Natural Heritage Trust

Helping Communities Helping Australia

An Australian Government Initiative

Weed control methods for community groups

Module 2

Australian Government

Department of the Environment and Heritage

CRC Weed management

Introduction

This module is an introductory guide for community group members and other individuals who have an interest in weed management but little previous experience or knowledge in weed control techniques. It should be read in conjunction with other modules in this manual and used together with information specific to the species and situation being addressed.

Why can weeds be hard to control?

The vast majority of plants that have become weeds have been introduced deliberately from overseas for agricultural, horticultural or ornamental reasons. Plants that become a problem, either to the natural environment or to agriculture, often do so because they have characteristics that enable them to colonise areas quickly, for example:

- the capacity to reproduce prolifically, either from seed or plant fragments
- seeds that can endure prolonged dormancy
- many dispersal mechanisms, including human activity
- fast growth rates enabling them to out-compete slower growing species
- freedom from the predators and diseases which keep their population in check in their countries of origin.

These factors make weeds difficult to manage.

Integrated weed management

Effective long-term weed management, where both effort and expense reduce over time, will generally only be achieved by the planned use of a number of appropriate methods in conjunction with other land management practices, such as revegetation. It is the bringing together of various weed control and land management methods that is often referred to as *integrated weed management* (IWM).

The aim is to incorporate methods which are cost-effective and practical and which will help reduce reliance on herbicides. The methods used should reinforce each other, with the ultimate goal of achieving long-term weed control without damaging the environment. Successful implementation of integrated weed management requires long-term planning based on knowledge of each of the weeds' life cycles, control methods and the environment (eg soil, climate, other vegetation). Plans also need to include regular monitoring to evaluate progress and allow actions to be adapted to changing conditions (see module 1 *Developing and implementing a weed management plan*).

A common example of IWM is the use of fire or slashing to destroy large vigorous weeds, followed by herbicide applications to control seedlings. This is then followed by hand removal of plants before they can re-seed. This may be complemented with either regeneration or revegetation with desirable species. An IWM approach generally means that less herbicide is needed and less follow-up time required than if just one method of control was applied.

This module presents many of the methods used to control various weeds, especially environmental weeds.

In particular, the following control categories are discussed:

- herbicides
- hand control
- mechanical methods
- cultivation
- mulching and smothering
- competition
- use of fire
- biological control
- grazing.

Discussion on each method concludes with a summary table of its advantages and disadvantages to help you make better control decisions. When used in conjunction with weed management guides, for example the Natural Heritage Trust/Weeds CRC series covering the *Weeds of National Significance* and the *Alert List for Environmental Weeds*, and local expertise this module can help you achieve your weed management objectives.

Prevention

The best, and most cost-effective, means of weed control is prevention by detecting the presence of weeds early and treating them before they spread. However, in a bushland situation it is particularly important to ensure the plant is properly identified before it is removed.

Timing

Whilst reading this manual keep in mind that, irrespective of the methods used to control weeds, correct timing of control is crucial to success. An understanding of each weed's growth cycle and the impact that the particular method used will have are important considerations when planning control activity. The best results are achieved when the weed is at its most vulnerable stage for the method being used. Correct timing will improve results and reduce future effort and cost.

The importance of local advice

Situations vary from location to location and different jurisdictions have different regulations concerning weed control. In all cases it is important to check with local weed control authorities to determine what are the appropriate and approved methods (see Appendix 2.1 'Weed control contacts table').

Herbicides

Herbicides are chemicals that are applied to kill plants.

Herbicides are often a very useful tool in the management of weeds. However, they are poisons and the risks associated with herbicide preparation, use, handling and storage need to be understood. Proper procedures must be followed to ensure the safety of users and other people, and to minimise risks to the broader environment. The use of herbicides is controlled by legislation in each state and territory and specific regulations apply. These are detailed on the registered label of each herbicide container. In special circumstances specific permits are issued for the use of herbicides in situations other than that specified by the label.

The aim of herbicide application is to use the right herbicide at the right dose, applied using the right method, at the right time and delivered by the right operator in an economical and safe way with minimal impacts on the environment.

This discussion on herbicide use is not intended for agricultural or commercial operations although many of the points will still apply. Recommendations made do not replace or supersede information on herbicide product labels or other regulations.

The right herbicide at the right dose

The way in which herbicide is applied and the dose used are as important to the success of control as the selection of the herbicide itself.

As each state and territory has its own legislation with respect to herbicides, the types of herbicide registered for use on a given species, the rates of application and even the method of application permitted may vary between state and territories and over time.

The label attached to all herbicide containers sold in Australia contains important information to help you select the correct product and apply it properly. You have a legal obligation to read and follow instructions given on the label. Label information includes:

- species on which the herbicide is registered for use
- key safety advice
- recommended protective equipment required when handling the herbicide
- application rates
- accidental spill and disposal instructions.

READ AND HEED THE LABEL!

For up-to-date information on herbicides contact your state or territory weed management agency or local shire or council. State and territory contact details are listed in Appendix 2.1 together with details for the Australian Pesticides and Veterinary Medicines Authority, which hosts the PUBCRIS database. This database contains information on all herbicides that are registered for use on weeds in each Australian state and territory.

Choosing the right herbicide application method

Herbicides may be applied in many different ways including foliar spray, basal bark, cut stump, scrape and paint, stem injection, frilling (or chipping), stem and leaf swiping and granular soil applications. Your decision on which application method to use needs to be made after considering:

- the weed to be treated
- label instructions
- all the risks involved

- the resources available to do the work, including follow-up
- your weed management objectives.

Foliar spraying

Foliar spraying is the application of herbicides, usually diluted with water or possibly diesel, at a specific rate using spray equipment onto the foliage of plants (until every leaf is wetted but not dripping). Spray equipment may vary from a simple garden sprayer or a backpack sprayer to boom sprays operated from vehicles, including aircraft. All other options should be considered before using foliar spraying, particularly in bushland applications, because of the increased potential for off-target damage (see below).

