



Foreword

The Pinnacle Nature Reserve is a local environmental icon. It is a place to exercise in beautiful surroundings, contemplate the space beyond our fences, and get to know the seasonal growth and behaviour of our flora and fauna. It offers refuge to birds and other wildlife that cross the urban boundary. The health benefits from the quality of life it offers are long term, and the connection to place brings a sense of belonging.

But all is not well with The Pinnacle. This Reserve, part of the Canberra Nature Park system that includes Black Mountain, Mount Taylor and Mount Majura – is threatened by extensive and serious weed infestations.

If you walk through the park in late spring or early summer you could suddenly be in a forest of vicious saffron thistles. You will see large patches of horehound on the north side of The Pinnacle - a plant that displaces local flora - and walk through a virtual sea of sorrel and exotic grasses. The weed menace is now so great that only

a few small sections of the reserve contain a natural suite of plants.

Canberra's nature reserve system is central to conserving local and regional biodiversity. This important legacy to future generations is at risk of being lost forever if efforts are not now made to prevent further decline, and retrieve its natural values.

Implementing this Plan is a small first step by the Friends of The Pinnacle, as weed control alone will not see us achieve our objectives for The Pinnacle. We must also respond to threats from excessive grazing, inappropriate fire regimes, and impaired water quality and erosion.

We are a small group of volunteers, and strongly supported by the ACT Government - but simply unable to implement this plan without your help. We hope this draft plan leaves you better informed, making constructive comments, and inspired to join us.

The Friends of the Pinnacle

FOTPIN recognises and acknowledges the first custodians and traditional owners, the Ngambri/Ngurnal and Ngunnawal peoples, in whose country we live, dwell and work.



Summary

This Community Weed Management Plan has been prepared for community comment by the Friends of the Pinnacle (FOTPIN). The draft Plan proposes a goal and objectives for managing weeds at the Pinnacle Nature Reserve. It describes priority weeds and management principles, treatments, spatial priorities and continuous improvement strategies for weed control. The Plan estimates the effort required to achieve the Plan's performance targets, and compares that to current weeding effort on a seasonal basis.

A systematic weed survey conducted in Spring 2009 provides a firm basis for strategically planning weed management at The Pinnacle. The survey revealed a low density of woody weeds, extensive patches of Saffron Thistle and *Verbascum*, particularly throughout the south-west, and widespread exotic grasses and clovers. The survey also highlighted the extremely good condition of the Red Stringybark community at the western end of The Pinnacle and number of other patches dominated by native grasses.

The priority weeds for control under this Plan include African Love Grass, St John's Wort, Blackberry and a range of woody weeds. There are many hectares of Saffron Thistle, Horehound and *Verbascum spp.* also to be controlled. Control treatments depend on the weed

species and season, and include spraying with herbicides, slashing, grubbing, and cutting and dabbing with herbicide.

Significantly, this Plan deals with the challenge of increasing and improving the area and condition of native grasses across the reserve. It is proposed to slash large areas of exotic grasses prior to seed set, so that later seeding native grasses can out-compete exotic grasses and gradually recolonise slashed areas. This strategy will be complemented with an experimental approach to directly restoring native grasses by sequentially burning, spraying, slashing, soil treatment and reseeded with native grasses.

FOTPIN concludes that the major barrier to implementing this Plan is trained volunteer time and effort. We estimate, without including time for monitoring and reporting, that achieving the Plan's performance targets will initially require 1,182 hours per year, distributed across autumn (135 hours), winter (132), spring (447) and summer (468). In addition to current effort levels, a further 462 hours of trained volunteer time is needed, respectively distributed across the seasons.

If successfully implemented, this Plan will make a necessary and substantial contribution to improving the ecological integrity of the Pinnacle Nature Reserve.



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1. The Pinnacle Nature Reserve

The Pinnacle Nature Reserve is a unit of the Canberra Nature Park (CNP)¹. Totalling approximately 138ha, the Reserve is located on Belconnen’s southern boundary, adjacent to the suburbs of Weetangera and Hawker.

The Reserve adjoins Springvale Drive and private residences to the north, and to unleased and leasehold agricultural land on its southern and western boundaries.

The Reserve is promulgated under the ACT’s Territory Plan, and managed by Parks, Conservation and Lands (PCL). It is subject to a formal Plan of Management, which applies to all units of the CNP².

This weed plan applies to land delineated by a red line in Figure 1, including an ACTEWAGL water reserve (water tanks shown).

Figure 1: Pinnacle Nature Reserve – area managed under this Plan.



Portions of the Reserve are not managed primarily for nature conservation purposes – in particular the area between Hawker residences and the fenced reserve. This segment is managed primarily for recreation and fire hazard reduction, and is not of direct concern to this Strategy. However, this area will be regularly inspected for weed infestations, and potential threats to The Pinnacle.

¹http://www.tams.act.gov.au/play/parks,_conservation_and_land/parks,_reserves_and_open_places/canberra_nature_park

²<http://incp.environment.act.gov.au/Plans/strategies.aspx?planid=1&plan=Canberra%20Nature%20Park%20Management%20Plan>

Agricultural land adjacent to the Reserve is also a point of potential weed incursion. This Plan does not address weed control on these lands, however, the potential for weed incursions will be monitored.

1.1 Vegetation and geology

The dry sclerophyll forest in the west of the reserve features *Eucalyptus macrorhyncha* as the dominant tree species. The surface is rocky and the soils are thin or shaly. Shrubs dominate the understorey with smaller shrubs, fallen timber and leaf-litter at ground level. There are also forbs including daisies, orchids and lilies. Weed invasions are relatively rare in this part of the reserve.

There are scattered large eucalypts surrounded by grassland over much of The Pinnacle to the east of the forest. Isolated shrubs such as *Bursaria sp.* and *Cassinia sp.* remain especially near outcrops of boulders or amongst rocky ground. Native clumping plants, ferns, lilies and low shrubs are also preserved near rocks. Introduced grasses and weeds are less numerous in some of these rocky outcroppings, while many others are seriously weed infested.

Introduced grasses are common and represent the "pasture-improvement" practices of past lessees and graziers. Open grassland has been invaded by *Acacia*, forming thickets where fires have stimulated germination.

Grassland has been severely modified by plantings to revegetate the reserve and involve the public some twenty years ago. A range of *Acacia* species and other native trees or large shrubs were introduced to The Pinnacle at that time. They support foraging native birds, though some of the shrub species are not endemic to the area.

In the east and south of the reserve boulder areas are also valuable refuges for native vegetation. Here older eucalypts remain, indicating woodland prior to pastoral activity, and there are younger eucalypts closer to Coulter Drive from a more recent planting effort.

Several gullies divide the expanse of grass areas and support sedges and other native wetland plants. A dam captures waters from a minor creek draining from the 'reservoirs' area. Gullies in the Stringybark forest are rich in native plants including Sundews during wet springs. To the south of the ridge - which The Pinnacle represents - surface flows are to the Molonglo River 2km south of the reserve. Drainage from the north slopes may have reached Ginninderra creek prior to urban development.

Geology is predominantly composed of Hawkins volcanic suite, 443-423Ma (Early Silurian) which was deposited during a shallow marine and terrestrial period. Some limestone was also deposited during these marine periods.

2. Why tackle weeds?

Invasive weeds are among the most serious threats to Australia's natural environment. Weeds have major economic, environmental and social impacts, causing damage to natural landscapes, agricultural lands, waterways and coastal areas.

A weed is any plant that requires action to reduce its effect on the economy, the environment, human health and amenity. Weeds typically produce large numbers of seeds - assisting their spread - and are often excellent at surviving and reproducing in disturbed environments.

A weed can be an exotic or native species that colonises and persists in an ecosystem in which it did not previously exist³. Weeds range in size from small herbs (e.g. Paterson's Curse) and grasses to shrubs (e.g. Briar Rose) and trees (e.g. Willows). Weeds also alter bushfire pattern and intensity, and contribute to loss of plant cover and soil disturbance. They threaten the survival of many native plants because they:

- usually grow faster than native plants and successfully compete for available nutrients, water, space and sunlight;
- often survive better than native plants as they may not be affected by the pests or diseases that control them in their natural habitats;
- reduce natural diversity by smothering native plants or preventing them from growing back after clearing, fire or other disturbance; and
- replace native plants that animals use for shelter, food and nesting⁴.

A range of weeds have been identified by the FOTPIN at The Pinnacle, including shrubby weeds such as *Cotoneaster sp.*, Briar Rose and Chinese Pistachio. There are also St John's Wort and Paterson's Curse, at least three species of thistles and the broad-leafed *Verbascum spp.* There are significant infestations of African Love Grass adjacent to the reserve, and small incursions along northern tracks into the reserve. Introduced pasture grasses dominate the majority of the reserve.

Preventing and reversing the impacts of weeds is an early and necessary step by us to enhance the biodiversity values of The Pinnacle. In parallel with weed management activities, we will encourage the restoration of native species.

In developing our weed management proposals we have responded to the ACT Government's formal park management arrangements, and its Weeds Strategy.



³<http://www.weeds.gov.au/weeds/index.html>

⁴http://www.environment.act.gov.au/__data/assets/pdf_file/0003/157026/WEED_STRATEGY_web_version.pdf

2.1 The Plan of Management for Canberra Nature Park

The ACT Government's *Plan of Management for the Canberra Nature Park* was published in October 1999⁵. The Plan sets out some 180 strategies to be implemented over the life of the Plan. FOTPIN has reviewed these strategies, and notes the Plan proposes to:

- monitor pest plant populations, including detection of new species;
- implement a planning and work programming approach to group activities - e.g. prepare action plans for each ParkCare group, and prioritise Service input for best output in line with overall management objectives; and
- keep records of eradication methods and success in controlling such species to assist management in future programs.

A list of CNP Plan strategies relevant to weed control is at **Appendix 1(a)**. FOTPIN is satisfied this weed management plan assists the ACT Government to implement the CNP Plan at The Pinnacle.

