Section 5

Follow-up, restoration and monitoring

Follow-up, restoration and monitoring

Follow-up weeding, maintenance, restoration and monitoring are critical to the success of weed management efforts. Provision for these activities should be integrated in your broom management plan (see Section 2) from its inception.

Follow-up, follow-up, follow-up!

Good planning and the allocation of sufficient time and resources to follow-up management activities are very important. Follow-up weed control needs to be ongoing for brooms due to their long-lived seed bank. Even when seedlings do not germinate and the seed bank may appear depleted, sites should still be checked every two years at a minimum, preferably during the flowering season, and especially after disturbance events such as fire.

Understanding the ecology of your site will help you plan and manage follow-up control and restoration. It will also help you utilise processes such as natural regeneration, not only to save time and effort, but also achieve more complete restoration.

Careful monitoring is the key to successful and systematic follow-up:

- Plan your monitoring program and determine exactly what changes you want to monitor.
- Visit sites at appropriate times of the year, for example after rain, during the active growing season or at flowering times.
- Visit sites regularly.
- Monitor for regrowth of target weeds as well as new and emerging weeds.
- Monitor the natural regeneration of desired plant species.
- Treat regrowth of target weeds using appropriate control methods (see Section 4).

No such thing as a 'clean sweep' with brooms

BEWARE! Brooms will leave their mark below the soil long after plants are gone.

After controlling old, well-established broom infestations, it may seem like the bulk of the work is done, but threats may still linger below the surface.

1. **Brooms leave a large, long-lived seed bank**
   - Seeds can germinate for many years and quickly re-establish infestations.
   - Soil moved from infested sites can start new infestations in far away places, and often will go unnoticed on machinery or vehicles. Hygiene is important at infested sites (see pages 47–56).
2. **Brooms can alter the level and type of nutrients in the soil**
   - Increased nutrients from decaying broom foliage and nitrogen fixation by brooms can foster weeds at the expense of native plants, which may not thrive in high nutrient conditions.

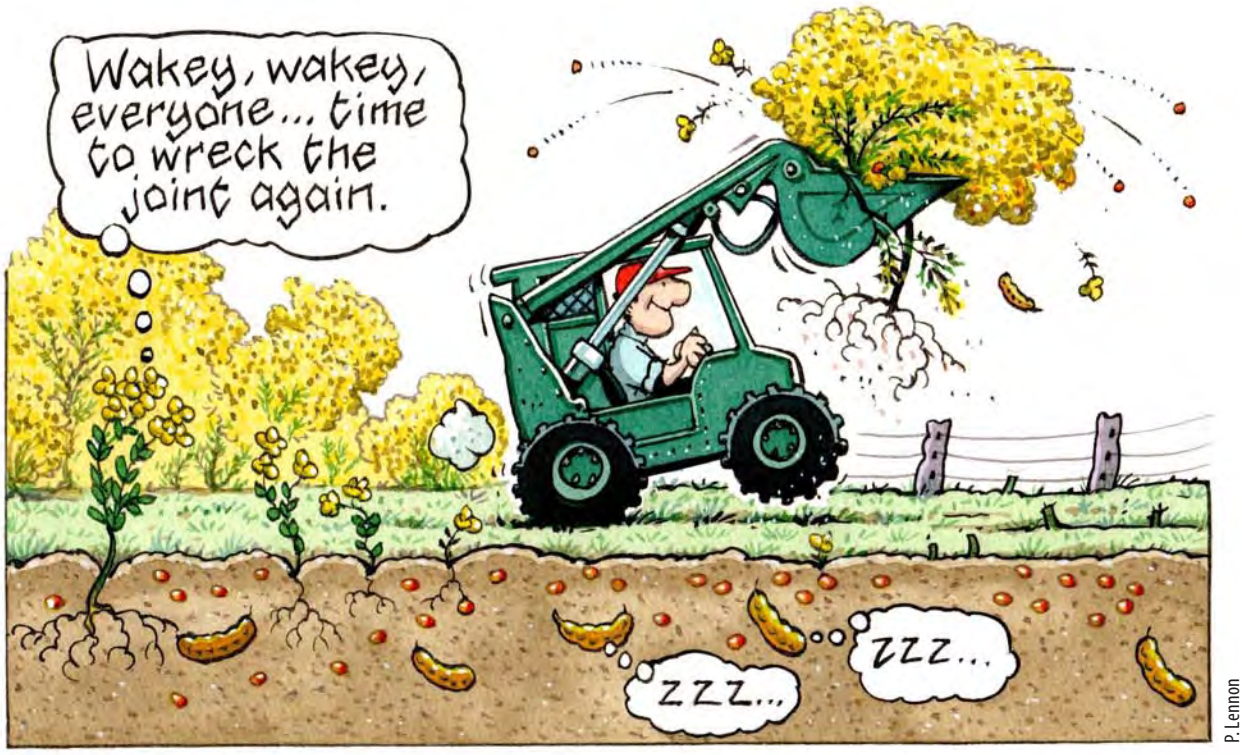
FOLLOW-UP…
keep out new weeds and control seedlings