Minimising off-target damage

When herbicides are used there is always some potential to damage plants and animals other than those that you wish to control, resulting in 'off-target damage'. The potential for off-target damage depends on the herbicide used, soil type and landform, weather, application method used and the skill of the operator. To minimise off-target damage consider the following:

- Only use spray application of herbicides if this is clearly the best option. Consider other methods such as stem injection, cut and swab and basal bark applications.
- If spraying is the best option:
  – minimise spray drift (see 'Preventing spray drift' below)
  – if practical use 'hoods' on spray equipment to focus spray.
- Select a herbicide and application rate that is most effective at controlling the weed with the least damage to desirable plants, humans and the broader environment. Note that in some instances it may be appropriate to use higher rates (within label regulations) if this means that follow-up spraying can be reduced and therefore herbicide use is actually reduced over the longer term.
- Develop a plan for storing, mixing, transporting, handling of spills and disposing of unused herbicides and containers **before** you purchase herbicides. Make sure all who will be involved in herbicide use know the plan and agree to follow it.
- Ensure equipment is well maintained and leak free. Do not place herbicide concentrate or mixture in unlabelled containers or containers from which it can be easily spilt.
- The person applying herbicide needs a good understanding of safe spraying techniques and limiting off-target damage.
- Establish a mixing area on a site which has easy access, is flat, has no desirable species present, is not subject to erosion or runoff and is rarely visited by the public.
- Use a dye to minimise missed areas and avoid over-spraying. This is also useful for other herbicide methods. Dyes, normally made from vegetable matter, allow you to see where you have sprayed and help to detect over-spraying.
- Always spray at the best possible time, when the plant is most susceptible to the herbicide used (usually when it is at its most vigorous growth stage) and when climatic conditions are most suitable (low wind, appropriate humidity and no rain expected). This will improve results and reduce the amount of herbicide that needs to be used in the future.
- Regular monitoring of treated areas is important to identify the effectiveness of the method and check for off-target damage. If impacts on target species are not as expected, or if off-target impacts are occurring, reconsider the use of spraying, equipment used, spraying technique, type of herbicide used and operator training to determine what needs to be changed to avoid future problems.
- Always follow up weed control work. If treatments are not followed up with further control of overlooked or surviving plants, the initial treatment will have been wasted.

Preventing spray drift

When using foliar spraying as an application method you need to be acutely aware of the risk of spray drift. When spraying you have an obligation to prevent the drift of herbicide onto desirable vegetation and beyond the boundaries of the site or property that you are working on.

Some general guidelines to avoid spray drift are:

- Identify where desirable vegetation is located and areas at risk of off-target damage on neighbouring properties. Avoid spraying when wind will blow spray towards these. Maintain a buffer distance from these areas.
- Spray only in suitable weather conditions. Milder temperatures and higher humidity are best. The higher humidity of tropical areas may allow spraying at higher temperatures than in temperate regions but consult with local, state or territory agencies to find out the best conditions for your situation. Consistent light winds are preferable (5–15 kph), blowing away from areas at risk.
- Avoid spraying during:
  – very calm conditions, as spray may travel in any direction, including toward sensitive areas
  – strong winds (greater than 15 kph)
  – changing weather conditions.
- Stop if conditions change whilst spraying.
- Select the least volatile herbicides (ie least likely to become a vapour). Seek expert advice if unsure.
- Notify neighbours of your spraying intentions.
- Minimise spray release height.
- Set equipment to produce the largest droplets which still give adequate spray cover.

Spraying and herbicide use in water catchments

The use of herbicides and herbicide additives near waterways, or in situations where herbicides may eventually enter waterways, requires very careful consideration and special care. If at all possible it is best to avoid herbicide use in these situations because of the potential risk to aquatic life and other users of water. If herbicides are to be used they must be registered for use near waterways or in aquatic situations and label instructions need to be strictly adhered to. Special permits may be required from state or territory environment protection authorities to use herbicides near or on waterways.

Here are some tips on how you may reduce environmental risks associated with herbicide use near waterways:

- High volume foliar spray applications increase the chances of direct or indirect contamination of waterways. Consider alternatives such as knapsack spraying, basal bark application, wick wiping or cut-stump/stem injection to reduce contamination risks.
- It is better to treat riparian weed infestations (situated near a waterway or water body) progressively rather than in one large-scale operation. This will reduce the risks of stream bank destabilisation and habitat loss. A progressive process will allow native vegetation to regenerate or revegetation to become established. Of course, as with all weed work, ongoing follow-up and vigilance will be required.
- Select herbicides that have the lowest tendency to leach, are persistent in the environment for the shortest time and have the lowest toxicity that will still be effective against the target weed. Talk to weed control contacts in your state or territory for advice.
- Mixing of chemicals and cleaning of equipment should be done well away from waterways in situations from which runoff will not directly enter waterways.
- Avoid spraying weeds that overhang waterways.
- Wherever possible direct spray away from waterways.
- Move upstream when spraying rather than downstream to aid dilution of any contamination and to avoid creating a ‘slug’ of herbicide entering the waterway.
- If land near waterways is cultivated run furrows across the slope to minimise runoff. Establishment of a grass buffer strip between cultivated land and a waterway is also useful to intercept runoff.
- Only spray when rain is not expected for some days.
- Keep records of spraying activity.

Check with local authorities to find out what regulations apply in your area for the application of herbicides near waterways.

Water used to mix with herbicides

The quality of the water you use to mix with herbicides can affect your results. Always use clean, good quality water. Dirty water contains particles that can absorb active ingredients and reduce the effectiveness of herbicide. Dirty water may also lead to blocked and damaged spray equipment.

Hard water, which contains high concentrations of calcium and magnesium, and water that is either too alkaline or acidic, can reduce herbicide performance. When the only available water is too hard, alkaline or acidic, additives can be obtained which overcome these problems.

Basal bark spraying

This method involves mixing an oil-soluble herbicide in diesel and spraying the full circumference of the trunk or stem. Basal bark spraying is often used to treat thinly barked woody weeds and undesirable trees. It is an effective way to treat saplings, regrowth and multi-stemmed shrubs and trees.

This method works by allowing the herbicide to enter the weed's underground storage organs, slowly killing it.

The stem or trunk needs to be reasonably free of mud or dust and should be fairly dry. It should be sprayed or painted with herbicide solution from ground level. The height to be covered varies with the species and maturity of the plant being treated. Check with local authorities for recommended coverage.

Basal bark spraying is a useful method in difficult terrain and usually works well, provided bark is not too thick for the solution to penetrate.

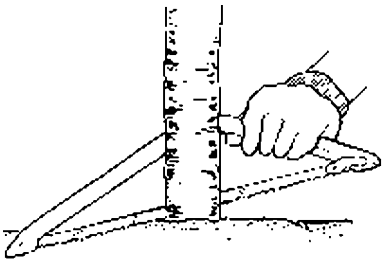
Basal bark spraying of mesquite. Lower stems are sprayed from ground level up to a height of 750 mm.
Photo: Rachele Osmond

Cut and paint, cut and swab, cut and daub and cut and spray

All of these names describe similar methods to apply herbicides directly to plants and are particularly useful for woody weeds.

