note: Other environmental factors may be confused with herbicide injury, such as salt exposure, water stress and pathogenic diseases. Such factors should be examined to ensure they are not inadvertently reported as herbicide sensitivity events.

**Table 3 Herbicide sensitivity to Roundup® (glyphosate 360 g/L) of native and some introduced plants – results from 1989–2004 for the spraying of 2 L of Roundup® in 30 L water per ha, from a helicopter, during winter (1 June to 31 August)**

Note some responses (16) were made in 2010 and 2011 at bitou bush threat abatement plan (Bitou TAP; DEC 2006) sites. * Indicates an exotic species

** Observation key: **OK** = no effect on foliage, **SL** = some foliage burn, **M** =25% foliage burn, **SD** = some dead, **MD** = most dead, **A** = more observations required, **NF** = no more observations required. Information sources are listed below the table.

| Botanical name | After 8 weeks observation** (Source) | After 6 months observation** (Source) | Comments |
|---|---|---|---|
| *Acacia binervia* | OK (5) | OK (5) | NF |
| *Acacia implexa* | SL (4) | OK (4) | A |
| *Acacia longifolia* var. *sophorae* | OK (1,2,4,6,11,15) | OK (1,2,4,6,11,15) | NF |
| *Acacia maidenii* | OK (4) M (8,9) | OK (4,8,9) | A; insect gall damage |
| *Acacia myrtifolia* | OK (5) | OK (5) | NF |
| *Acacia saligna** | SL (4,6) | OK (4,6) | A |
| *Acacia suaveolens* | SL (4,6) | SD (4) OK (6) | A |
| *Acacia terminalis* | SL (4) | OK (4) | A |
| *Acacia ulicifolia* | OK (2,4,6) | OK (2,4,6,8) | A |
| *Acmena smithii* | OK (4,6,8,16) | OK (4,6,16‡) | A |
| *Acronychia imperforata* | M (15,16) | OK (15,16‡) | A |
| *Actinotus helianthi* | OK (2,4,6) | OK (2,4,6) | NF |
| *Actinotus minor* | OK (6) | OK (6) | A |
| *Aegiceras corniculatum* | OK (3) | OK (3) | A |
| *Alectryon coriaceous* | SL (15,16) | OK (15,16‡) | A |
| *Alectryon subcinereus* | OK (4) | OK (4) | A |
| *Allocasuarina distyla* | OK (2,6) | OK (2,6) | A |
| *Allocasuarina littoralis* | OK (2,6) | OK (2,6) | A |
| *Allocasuarina nana* | OK (6) | OK (6) | A |
| *Alphitonia excelsa* | OK (3,16) M (8) | OK (3,16‡) SD (8) | A |
| *Ammophila arenaria** | OK (4) | OK (4) | A |
| *Amperea xiphoclada* | OK (6) | OK (6) | A |
| *Andropogon virginicus** | OK (11) | OK (11) | A |
| *Angophora costata* | OK (6) | OK (6) | A |