2.2 The ACT Government's Weeds Strategy

In April 2009 the ACT Government released the ACT Weeds Strategy (2009-2019), a framework document for Government and non-government land managers, and the community, to work as partners to control weeds. The Strategy sets out five principles:

- weed management is essential for the sustainable management of natural resources and the environment and for social well-being, and requires an integrated, community-wide approach;
- prevention and early intervention are the most cost effective approaches that can be deployed against weeds;
- successful weed management requires a coordinated approach involving all levels of government in partnership with industry, landholders and the community;
- all land managers have a duty of care to manage weeds on their land; and
- community interests shall be protected from weeds by appropriate legislation.

The ACT Strategy seeks adoption of these principles at appropriate levels of weed management, and contains objectives and actions for achieving the desired outcomes⁶.

The ACT Weeds Strategy sets out the ACT's goals for weed management, and a broad framework for implementation. The ACT Government's Weed & Invertebrate Pest Management Guidelines⁷ provide guidance to prioritise and address specific weed problems. This Community Weed Management Plan implements the Weed Strategy and Pest Management Guidelines in the control of weeds at The Pinnacle.

FOTPIN's goal for weed management is to reduce the occurrence of target weed plants to isolated individuals, facilitating ecological restoration of the Pinnacle.

Measuring success towards this objective therefore commences with determining the nature and location of invasive weeds at The Pinnacle.

⁵ <http://incp.environment.act.gov.au/Plans/PlanDetails.aspx?planid=1>

⁶ http://www.environment.act.gov.au/__data/assets/pdf_file/0003/157026/WEED_STRATEGY_web_version.pdf

⁷ ACT Parks, Conservation & Lands, Programs Coordination, Stromlo Depot GPO Box 158, Canberra ACT 2601

3 Weed survey and infestation mapping

During October-December 2009 we surveyed The Pinnacle for target invasive weeds. The survey was conducted in two stages:

- **Transect surveys.** Over the weekend of 24 and 25 October we recorded target weeds along 20 north/south transects, 100m apart, between the northern and southern boundaries of the reserve, on grid eastings from 685100 to 687100 inclusive. Data on weeds, understorey, ground surface types and other features (e.g. fallen timber, rabbit burrows) was collected.

All individual plants of target weeds were recorded to 5m from either side of the transect line, other than where the infestation met the requirements for a 'patch'. Excepting Briar Rose, patches were recorded for all weeds to 50m either side of the transect. The transect surveys enabled us to identify most weed patches⁸ for subsequent mapping, and to estimate weed populations.

- **Patch mapping.** During November and December we mapped weed patches. Mapping included estimating patch density, and where this was not practicable, estimating the relative density. Patch mapping included mapping patches identified whilst walking between transect-derived patches.

The location of weeds along transects is calculated from GPS recordings of distance to the northern or southern end of the transect. Patches are mapped directly by a GPS as 'tracks'. ExpertGPS⁹ was employed to analyse and present waypoint and track information¹⁰.

We estimated the number of individual plants per hectare by dividing each transect into 100m sections and counting the number of the target weed counted within each section. The total number was estimated as the sum of the number in all sections divided by the area surveyed (total transect length by transect width, in hectares). An average total value and confidence limits were estimated using a bootstrap method. The same number of sections as in the actual data set was randomly sampled, with replacement, and the summary statistic recalculated. Five thousand permutations of the original data were used.

There are a number of limitations to our survey methods. The most important of these are:

- some weeds were difficult to detect due to size (e.g. St John's Wort), were submerged in tall grasses or thistles (e.g. Horehound), or germinated later in areas waterlogged during the survey and mapping (e.g. Nodding Thistle below the water tanks);
- weeds that were not recorded and mapped as patches, but were present in patches, and incompletely recorded in this report. These patches will be detected and recorded as weed controls are implemented; and

⁸ In some instances tall exotic grass species prevented locating some weed patches out to 50m.

⁹ www.expertgps.com

¹⁰ FOTPIN gratefully acknowledges the ACT Government for supplying the aerial photos.

- not all weed species were identified in the survey (e.g. Prickly Lettuce, Hoary Mustard). Weed species surveyed were those judged by us as most significant to The Pinnacle at the time of the survey.

Our transect surveys provided estimates of individual weed plants. These records do not include continuous patches. For species with clumped distributions, the estimates will be over-estimates because the method of calculation assumes a random distribution across the park. For example, Blackberry had a clumped distribution and abundance is more likely to be closer to the lower 95% confidence value than the average value.

3.1 Survey and mapping results

For the vast majority of The Pinnacle, the understorey consists of exotic grasses, sorrel and clovers, the legacy of its pastoral history. This exotic community represents the major barrier to restoring native fauna and flora at The Pinnacle, and is the most difficult to address. Figure 2 shows transect recordings of exotic grasses, sorrel and clovers across The Pinnacle.

Figure 2: A pastoral legacy: recordings of exotic grasses (orange), sorrel (black) and clovers (green)



There are several areas of The Pinnacle that retain native grasses, the largest of which are in the north-west associated with the stringybark community on steep slopes, and in the east. Figure 3 shows transect recordings of native grasses across The Pinnacle.

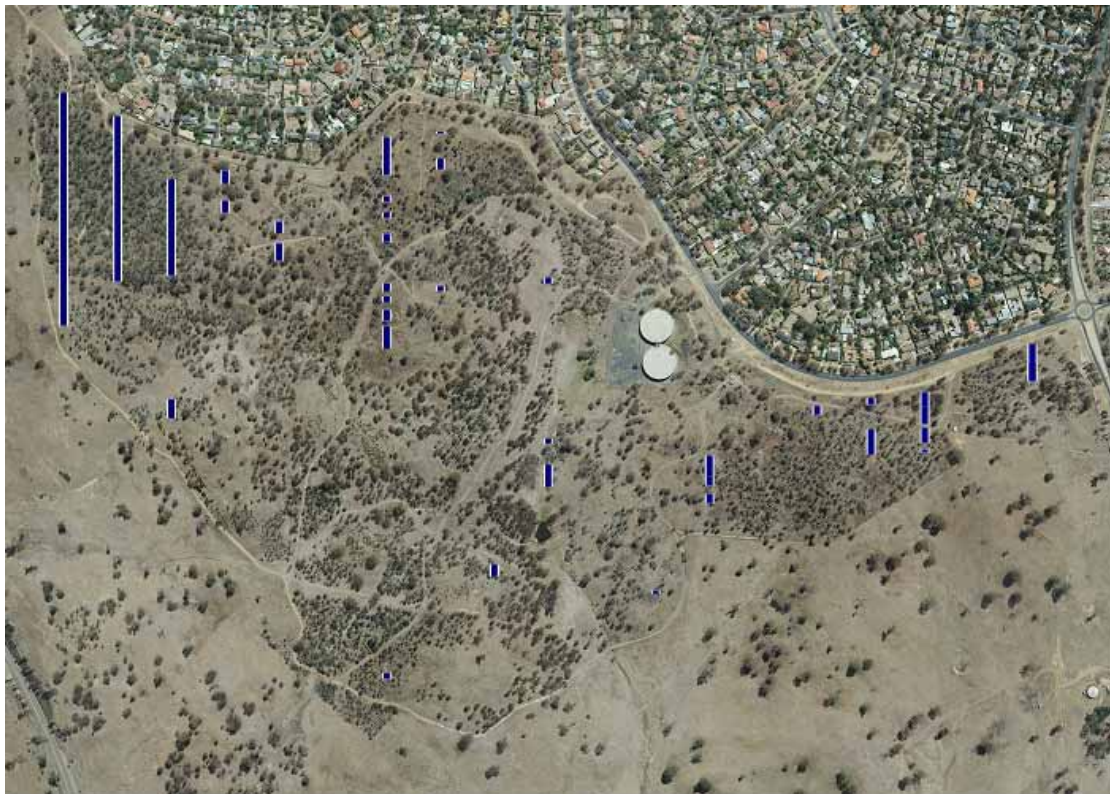
After the exotic grass community, the most widespread weeds at The Pinnacle are Saffron Thistle (*Carthamus lanatus*), *Verbascum spp.*, Horehound (*Marrubium*

vulgare) and St John's Wort (*Hypericum perforatum*). Presumably reflecting grazing history, the park's south west is heavily infested with all of these species. The eastern and northern sections are not as severely affected (Figure 4).

Figure 4 shows the location of mapped weed patches. Key findings are that the majority of heavy infestations are located to the south west of the Reserve, and that the stringybark forest (NW corner), northern boundary and eastern portion are relatively clear of non-grassy weed infestations. It is also significant that:

- Horehound (shaded blue) is located primarily in two large patches immediately to the north of The Pinnacle itself;
- *Verbascum virgatum* (pink) and *Verbascum thapsus* (brown) are often found in the same or immediately nearby patches, making estimates of total plant numbers and patch boundaries imprecise; and
- St John's Wort patches (yellow) are distributed across the reserve, reflecting the invasive nature of this weed.

Figure 3: Transect recordings of native grasses (blue lines)



Detailed records for target weed species are provided in Table 1. The location of individual plants along transects, and mapped weed patches are shown for each target weed in **Appendix 2**.