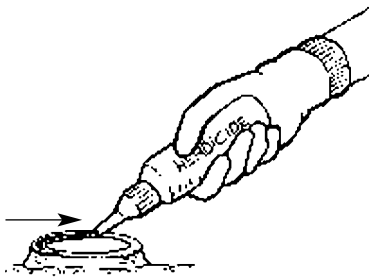
To use these methods clear the area around the base of the stem, then cut the stem horizontally as close to the ground as possible, using secateurs, loppers, bush saw or chain saw. It is important that the cut is horizontal to avoid runoff of herbicide, and sharp angled cuts may also present an injury risk. Herbicide is then applied as soon as possible (preferably within 10 seconds) to the exposed surface before the plant's cells close up and inhibit the entry of the herbicide. On larger stems focus herbicide application on the sap wood and not the heartwood, as herbicide will not be translocated through the stump by the heartwood and will be wasted. It is easiest to have two people for this process, one to cut and one ready to apply the herbicide as soon as possible. This approach, though reliable, does not always provide a 100% kill rate, and ongoing follow-up and monitoring of treated plants will be required.

Step 1



Cut stem horizontally

Step 2



Herbicide only applied to sapwood

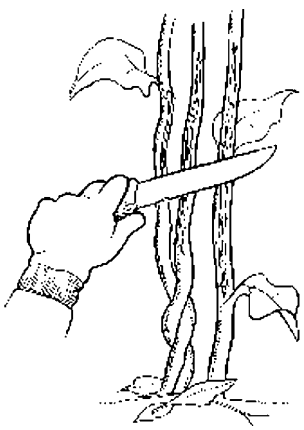
*A variation to the cut and swab method, in this case cut and spray, with a chain saw being a handy tool to use on prickly acacia bush (*Acacia nilotica*). Herbicide is best applied within 10 seconds after cutting. Prickly acacia field day, northwestern Queensland.*
Photo: Nathan March

Scrape and paint

This method is useful on vines and scrambling plants with a woody stem. Using a knife and starting from the base, scrape 20 mm to 1 m of the stem to expose the sapwood and apply herbicide to the scraped area within 10 seconds. Do not ringbark the stem. Scrape about one-third of the stem diameter. Larger stems (>10 mm) can be scraped on two sides.

Vine 'curtains' can be cut at chest level and again at about 300 mm above the ground. Scrape or cut and paint these lower stems, and spray new growth. Pulling vines out of trees may cause a lot of damage to tree foliage or bark and it may be better to leave the vine to die in the tree after treatment.

As with all herbicide methods avoid using cut and swab or scrape and paint and similar methods if rain is expected. Herbicide labels have information on the amount of time needed after application before rain for the chemical to still be effective.



Stem scraping

Stem injection

There are a variety of methods in this category. The aim is to get herbicide into the sapwood tissue (cambium layer) of woody weeds and weed trees so that it will be transported throughout the plant. These methods target individual plants and the risk of off-target damage is diminished (provided accidental spillages do not occur).

Use a cordless drill or a brace and bit to drill holes into the base of the plant. Holes should be drilled at an angle of 45^{o} and be made no more than 50 mm apart right around the trunk. This angle will aid herbicide retention in the hole, increasing absorption by the plant and reducing the risk of spillage. Herbicide must be injected in the holes within 10 seconds of the hole being made. Again it will be easiest to have two people on hand for this task, one to drill and one to fill with herbicide. Be careful not to overfill the holes as excess herbicide running out of the hole is wasted and will contaminate the environment. Injection guns enable you to deliver a precise amount of herbicide to each hole. A squeeze bottle with a firmly fixed tube to dispense the herbicide or veterinary syringes may also be useful.

An alternative method, if a drill or injection gun is not available, is to use a chisel or tomahawk to make angled cuts into the sapwood around the base of the stem/trunk (chipping or sometimes referred to as frilling). These cuts are then filled with herbicide immediately. It is important not to ringbark the plant as this may kill vegetation above the ringbark but will prevent transportation of the herbicide through the plant's entire system and allow trees to resprout below ringbark lines.

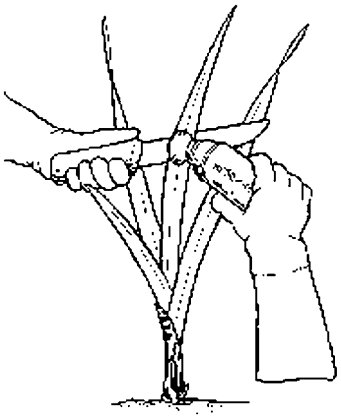
*A stem injection gun being used to apply herbicide to a willow (*Salix spp.*)*
Photo: Trish Chadwick, NSW DIPNR

Chipping is an alternate means to get herbicide into a willow. Evenly spaced downward cuts are made around the trunk with a chisel or a tomahawk and filled with herbicide.
Photo: Lisa Menke, NSW Dept of Environment and Conservation

Stem and leaf swiping

This method is useful for leafy herbaceous plants. If fruit or seed is present remove and bag this first to prevent additions to the soil seedbank. The method involves the use of a wick or rope applicator (equipment is available commercially) to swipe stems and/or leaves with herbicide. A flat-bladed device may be required to provide some resistance for the applicator when the leaf or stem being treated is soft.

Extreme care is needed to avoid spillage and contact with skin.



Leaf swiping

Other herbicide application methods

Granular or soil residual herbicides

These are herbicides that are mixed into a solid medium, such as clay, and formed into pellets or granules. They are then spread over the soil, either manually or by a mechanised dispenser or even an aircraft. The release of the herbicide is usually triggered by rain, which allows the active ingredient to be released from the pellet so that it can be absorbed into the roots of plants. The herbicide may remain active in the soil for some time, helping to control newly emerging weeds. This type of application is most suitable for weeds in agricultural and forestry situations where sensitive desirable vegetation is not at risk from the herbicide. Heavy rain may wash herbicide off site, potentially contaminating catchments and reducing effectiveness in the intended area of control. Granular applications can be a useful alternative to sprays where spray drift is a major problem or where access is difficult and aerial application onto large infestations may be warranted.

Aerial applications

Helicopters or fixed wing aircraft may be useful to apply herbicides where the area to be treated is large and/or inaccessible. Clearly the risk of off-target damage may be high, but if an area is dominated by a particular weed it can be appropriate and, at a large scale, economical to employ this method. Mimosa (*Mimosa pigra*) in the Northern Territory is an example of a species where aerial applications are often employed. However, it is essential that follow-up work is carried out to treat regrowth after spraying.

*Helicopter spraying of a large parkinsonia (*Parkinsonia aculeata*) infestation in central Queensland.*
Photo: John McKenzie

Wickwipers or weed wipers

This method employs vehicle-mounted or hand-held equipment to wipe or brush herbicide onto weeds. The herbicide is applied from wicks, sponges or other material saturated with herbicide. The level of application can be adjusted so that only species growing above a certain height will receive herbicide and in this way the method can be very selective. Problems with spray drift are also avoided. This method is particularly useful in pasture or grassland situations. Serrated tussock (*Nassella trichotoma*) is an example of a pasture-invading weed that can be treated in this way. Desirable species need to be grazed first so that they are well below the height of mature serrated tussock

plants. This method is more effective if a second pass in the opposite direction is done but is not suitable if obstacles such as rocks and stumps are present. If weeds are present that are below the height of application, follow-up spot spraying or manual removal will be required.