RESTORE…
where necessary, to encourage desired plants

MONITOR…
make sure brooms don't re-establish and seeds are not spread in soil

AND

MANAGE NEW INFESTATIONS QUICKLY
BEFORE **they can get a foothold and cause impacts!**



P. Lennon

Things to watch out for with brooms

- The long seed dormancy of brooms requires sites to be regularly inspected and treated over the long-term. It is likely that this will need to be continued for several decades.
- Plants resprouting from the roots after fire, cutting, slashing or grazing have the potential to flower and set seed within 6–12 months, unless re-treated.
- Seedlings can flower in their first or second year in ideal conditions but are more likely to flower at three years. In more extreme environments, brooms may not flower until four or five years. Check your site and keep records to inform management and control decisions.
- Fire and other major site disturbance can be both an opportunity and a threat (see Case Study 3 'Call to action after fire' on page 121). If you are able to control all seedlings after fire, there is opportunity to greatly reduce the soil seed bank. On the other hand, if resources are not available to treat mass germination of seedlings, there is an imminent threat that the broom problem will get worse.
- One plant is capable of producing up to 20,000 seeds in a good season. Follow-up control should target **all** flowering plants to prevent seed set.
- Follow-up control in natural ecosystems should not impact on existing and regenerating native plants. Use caution, as repeated use of some herbicides commonly used on brooms can have large residual and off-target effects on canopy trees.
- Disturbance events that trigger germination of broom seed can also trigger germination of seeds of native plants.

Identifying new broom outbreaks and acting quickly to control them ensures that large, long-lived seed banks do not establish. Prevention is better than cure!

Follow-up

Learn from other people's mistakes, instead of making your own

'The biggest mistake people make is taking on larger areas than they can afford to control and not following up every second year. You must have the money to keep spraying out the continuing germination, otherwise you've wasted your initial outlay. If you get a few dry years there's minimal germination and you think you've got rid of it. You're lulled into a false sense of security. Then you have a wet year and it comes up thick as hairs on a cat's back. Follow-up, follow-up, follow-up!'
Mandy O'Brien, primary producer.

Site restoration

Restoration of native ecosystems

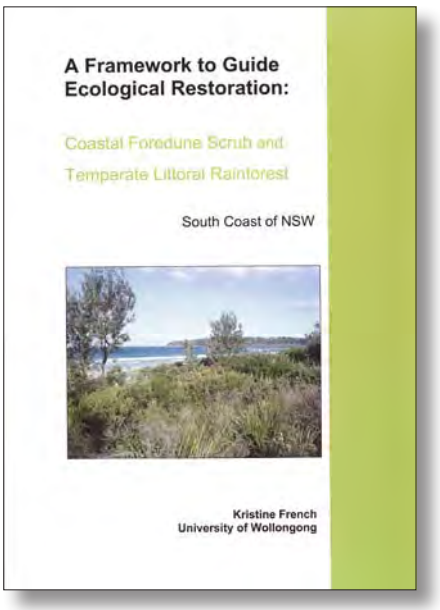
Restoring ecosystem health and function is a difficult task, not only because the impact of weeds might be extensive, but also because natural ecosystems are very complex.