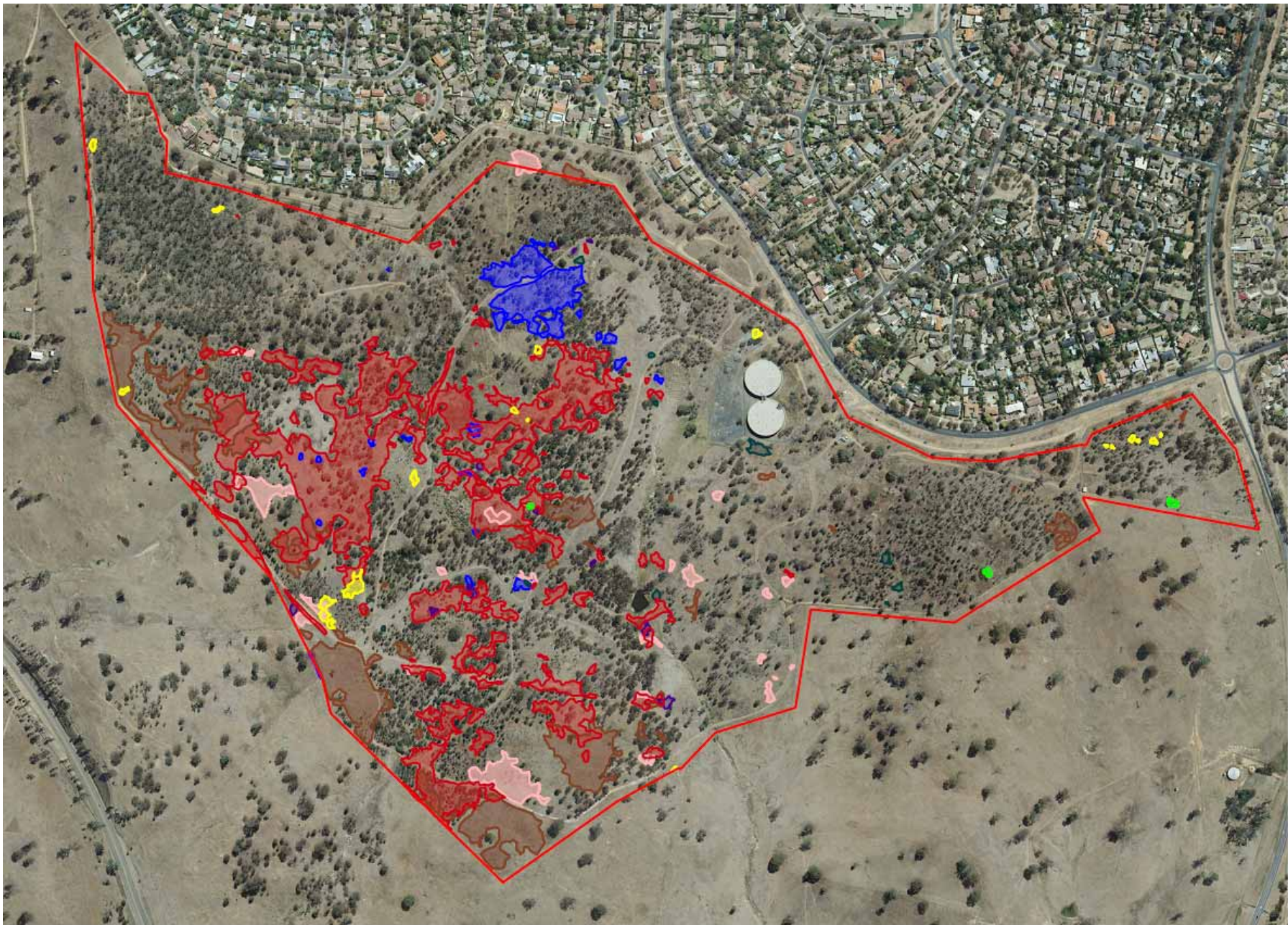


Figure 4: Location of mapped weed patches.

Table 1: Target weed patches and individual plants.

Category	Individual plants		Patches and individual plants ¹¹				
	no./ha	Total points ¹²	No.	Area	Size	Dens	Indiv
African Love Grass	Not recorded.		Not recorded.				
Blackberry	0.4 (0-1)	54 (14-135)	Not mapped				
Briar Rose	17.2 (13-22)	2,322 (1741-2956)					
Cootamundra Wattle	0.4 (0-1)	54 (0- 148)					
Capeweed	1.7 (0.9-2.7)	229.5 (122-365)					
Horehound	2.4 (1.3-3.7)	324 (176-500)	24	1.69	7-8,607	5.8	98,000
Nodding Thistle	2.3 (1.3-3.4)	310.5 (176-459)	11	0.11	23-275	1.05	1,200
Paterson's Curse	3.5 (2.3-4.8)	472.5 (311-648)	Not mapped				
Saffron Thistle	3.6 (2.1-5.2)	486 (284-702)	64	11.9	3-48,126	Not estimated	
Scotch Thistle	1.6 (0.8-2.5)	216 (108-337)	11	0.15	16-567	0.8	1,200
St John's Wort	5.3 (3.5-7.2)	715.5 (473-972)	18	0.25	9-739	2.5	6,200
<i>Verbascum thapsus</i>	3.5 (2.4-4.6)	472.5 (324-621)	34	6.14	14-14,981	1.2	73,110
<i>Verbascum virgatum</i>	2.9 (1.8-4.4)	391.5 (243-594)	25	1.36	16-4,969	0.55	7,550
Woody weeds	1.8 (1.1-2.6)	243 (149-351)	3	0.037	72-167	Not recorded	

4. Controlling weeds

The ACT Weed Strategy identifies broad approaches to weed control, advocating best practice management and initiatives developed through research. These practices usually involve multiple control measures and site rehabilitation to prevent re-infestation. The Strategy also recommends integrated programs, involving neighbouring land managers to reduce re-invasion.

Integrated approaches to weed control at The Pinnacle potentially include a range of types of intervention; however, not all are suitable or appropriate for The Pinnacle at this time. The types of intervention and their suitability are outlined in **Appendix 1(b)**.

There is considerable information available on treatment options for weeds. These treatments are informed by the weed's capacity for regeneration, seed production and response to herbicide. This information, derived from weeds.gov.au and the Pest Management Guidelines, is set out in **Appendix 1(c)**.

¹¹ No. = Number of patches. Area of patches in hectares. Size is smallest/largest patches. Dens = average density. Indiv = estimated plants in patches. The sum of indiv and upper limit of point records is an estimate of the maximum # of weed plants at the time of the survey.

¹² 95% confidence limits (upper and lower) in parenthesis

4.1 Weed management objectives and priorities

FOTPIN considers the objectives for weed management at The Pinnacle to be, in order of priority:

- reducing the occurrence of target weeds to isolated plants; and
- protecting and enhancing the extent and condition of native grasses and herbs.

Prioritising weeds for control is informed by the relative invasiveness of a weed, as well as potential for effective control. Table 3 reflects these criteria, and prioritises weeds for treatment.

Table 2: Weed management priorities¹³.

<i>Invasiveness</i>	<i>Target Weed¹⁴</i>	<i>Potential for effective control</i>	<i>Priority for treatment</i>
Highly invasive weeds that readily form mono-cultures.	African Love Grass St John's Wort	High	Very High
Invasive weeds that readily form monocultures, including in undisturbed areas.	Blackberry, Briar Rose, Woody Weeds Cootamundra Wattle	High	High
Invasive weeds that only form mono-cultures in disturbed areas	<i>Verbascum spp.</i> , Thistles (Nodding, Scotch, Saffron) Horehound, Capeweed Paterson's Curse	High	Medium
Weeds that usually only invade degraded or highly disturbed areas	Exotic Grasses and Herbs, Sorrel	Low-Medium	Low-Medium

4.2 Weed management principles and practices

Until other management and planning themes are addressed at The Pinnacle (for example restoration planning), active planting and seeding is not a key strategy in this Plan. However, future restoration outcomes will be assisted by adopting the following principles and practices in weed control.

4.2.1 Minimising soil disturbance

To avoid soil erosion and weed seed emergence after soil disturbance, we will minimise soil disturbance during weed control. We will do this by preferentially choosing, where possible, weed treatments that don't disturb soil, such as the spot use of herbicides. Where grubbing, chipping or pulling weeds is required, we will train volunteers to minimise soil disturbance in the following ways:

- to pack down soil after disturbance;

¹³ Adapted from p6, PCL Pest Management Guidelines.

¹⁴ A general alert exists for Mexican Feathergrass, Giant Willowherb and African Fountain Grass, which if detected would be a very high priority for treatment.

- to mulch disturbed sites with non-seed bearing exotic plant material (native grass hay may also be used in high priority restoration zones in the right season, and if available); and
- when grubbing, chipping or pulling in rocky outcrops, any disturbed rocks will be replaced.

4.2.2 Slashing adjacent to high priority native vegetation

Around high priority native vegetation areas (including Forest Block, Eastern and Weetangera Paddocks, and potentially some rocky outcrops), we will aim to slash introduced grasses after flowering but prior to seeding. This action to manage introduced pasture grasses at targeted sites, in addition to the other elements of this plan, should advantage native grasses and forbs over time. This will prevent seed set of introduced grasses but encouraging seed set of native grasses, and allow native vegetation to gradually extend from high quality areas of the reserve into poorer areas.

Figure 5 shows areas of exotic grasses, shaded green, proposed to be slashed to advantage native grasses. As with Figure 3, the blue lines show portions of transects dominated by native grasses. The area proposed to be slashed totals 9.3ha.

Figure 5: Proposed zones for slashing exotic grasses and herbs.



4.2.3 Protecting high priority native vegetation

We will maximise treatment and restoration outcomes by controlling widespread weed species (eg exotic grasses, Saffron Thistle) working outwards from the best native vegetation areas of the park (including within the Forest Block, Eastern and Weetangera, and potentially some rocky outcrops). This will provide a higher chance of native species in the seedbank recolonising areas following weed removal. In the centre of a weed patch, the same weeds are more likely to germinate.

4.2.4 Targeting weed patches

Weeds with discrete distribution patterns (identified by GPS) can be removed by targeting these patches. Long term, geo-referenced monitoring of these areas will be essential as these species may again germinate if conditions are suitable and we stop focusing on their control.

4.2.5 Managing the seedbank

Managing the weed seedbank is vital to efficiently achieving our weed control objectives at The Pinnacle. Seedbank management is directed at minimising seed introduction and efficiently removing viable seeds, where seeds can be:

- gained into the seedbank through weed plants setting and releasing seed before the plants are controlled, seeds blowing into The Pinnacle, or being transported in by birds, animals, people or machinery; and
- lost from the seedbank by losing viability over time – weed seeds have different life-spans in the soil seedbank, and by controlling the production of new seeds (removing weed plants, slashing before seed set), weeds will die out in the reserve. Weed seeds from the seedbank may also germinate, but the weed plants should be controlled before they set seed. Over time this will result in a net loss to the seedbank.