The right time

Usually it is best to apply herbicides when weeds are actively growing. Also, time applications when plants are smaller if possible as less herbicide will be needed and they are easier to kill. Get to know the life cycle of the plant to assess when the most suitable conditions are likely to occur, but also take account of seasonal variations and local conditions which may have an impact on plant health. Avoid using herbicide when weeds are under stress, for example from extremes of heat or cold, drought, waterlogging or disease.

Do not apply during wet, windy or very hot weather or when these conditions are anticipated.

The right operator: Training

It is beyond the scope of this module to cover all aspects of herbicide use. All people using herbicides are encouraged to undertake appropriate herbicide training. In most states and territories short courses are available, such as 'Chemcert', which provide information and hands-on training in herbicide and equipment use and safety precautions. In some states and territories, and in certain situations, training may be a prerequisite to using herbicides. Check with local authorities to determine what is required for your situation.

Keeping records

It is good practice to keep records of herbicide application. This enables you to review the effectiveness of herbicide treatments as part of your weed management planning. It will also allow you to demonstrate to others what has been happening on the site in respect of herbicide treatments. A simple example of a record sheet is included with this module (Appendix 2.2). Commercial or agricultural operators are usually required to maintain more detailed records and this may also be required if special permits or restrictions apply to a particular herbicide.

Personal safety and herbicide use

Herbicides need to be handled with care. Herbicides should always be kept well away from children and preferably stored in a locked cabinet and in the original labelled container.

Ensure that all who are going to use herbicides read and understand the label and can speak to someone qualified in herbicide use if they have any questions.

Herbicides can enter the human body through the skin, or by inhalation or swallowing. Basic safety precautions that should always be observed when using herbicides are:

- Read the label **before** opening the container and follow instructions exactly. If you do not understand the instructions seek advice from appropriate people, eg local or state government authorities.
- Store only the amount of herbicide that you need. Surplus chemicals remain a hazard.
- Wear protective clothing: long sleeves, long pants, sturdy shoes and gloves and eye protection (goggles/safety glasses). Cotton, leather, canvas and other absorbent materials are not resistant to herbicides so the more layers the better. A PVC apron covering from shoulders to boots should be worn during the mixing process. Note that protective equipment should be worn during:
  - mixing of herbicides – be extremely cautious at this point as herbicide is in its concentrated form
  - application
  - entering a treated area before the herbicide has dried or dissipated.
- Always wear chemical-resistant gloves. A respirator is advised when mixing or pouring liquid herbicides.
- Do not eat, drink or smoke while using herbicide and wash hands after handling.
- Wash skin and equipment afterwards. Shower and wash hair at the end of the workday. Wash contaminated clothing separately.
- Know what the correct procedures are in the event of an accidental spill.

Additives

There are a range of products available which are designed to be added to herbicides to improve their performance. These additives, sometimes called adjuvants, are available to help herbicide stick to plant surfaces or penetrate deeper into plants. Adjuvants that help herbicides stick or wet plant surfaces are called 'surfactants', while those that help herbicides enter the plant are called 'penetrants'. Control of weed species with waxy leaf surfaces or other properties that repel liquid herbicide may be improved with the use of adjuvants. However, care needs to be taken to ensure that excessive runoff does not result from their use (foliage may become saturated more rapidly) and that the adjuvant itself is safe to use. Some adjuvants, for example, may be harmful to aquatic life, even if the actual herbicide is not. As always check with local authorities to determine what is appropriate to use in your situation.

Treatment	Advantages (benefits)	Disadvantages (limitations)
Herbicides (sprays)	• Selective (depending on choice of herbicide, timing, plant life cycles, operator skills) • Can prevent weeds seeding and spreading • Appropriate on small and large weed infestations • Minimise direct soil disturbance • Inexpensive	• Potential for non-selective damage / may destroy local flora • Potential impacts on the broader environment • Technical proficiency required • Operator / public hazards
Woody weed treatments (cut and swab, stem injection, scrape and paint etc)	• Selective • Minimise risks to local flora • Prevent seeding and vegetative spread • Inexpensive (on small infestations)	• Site disturbances can be excessive, care is needed • Can spread weed propagules • Can destroy native fauna habitat • Can encourage weed growth / germination • Operator / public hazards • Costly and labour intensive (on large infestations)

Hand control

Hand, or manual, methods offer alternatives to herbicide treatments, particularly in sensitive areas with high conservation value. They also form a useful part of an integrated approach, especially for follow-up control after herbicide applications or other methods have been used. These techniques are, of course, labour intensive and generally not suited to the treatment of extensive infestations. However, they do provide an opportunity to get close to the weed, which can improve your identification skills and aid your understanding of the weed's biology.

Hand pulling

Hand pulling is useful for isolated occurrences of seedlings or other small, soft, non-bulbous weeds.

It is best undertaken when soil is moist and loose so that you have a better chance of removing the entire plant while minimising soil disturbance. Remove any seeds or fruit that are present and bag these for disposal.

For small seedlings and soft plants take hold of the plant firmly at ground level and pull. Avoid grabbing the plant too high as it is likely to break and remaining plant material may reshoot. After removing the plant tamp the disturbed soil down.

For small woody plants like young boneseed and bitou bush (*Chrysanthemoides monilifera* spp.) take hold of the stem at ground level, and manipulate it backwards and forwards gently until it comes away cleanly. If the plant has a spreading root system it may be necessary to pull roots individually. If so always pull roots horizontally through the soil towards the plant, reducing disturbance and the risk that roots will break. A screwdriver or similar tool may be useful to loosen roots.

Plants that do not regrow from their roots can be crowned. Hold leaves and stems together and use a knife to cut through all the roots below the crown (the parts of the plant above the roots).

Cutting out the crown

Digging

In a bushland situation digging, hoeing or grubbing out weeds can be effective for isolated weed occurrences and are useful follow-up techniques. With practice, gentle digging and grubbing out of weeds will keep soil disturbance to a minimum. However, digging is not always the best method for species with extensive tuber, rhizome or root systems. For example, larger woody weeds may be more effectively treated with herbicides, which will cause minimal soil disturbance compared with digging out deep or extensive root systems. Species like bridal creeper (*Asparagus asparagoides*) develop extensive tubers and rhizomes underground that are difficult to completely remove, and older established infestations may be better controlled with careful use of herbicides.

Treatment	Advantages (benefits)	Disadvantages (limitations)
Manual removal (hand weeding, digging, grubbing etc)	• Selective • Minimises risks to local flora • Supplements other controls • Can prevent seeding and spread • Effective on small infestations • Develops plant identification skills and familiarity with sites	• Can disturb soils if poorly done • Timing limitations, needs moist soils • Can spread weed propagules • Unsuited to large infestations • Inappropriate for some weed species and large plants • Labour intensive

Mechanical methods

Machines, from lawn mowers to large earth moving equipment, can play an important role in weed management. The use of any machinery introduces risks of site disturbance and the potential to spread weeds as a consequence of plant material attaching to machinery and redepositing elsewhere. Good planning to minimise site disturbance and restore treated sites is essential, as is attention to machinery hygiene.