| Botanical name | After 8 weeks observation** (Source) | After 6 months observation** (Source) | Comments |
|---|---|---|---|
| *Anredera cordifolia* | OK (4) | OK (4) | A |
| *Aotus ericoides* | OK (2,6) | OK (2,6) | A |
| *Araujia hortorum* | OK (4) | OK (4) | A |
| *Aristida ramosa* | M (6) | OK (6) | A |
| *Astroloma pinifolium* | OK (2,6) | OK (2,6) | A |
| *Austromyrtus dulcis* | OK (3,16) | OK (3,16‡) | A |
| *Avicennia marina* | OK (3) | OK (3) | A |
| *Baeckea brevifolia* | OK (6) | OK (6) | A |
| *Baeckea imbricata* | OK (6) | OK (6) | A |
| *Banksia aemula* | SL (15) | OK (15) | A |
| *Banksia ericifolia* | OK (6) | OK (6) | A |
| *Banksia integrifolia* | OK (1,4,6,11)<br>SL (12,13,15,16) | OK (1,4,6,11,12,13,15) | A; a few died (12) |
| *Banksia oblongifolia* | OK (5,16) | OK (5,16‡) | A |
| *Banksia serrata* | OK (2,4,6) | OK (2,4,6) | NF |
| *Billardiera scandens* | OK (2,4) M (15) | OK (2,4,15) | A |
| *Blechnum* sp. | OK (3) | OK (3) | A |
| *Bossiaea ensata* | OK (2,6) | OK (2,6) | NF |
| *Bossiaea heterophylla* | OK (2,4,6) | OK (2,4,6) | NF |
| *Brachyloma daphnoides* | OK (4) | OK (4) | A |
| *Breynia oblongifolia* | OK (2,4,6,11,16) M (8,15) | OK (2,4,6,8?,11,15,16‡) | NF |
| *Briza maxima** | OK (2) | OK (2) | A |
| *Cakile maritima* subsp. *maritima** | OK (4,11) | OK (4,11) | A |
| *Callistemon citrinus* | OK (2) | OK (2) | A |
| *Callitris globoidea* | M (15) | OK (15) | A |
| *Canavalia rosea* | OK (3) | OK (3) | A |
| *Canthium coprosmoides* | OK (4) | OK (4) | A |
| *Carpobrotus glaucescens* | SL (2)<br>M (1,4,5,6,7,10,14,15) | OK (2)<br>SD (1,4,5,6,7,10,14,15) | NF; susceptible if fully exposed |
| *Cassina* sp. | OK (4) | OK (4) | A |
| *Cassine australis* var. *australis* | OK (4) | OK (4) | A |
| *Cassinia aculeata* | M (5) | M (5) | A |
| *Cassytha pubescens* | OK (2,4,8,11) | OK (2,4,8,11) | NF |
| *Casuarina equisetifolia* | SL–M (15) | OK (15) | A |
| *Casuarina glauca* | OK (2,16) SL–M (15) | OK (2,16‡) SL–OK (15) | A |
| *Cayratia clematidea* | OK (4) M (8,9,15) | OK (4,15) SD (8,9) | A |
| *Cenchrus clandestinus** | OK (4) | OK (4) | A |
| *Cheilanthes sieberi* | OK (4) | OK (4) | A |
| *Cissus antarctica* | OK (4,6) | OK (4,6) | NF |
| *Clematis aristata* | OK (5) | OK (5) | A |

| Botanical name | After 8 weeks observation** (Source) | After 6 months observation** (Source) | Comments |
|---|---|---|---|
| *Clematis glycinoides* | SL (4) | OK (4) | A |
| *Clerodendrum floribundum* | OK (11) M–SD (15) | OK (11) M–SD (15) | A |
| *Comesperma ericinum* | OK (2) | OK (2) | A |
| *Commelina cyanea* | OK (2,4,6,11)<br>M (10,15,16) | OK (2,4,6,10,11,16‡)<br>SD (15) | NF |
| *Commersonia fraseri* | OK (4) | OK (4) | A |
| *Conospermum taxifolium* | OK (2) | OK (2) | A |
| *Correa alba* | OK (2,6) | OK (2,6) | A |
| *Corymbia gummifera* | OK (4,6) | OK (4,6) | A |
| *Cotoneaster glaucophylla** | OK (4) | OK (4) | A |
| *Crinum pedunculatum* | M (15) | SL–OK (15) | A |
| *Cryptocarya triplinervis* | SL (15) | M (15) | A |
| *Cupaniopsis anacardioides* | OK (3,11,16) SL (15) | OK (3,11,15,16‡) | A |
| *Cuscuta campestris** | SD (5) | SD (5) | A |
| *Cyperus enervis* | OK (11) | OK (11) | A |
| *Dianella caerulea* | OK (2,6,8,16) | OK (2,6,8) | A |
| *Dianella caerulea* var. *producta* | OK (4) | OK (4) | A |
| *Dianella congesta* | SL (15) OK (16) | OK (15,16‡) | A |
| *Dianella revoluta* | OK (2,4) | OK (2,4) | NF |
| *Dichondra repens* | OK (4) | OK (4) | A |
| *Digitaria didactyla* | OK (16) | | A |
| *Dillwynia floribunda* | OK (6) | OK (6) | A |
| *Dillwynia glaberrima* | OK (2,6) | OK (2,6) | A |
| *Dodonaea triquetra* | OK (1,4) M (8,9) | OK (1,4,10) SD (8,9) | A |
| *Duboisia myoporoides* | SL (4) M (8,9) OK (16) | OK (4) SD (8,9) | A |
| *Einadia hastata* | OK (4) | OK (4) | A |
| *Elaeocarpus obovatus* | OK (16) | OK (16‡) | A |
| *Elaeocarpus reticulatus* | OK (4,6) | OK (4,6) | A |
| *Empodisma minus* | OK (3) | OK (3) | A |
| *Endiandra sieberi* | OK (4) | OK (4) | A |
| *Entolasia stricta* | M (5) | M (5) | A |
| *Epacris microphylla* | OK (6) | OK (6) | A |
| *Epacris obtusifolia* | SL (6) | SL (6) | A |
| *Erythrina x sykesii* | OK (4) | OK (4) | A |
| *Eucalyptus botryoides* | OK (4,6) SL (14) | OK (4,6,14) | A |
| *Eucalyptus globoidea* | OK (6) | OK (6) | A |
| *Eucalyptus gummifera* | OK (4) | OK (4) | A |
| *Eucalyptus pilularis* | OK (2,4) | OK (2,4) | NF |
| *Eucalyptus punctata* | OK (4) | OK (4) | A |
| *Eucalyptus robusta* | OK (4) | OK (4) | A |