Of the priority weeds in this plan:

- Verbascum has a long life-span in the seedbank (40-100 years);
- African Love Grass most likely has a long lifespan also (another species in the genus was found to be still viable after 1500 years);
- St John's Wort seeds lasts at least 10 years, but most germinate in the first few years¹⁵;
- Horehound may survive in the seedbank for 7-10 years¹⁶;
- Saffron Thistle – some seeds survive up to 8 years, but most are destroyed¹⁷;
- Nodding Thistle can be viable up to 20 years;
- Scotch Thistle can be viable up to 8 years; and
- Paterson's Curse is viable for at least 7 years.

¹⁵ (http://dpi.vic.gov.au/DPI/Vro/vrosite.nsf/pages/invasive_st_johns_wort)

¹⁶ (http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/invasive_horehound)

¹⁷ http://dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/invasive_saffron_thistle

To minimise these weed species in the seedbank, we will conduct long-term control and monitoring. If no new plants are observed after the seed viability period has passed, then the species is likely to have been effectively controlled in the reserve. However, because of the potential for weed seeds to be transported by humans, birds and animals entering the reserve, weed monitoring at the reserve will need to be continued beyond the seedbank lifespan of the target weed species.

In the long term, restoration of a native plant community may help to reduce the risk of reinfestation of many weed species.

4.2.6 Preventing seed set and dispersal.

Preventing weeds from setting seed, and if they do avoiding dispersal, is an important factor in weed control at The Pinnacle. The following practices will therefore be incorporated into weed controls at The Pinnacle:

- where volunteers discover an isolated weed plant that is in seed, they will bag the seed head in a plastic bag to avoid the seeds spreading. The bag will then be sealed and disposed of by: leaving the bag in the sun, incinerating it, putting it into a container of water so that the seeds decompose;
- where there are patches of flowering weeds (particularly introduced grasses, but potentially also thistles and others in association with introduced grasses), slashing the patch before seed set may be the most efficient option to avoid a new infestation of seed;
- priority for slashing flowering weeds at peak times will be given to patches on the edge of high priority vegetation to avoid the infestation spreading into the good quality vegetation, and to allow the native vegetation to spread outwards from the good sites; and
- where weed seeds are wind-borne (e.g. thistles), it will be a priority to control plants before seed set, or to bag seed heads to avoid new patches forming.

4.3 Restoring native grasses

The most widespread group of weeds at The Pinnacle are the exotic grasses, along with sorrel and exotic clover species. This cluster of species likely represents the most profound environmental change throughout the park, both because they cover the majority of the area, and because they exclude most other native plants. They also represent a substantial barrier to the restoration of native fauna. Restoration of The Pinnacle therefore requires that this most widespread and difficult problem is addressed.

Although grassy woodland restoration remains in an experimental phase, research led by Susan Prober has provided some promising leads. Given this, we aim to adopt a research approach to better understand how to treat exotic grasses and restore the native understorey of The Pinnacle.

We will use a small-scale experimental approach to trial a limited number of treatments but with substantial replication to ensure that we have adequate statistical power to make robust inferences. Our core actions are to reduce weed cover and weed seed banks, reduce competitiveness of exotic grasses by reducing nutrients, and add native grass seed to all treatments. We expect that reducing weed cover and seed banks will require substantial effort, so rather than apply single treatments, we will apply a combination. To reduce the prevalence of exotic grasses we will propose:

- burning in autumn¹⁸ to stimulate germination of weed seed;
- spraying herbicide in spring to kill germinating and resprouting weeds; and
- slashing in spring and summer any weeds that continue to grow and flower.

Although repeated burning at short intervals may be detrimental to native species, proposed burning is designed to be detrimental to exotic species and is only applied once during the experiment. To reduce nutrients, we will add sugar. We will seed plots with a range of native species to maximise the opportunities for natives to establish across a range of conditions. The mix will include *Themeda*, and depending on availability, *Stipa*, *Danthonia*, *Bothriochloa macra* and *Microlaena stipoides*.

See **Appendix 3** for detailed information and budget for this experimental approach to treating exotic grasses and restoring native grasses. We will initially seek approval and cooperation from the ACT Government to conduct the experiment, and when funding opportunities arise, a detailed implementation plan will be prepared.



¹⁸ Only Act Parks, Conservation and Lands can undertake ecological or hazard reduction burns. FOTPIN will propose an ecological burn be added to the Bushfire Operational Plan, which will be prioritised according to resources and priority. External factors will determine whether a burn takes place or not.

4.4 Priority treatments

Table 4 summarises FOTPIN's proposals for treating target weeds. This summarises the decision-making process outlined in **Appendix 1(c)**, which was based on the Pest Management Guidelines and our experience.

Table 3: Summary of proposed weed treatments.

Priority Weed	Proposed Treatment(s)
African Love Grass	Foliar spray with Roundup Biactive®.
St John's Wort	Foliar spray with Starane Advanced®.
Blackberry	Foliar spray with Brushoff®.
Briar Rose, Woody Weeds, Cootamundra Wattle	Grubbing. Cut and dab, and foliar spray, with Roundup.
Saffron Thistle	Grub isolated plants. Infestations amongst exotic grasses, foliar spray with MCPA ¹⁹ at rosette stage; otherwise slash prior to flowering.
<i>Verbascum spp.</i>	Rosettes and flowering plants: grub or foliar spray with Roundup Biactive®. Mature seedpods: bag and remove.
Nodding and Scotch Thistle	Rosettes: grub or foliar spray with MCPA. Grub prior to flowering.
Horehound	Grub individual plants and small patches. Foliar spray of MCPA over large patches.
Paterson's Curse	Foliar spray with Roundup Biactive®.
Capeweed	Foliar spray with Agritone ²⁰ .
Exotic grasses	Slash with brushcutter.

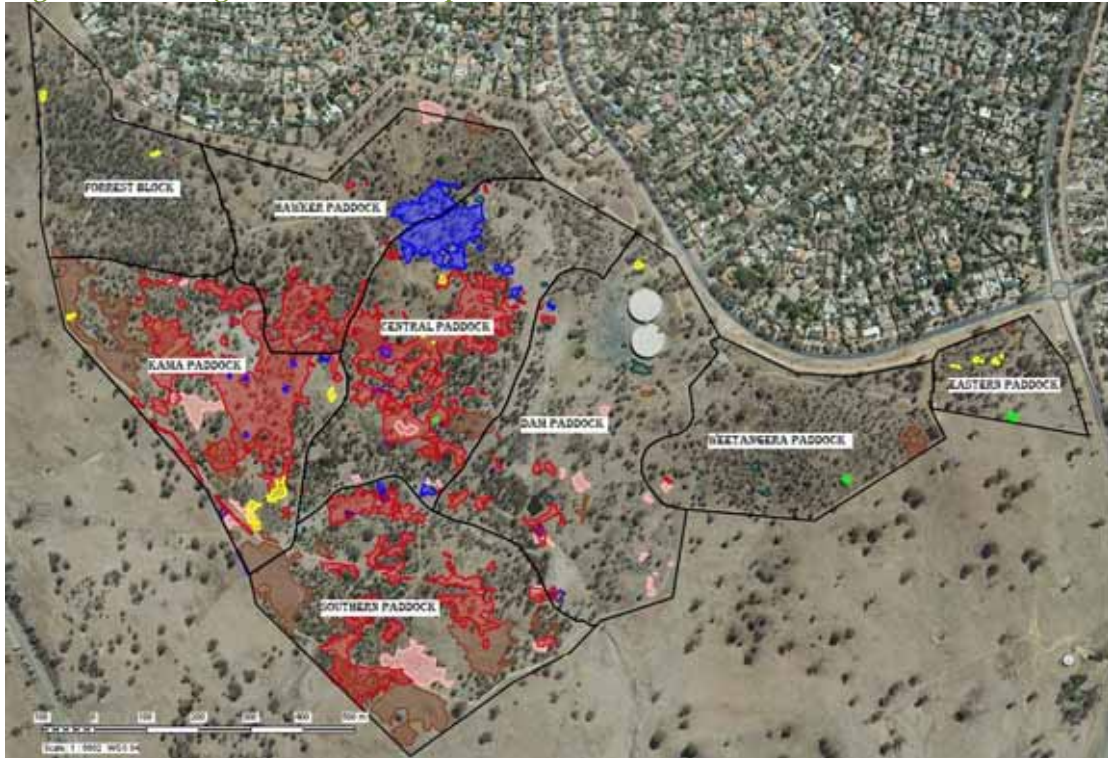
4.5 Geographic priorities

Weed control at The Pinnacle is a large undertaking for a community group. Given the size of the Reserve, the range of habitats present and varying weed distribution, we have apportioned the reserve into eight management zones, or 'paddocks' (Figure 6).

¹⁹ MCPA is not listed as one of the herbicides available to volunteers in PCL's Volunteer Policy. MCPA use is approved on a 'case by case' basis.

²⁰ Agritone is registered in the ACT for control of Capeweed however it is not a herbicide presently approved for use by volunteers.

Figure 6: Management zones or ‘paddocks’



Using the ‘paddocks’ and weed infestation information in Figure 4, we propose to undertake weed control based on relative habitat quality, such that priority is generally given to firstly controlling weeds in the Forest Block, Eastern and Weetangera Paddocks, followed by, in order;

- the Hawker and Dam Paddocks;
- the Central and Kama Paddocks; and
- the Southern Paddock.

In this way infestations – particularly Saffron Thistles and Verbascum - are progressively controlled in the less infested paddocks, ‘retreating’ to the Southern Paddock, and eventually found only as isolated plants.

4.6 Weed treatment program

FOTPIN has prioritised weeds for treatment (Table 2), prioritised treatments according to effectiveness, efficiency and consistency with weed management principles (Table 3), and prioritised control activities on a geographic basis. Through rigorously applying target weed, treatment and geographic priorities, we will maximise the likelihood of achieving the Plan’s weed management goal.