Slashing and mowing

Slashing and mowing may be valid components of an integrated weed management plan, depending on the weed being treated. These methods will not eradicate weeds but they can stress weeds, providing desirable vegetation with a competitive edge, leaving weeds more susceptible to biocontrol agents and also preventing or greatly reducing weed seed production.

Proper timing of the use of slashing or mowing is required for optimal results, otherwise these methods can actually spread weeds. Timing should be based on the growth stage of the weed species and the growth stage of desirable vegetation. Ideally mowing should be carried out at a time that is not so early that seed heads emerging later produce an abundance of seed, and not so late that viable seed has already been set. It should also coincide with the time when desirable plants are dormant. The idea is to exploit differences in the growth habits of grassy weeds and desirable grass species. This happy coincidence will not always be achievable and decisions will need to be made based on priorities for action. For example, in areas with little or no native vegetation that are already heavily degraded with weed infestations, mowing may provide an effective means to reduce weed seed production. This will help protect better quality areas from invasion. Resources can then be devoted to removing weeds from less infested areas.

Timing decisions will be further complicated if multiple weed species are present with different flowering and seeding times. Again, it will be a matter of prioritising which species are most important for the management of the site and what opportunities exist to integrate mowing with other methods to manage priority species.

Some weeds will regrow readily after mowing, and mowing can actually encourage fresh growth (eg Coolatai grass *Hyparrhenia hirta*). This new growth is more responsive to herbicide treatments.

Where catchers can be used as part of mowing, seed heads can be collected for subsequent destruction or appropriate disposal, further helping to suppress subsequent generations of weeds and weed spread.

Be mindful of the damage that heavy mowers can cause, particularly when the ground is wet. Thorough cleaning of machinery used in slashing and mowing is essential to ensure that seed from the area treated is not inadvertently transported to new areas. Machinery like mowers and slashers can potentially become major dispersers of grasses like Chilean needle grass (*Nassella neesiana*).

*Slashing trials being conducted on a Chilean needle grass (*Nassella neesiana*) infestation. This species produces seed at the base of its stem as well as normal seed heads, so follow-up work will also be required as well as careful machinery hygiene to prevent seed spread.*
Photo: DPI Victoria

*Slashing with a brushcutter can help open up dense stands of blackberry (*Rubus fruticosus *aggregate) for follow-up control by other methods. Photo: Adam Whitchurch, DPI Victoria*

*Mechanical control of parkinsonia (*Parkinsonia aculeata*) with an Ellrott front-mounted bladeplough. Photo: John McKenzie*

Bulldozers and tractors

For some species, and in certain circumstances, heavy earth moving equipment can form an effective part of integrated weed management, particularly for severe infestations of larger woody weeds. Bulldozers are important in dealing with large infestations of prickle bush species including prickly acacia, mesquite (*Prosopis* spp.) and parkinsonia and allow treatments such as blade ploughing, chain pulling, dozer pushing and stick-raking. The method used will depend on the extent of the infestation and the maturity of the plants to be treated.

Blade ploughing employs a large plough device attached to a bulldozer which cuts trees off below the soil surface and below the zone from which they can rebud. This is best done when trees are young and easier to cut through. Chaining, where two bulldozers drag a heavy chain through dense infestations, is used to knock plants down to the ground to provide fuel for follow-up fires. Ongoing control with herbicides is required to treat regrowth. Dozer pushing is used to destroy individual trees, and stick-raking attachments on bulldozers are used to cut trees below ground level and mound them into windrows for burning.

Heavy machinery can also be usefully integrated into the treatment of other woody weeds such as blackberry (*Rubus fruiticosus* agg.) and gorse (*Ulex europaeus*) where bulldozers or heavy tractors can be used to cut bushes off at or below the soil surface. Follow-up treatments and planned revegetation or pasture establishment will be required to help keep these weeds under control.

Bulldozers or heavy tractors using blade ploughs can also be used to ‘scalp’ areas of weed infested land to depths often around 200–300 mm to remove plant crowns and as much seed and root material as possible. This method, however, also removes soil nutrients that may have accumulated from land use practices such as application of fertiliser, which actually favour many weeds over native vegetation since the latter is generally adapted to low nutrient conditions. Scalping may be appropriate for highly degraded areas but expert assessment of the soil profile and selection of species to revegetate the site is needed to avoid causing serious damage.

A gorse infestation in Zeehan, Tasmania, being mechanically cleared and mulched.
Photo: Greening Australia, Tasmania

Grooming

Tractors and earth moving equipment fitted with specialised 'grooming' arms can be effective at treating large infestations of woody weeds in hard to reach places. The grooming devices shred plant material down to ground level, reducing biomass. Follow-up treatments of any regrowth, using herbicides or manual methods, require far less chemical and effort than would have been the case if the original infestation had been treated. Initial use of grooming can be expensive but this needs to be balanced against long-term reduction in herbicide costs. The method has been useful for large infestations of blackberry where regrowth has revealed that the original large infestation was based on a few parent plants which could then become the focus of treatment.

Clearly these methods cause major disturbance to vegetation and soil and should only be contemplated where resources exist to carry out necessary follow-up work. This includes restoration of the site with desirable vegetation.

Earth moving equipment fitted with a grooming head treating a dense stand of blackberry.
Photo: Sandy Cummings, Fleurieu APCB

Cultivation

Cultivation, defined as working the soil with implements, is often used in cropping situations to prepare the soil for sowing and to destroy competing plants. Its use is diminishing in order to conserve soil, with herbicides being used more extensively to control weeds.

Cultivation works by cutting, uprooting and burying shallow rooted plants. It has a limited application in bushland settings, where the disturbance caused would only serve to stimulate weed growth and help spread seeds and other propagules while destroying native vegetation. It may form a useful part of managing weeds invading pasture, such as serrated tussock, provided cultivation is followed up with the establishment of vigorous pasture to suppress germination of weed seeds from the soil seedbank.