Healthy, functioning ecosystems are dynamic and can have a high level of resistance to invasion by weeds. Restoring species diversity and structure may help to restore resilience and reduce the need for intensive ongoing management. It may also contribute to restoring a healthy self-sustaining plant community.

'Like any weed control, it is a process, not an event. We need to look not only to the short term gains, but also ensure that sites have the best possible chance for regeneration in the long term.'
Alex Shackleton, City of Greater Geelong (see Case Study 5 on page 129 for her story).

Because brooms can form large, dense stands, removal of infestations can leave a 'gap' in vegetation structure. This gap will be filled naturally with either opportunistic indigenous species or another suite of weeds. It is often advisable to wait and see what naturally fills the gaps before proceeding with revegetation. In the interim, any new weeds must be controlled, including broom regrowth.

Planting to reduce erosion



A five-step approach to ecological restoration following weed management has been developed for coastal foredune shrub and temperate littoral rainforest (French 2010) available at www.weeds.org.au/WoNS/bitoubush. This approach can be used as a template for many vegetation types and many of the techniques will be useful when restoring natural areas following broom control.

Five-step approach to ecological restoration

Step 1	Make a species list containing all the plants that would have historically been present at the site; define your project goal based on this.
Step 2	Commence weed management according to your site management plan.
Step 3	Allow natural regeneration to occur and monitor regrowth; noting that soil nutrients may have changed, so a different mix of species may occur.
Step 4	Reassess the site and make a species list of plants that are now growing there; compare this list with the pre-disturbance list to determine which species are missing.
Step 5	Propagate and plant missing species that do not return from seed bank or via natural dispersal. Allow sufficient time for natural regeneration.

Wait before commencing replanting activities unless urgently required. Natural regeneration of some species can occur, saving resources. Some native species can take up to two years to emerge after disturbance. Due to the difficulty in propagating many common native species, natural regeneration may be the only chance for their recovery.

Natural regeneration

The ability of a site to regenerate naturally depends on multiple factors, including its resilience, the remaining seed bank, and the duration and extent of weed invasion. In many sites, at least some of the plant species present before disturbance will regenerate naturally. In many plant communities, natural regeneration takes place in successional stages. The cycle of natural succession begins after a major disturbance event, such as weed control. The first plants to appear are generally fast growing plants that can quickly germinate, grow and produce a new crop of seeds. A successional process will then occur, sometimes over many years, whereby these early coloniser plants thin out and are replaced by other plant species.

It can pay to wait and see what emerges over several years of natural regeneration, but be prepared to closely monitor and control any new weeds that emerge.

Natural regeneration can make a number of important contributions to site restoration:

- It ensures plants of local provenance regenerate.
- Success rates of naturally regenerated plants are generally higher than planted seedlings.
- It is the most economical form of restoration.
- It saves time and effort planting species that are going to regenerate anyway, allowing targeting of *missing* species for propagation and replanting.
- It allows important ecosystem processes to occur, for example the mass germination of seedlings followed by natural thinning out until just a few strong individual plants remain to grow to maturity.

Follow-up

Site resilience

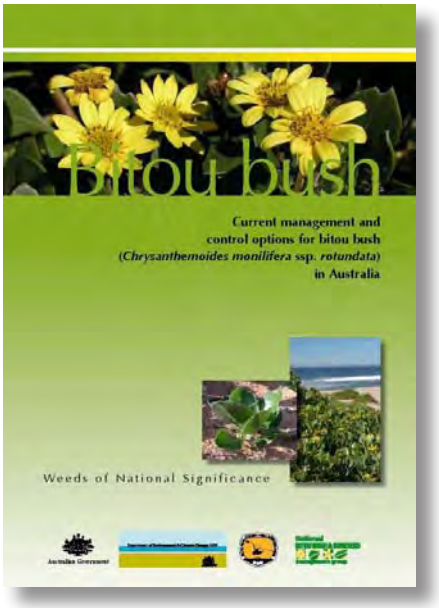
Assessing the resilience of your site will help you understand how much natural regeneration is likely to occur. On most sites, resilience will be determined by:

- The seed bank in the soil and in surrounding remnant native vegetation.
- The amount and quality of surviving remnant vegetation.
- Distance from less disturbed sites that can act as native seed source.
- The severity and time span of disturbance (including the severity and length of time of the weed invasion), and associated changes in soil nutrients.
- The presence of other degrading factors such as feral animals, erosion and nutrient enriched stormwater.
- The presence of ecosystem elements, such as native animals, that disperse seed or help cycle nutrients through the soil.

The composition of native species in some habitats is not always reflected in the soil-borne seed bank; the seed bank may also be held in surrounding plants. For instance, seventy four percent of plant species growing on undisturbed secondary dunes along the NSW south coast are not present in the soil seed bank (French 2010). For example, *Banksia* species that store their seeds in cones have no propagules in the soil-stored seed bank. Sites that are heavily infested with weeds for many years are likely to have severely depleted and less diverse native seed banks. Even if seeds are present, some species require a fire or other disturbance event for germination to occur. Understanding the ecology of the vegetation type you are working in is very important.

Indicative guide to site resilience based on age of weed infestation (adapted from the Bitou Bush Management Manual 2008)

↑ LOW | resilience | HIGH ↓	
	Newly colonised by weeds; rich native seed bank; broad range of native plant species growing; many adult native plants available to flower and seed.
	Weed infestation for up to five years; strong native seed bank; some native plants growing; some adult plants available for flowering and seeding.
	Established weed infestation; native seed bank persisting and viable but likely to only be apparent over time; few native plants growing and available for flowering and seeding (monitor and assess).
	Long established weed infestation; denuded seed bank and few seeding adults (monitor and assess); elevated soil nutrients.



Seed dispersal

Seed dispersal is a natural mechanism that contributes to site resilience. Seeds disperse in a variety of ways.

Seeds can:

- fall at the base of the parent plant or be propelled to adjacent areas,
- be carried short distances by insects or overland flow,
- be carried longer distances by birds or mammals, or
- be blown by the wind or transported within watercourses, sometimes over great distances.

Seeds that arrive at your site from long distances are particularly important. They enable natural regeneration of plant species that disperse from vegetation remnants nearby.

For this reason, isolated sites that do not have good quality remnant vegetation nearby are disadvantaged and may require more intensive revegetation works.

Many of our most invasive weed species disperse seeds over long distances. Regular monitoring is important to identify any new weeds that disperse into your site and to control them promptly and appropriately.

S. Booth

A banksia naturally germinating from seed

Propagation, replanting and seeding

Once weeds have been removed, it is important that they are replaced with native species; otherwise more weeds may emerge to fill the gap. It is possible that natural regeneration will not result in plant diversity equivalent to that present before disturbance, even in sites that have high levels of resilience. It is also highly unlikely that revegetation will replicate the same complexity and diversity. Many native plants, even common species, can be difficult to propagate, or not available due to inability to collect or germinate seed in large enough quantities.

If natural regeneration does not occur at a sufficient rate (e.g. in sites prone to erosion) or some of the desired species are not able to regenerate naturally (e.g. from seed bank or via dispersal) and native plants are still missing from the site, some level of revegetation may be needed. Planting and seeding activities should be carefully integrated into your overall weeding and restoration plan. Most revegetation projects can be divided into a six-step process.

Six-step approach to revegetation

Step 1	Develop a revegetation plan; incorporate into your weed management plan – see Section 2.
Step 2	Select a revegetation method.
Step 3	Undertake site preparation; e.g. spot spraying, safety assessment.
Step 4	Order seeds or seedlings and other supplies well in advance of planting time, organise labour, contractors, volunteers etc.
Step 5	Undertake revegetation activity; plant seedlings, broadcast seed.
Step 6	Monitor revegetation and undertake maintenance activities such as watering and weed control.