The above translates to the following seasonal strategies for plan implementation, undertaken on a priority paddock basis:

- (1) **year-round:** volunteers spray **African Love Grass**, and grub or spray **Briar Rose**.
- (2) **autumn and winter:** volunteers will:

- grub, spray or remove seed heads on **Verbascum**;
- spray **Nodding** and **Scotch Thistles**; and
- grub or spray **Horehound**, **Paterson’s Curse** and **Capeweed**.

(3) **spring and summer**: volunteers will, in order of priority:

- apply foliar spray to flowering **St John’s Wort**²¹;
- apply foliar spray to **Blackberry**;
- cut and dab **woody weeds** and **Cootamundra Wattle**;
- spray **Saffron Thistle** rosettes, or slash prior to flowering;
- grub **Scotch** and **Nodding Thistle**, and **Verbascum**;
- spray **Horehound**;
- spray **Paterson’s Curse** and **Capeweed**; and
- slash **exotic grasses**.

Controlling Horehound at The Pinnacle is possibly more complex than for other weeds. Horehound has formed dense monocultures over large areas of sloping, erodible soil. Though undesirable, FOTPIN considers these infestations protect the soil from erosion, and so treatments may need to be combined with soil protection measures.

Given the above, our plan is to grub individual plants across the reserve. Smaller patches will be grubbed or sprayed and may for example, and depending on the site, be direct seeded with local replacement species. Treatment options for large patches will include spraying, and will be trialled in conjunction with soil protection measures. These trials, part of the proposed adaptive implementation program, will help determine the most suitable soil protection regimes for successful treatment of large patches.

Scotch and Nodding Thistles, Verbascum and St. John’s Wort germinate during the spring to autumn period. Volunteer teams will repeat treatment ‘sweeps’ across the reserve, monitoring and treating infested paddocks on a priority basis - possibly up to four times, depending on the season. **Appendix 1(d)** sets out a management calendar for the above treatment program.

5. Adaptive implementation

Adaptive implementation is a process used to ensure continuous improvement in designing and implementing interventions to achieve desired outcomes. Typically, adaptive implementation includes the elements shown in Figure 6.

Some of the features of adaptive implementation have been developed in preparing this plan, in particular:

²¹ Note that PCL contract boom and spot spraying for St John’s Wort at The Pinnacle. FOTPIN is proposing to supplement this with volunteer-based spraying.

- a weed survey and mapping program, which is a baseline for monitoring weed infestations (Section 3);
- management objectives for weeds, Section 4.1; and
- management strategies and actions, Section 4.6.

The **performance indicator** or ‘**target**’ for weed control is whether *all detected plants are treated, and that no new seed is added to the soil seed-bank from plants on the Reserve.*

Figure 7: A conceptual model for adaptive implementation



This weed plan will be implemented over a 10 year period. Given the limited resources presently available to implementing this plan, competent monitoring, reporting and adaptive implementation systems will be essential to maximise the efficiency and effectiveness of our implementation program. It is proposed that this weed plan contain the following adaptive and continuous improvement elements:

Monitoring. The plan will include a community monitoring program that, as a minimum;

- includes late spring transect surveys and infestation mapping every three years;
- records effort and resources applied implementing the plan;
- maps Capeweed, Paterson’s Curse and Cootamundra Wattle patches in 2010;
- records the timing, location and nature of treatments; and
- records approximate number of a plants treated (excluding heavy infestations, such as with Saffron Thistles and Verbascum).

Reporting. The plan will include a community reporting program that, as a minimum;

- reports biannually on effort, treatments and performance against targets²²;
- reports less frequently (possibly every 3 yrs) on all data and information collected through the monitoring program; and
- describes changes to implementation, derived from the adaptive implementation program.

Adaptive implementation. The plan will include an adaptive implementation program that, as a minimum;

- identifies key scientific uncertainties in weed control at The Pinnacle;
- creates learning opportunities through experimental design and activity;
- actively incorporates new learnings – from external sources and in implementing this plan – into our management strategies; and
- provides for a mid and end of term community review of the plan and its implementation.

Appendix 1(e) sets out elements of the proposed biannual report

Reasonable assurance

The final plan will include a reasonable assurance statement. The purpose of this statement is to give confidence to the reader, by way of summarising evidence presented elsewhere in the plan, that implementing the plan will achieve the desired performance targets for a target weed. Therefore, a reasonable assurance statement is dependent on sound environmental information, on characterising the effectiveness of management proposals, and certainty that sufficient effort and resources will be available to implement management proposals.

For example FOTPIN may provide a high degree of confidence that ***all Nodding and Scotch Thistle plants are treated, and that no new seed is added to the soil seed-bank from plants on the Reserve*** because:

- the upper estimate of thistle population is 800 isolated individuals and plants within patches totalling an area of 2,600m². The manner in which the population is estimated, using 95% upper confidence limit, introduces a conservative ‘margin of safety’ for estimating effort;
- our weeding effort trials to date demonstrate isolated plants can be grubbed at a rate of 30 plants per hour, and patch plants grubbed at a rate of 200 per hour. This and other trials suggest thistles may be sprayed as individual plants at 100/per hour or in patches at 400 m² per hour. This means up to 9 hours effort is required to treat isolated plants and 7 hours effort for thistle patches;
- Nodding and Scotch Thistles will be treated during spring, summer and autumn, with up to four treatment cycles across the reserve, timed to ensure plants do not set seed. This means a total of 15 hours effort is required every

²² A mockup biannual report is presented in Appendix 1(e) for the purpose of public comment.

six weeks over a period totalling 24 weeks, meaning a total of 60 hours to treat these weeds; and

- current reliable FOTPIN weeding effort over this period is equivalent to about 630hrs.

If Scotch and Nodding Thistles were FOTPIN's weeding priority then, based on the above case, we would give reasonable assurance of achieving the plan's performance target for these weed species.

If at the time of the final plan reasonable assurance cannot be provided for certain weeds, then we may provide 'limited assurance', with an expectation that during the life of the plan additional information and resources may become available, so as to provide 'reasonable assurance'.

6. Resourcing the plan

Achieving the plan's performance targets and management objectives depends on adequate equipment, chemicals and volunteer time, sustained for many years.

FOTPIN believes equipment and chemical requirements - other than those required to restore native grasses (Section 4.3) - are not presently constraints to implementing the plan. Our members have hoes, mattocks, spray backpacks, brushcutters and GPS units, and will purchase or be granted more units and chemicals as required. Volunteers to be spraying herbicides will be trained and accredited under the 'ChemCert' program²³.

The constraint to implementing this plan is volunteer time to treat weeds, which will be particularly needed during peak weed growing season (October to April), when slashing and spraying activities are implemented concurrently.

Our proposal to restore native grasses, detailed in Appendix 3, requires an investment of some \$11,500. FOTPIN is unable to undertake this project without external support.

Table 4 sets out the resourcing effort required to treat known infestations of target weeds, including the number of individual plants or patch area that may be treated in an hour. For example we estimate 1,740m² of Saffron Thistle can be slashed in one hour by one person operating a brushcutter. 11.9ha of Saffron Thistle patches have been mapped, and so to slash this will require approximately 54hrs of effort during a 4-5 week window of opportunity.

Some weeds, for example Verbascum and Nodding and Scotch Thistle, germinate, flower and seed throughout the spring-autumn period. Our experience indicates that up to four repeat treatments during this period are required to prevent seeding

Table 4 indicates where repeat treatments are required and factors those into the effort required to achieve this plan's performance targets.

²³ <http://www.chemcert.com.au/>

Table 4: Annual effort to achieve proposed performance targets.

Target weed	Treatment	Recorded	Units	per hr	repeats	hours
African Love Grass	foliar spray	-	plants	-	-	24
St John's Wort	foliar spray	7,172	plants	200	3	108
Blackberry	foliar spray	135	plants	30	1	6
Briar Rose	foliar spray	2,956	plants	150	1	21
Woody weeds ²⁴	cut/dab	12	plant	6	1	4
Cootamundra Wattle	cut/dab	148	plants	20	1	9
Saffron Thistle	grub	702	plants	30	1	24
	spray/slash	119,000	m ²	1,740	1	69
Horehound	grub	500	plants	25	1	23
	foliar spray	16,920	m ²	500	1	36
<i>Verbascum spp.</i>	grub	1,215	plants	60	4	83
	foliar spray	79,000	m ²	500	4	645
Scotch and Nodding Thistles	foliar spray	796	plants	100	4	33
	foliar spray	2,600	m ²	400	4	27
Paterson's Curse	foliar spray	648	plants	300	1	6
	foliar spray	15,000	m ²	1,740	1	9
Capeweed	foliar spray	330	plants	200	1	3
	foliar spray	10,000	m ²	1,740	1	6
TOTAL VOLUNTEER HOURS FOR NON-GRASS SPECIES						1131

FOTPIN has measured trained volunteer time required to implement some of the treatments, in particular:

- Briar Rose can be grubbed at a rate of 45 plants per hours;
- isolated *Verbascum* can be grubbed at a rate of 60 plants per hour, or in patches, at a rate of 400 per hour;
- Saffron Thistle can be slashed at a rate of 1,740m² per hour.

Treatment efficiencies have been derived for other weeds and/or treatments from the above measurements, and it is considered that;

- spraying St John's Wort, which is commonplace and mostly found outside patches, can be sprayed at a higher rate than grubbing *Verbascum*;
- spraying *Verbascum* patches is more time effective than grubbing *Verbascum*; and
- spraying Saffron Thistle, Paterson's Curse and Capeweed will be at a similar areal rate to slashing Saffron Thistle.

The remaining weeds and treatments carry less precise effort estimates, however, errors in those estimates represent a lower risk to achieving the Plan's performance targets than those specifically addressed above.

²⁴ Since the survey all known woody weeds have been treated in the reserve, and all briar roses grubbed. For planning purposes it is assumed woody weeds require no further treatment, and that germinating plants will be sprayed as they are detected treating other weeds. It is assumed all grubbed briar rose will reshoot from root stock, and will be sprayed as they are detected treating other weeds.

Table 5: Scenarios for volunteer effort.