Treatment	Advantages (benefits)	Disadvantages (limitations)
Soil cultivation and scalping	• Can eradicate weeds • Reduce nutrient loads • Remove soil-stored seedbank • Can aid site rehabilitation	• Non-selective • Disturb soils • Spread propagules • Destroy local flora and fauna habitat • Remove soil-stored local flora seedbank • Potential for erosion / runoff • Expensive • Site rehabilitation required • Technical proficiency required
Slashing, mowing, cutting (brushcutters, mowers, slashers)	• Minimise soil disturbances • Minimise risks to local flora • Can prevent seeding and spread • Remove excess foliage (for follow-up treatments) • Supplement other methods • Help to weaken plants, making them susceptible to other forms of control • Inexpensive	• Usually don't eradicate weeds • Can prevent seeding by local flora • Can introduce / spread weed propagules • Can encourage weed growth • Can increase fuel loads (dried material)
Mechanical (grooming, bulldozer)	• Can be quick • Can be cost-effective for extensive infestations (prickle bushes)	• Significant disturbance • Vehicle hygiene risks • Expensive for small infestations • Comprehensive follow-up may be required

Mulching and smothering

Mulch may help to control weeds by excluding light from the soil surface, by reducing temperature variations that would otherwise stimulate weed seed germination and by physically impeding weed growth. Many forms of vegetative material including bark, wood chips and mats made from vegetative material are used, as are synthetic materials such as black plastic sheeting and mineral aggregates.

The application of mulches outside the garden or horticultural environment is probably limited, except perhaps for highly disturbed or degraded areas where no indigenous species regeneration will be affected by the mulch, or around seedlings planted as part of revegetation work. It is important that sheet materials used for mulching, synthetic or otherwise, are well secured to prevent them being torn (introducing gaps), blown or washed away.

Mulching may assist revegetation establish by suppressing weeds around young native plants and improving retention of soil moisture. Organic mulches such as hay or straw, however, may also contain weed seeds and can temporarily tie up nitrogen in the soil.

Solarisation

This method also employs sheeting, usually black or clear plastic, to cover weeds and allow the sun's energy to raise temperatures under the sheeting to an extent that weeds and their seeds are destroyed. It can be useful to treat small infestations of tenacious grass and herbaceous species and is best used in the warmer months and in locations with open and sunny aspects.

Black plastic sheeting has been used to control some aquatic weeds, for example *Lagarosiphon major*, in still water conditions. This species is on the *Alert List for Environmental Weeds*.

It is also a method to sterilise weeds to be disposed of, by accelerating composting and subjecting the material to high temperatures. This can eliminate the need to take material off site and reduces the risk of inadvertently aiding weed spread.

Treatment	Advantages (benefits)	Disadvantages (limitations)
Mulches and smothering treatments	• Inhibit / prevent weed seeding and spread • Can compliment site rehabilitation • Erosion / runoff control • Aesthetics enhanced	• Usually non-selective • Can encourage weed growth • Prevent local plant growth and spread • Can introduce weed propagules • Can alter soil chemistry • Affect soil conditions and soil micro-fauna • Ongoing maintenance required • Aesthetics undermined • Costly and labour intensive
Solarisation (plastic sheeting)	• Can be selective • Can control tenacious weeds • Inhibits / prevents seeding and spread • Supplements other methods • Appropriate on a small scale • Low costs (once installed)	• Usually non-selective • Ineffectual on many weeds • Unsuitable for large infestations • Prevents local plant growth and spread • Affects soil conditions and soil micro-fauna • Ongoing maintenance required

Competition

Ultimately, the best way to keep an area free of weeds, or at least to keep weed numbers down to a manageable level, is to have a good cover of desirable vegetation which prevents weeds establishing. In bushland settings this cover should comprise native species indigenous to the area (local provenance). In agricultural settings pasture species might be desirable.

The objective of most site plans involving bushland settings is to restore the original ecosystem by establishing local native species to replace the weeds. This may not always be possible, for example if seeds of original species are unobtainable or if the site has been so extensively changed that original species would no longer grow there (eg a mine or quarry site). In these cases alternate species need to be found but these should still be from native species as close as possible to the site. Natives from other regions may themselves become weeds; for example, Cootamundra wattle (*Acacia baileyana*) is a weed in Australia outside its original range in New South Wales.

Regeneration

Native species can be allowed to regenerate from seed stored in the soil seedbank or seed held in remnant native canopy species. In these circumstances weed control should be paced so that gaps are not created for fresh invasion. This approach is embodied in the 'Bradley' method developed by the sisters Joan and Eileen Bradley during the 1960s–1970s. The main principles of this method are to:

- work from minimally disturbed sites in towards the most weed infested areas
- minimise disturbance to the soil
- allow the rate of native plant regeneration to dictate the rate of weed removal.

Manipulation of the seedbank

Where a substantial native seedbank exists in the soil or the plant canopy this may be exploited by direct manipulation, such as burning, to stimulate germination. This technique should only be applied to sites where monitoring confirms the presence of a substantial seed resource and the ecosystem is fire adapted. It would not be appropriate, for example in rainforest ecosystems. Otherwise a more interventionist revegetation technique is required.

Sowing of seed

Direct seeding with desirable species requires knowledge about their germination and seedling establishment requirements so that the plants can be given the best opportunity to successfully establish in the shortest time possible, thus reducing the chances of reinvasion by weeds. Many seeds require some form of pre-treatment (eg scarification, heat or smoke) to stimulate germination. Timing of the sowing to take advantage of reliable rainfall or low seed predator activity may help to maximise the chances of establishment.

Planting seedlings

Planting native seedlings is a more labour intensive and expensive task than seeding but generally achieves higher establishment rates. Planting should be carried out at times that will give plants the best chance of establishment, and some temporary protection from grazing may also be required. Mulch may assist to suppress weeds and retain soil moisture whilst seedlings become established.

Selection and revegetation timing can be complex matters and advice from suitably qualified and experienced people is well worth obtaining.

Treatment	Advantages (benefits)	Disadvantages (limitations)
Competition strategies and practices (direct seeding, plantings, natural revegetation)	• Suppress weeds • Can alter light levels and nutrient – moisture availability • Restore vegetation structure • Restore floristic diversity • Enhance fauna habitat	• Altered conditions can favour weeds • Can undermine vegetation structure with inappropriate species selection • Often entail intensive management input during establishment phase • Can be labour intensive (costly) • Specialist knowledge required

Using fire for weed control

The use of fire is particularly relevant to the long-term management of environmental weeds in Australia, as the ecology of many native species is closely tied to, or even dependent upon, fire. However, areas left bare by fire are susceptible to erosion and new weed invasions so it is advisable to restrict the area that requires follow-up after planned fires to manageable levels. In areas with good native vegetation, fire should not be used in frequent succession on the same site as this is more likely to favour weedy species. Moreover, the risks to people, fauna and property need be understood and managed, and appropriate measures taken and legal permissions obtained before fire is used.

If fire is to be used as a control method at least four aspects need to be considered.

Aspects to consider when using fire

1. The response of the weed to burning

Some weeds do not burn well while alive. Even when shoots are successfully burnt the plant may still regenerate. Fire may also affect germination from the soil seedbank, either detrimentally by killing the native seeds exposed to excess heat or, conversely, by stimulating weed germination. In the case of bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*), seeds on the surface are killed by fire while seeds buried 30 mm or deeper in the soil may actually be stimulated to germinate. If the new bitou bush growth that occurs following fire is treated (with herbicide or hand pulling depending on the scale of infestation), this can help deplete the soil seedbank of bitou bush seed.