| Botanical name | After 8 weeks observation** (Source) | After 6 months observation** (Source) | Comments |
|---|---|---|---|
| *Eucalyptus signata* | OK (2) | OK (2) | A |
| *Euroschinus falcata* var. *falcata* | OK (4,16) | OK (4,16‡) | A |
| *Eustrephus latifolius* | OK (3,16) OK–SL (15) | OK (3,16‡) OK–M (15) | A |
| *Excoecaria agallocha* | OK (3) | OK (3) | A |
| *Exocarpos cupressiformis* | OK (4) | OK (4) | A |
| *Ficinia nodosa* | OK (16) | OK (16‡) | A |
| *Ficus fraseri* | M (11) | M (11) | A; resprouting |
| *Ficus rubiginosa* | OK (4) | OK (4) | A |
| *Gahnia clarkei/minus* | OK (3,4) | OK (3,4) | NF |
| *Geitonoplesium cymosum* | OK (4,16) | OK (4,16‡) | A |
| *Gleichenia dicarpa* | OK (3,6) | OK (3,6) | A |
| *Gleichenia microphylla* | OK (6) | OK (6) | A |
| *Glochidion ferdinandi* | OK (4) | OK (4) | A |
| *Glycine clandestina* | M (4) | SD (4) | A |
| *Gonocarpus teucrioides* | OK (2) SD (6) | OK (2) SD (6) | A |
| *Hardenbergia violacea* | OK (2) M (4) SL (15) | OK (2) SD (4) M–SD(15) | A |
| *Hibbertia fasciculata* | OK (2) | OK (2) | A |
| *Hibbertia linearis* | OK (2) | OK (2) | A |
| *Hibbertia obtusifolia* | OK (2,4,6) | OK (2,4,6) | NF |
| *Hibbertia scandens* | OK (2,5,7,10,16) SL (15) MD (16) | OK (2,5,7,10,15,16‡) MD (16‡) | NF |
| *Hibbertia vestita* | OK (3) | OK (3) | A |
| *Homoranthus virgatus* | OK (3) | OK (3) | A |
| *Hydrocotyle bonariensis** | OK (1,2,4) M (5,15) | OK (1,2,4) M (5) M–SD (15) | NF |
| *Imperata cylindrica* | M (5,16) | M (5,16) OK (16‡) | A |
| *Imperata cylindrica* var. *major* | OK (2,4,5,7,11) SL (6) | OK (2,4,5,7,11) SL (6) | NF |
| *Indigofera australis* | OK (4) | OK (4) | A |
| *Ipomoea brasiliensis* | OK (3) | OK (3) | A |
| *Ipomoea cairica** | OK (15) | OK (15) | A |
| *Ipomoea indica** | OK (4) | OK (4) | A |
| *Isolepis nodosa* | OK (2,11). SL (6) M (15) | OK (2,6,11,15) | A |
| *Jacksonia scoparia* | OK (2) | OK (2) | A |
| *Kennedia rubicunda* | OK (1,2) M (4) SL (6) | OK (1,2,6) SD (4) | NF; susceptible if fully exposed |
| *Lantana camara** | SL (4) M (15) | OK (4,15) | A |
| *Leptomeria acida* | OK (15) | OK (15) | A |
| *Leptospermum juniperinum* | OK (4) | OK (4) | A |
| *Leptospermum laevigatum* | OK (1,2,4,6) | OK (1,2,4,6) | NF |
| *Leptospermum liversidgei* | OK (2) | OK (2) | A |