Follow-up

Considerations when developing a revegetation plan

- **Which native plant species are you going to use?** Comparing the pre-disturbance and actual plant lists from your sites is a good starting point, but establishing a comprehensive pre-disturbance list is difficult. The final list of plants will be dictated by what is available. Consult your suppliers and be realistic about what plant species can be sourced. Contact your natural resource management agency or local council bushcare officer for guidance. Plant lists and guides to plant communities may be available for your area. Useful resources are listed in Section 7.
- **What is the availability of seed or tube-stock seedlings for the species you chose to plant?** Can the local native nursery be engaged to propagate species they do not currently stock or does your group have the ability to do so? Many species of native plants will not be available due to issues in collecting or propagating from seed. What is the time lag between placing an order with the nursery and availability of viable seedlings? This can easily take over 12 months depending on the species.
- **How important is local provenance to your project or site?** Local provenance is generally less important for species with seed that is naturally dispersed long distances. With very rare or localised plants, local provenance may be more important. Advice should be sought from local plant experts or natural resource management officer.
- **Do you have the relevant permits, knowledge and skills to collect seed and propagate seedlings?** If you decide to gather seed and propagate seedlings, this requires appropriate permits and knowledge of native plant species, as well as knowledge of when and where to gather seed and propagation techniques such as seed scarifying. See the Florabank guidelines for more information www.florabank.org.au/default.asp?V_DOC_ID=755.
- **Have you considered rare and cryptic species?** Rare and cryptic species are often overlooked in restoration programs. It is important to promote recovery of these species to improve plant community resilience. If you decide to include these species in revegetation efforts, be aware that they are often difficult to propagate, probably occur naturally at low densities, and may require specific habitat of very high quality to survive. If working with threatened plant species, always contact the relevant natural resource management or conservation agency to obtain permits and find out who is working on that species' recovery. You may be able to help each other.

When choosing native plant species to replant, it is preferable to use locally endemic species. You can ensure local provenance by sourcing seeds from nearby bushland. Try to include rare and cryptic species in your list to restore healthy biodiversity. Seed collection will usually require a permit and should be collected according to Florabank or other recognised guidelines.

Note: Many local councils run community nurseries that can be a good source of advice and local provenance plant material.

WildCount OEH

Working around the needs of resident fauna may mean balancing the need for broom control with habitat protection

Monitoring

Monitoring is the repeated collection and analysis of observations with the aim of providing information to answer a specific management question.

One of the first activities to conduct at your site is monitoring.

It will establish an historical summary of the *before*, against which you can compare the *after*. In other words, it will provide a benchmark to assess progress at the site.

To ensure that sufficient time and resources are allocated, monitoring should be included in your broom management plan (see Section 2). Many funding bodies require that some form of monitoring be incorporated into your project. Monitoring will inform project reports and provide quality information for promoting your activities and allowing adaptive management.

Monitoring is used to evaluate the progress and effectiveness of your project by comparing data in light of your goals and objectives. If done regularly, it will help keep track of progress, show what is working and what is not, help you fine-tune your methods and motivate you as it highlights successes.

If you set out clear, achievable and quantifiable goals at the beginning of your project, monitoring will be a relatively straightforward and rewarding activity.

Monitoring made easy

Monitoring can be simple and achievable. Monitoring can be as easy as taking photos from set points, to assessing vegetation cover and counting numbers of individuals, or measuring health of individual plants. The trick is to record these observations in a systematic and consistent way that enables measurements and comparisons to be made.