2. Habitat

Because burning may destroy fire-sensitive ecosystems such as rainforest, it is not always an option for controlling weed invasions. Lantana (*Lantana camara*), for example, invades the margins between rainforest and sclerophyll forest. Fire may kill the lantana but it may also promote certain sclerophyll species and be detrimental to the rainforest species. If the management aim of such areas is to maintain or increase the rainforest boundaries, fire is not appropriate.

3. The fire regime employed

Not all fires are alike. The factors which govern the impact of a fire on the native and weed flora include the fuel load, weather, topography and soil moisture, all of which influence the intensity of a fire, rate of spread and penetration of heat into the soil seedbank. Fires of low intensity, as is the case for many prescribed fires in a specified area, can produce responses substantially different from those of high-intensity wildfires. This is particularly the case for native species, which require a relatively high minimum temperature to shed seed stored in the canopy or a relatively high transmission of heat into the soil to germinate the seedbank. Thus the fire regime has implications beyond its potential to kill the weed species – it can also affect the composition of regenerating native species and hence the post-fire plant community.

*With sufficient fuel (grasses, rubber vine leaves, other vegetation) fire can successfully control rubber vine (*Cryptostegia grandiflora*). Fire is especially efficient in combination with the biological control agent rubber vine rust (*Maraualia cryptostegiae*).*
Photo: Joe Vitelli

4. The season of fire

If the fire is mistimed with respect to fruiting maturity or seed shed of desirable species, it may deplete the seedbank. In terms of management there are clearly seasons when the use of fire is dangerous because of the risk of escape, especially into adjacent urban areas. The level of risk may also depend upon seasonal conditions. The use of fire will need to be outside fire ban seasons and requires the appropriate legal permissions from fire and native vegetation authorities.

When dealing with large infestations it may be inadvisable to use fire to burn the entire infestation. Apart from the risk of fire escaping control, large fires can cause significant change to organisms in the soil and the ecology of an area. It may be better to limit annual burning to 10–20% of the area to be controlled.

In addition to the above considerations fire should only be used when there are:

- adequate resources to control it
- adequate resources to do the follow-up weed control and revegetation
- appropriate approvals from relevant local authorities.

Wildfires or unplanned fire

If your site is subjected to an unplanned fire then regular examination of the area will be needed to see what weed activity is taking place after the fire and how desirable vegetation is coping. The information gained can inform ongoing management of the site. Your objectives may need to change and you might be able to capitalise on the opportunity to get easier access to weed seedlings and to re-establish desirable vegetation.

Treatment	Advantages (benefits)	Disadvantages (limitations)
Fire (control burns, spot-burns)	• Removes rank and excessive foliage (for follow-up spray treatments) • Supplements other methods • Encourages local flora regeneration • Encourages germination of soil-stored weed seedbank (for follow-up treatments) • Relatively inexpensive • May kill weed seedbanks	• Usually does not eradicate weeds • Inappropriate for non-fire adapted ecosystems • Seasonal and timing limitations • Encourages weed growth / germination • Altered nutrient-moisture availability can favour weeds • Potential for runoff / erosion • Fauna, people, property risks • Can be costly if establishment of fire breaks, spelling of pasture and personnel required to control fire are involved • Specialist knowledge required

Flame weeding and steaming

These techniques employ a burst of intense heat to kill weeds and are generally used in horticultural applications and by some councils to treat roadside and footpath weeds where there is an objective to reduce chemical use. They are more effective on broadleaf weeds than grasses, which are more resistant to heat methods.

Flame weeding

Flame burners are devices that employ propane gas or kerosene as fuel to provide a constant flame and use a hand wand to allow the flame to be applied onto the target weeds. The method does not require that the plant is burnt; in fact for many species this may actually stimulate regrowth. Rather, the method works best when plant leaves are severely wilted as a result of exposure to the intense heat and subsequently die.

Steam weeding

This method uses apparatus to produce pressurised heated water directly onto target weeds to break down cell structure, leading to plant death.

Flame and steam weeding are expensive to use, may require repeated applications and are also characterised by slow work rates. The risk of off-target damage and, in the case of flame weeding, the risk of fire escaping needs also to be considered. Prolonged use of these methods in urban areas has seen a change in the weed flora to favour deeper-rooted perennials that are more resistant to heat treatments.

Biological control (biocontrol)

Biological control of weeds offers the potential to deliver inexpensive, long-term control. Additionally, impacts associated with other methods such as herbicide or mechanical controls are reduced. However, it needs to be appreciated that the establishment of effective agents requires considerable initial investment and time to find the agents, confirm that their actions are specific to the target species and establish them in the field. Although the return on this initial investment can be substantial, there are no guarantees that effective agents suitable for release will be found. Once a successful agent is established it becomes self-sustaining, with target weed populations reduced to a level where investment in other weed control methods can be reduced.

Classical biological control is based on the principle that populations of plants in their native range are held in check by organisms such as insects, birds and mammals that feed on them, or diseases which control them. When a plant is taken out of its native range and introduced into a new area, these controls are absent and, if other conditions are right, the population of the plant may explode. This is one reason why many introduced species have become weeds in our environment.

Biological control seeks to find organisms in the weed's native range that are specific to that plant and will not damage native or desirable vegetation. Most often insects or organisms like fungi or rusts are likely candidates for biocontrol agents. Complete eradication is not a desirable or achievable objective of biological control. The aim is to create an ecological balance between a plant and its natural enemies in the introduced range and to reduce weed density to a level below that at which it causes economic or environmental damage.

Prioritising sites for biological control

If biological agents are available for weeds that you are looking to control you will need to assess how appropriate your site is for their use. Knowing where your weeds are, and establishing the characteristics of their distribution, are the first steps in prioritising the use of biocontrol as part of your weed management plan. The mapping of weeds is discussed in some detail in module 1 *Developing and implementing a weed management plan*.

Established weeds normally consist of three different types of infestations:

- small, isolated infestations
- the core of large infestations
- infestation perimeters.

The core of large infestations are usually the most expensive to control, have well-developed soil seedbanks and are often spread over a number of properties or sites where it may be difficult to coordinate chemical, manual or mechanical control activities. In these circumstances biological control can help by suppressing the growth rate and reproductive capacity of target weeds, while chemical and/or physical methods are simultaneously used to control isolated populations and contain the spread of weeds at the perimeter of the larger infestation.

Generally speaking, biological control is most appropriate where weed infestations are a low priority for immediate control. In agricultural situations weed control is normally focused on protecting economic return in the short term. Therefore, biological control, which takes some time to establish, is more appropriate on agricultural lands or rangelands of relatively low productive potential. Similarly, control of weeds in areas of particularly high conservation or heritage value is best addressed by appropriate chemical or physical methods in order to achieve more immediate results.