Weeding effort scenarios		Volunteer events (hours)				
	Description	Autumn	Winter	Spring	Summer	Total
(1)	2 weekend events* per month	6(90)	6(90)	6(90)	6(90)	24(360)
(2)	Current scenario. (1) + 2 weekend and 2 weekday events per month in spring and summer (~)	6(90)	6(90)	18(270)	18(270)	48(720)
(3)	(1) + 4 weekend and 4 weekday events per month in spring and summer	6(90)	6(90)	30(450)	30(450)	72(1180)

*an event is comprised of 5 people working 3hrs (15hrs)

Table 6 sets out weed infestation information, treatment efficiencies and effort required to achieve weed treatment performance targets, on a seasonal basis.

Further, we estimate that for controlling weeds at The Pinnacle²⁵:

- monitoring efforts will be equivalent to ~5% of on-ground effort time;
- reporting effort will be in the order of 2-5% of total effort; and
- continuous improvement processes will be ongoing and within the error of estimating total effort.



²⁵ based on current benchmarks and relative complexity.

Table 6: Timing of volunteer effort to treat target weeds.

Weeds/priorities	#	units	rpts	units/hr	hrs	bal	AUTUMN			WINTER			SPRING			SUMMER		
							events	hrs	treated	events	hrs	treated	events	hrs	treated	events	hrs	treated
African Love Grass	-	plant	1	-	24	-	0.4	6	-	0.4	6	-	0.4	6	-	0.4	6	-
St John's Wort	7,172	plant	3	200	108	-84							3.2	48	9,600	4	60	12,000
Blackberry	135	plant	1	30	6	-45							0.2	3	90	0.2	3	90
Briar Rose	2,956	plant	1	150	21	-194							0.8	12	1,800	0.6	9	1,350
Cootamundra Wattle	148	plant	1	20	9	-32							0.6	9	180			
Saffron Thistle	702	plant	1	30	24	-18							1.6	24	720			
Saffron Thistle	119,000	m ²	1	1,740	69	-1,060							2.6	39	67,860	2	30	52,200
Horehound	500	plant	1	25	23	-63				1.5	23	563						
Horehound	16,920	m ²	1	500	36	-1,080	1.2	18	9,000	1.2	18	22						
<i>Verbascum spp.</i>	1,215	plant	4	60	83	-90	1.5	23	1,350				2	30	1,800	2	30	900
<i>Verbascum spp.</i>	79,000	m ²	4	500	645	-6,500	4	60	30,000	5	75	37,500	15	225	112,500	19	285	142,500
Scotch/Nodding	796	plant	4	100	33	-116	0.5	8	750				0.9	14	1,350	0.8	12	1,200
Scotch/Nodding	2,600	m ²	4	400	27	-400	0.5	8	3,000				0.7	11	4,200	0.6	9	3,600
Paterson's Curse	648	plant	1	300	6	-1,152	0.2	3	900	0.2	3	900						
Paterson's Curse	15,000	m ²	1	1,740	9	-660	0.4	6	10,440	0.2	3	5,220						
Capeweed	330	plant	1	200	3	-270	0.1	2	300	0.1	2	300						
Capeweed	10,000	m ²	1	1,740	6	-440	0.2	3	5,220	0.2	3	5,220						
Exotic grasses	87,000	m ²	1	1,740	51	-1,740							1.8	27	46,980	1.6	24	648
Total					1182		9	135		8.8	132		30	447		31.2	468	
Current effort level							6	90		6	90		18	270		18	270	
Deficit (hours)								-45			-42		-10	-177		-11	-198	

Table 6 sets out the basis for determining volunteer time to treat target weeds, as patches (m²) or isolated plants. Survey data is provided (#), treatment repeats (rpts), units of weed treated per hour and hours required to treat the weed, on a seasonal basis. Weeds in bold are weeds for which there is a high likelihood of meeting performance targets, and for which FOTPIN may be able to give *reasonable assurance*. Values may not add due to rounding. The above suggests that across all seasons additional volunteer effort will be required to achieve the control performance targets for all priority weeds, ranging from an additional 42 hours effort in winter to 198 hours in summer. At current effort levels FOTPIN may be able to give reasonable assurance of achieving performance targets for African Love Grass, St John's Wort, Blackberry, Briar Rose, Cootamundra Wattle, Saffron Thistle and Horehound in Yr1 of the Plan. As the seedbank for these weeds diminishes performance targets will be more easily achieved and assurance may be given for additional priority weeds.

Appendices

Appendix 1(a): Related strategies in the Canberra Nature Park Management Plan (1999).

Chapter heading	Heading	Strategy #	Strategy
Management of Natural Resources	Specific reserve management	3.2.1	Develop a management strategy for each CNP reserve including identification of values, features and facilities, fire history, exotic species, vegetation, specific management objectives, management zones, actions and priorities, and opportunities for volunteer participation.
	Ecological communities	3.3.8	Participate in surveys, research and monitoring of plant species and communities as part of specific reserve management strategies.
Management for Protection of the Environment	Fire management	5.1.8	Integrate fire risk management to meet human needs while recognising the use of fire in vegetation management.
	Exotic plants	5.6.2	Encourage participation by volunteers, particularly ParkCare groups, in the control of pest plants.
			Monitor areas that have had exotic plants removed to identify the need for rehabilitation to minimise erosion, and to minimise the re-establishment of pest plants from seeds remaining in the soil or from rootstock.
			Keep records of eradication methods and success in controlling such species to assist management in future programs.
			Monitor pest plant populations, including detection of new species.
Pollution control and waste management	5.7.2	Remove vegetation wastes generated by volunteer activities as quickly as possible and investigate alternatives to removal for some wastes e.g. chipping of seed free material and use of mulch on site.	
Community Awareness and Participation	Community participation	7.3.2	Encourage community participation in management programs including through community group information networks.
Community Awareness and Participation	ParkCare	7.4.3	Implement a planning and work programming approach to group activities - e.g. prepare action plans for each ParkCare group, and prioritise Service input for best output in line with overall management objectives.
			Liase and cooperate with other agencies and groups (e.g. Greening Australia, Landcare, ATCV, Society for Growing Australian Plants, COG) to foster community networking and achieve efficient outcomes.
Uses Requiring Approval	Research activities	8.1.7	Assist in the identification of long-term research and monitoring needs and mechanisms for implementation consistent with strategies (e.g. Action Plans and the Nature Conservation Strategy).
			Further develop and implement the GIS. Develop a local system for field use to identify, monitor natural and cultural resources and address aspects including resource location and significance and indicators of change.

Appendix 1(b): Weed management interventions (ACT Weed Strategy 2009).

Type of intervention	Suitability at The Pinnacle
<p><u>Herbicide use:</u> includes spot spraying, cut stump treatment, stem injection, and basal spray. Chemicals can be specific, targeting particular species or group of species, with low toxicity to humans, other animals and non-target plants.</p>	<p>Yes. The extent of weed invasion requires effective and efficient control measures. Volunteers using herbicides will be “ChemCert” trained and have suitable personal protective equipment</p>
<p><u>Biological control:</u> usually involves introducing predators or diseases from a weed’s area of origin. Testing biological control agents is often expensive, time consuming, and can be ineffective in isolation from other control mechanisms.</p>	<p>Yes, where PCL is implementing a biological control strategy.</p>
<p><u>Hygiene:</u> ensuring machinery operators apply hygiene protocols.</p>	<p>Yes, requiring contract sprayers and volunteers to apply appropriate hygiene protocols to machinery and equipment.</p>
<p><u>Mechanical/physical removal:</u> mechanical slashing, physically removing by hand including pulling, hoeing and cutting.</p>	<p>Yes, in conjunction with remedial planting and restoration work, and minimal soil disturbance. Slashing exotic grasses before seeding and before native grasses flower. OHS training and personal protective equipment for volunteers.</p>
<p><u>Pasture and vegetation management:</u> improving the competitiveness of native grasses, forbs and shrubs by maintaining adequate cover to prevent weed infestations.</p>	<p>Possibly, to be explored through proposed grassland restoration experiment and appropriate management.</p>
<p><u>Fire:</u> using fire to maintain/increase native species and reduce the extent of exotic species.</p>	<p>Possibly, working with PCL to explore the use of fire could be appropriate.</p>
<p><u>Grazing management:</u> the selective grazing of some weed species by livestock such as sheep and goats.</p>	<p>Unlikely, management of kangaroo grazing using movable fencing may be impractical.</p>
<p><u>Isolation of infestation:</u> removing stock from infested areas to prevent weed spread, establishment of buffers for containment of weed species.</p>	<p>Unlikely, difficult to achieve with kangaroo and rabbit populations transporting seed.</p>

Appendix 1(c): Summary of treatment decisions for target weeds.

Weed	Non-herbicide treatments	Herbicide options ²⁶	Treatment constraints and opportunities	Proposed Treatment
1. African Love Grass²⁷	Scattered plants can be chipped before flowering.	Roundup & Taskforce®	Physical disturbance promotes seed spread. Glyphosate is available to trained volunteers and has wide application.	Foliar spray with Roundup ²⁸ Biactive®.
2. St John's Wort²⁹	Handpulling and grubbing before flowering.	Various	Will regrow if root pieces are left after grubbing. Starane is a partially selective herbicide, and available to trained volunteers.	Foliar spray with Starane Advanced®.
3. Blackberry	Burning, slashing, grazing and grubbing.		Brushoff is recommended.	Foliar spray with Brushoff®.
4. Briar Rose	Grubbing. Handpulling smaller plants.		Can be poisoned by cutting stems back to near ground level and painting with Glyphosate. Glyphosate is used for other weeds.	Cut and dab, foliar spray with Roundup.
5. Woody weeds			Can be poisoned by cutting stems back to near ground level and painting the cut stem with Roundup.	Cut and dab with Roundup.
6. Cootamundra Wattle	Smaller plants are removed by pulling.		All herbicide options are non-selective, and spraying large infestations close to native species may be impractical. Mowing, cutting or slashing effectively prevents seed production if conducted just before flowering. Plants will regrow if slashing is conducted too early.	Grub isolated plants. Patches amongst exotic grasses, foliar spray with MCPA at rosette stage. Slash prior to flowering.
7. Saffron Thistle	Mowing, cutting or slashing.	Roundup Biactive® Brushoff®	When pulling, loosening soil stimulates seed germination. If flowering has occurred, heads must be removed, bagged and disposed. Roundup is recommended and used for other weeds.	Grub or foliar spray with Roundup Biactive®. Mature seedpods: bag and remove.
9. Nodding Thistle	Grubbing, ensuring most of the taproot is removed. Mowing or slashing immediately before flowering.	Various.	All herbicide spraying options are non-selective, and common infestations with saffron thistle suggests common treatment would be efficient. Grubbing out plants can be undertaken early in the growing season.	Rosettes: grub or foliar spray with MCPA. Grub prior to flowering.
10. Scotch Thistle				
11. Horehound	Manual removal of seedlings, prior to flowering.	MCPA 500®	MCPA is partially selective. Horehound is mostly in two large patches as a mono-culture, targeted spraying will minimise non-target kills.	Grubbing isolated individuals, foliar spray of MCPA over large patches.