| Botanical name | After 8 weeks observation** (Source) | After 6 months observation** (Source) | Comments |
|---|---|---|---|
| *Leptospermum polygalifolium* | OK (5) | OK (5) | A |
| *Leucopogon ericoides* | OK (2,6) | OK (2,6) | A |
| *Leucopogon parviflorus* | OK (1,2,11,16) | OK (1,2,11,16‡) | NF |
| *Leucopogon* (species TBA) | OK (15) | OK (15) | A |
| *Leucopogon virgatus* | OK (2) | OK (2) | A |
| *Lomandra longifolia* | OK (1,4,6,8,16) M (15) | OK (1,4,6,8,15,16‡) | NF |
| *Lomandra multiflora* | OK (2,6) | OK (2,6) | A |
| *Lupinus cosentinii** | OK (4) | OK (4) | A |
| *Macaranga tanarius* | OK (15) | OK (15) | A |
| *Maclura cochinchinensis* | OK (11) M (15) | OK (10,15) | A |
| *Macrozamia* spp. | OK (4) | OK (4) | A |
| *Marsdenia rostrata* | OK (4) | OK (4) | A |
| *Melaleuca armillaris* | OK (4,6) | OK (4,6) | A |
| *Melaleuca ericifolia* | OK (4) | OK (4) | A |
| *Melaleuca nodosa* | OK (5) | OK (5) | A |
| *Melastoma affine* | OK (3) | OK (3) | A |
| *Monotoca elliptica* | OK (1,2,4,6,8) | OK (1,2,4,6,8) | NF |
| *Monotoca scoparia* | OK (2,6) | OK (2,6) | A |
| *Muehlenbeckia gracillima* | SL (11) | OK (11) | A |
| *Myoporum boninense* | OK (2) SD (14) | OK (2) MD (14) | A |
| *Myoporum insulare* | OK (2) | OK (2) | A |
| *Myoporum lucidum* | OK (14) | OK (14) | A |
| *Nematolepis squamea* | OK (2) | OK (2) | A |
| *Nephrolepis cordifolia** | OK (4) | OK (4) | A |
| *Notelaea longifolia* | OK (4) M (8) SL (15) | OK (4,8,15) | A |
| *Oplismenus imbecillis* | OK (16) | | A |
| *Opuntia* sp.* | OK (4) | OK (4) | A |
| *Pandorea pandorana* | OK (2) M (8) | OK (2) SD (8) | A |
| *Parsonsia straminea* | OK (3) | OK (3) | A |
| *Pelargonium australe* | OK (4) SD (6) | OK (4) SD (6) | A |
| *Persoonia lanceolata* | OK (2,4,5) | OK (2,4,5) | NF |
| *Persoonia linearis* | OK (4) | OK (4) | A |
| *Persoonia stradbrokensis* | SL (10) M (15) | OK (10) M–SD (15) | A |
| *Persoonia tenuifolia* | M (15) | M (15) | A |
| *Phragmites australis* | OK (4) MD (6) | OK (4) SL (6) | A |
| *Pimelea linifolia* | OK (3,6) M (4) | OK (3,6) SD (4) | A |
| *Pinus* sp.* | OK (4) | OK (4) | A |
| *Pittosporum revolutum* | OK (4) | OK (4) | A |
| *Pittosporum undulatum* | OK (2) SL (14) | OK (2,14) | A |