Some tips for good monitoring

- Seek technical advice before you begin monitoring.
- Keep a site diary to record your observations.
- Use simple, consistent methods and document these.
- Use standardised datasheets for data collection.
- Record observations at monitoring points at similar times of year.
- Pick appropriate times for monitoring. For example, brooms are easier to locate when in flower, so time photo points or at least one monitoring visit when plants are flowering. Conversely, Scotch broom is difficult to monitor when it is leafless, so consider this in planning monitoring timelines.
- Monitor before and after weed control and restoration activities.
- If resources allow, collect additional data from similar, but less degraded, sites nearby for comparison and reference.
- Keep copies of the data and enter it electronically for ease of analysis.
- If monitoring methods are simple and clearly documented, it should not matter who does the monitoring. However, if one person is usually responsible for monitoring, consider doing it with another person or mentoring another person for long-term continuity.

Designing your monitoring questions

Deciding what changes you want to monitor and what questions you want to answer is the first essential step of any monitoring program. It will determine what data to collect, how to collect it and how often. Monitoring questions need not be

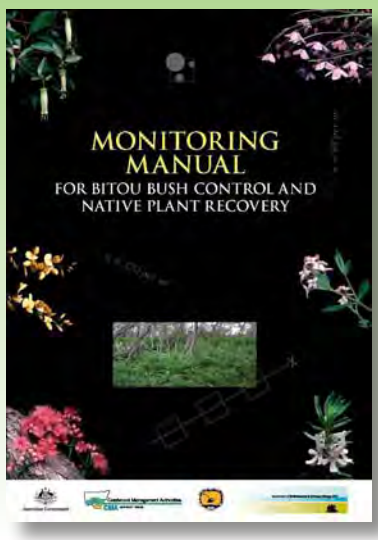
complex but they must be specific, measurable and clearly defined.

Some possible monitoring questions include:

- **Has the density of the broom reduced?** This could be monitored by measuring the density of the broom at specific points at the same time over several years.
- **Has the abundance of native vegetation increased?** This could be measured by estimating cover or assessing density over time.
- **Which control method is most effective?** To answer this question, monitor areas where different control methods are used and compare results over time. Make sure your monitoring method is consistent across the different sites.

BITOU BUSH MONITORING MANUAL

The bitou bush monitoring manual (Hughes *et al.* 2009) outlines a three-tiered approach to monitoring with techniques ranging from simple qualitative assessments to robust research studies, allowing managers to adopt the level most suitable to their objectives and desired outcomes, skills and resources. The manual is appropriate for use on most weeds, including broom species. Available at www.environment.nsw.gov.au/bitouTAP/monitoring.htm.



Site diary

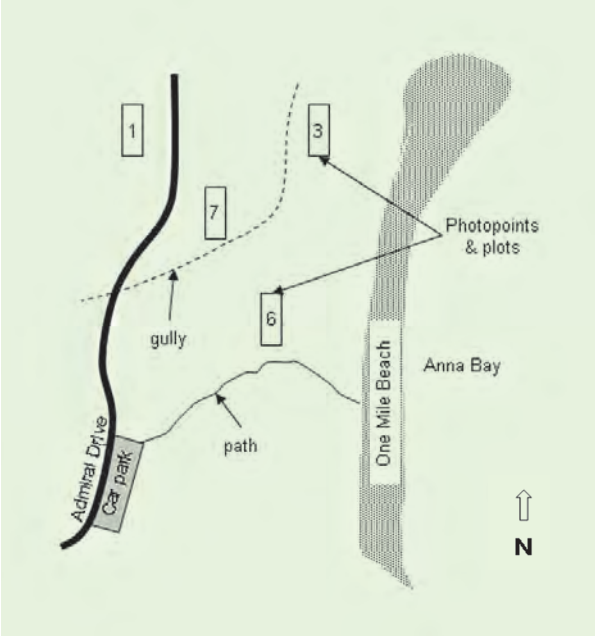
A site diary is indispensable for recording details about activities conducted at your site, and observations before and after each activity. It can include species lists, animal sightings, observations about seasonal changes, fire, floods and climatic conditions. To be most effective, ensure that all site and weed management activities are recorded. Make your observations and descriptions as consistent as possible, so they can be compared across the site and over time. A site diary can comprise a range of methods for recording information: written, audio, graphic and photographic. Monitoring points, photopoints and sampling areas can be recorded on maps. As an alternative to a site diary, the bitou bush monitoring manual has datasheets to capture the above information and also includes an area for a mud map.