²⁶ Based on options in the PCL Pest Management Guidelines.

²⁷ Spraying African Love Grass with Taskforce® is a PCL priority. This Strategy does not propose an alternative approach.

²⁸ Roundup Biactive® is the form of glyphosate recommended in the PCL Guidelines.

²⁹ Spraying St John's Wort with Starane is a PCL priority. This Strategy does not propose an alternative approach.

Weed	Non-herbicide treatments	Herbicide options ²⁶	Treatment constraints and opportunities	Proposed Treatment
12. Paterson's Curse	Physical control (e.g. hand hoeing and pulling).	Various	Flowering plants must be destroyed as seeds will mature after the plant is cut, etc. Herbicides are partially or non-selective, and should be applied when plant actively growing.	Hand hoeing isolated plants at the rosette stage. Foliar spray with Roundup.
13. Capeweed	Grubbing small areas or light infestations.	Agritone is registered in the ACT.	Grubbing is generally inefficient and exposes soil to erosion.	Foliar spray with Agritone.

Appendix 1(d): Management calendar and priorities.

Target weed (in order of priority)	Autumn				Winter				Spring				Summer			
	Cut n dab	Foliar spray	Grubbing	Slashing	Cut n dab	Foliar spray	Grubbing	Slashing	Cut n dab	Foliar spray	Grubbing	Slashing	Cut n dab	Foliar spray	Grubbing	Slashing
1. African Love Grass		■				■				■				■		
2. St John's Wort										■				■		
3. Blackberry										■				■		
4. Briar Rose									■		■			■		
5. Woody weeds													■		■	
6. Cootamundra Wattle									■							
7. Saffron Thistle										■		■				■
8. <i>Verbascum spp.</i>		■	■			■	■			■	■			■	■	
9. Scotch/Nodding Thistles		■	■							■	■			■	■	
10. Horehound		■	■			■	■									
11. Paterson's Curse		■	■			■	■									
12. Capeweed		■				■										
13. Exotic grasses												■				■

Appendix 1(e): Draft biannual performance report.

This table will help report on achievement of performance targets for target weeds. In the final column it reports on approximate hours treating target weeds, and estimated effort (in parenthesis). The estimated actual hours spent treating each weed in each paddock is shown in the respective cell. The table will be accompanied by explanatory text and FOTPIN’s response to not achieving the performance target, as well as any variation between estimated and actual effort. For example, for the period that this report applies to:

- **African Love Grass** was present only in the Dam Paddock, and the performance target for it was not achieved. It is likely this resulted from insufficient effort (only half the estimated time was available to treat the weed);
- **Briar Rose** was present in all paddocks and the performance target was achieved for all paddocks. The effort information suggests the required effort was close to the estimated effort, and that the basis on the which the estimate was made is sound;
- **Scotch and Nodding Thistle**. These are treated at the same time by the same method, and so effort records are combined. The report suggests that relatively few thistles are present in the Forest, Weetangera and Hawker paddocks, and that the performance target was readily achieved for these paddocks. For the Dam, Central, Kama and Southern paddocks the performance target was not achieved, and that this may be due to insufficient effort in all four paddocks. This would suggest also that weeding effort should be refocused to achieve the performance targets in Dam and Central paddocks.

Weed\Paddock	Forest	Eastern	Weetangera	Hawker	Dam	Central	Kama	Southern	Total hrs (est.)
African Love Grass					12				12 (24)
St John’s Wort									
Blackberry									
Briar Rose	1	2	3	4	5	6	4	4	29 (21)
Woody weeds									
Cootamundra Wattle									
Saffron Thistle									
Verbascum spp									
Scotch/Nodding Thistles	1		2	3	10	4	10	10	40 (60)
Horehound									
Paterson’s Curse									
Capeweed									
Exotic grasses									

Weed absent/negligible presence	Target achieved	Target not achieved
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Appendix 2. Target weeds – nature and location

This section outlines the nature and location of target weeds³⁰ at The Pinnacle.

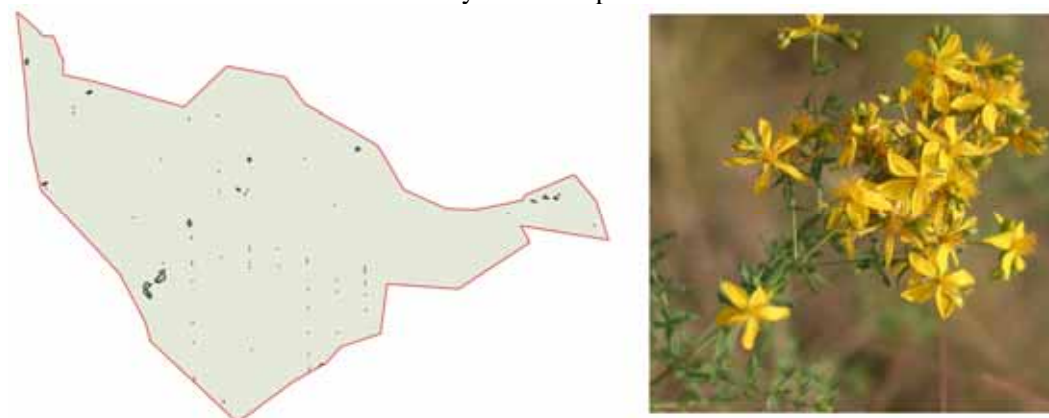
1. African Love Grass

Eragrostis curvula is a relatively large, densely tufted, long-lived grass usually growing 30 to 120 cm tall. Its hairless stems are usually slender and upright, although they may sometimes be slightly drooping or weeping in nature when mature. African Love Grass reproduces by seed, which can be dispersed by wind, water, animals and vehicles, and in mud, soil and contaminated agricultural produce. Slashing infested roadsides is a common method of dispersal, and the seed is easily transported to new areas on the machinery. African Love Grass was not detected during the transect survey; however, there are significant infestations along adjacent road easements, and small incursions alongside tracks into the northern boundary near the Dungowan Street entrance and the water tanks.



2. St. John's Wort

Hypericum perforatum is an erect, perennial herb that grows to about 1.2 m in height. The root system consists of a tap root and lateral roots. The stems are often reddish in colour. The leaves lack stalks and are arranged in opposite pairs along the stem. The flowers are 1-2 cm in diameter and made up of five, bright yellow petals. The fruit is a sticky three-celled capsule that splits open from the top when mature, containing numerous, small, golden-brown seeds. Seed heads can adhere to the coats of livestock, and remain viable after being consumed by livestock. Wind and water currents may also transport seed.



St John's Wort reproduces from crowns, lateral roots and seed. A mature plant can produce up to 30,000 seeds, which can be viable for up to 10 years. St John's Wort is located across the reserve, and in larger patches near the south west boundary.

³⁰ Adapted from weeds.gov.au

3. Blackberry

Rubus fruticosus is a mostly evergreen sprawling woody shrub. First year canes are usually distinctly angled, the faces of the angles furrowed or flat, and the angles usually bearing prickles. Flowers are white or pink. Blackberry fruits are initially green, ripening black. Blackberry is dispersed by fruit and vegetative means. Fruits may contain as many as 80 seeds which are easily dispersed by birds, mammals (especially foxes) and water. Bushwalkers and other recreational users can also spread seeds. At the end of each season the tips of the canes turn over and reach to the ground where they root and produce new plants, forming mounds. We estimate there to be no more than 135 individual plants across the reserve at the time of the survey.



4. Briar Rose

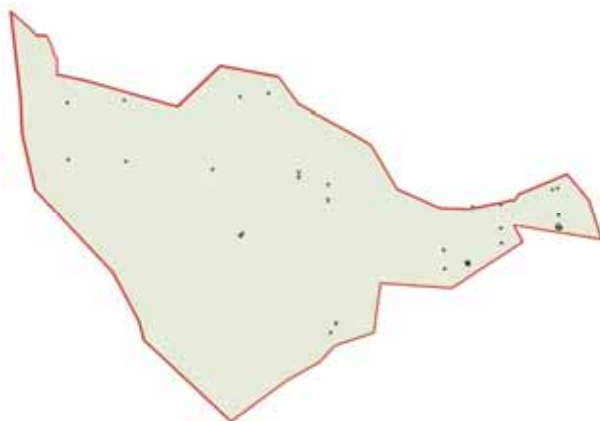
Rosa rubiginosa is an upright shrub, usually growing 1.5-2 m high. The stems may be arching, are smooth and green to reddish-brown when young, becoming rough and woody with age. The stems bear numerous backwards curving flat prickles 1-1.5 cm long. Briar Rose has pink to pinkish-white flowers, and the fruit is orange to orange-red, oval or egg shaped rosehip 15-20 mm long, and with small bristles at the base.



Briar Rose is almost entirely dispersed by seed, which are highly viable and can be carried some distance by birds and foxes, which eat the brightly coloured fruit and deposit the seed in another area. Seeds may also be transported by streams and water flowing off steep country. Briar Rose can also reproduce vegetatively from perennial root systems and crown fragments. There are estimated to be almost 3,000 plants dispersed across the reserve.