| Botanical name | After 8 weeks observation** (Source) | After 6 months observation** (Source) | Comments |
|---|---|---|---|
| *Planchonella australis* | OK (4) | OK (4) | A |
| *Platysace lanceolata* | OK (2) SL (15) | OK (2,15) | A |
| *Polygalifolium* | OK (5) | OK (5) | A |
| *Polyscias elegans* | OK (16) | OK (16‡) | A |
| *Polyscias sambucifolia* | OK (5) SL (11) | OK (5,11) | A |
| *Pomaderris discolor* | OK (2) | OK (2) | A |
| *Protasparagus densiflorus* (syn. *Asparagus aethiopicus)** | OK (4) | OK (4) | A |
| *Pteridium esculentum* | OK (2,4,11,16) SL (5,6,7) | OK (2,4,5,7,11,16‡) SL (6) | NF |
| *Pultenaea retusa* | OK (6) | OK (6) | A |
| *Pultenaea villosa* | OK (5) | OK (5) | A |
| *Rapanea variabilis* | OK (4,16) M–SD (15) | OK (4,16‡) M (15) | A |
| *Rhagodia candolleana* | OK (4) SL–M (15) | OK (4,15) | A |
| *Rhodomyrtus psidioides* | SL (11) | OK (11) | A |
| *Ricinocarpos pinifolius* | OK (2,4) | OK (2,4) | A |
| *Ricinus communis* | OK (4) | OK (4) | A |
| *Rubus mollucanus* | OK (16) | | A |
| *Rubus* sp.* | OK (4) M (15) | OK (4,15) | A |
| *Scaevola calendulacea* | OK (2) SL (5) M–SD (15) | OK (2) SD (5,15) | NF |
| *Scaevola ramosissima* | OK (6) | OK (6) | A |
| *Schoenus ericetorum* | OK (2) SL (6) | OK (2) SL (6) | A |
| *Scolopia braunii* | OK (4) | OK (4) | A |
| *Senna pendula* var *glabrata** | OK (15) | OK (15) | A |
| *Senecio linearifolius* | SL (14) | OK (14) | A |
| *Senecio pinnatifolius* | OK (11) | OK (11) | A |
| *Sesuvium portulacastrum* | OK (3) SL (11) | OK (3,11) | A |
| *Smilax australis* | OK (3,16) SL (11,15) | OK (3,11) M (15) | A |
| *Smilax glyciphylla* | OK (4) | OK (4) | A |
| *Solanum nigrum* | OK (4) | OK (4) | A |
| *Solanum vescum* | SL (4) | OK (4) | A |
| *Sonchus oleraceus* | OK (4) | OK (4) | A |
| *Spinifex hirsutus* | OK (2) | OK (2) | A |
| *Spinifex sericeus* | OK (4,11) | OK (4,11) | A |
| *Sporobolus virginicus* | OK (16) | OK (16‡) | A |
| *Sprengelia incarnata* | M (6) | M (6) | A |
| *Stackhousia spathulata* | OK (2) M (15) | OK (2) M (15) | A |
| *Stephania japonica* | OK (3,11) M (8,9) SL (15) | OK (3,11,15) SD (8) | A |
| *Stylidium graminifolium* | OK (2,6) | OK (2,6) | A |
| *Styphelia viridis* subsp. *breviflora* | M (15) | OK (15) | A |

| Botanical name | After 8 weeks observation** (Source) | After 6 months observation** (Source) | Comments |
|---|---|---|---|
| *Styphelia viridis* subsp. *viridis* | OK (2) | OK (2) | A |
| *Syzygium australe* | OK (11) | OK (11) | A |
| *Syzygium oleosum* | OK (3,8,16) SL (15) | OK (3,8,16‡) OK–M (15) | A |
| *Tetragonia tetragonoides* | OK (5) M (10) SL (15) | OK (5,10,15) | A |
| *Themeda australis* | OK (1,4) M & SD (5) | OK (1,4) M & SD (5) | A |
| *Trachymene anisocarpa* | OK (4) | OK (4) | A |
| *Tylophora benthamii* | OK (11) | OK (11) | A |
| *Viminaria juncea* | SL (6) | SL (6) | A |
| *Viola hederacea* | OK (4,16) | OK (4,16‡) | A |
| *Westringia fruticosa* | OK (2,6) M (5) | OK (2,6) M (5) | A |
| *Wikstroemia indica* | SL (15) | M (15) | A |
| *Zoysia macrantha* | OK (3,6) SD (16) | OK (3,6) | A |

**Sources of information**

1. Toth J, Milham PJ and Nazer C at Jervis Bay
2. Whelan RJ and Kohler G at Hill 60 Port Kembla and Hawks Nest
3. Watson GW near Yamba
4. Gosper C at Perkins Beach
5. Schroder M at Myall Lake, Tomaree and Glenrock
6. Prior T at La Perouse National Park
7. Thomas J at Angourie
8. Brown D at Wyrrabalong National Park
9. Clifford P at Wyrrabalong National Park
10. Readford R at Ballina
11. Floyd AG at Coffs Harbour
12. Holloway G at Kingscliff
13. Tye IE near Yamba
14. Thompson K at Southern Shoalhaven
15. Flower P and Clarke M at Sandon in Yuraygir National Park
16. Cameron L at Billinudgel Nature Reserve

‡ Responses at 4 (not 6) months following control.