The feasibility of using conventional chemical or physical methods will also influence the decision to use biological methods. If access to the infestation is difficult due to the terrain, or if an area is sensitive to herbicide uses (eg aquatic or riparian locations where sensitive native plant species are present or the land is used for organic agriculture), biological control may be a preferable option.

Integration with other techniques

The previous section addressed where you might use biological control as a priority method but what about its use in conjunction with other methods? Where biological control is available, each weed species will require a different integration strategy to achieve the best results of combining biological control with conventional methods in light of the life cycles of both the weed and the biological agent. For example, some agents are dormant at certain times of the year. By using herbicide applications during the hibernation period the agent will not be directly affected and, when they emerge from hibernation, will attack any target weeds that survived the herbicide treatment.

In other cases it may not be feasible to alter the timing of control methods to suit the life cycle of a biological control agent. If the agent is likely to be killed as a consequence of the use of other methods (eg pesticides), then it may be necessary to maintain a small population of the weed species to act as a refuge for the agent. New weed infestations can then be recolonised by the agents from the refuge. An example of this approach can be seen in the Sunraysia district along the Victorian / New South Wales border, where biological control is used in the battle against bridal creeper (*Asparagus asparagoides*). Bridal creeper causes problems in citrus orchards and herbicides can kill off agents such as the leafhopper (*Zygina* spp.) and rust fungus (*Puccinia myrsiphilli*). These agents have been released in roadside infestations and shelter belts near orchards to provide a reservoir of agents, if needed, while at the same time suppressing bridal creeper spread in these unmanaged areas. This, in turn, helps to reduce reinfestation back into the orchards.

In some cases agents can be so effective that no other control is needed. For example, the aquatic weed salvinia (*Salvinia molesta*) has been successfully controlled, though not eradicated, where it occurs in tropical and subtropical climates by the salvinia weevil (*Cyrtobagous salviniae*).

Setting up biological control

If a decision has been made that a site could be suitable for the use of biological control, the following general protocol should be followed:

- Establish where agents can be acquired.
- Determine the requirements to acquire and transport the agents.
- Determine what permits are required.
- Consult with others in the area and establish cooperation for the implementation and monitoring of the program.
- Determine the methods and site requirements for introducing an agent (equipment, water etc).
- Find out what records should be kept at the time of establishment and for subsequent monitoring.

The bridal creeper rust fungus attacks leaves and stems, reducing the amount of green plant material. Photo: John Virtue

Treatment	Advantages (benefits)	Disadvantages (limitations)
Biological controls	• Selective • Can suppress weed growth and spread • Supplement other methods • Value for money • Minimal labour inputs (in the field) • Minimal direct environmental impacts	• Timing limitations • Variable results • Do not eliminate weeds • Other controls required • Expensive to develop • Limited range of weeds have agents

Grazing

Livestock such as cows, sheep, horses and goats can contribute to weed control by:

- reducing flowering and seed dispersal
- stressing weed plants
- preventing weed domination of pastures.

Grazing, however, requires careful management that accommodates:

- the timing of grazing with critical stages in weed life cycle while minimising permanent damage to desirable pasture species
- the dietary needs of stock
- different grazing habits of livestock species; goats, for example, will preferentially graze fibrous plants like blackberry that other stock will avoid. Other livestock may preferentially graze desirable species
- the need to contain stock with good fencing to avoid off-target damage
- condition of the land with intensity of grazing. For example, avoid heavy grazing pressure on regenerating pasture plants. Overgrazing may also leave bare ground, encouraging weed invasion.

Grazing animals can damage native vegetation and soil structure and may introduce weed species transported on fur or hooves, or in droppings, from other areas. Cattle, for example, are major agents in the spread of prickly acacia. After cattle eat prickly acacia pods the seeds pass through their gut (scarified by gut acids) and are subsequently deposited on the soil in a perfect environment for germination. Also, a number of weed species palatable to stock are toxic. Paterson's curse, also known as salvation Jane (*Echium plantagineum*); rubber vine (*Cryptostegia grandiflora*); and the fruit of lantana (*Lantana camara*) are toxic to stock, so it is important to confirm that stock will not be harmed by the weed to be grazed.

Treatment	Advantages (benefits)	Disadvantages (limitations)
Grazing (goats, cows, sheep, horses)	• Selective (depending on grazing animal and weed species being targeted) • Can remove excess foliage (for follow-up treatments) • Supplements other controls • Inexpensive	• Timing limitations • Disturbs soils • Can introduce / spread weed propagules • Encourages weed growth • Destroys local flora • Inappropriate for many ecosystems • Can elevate nutrient levels • Potential for erosion / runoff • Site rehabilitation required • On-going management required • Danger to stock if weed toxic

Appendix 2.1: Weed control contacts

State / Territory	Department	Phone	Email	Website
Australian Capital Territory	Environment ACT	Ph: 02 6207 9777 Fax: 02 6207 2227	EnvironmentACT@act.gov.au	www.environment.act.gov.au/ie4/petsandlocalwildlife/pests.html
New South Wales	NSW Dept. of Primary Industries	Ph: 02 6391 3100 1800 680 244 Fax: 02 6391 3336	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au/weeds
Northern Territory	Dept. of Infrastructure, Planning and Environment	Ph: 08 89992020 Fax: 08 89992015	weedinfo.DIPE@nt.gov.au	www.ipe.nt.gov.au
Queensland	Dept. of Natural Resources and Mines	Ph: 07 3375 0700 Fax: 07 3379 6815	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au/pests/index.html
South Australia	Dept. of Water, Land and Biodiversity Conservation	Ph: 08 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au/
Tasmania	Dept. of Primary Industries, Water and Environment	Ph: (cost of a local call) 1300 368 550	Quarantine.Enquiries@dpiwe.tas.gov.au Christian.Goninon@dpiwe.tas.gov.au	www.tas.gov.au/ OR www.dpiwe.tas.gov.au/inter.nsf/ThemeNodes/SSKA-52J2K4?open
Victoria	Dept. of Primary Industries	Ph: 03 9210 9379	ktri@dpi.vic.gov.au	www.dpi.vic.gov.au/
Western Australia	Dept. of Agriculture	Ph: 08 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au/progserv/plants/weeds/index.htm

Appendix 2.2: Herbicide application record sheet

Site location details: **Contact details of owner/manager:**								
Date, start & finish time	**Operator details:** Name, address and contact details (if not self)	**Weed species treated and method used**	**Name of herbicide and any additives used**	**Amount of concentrated product used (litres/millilitres or grams)**	**Total quantity applied:** Total amount of water, oil or other substances mixed with concentrated product	**Area sprayed (ha)** (mark on weed map)	**Estimated wind speed & direction**	**Comments:** Other weather details, risks identified etc