Updating the site map

Creating a series of maps of your site is an effective way to help you understand your site and your project and is a useful adjunct to the site diary. Visual representations summarise complex information in a meaningful, accessible format. If done systematically, maps can chart the dynamics of your site and successes of your control program. When working in a community group, mapping can be an appealing way to employ the more creative members of your group and engage with young people.

For detailed instructions on how to create and update your site map, see the bitou bush monitoring manual (Hughes *et al.* 2009) here: www.environment.nsw.gov.au/bitouTAP/monitoring.htm. Maps (or layers) can be redrawn and dated regularly or at important stages of your project, then presented in series to show changes.

A set of national core attributes to collect when mapping weeds can be accessed online at www.weeds.org.au/docs/National_Core_Attributes_for_Weed_Mapping.pdf.



Site mud maps can be redrawn and dated regularly

At a minimum, information should be collected for each of these national core attributes when monitoring and reporting at regional, state or national levels. This will allow your data collection to be consistent and feed into other monitoring efforts.

Selecting monitoring locations

Here are some basic principles for choosing locations to make observations:

- Monitoring locations should be easy and safe to access.
- Establish permanent monitoring points so that you can return to make your observations from exactly the same spot year after year.
- Mark your monitoring points using GPS or map coordinates and a physical marker such as a stake, or flagging tape tied around a tree. It pays to also mark your location on a mud map and enter it in your site diary.
- You may want to select monitoring sites based on where you have used certain control methods.

Photopoints

This is a very simple but effective method of documenting change and progress. Photopoints are a series of photographs recording any activity or feature of your site taken from fixed locations over time. A picture will indeed speak a thousand words to members of your group, the wider community and funding bodies. However, there are limitations to photographic records of vegetation. Not all sites are suitable for photopoint monitoring and it is often difficult to interpret images of green on green, so photopoints should ideally be accompanied by observational data or detailed monitoring data, such as measures of plant density. Photopoints are particularly useful for recording the results of weed control on a large weed infestation over time.

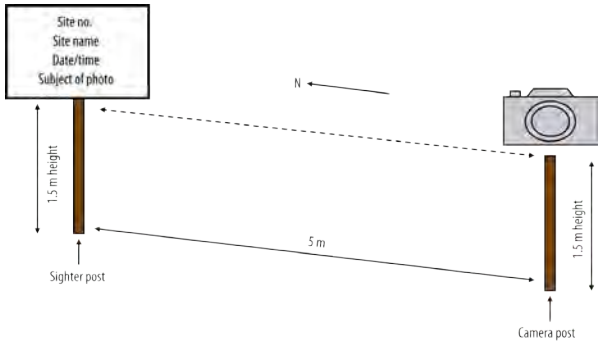
Using photopoints requires preparation and a systematic method, supported by meticulous documentation:

- Establish and record your photopoint locations; GPS coordinates, compass bearings, post markers (see *selecting monitoring* locations). Give each photopoint a unique number or name.
- Return to the same photopoints to record changes over time. It is important to use exactly the same location, face the same direction with the camera at the same height, at the same time of day, so that images are comparable. If possible, use the same camera and lens. Always consider where the sun is and try not to take a photo into the sun.
- A simplified photopoint method is to use two permanently installed posts. Rest your camera on top of one post and place the other post in the centre of the frame. Include an object of known size in the photo for scale. If possible include an identification label for the site. By repeating the same method each time, your photograph will always be taken from the same spot at the same height in the same direction with the post for reference.

Follow-up

A. Meiklejohn

Install a permanent monitoring marker



Suggested photo point marker specifications

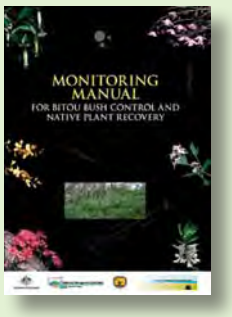
Take lots of photos; digital files are cheap – the moment is lost forever. Make sure you have a digital filing system that matches your field notes so you can easily locate and cross-reference images for years to come. Make backups and make sure others have access to this priceless archive.