**Table 4** **Herbicide sensitivity to Brush-Off® (metsulfuron methyl 600 g/kg) of native and some introduced plants – results from 1992–2004 for the spraying of 30 g of Brush-Off® in 30 L water per ha, from a helicopter, during winter (1 June to 31 August)**

Note responses 10 months following control were made in 2010 and 2011.

* Indicates an exotic species

** Observation key: **OK** = no effect on foliage, **SL** = some foliage burn, **M** =25% foliage burn, **SD** = some dead, **MD** = most dead, **A** = more observations required, **NF** = no more observations required. Information sources are listed below the table.

| Botanical name | After 8 weeks observation** (Source) | After 6 months observation** (Source) | After 10 months‡ observation** (Source) | Comments |
|---|---|---|---|---|
| *Acacia melanoxylon* | OK (3) | OK (3) | | A |
| *Acacia sophorae* | OK (1,2,3) | OK (1,2,3) | | A |
| *Acacia suaveolens* | OK (2) | OK (2) | | A |
| *Acacia ulicifolia* | OK (2) | OK (2) | | A |
| *Acmena smithii* | OK (2,3) | OK (2,3) | | A |
| *Actinotus helianthi* | OK (2) | OK (2) | | A |
| *Allocasuarina littoralis* | OK (2) | OK (2) | | A |
| *Andropogon virginicus** | SL (3) | OK (3) | | A |
| *Aotus ericoides* | OK (2) | OK (2) | | A |
| *Asplenium difforme* | M (5) | | | A |
| *Astroloma pinifolium* | OK (2) | OK (2) | | A |
| *Banksia integrifolia* | OK (1,2,3) | OK (1,2,3) | OK (4) SL (4) | A |
| *Banksia serrata* | OK (1,2) | OK (1,2) | SL (4) | A |
| *Billardiera scandens* | OK (2) | OK (2) | | A |
| *Bossiaea ensata* | OK (2) | OK (2) | | A |
| *Bossiaea heterophylla* | OK (2) | OK (2) | | A |
| *Breynia oblongifolia* | OK (2,3) | OK (2,3) | OK (4) | A |
| *Bryophyllum delagoense** | | OK (5) | | A |
| *Cakile maritima* subsp. *maritima** | OK (3) | OK (3) | | A |
| *Callistemon citrinus* | OK (2) | OK (2) | | A |
| *Canavalia rosea* | SL (3) | OK (3) | | A |
| *Carpobrotus glaucescens* | M (2), SD (5) | OK (2), MD (5) | | A |
| *Cassytha pubescens* | OK (2) | OK (2) | | A |
| *Casuarina glauca* | OK (3) | OK (2) | | A |
| *Cayratia clematidea* | OK (3) | OK (3) | | A |
| *Conospermum taxifolium* | OK (2) | OK (2) | | A |
| *Correa alba* | OK (2) | OK (2) | OK (4) | A |
| *Crinum pedunculatum* | OK (3) | OK (3) | | A |
| *Cupaniopsis anacardioides* | OK (3) | OK (3) | | A |
| *Cyperus enervis* | OK (3) | OK (3) | | A |
| *Dianella caerulea* | SL (2) | OK (2) | | A |
| *Dillwynia glaberrima* | OK (2) | OK (2) | | A |

| Botanical name | After 8 weeks observation** (Source) | After 6 months observation** (Source) | After 10 months‡ observation** (Source) | Comments |
|---|---|---|---|---|
| *Eucalyptus pilularis* | OK (2) | OK (2) | | A |
| *Eucalyptus signata* | OK (2) | OK (2) | | A |
| *Ficus fraseri* | M (3) | M (3) | | A |
| *Gonocarpus teucrioides* | SD (1) | OK (2) | | A |
| *Hardenbergia violacea* | OK (2) | OK (2) | | A |
| *Hibbertia fasciculata* | OK (2,3) | OK (2,3) | | A |
| *Hibbertia linearis* | OK (2) | OK (2) | | A |
| *Hibbertia obtusifolia* | OK (2) | OK (2) | | A |
| *Hibbertia scandens* | OK (2) | OK (2) | | A |
| *Imperata cylindrica* | OK (2,3) | OK (2,3) | OK (4) | A |
| *Ipomoea brasiliensis* | OK (3) | OK (3) | | A |
| *Isolepis nodosa* | OK (3) | OK (3) | | A |
| *Juncus kraussii* | OK (1,2) | OK (1,2) | | A |
| *Kennedia rubicunda* | OK (2) | OK (2) | | A |
| *Leptospermum laevigatum* | OK (2) | OK (2) | OK (4) | A |
| *Leptospermum liversidgei* | OK (2) | OK (2) | | A |
| *Leucopogon ericoides* | OK (2,3) | OK (2,3) | | A |
| *Leucopogon lanceolatus* | OK (2) | OK (2) | | A |
| *Leucopogon parviflorus* | OK (2) | OK (2) | | A |
| *Leucopogon virgatus* | OK (2) | OK (2) | | A |
| *Lomandra longifolia* | OK (1,2,3) | OK (1,2,3) | OK (4) | A |
| *Maclura cochinchinensis* | M (3) | OK (3) | | A |
| *Melaleuca quinquenervia* | OK (3) | OK (3) | | A |
| *Monotoca elliptica* | OK (1,2) | OK (1,2) | | A |
| *Monotoca scoparia* | OK (2) | OK (2) | | A |
| *Muehlenbeckia gracillima* | SL (3) | OK (3) | | A |
| *Myoporum boninense* | OK (2) | OK (2) | | A |
| *Nematolepis squamea* | OK (2) | OK (2) | | A |
| *Pandorea pandorana* | OK (2) | OK (2) | | A |
| *Persoonia lanceolata* | OK (2) | OK (2) | | A |
| *Persoonia stradbrokensis* | SL (3) | SL (3) | | A |
| *Pittosporum undulatum* | OK (3) | OK (3) | | A |
| *Platycerium bifurcatum* | OK (3) | OK (3) | | A |
| *Platysace lanceolata* | OK (2) | OK (2) | | A |
| *Polyscias sambucifolia* | SL (3) | SL (3) | | A |
| *Pteridium esculentum* | OK (2,3) | OK (2,3) | | A |
| *Pultenaea* sp. | | | OK (4) | A |
| *Pyrrosia rupestris* | OK (3) | OK (3) | | A |

| Botanical name | After 8 weeks observation** (Source) | After 6 months observation** (Source) | After 10 months‡ observation** (Source) | Comments |
|---|---|---|---|---|
| *Rhodomyrtus psidioides* | SL (3) | OK (3) | | A |
| *Ricinocarpos pinifolius* | OK (2) | OK (2) | | A |
| *Rubus parvifolius** | OK (3) | OK (3) | | A |
| *Scaevola calendulacea* | OK (2,3) | OK (2,3) | | A |
| *Scaevola* sp. | | | OK (4) | A |
| *Schoenus ericetorum* | OK (1,2) | OK (1,2) | | A |
| *Senecio pinnatifolius* | OK (3), MD (5) | OK (3) | | A |
| *Sesuvium portulacastrum* | M (3) | OK (3) | | A |
| *Smilax australis* | SL (3) | OK (3) | | A |
| *Spinifex hirsutus* | OK (2) | OK (2) | | A |
| *Spinifex sericeus* | OK (3) | OK (3) | | A |
| *Stackhousia spathulata* | OK (2) | OK (2) | | A |
| *Stephania japonica* | OK (3) | OK (3) | | A |
| *Styphelia viridis* subsp. *viridis* | OK (2) | OK (2) | | A |
| *Syzygium australe* | OK (3) | OK (3) | | A |
| *Syzygium* sp. | | | OK (4) | A |
| *Themeda triandra* | | | OK (4) | A |
| *Tylophora benthamii* | OK (3) | OK (3) | | A |
| *Westringia fruticosa* | | | OK (4) | A |
| *Wollastonia uniflora* | SD (5) | | | A |
| *Zoysia macrantha* | OK (3) | OK (3), OK (5) | | A |

**Sources of information**

1. Toth J at Jervis Bay
2. Kohler GE, van Tets I and Whelan RJ at Hawkes Nest
3. Floyd AG at Boambee Beach, Coffs Harbour
4. Miller F at Myall Lakes National Park
5. Court S at Cape Byron State Conservation Area

‡ Interpret with care given responses were made long after control.