Parks Victoria

Include a site label in your photographs

Things to consider with photopoints

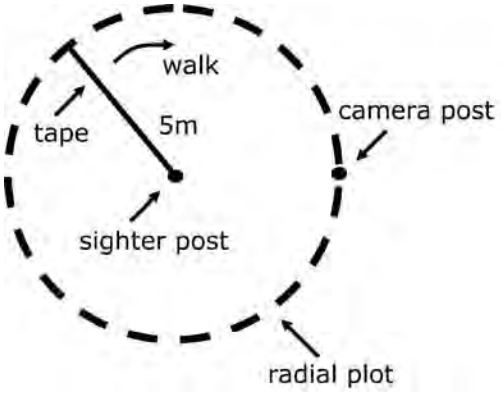
- Ideally, include a reference point (or several) in the camera frame for orientation and scale; a rocky outcrop, the horizon, a tree, or one of your marker posts.
- Select a location that dissects the subject vegetation to show its profile; a cutting, a creek, a path. But remember, vegetation develops unique characteristics along fringes.
- For detail shots, remember your subject will grow and change over time, so think about multiple close, middle and distant points.
- Observe which direction gives the best lighting conditions and note the time of day; hint: low sunlight angles in early morning or late afternoon can offer ideal lighting conditions.
- Standard datasheets are available in the bitou bush monitoring manual www.environment.nsw.gov.au/bitouTAP/monitoring.htm.



Supporting photopoints with observational data

The locations you chose for photopoints can also be used as plots for collecting observational data that can help interpret the images and add new and useful information.

- At a photopoint location marker, use a tape measure and stakes to permanently mark a circular or rectangular plot (quadrat).
- Identify and measure all species or select key species to observe, including weeds.
- Note density, plant cover or other features from the list on the following page.
- A useful feature to note is the age of plants (e.g. seedlings, juveniles, adults) to record recruitment over time.



Circular photopoint and monitoring plot

The bitou bush monitoring manual has instructions on how to set up and collect supporting data on plant species abundance. See www.environment.nsw.gov.au/bitouTAP/monitoring.htm.

Observational data collection methods

There are a variety of other methods you can use to monitor changes at your site. Collecting quantitative data requires more effort, but can provide data that will enable you to answer monitoring questions with much greater certainty.

Some sampling methods include:

- **Quadrats:** a square or rectangular plot often used to sample vegetation. Quadrats are a sampling unit where plant abundance or the number of species can be assessed.
- **Transects:** single dimensional plots or 'lines' along which plant abundance can be measured or points or quadrats are established. The trick with transects is to avoid following natural feature lines, which could introduce bias to your observations. To avoid bias, follow a compass bearing when establishing transect lines.

Parks Victoria

Transect monitoring

Follow-up

Gathering statistically robust data requires a systematic approach to establishing sampling units (e.g. quadrats or transects). These should be permanent, randomly or systematically selected and numerous enough to be representative of your site. See the bitou bush monitoring manual (www.environment.nsw.gov.au/bitouTAP/monitoring.htm) for instructions on how to employ these methods in the field and important considerations necessary before starting your monitoring program. In addition, enlist the advice of someone versed in environmental survey methods, receive training and give careful thought to your monitoring program prior to commencing weed management.

Some suggested features to record when measuring vegetation and habitat

- Presence or absence of species (i.e. dated species lists).
- Density – number of individuals of a species in a defined area.
- Cover – percentage foliage cover of one or all species in a defined area.
- Frequency – usually expressed as the percentage of sampling units a species occurs at.
- Reproduction – flowering and seeding rates.
- Growth stage – density of seedlings, juveniles, and adults.
- Trunk or stem diameter.
- Plant height.
- Individual plant health for key species.
- Success rate of planted seedling (from Buchanan 2009, p. 148).