5. Woody weeds

Woody weeds are located across the reserve, and include *Cotoneaster spp.*, *Privet*, *Hawthorn*, *African Boxthorn*, *Chinese Pistachio* (see image) and *Pyracantha spp.* These are generally deciduous medium shrubs or small trees that reproduce vegetatively or by seed. The fruit are eaten and dispersed by birds and animals which can carry and drop the seed some distance away. A mature *Pyracantha* can produce about one million seeds per year. There are estimated to be up to 351 individual woody weed plants dispersed across the reserve at the time of the survey.



6. Horehound

Marrubium vulgare is an erect, multi-stemmed, semi-woody, perennial herb to about 60 cm high. The stems are densely covered with white hairs. The leaves are arranged in opposite pairs, 10-35 mm long and 10-30 mm wide and densely covered on the lower surface with white hairs. The flowers are densely clustered at the bases of leaf pairs. Each flower has a tube of white petals, 6-12 mm long surrounded by a densely hairy calyx with 10 hooked lobes. After flowering, the calyx becomes a dry, brown, spiny, burr-like structure that surrounds the fruit and aids in seed dispersal.



The calyx is an effective adaptation for dispersal of the seeds by animals. Sheep are a major dispersal agent because the burrs stick to their wool. The burrs also adhere to the fur of kangaroos and rabbits, the feathers of emus and to human-made objects such as clothing, bags and tyres. The seeds, which can remain viable for up to 10 years, are also dispersed by water, as a contaminant of fodder and through horse droppings. There are estimated to be up to 500 individual horehound plants at The Pinnacle, as well as patches covering a total of 1.7ha. Horehound is widely distributed across the western and central portion of the Reserve.

7. Cootamundra Wattle

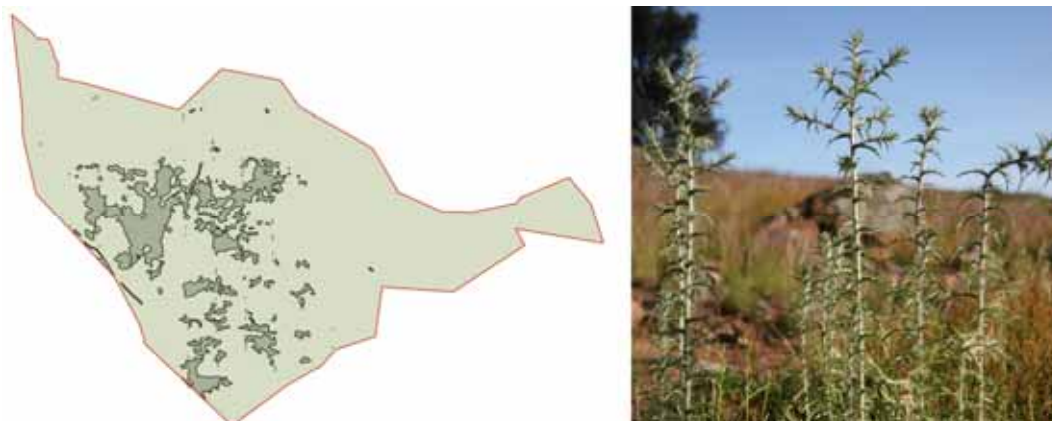
Acacia baileyana is a shrub or tree that grows to 10 m high with a spreading crown and smooth grey or brown bark on the main stem/trunk and most branches. The branchlets and younger branches have prominent vertical ridges and are covered with a whitish, waxy bloom. They sometimes also bear numerous short soft white hairs. The leaves are finely divided into small leaflets, giving the leaves a "feathery" or "fern-like" appearance and silvery grey-green or blue-green with a whitish bloom. They flower between June and September, and seed pods mature between October and January, including in plants as young as two years old.

There are up to 148 individual plants located throughout the reserve. It is invasive in undisturbed areas, and capable of forming monocultures. Its weediness is through its ability to produce high numbers of flowers and seeds, which remain viable in the soil for more than ten years - creating the potential for mass germination in the event of fire or soil disturbance. However, Cootamundra Wattle is a native species not far out of its natural range, and native fauna are expected to benefit from its presence more than from exotic woody weeds.



8. Saffron Thistle

Carthamus lanatus is an erect annual herb growing to 1 m high, usually with a single ribbed stem which has many branches in the upper half. Its rosette leaves are up to 20 cm long, deeply divided with broad lobes at their ends, each lobe ending in a short spine. Its stem leaves are smaller, up to 11 cm long and 5 cm wide, turned downwards, very rigid and armed with stout spines. The leaves have no stalks and their base clasps the stem. The flowers are yellow to cream, in solitary heads at the end of the branches, each head surrounded by spiny leaves.



Each flower head produces 10 to 16 seeds. Seeds are brownish-grey, 3-8 mm long, with a four-angled base, sometimes with a tuft of stiff bristles. The seed is not dispersed by wind and

normally falls to the ground close to the parent plant, which can be viable for up to 8 years. However, the stiff bristles on the seed assist it to stick to clothing, wool and fur. Seed is also transported in mud stuck to implements and vehicles. The dried seed heads also tangle in the wool of sheep and sometimes the whole plant breaks off at the base and is carried along by the wind as a 'tumble-weed'.

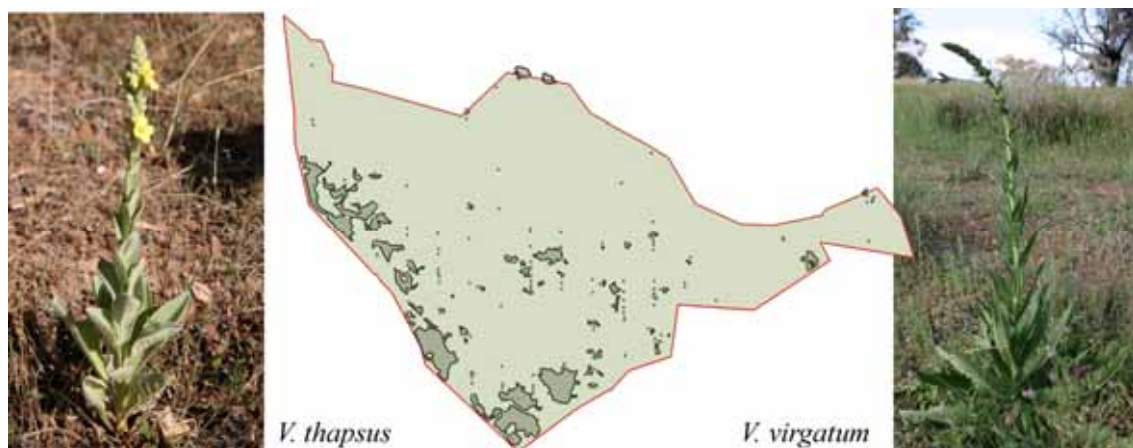
Saffron Thistle is located across the west, central and southern sections of The Pinnacle. There are approximately 11.9ha of thistle patches, and up to some 700³¹ individual plants scattered throughout the reserve.

9. Verbascum

There are two *Verbascum* species at The Pinnacle, *V. thapsus* and *V. virgatum*. *V. thapsus* is a large, short-lived herb growing 1-3 m in height. It initially grows as a basal rosette of leaves, but becomes very upright as it grows. It usually has a single main stem, but occasionally small branches grow from the upper leaf axils. The yellow flowers are densely clustered and produced on a long spike-like raceme, 20-100 cm long, at the tops of the stems. The fruits contain up to 600 reddish-brown, rod-shaped, pitted seeds. As seeds are very small, they readily contaminate soil or agricultural produce, and can be dispersed by wind, water or animals. However, most seeds fall close to the parent plant.

V. thapsus can produce between 100,000 and 180,000 seeds per plant, which may be viable for up to 100 years. In Denmark, seeds from soil samples claimed to be more than 650 year old were found to be viable. *V. thapsus* adapts easily to a wide variety of natural habitats, grows vigorously to out-compete native species, and can threaten the regeneration of degraded areas.

There is little documentation on *V. virgatum*, however, it is similar in form and seeding as *V. thapsus*, is commonly found in patches with *thapsus*, and is given the same priority for treatment as *V. thapsus*. *V. thapsus* and *V. virgatum* are found as isolated individuals and significant patches, mostly across the south western portion of the reserve and adjacent to the boundary fence. Combined there were more than 1,200 individuals across the reserve, with patches covering an area of 7.5ha.



³¹ Based on the October 2009 survey.

10. Nodding Thistles

Carduus nutans is a coarse erect annual herb to 1.5 m tall. Its erect stems are hairless with spiny wings about 3-8 mm wide. The lower leaves are up to 40 cm long by 7.5 cm wide, while upper leaves are smaller. Each leaf is deeply lobed, with marginal spines 2-7 mm long. Solitary terminal flower-heads form on the main stems and on the lateral branches, on stalks 10-40 mm long. The largest heads are 35-60 mm diameter, and droop or "nod" to one side when mature.

Nodding Thistle reproduces only by seed. The seed develops with a tuft of silky hairs on one end, but this easily falls off and does not aid dispersal. Most seed falls from the head within 2 m of the base of the plant, rarely more than 10 m from the plant, and can be viable for up to 20 years. Longer distance dispersal has been through human activity, on machinery, in soil, on livestock, in hay and as a contaminant of agricultural seed.

Nodding Thistle is located across the Reserve. There were approximately 1,100m² of thistle patches, and up to some 460 individual plants scattered throughout the reserve at the time of the survey. The following figure shows the location of Scotch and Nodding Thistles.



11. Scotch Thistle

Onopordum acanthium is an erect annual or biennial herb commonly to 1.2 m tall. Initially the plant forms a flat rosette of stalked leaves. The leaves have toothed, spiny edges and a whitish appearance because of a covering of white woolly hairs, which are dense on the underside. The rosette can be 50 cm in diameter. The erect stem and wing-like, spiny leaves which ultimately develops are also covered with white woolly hairs.

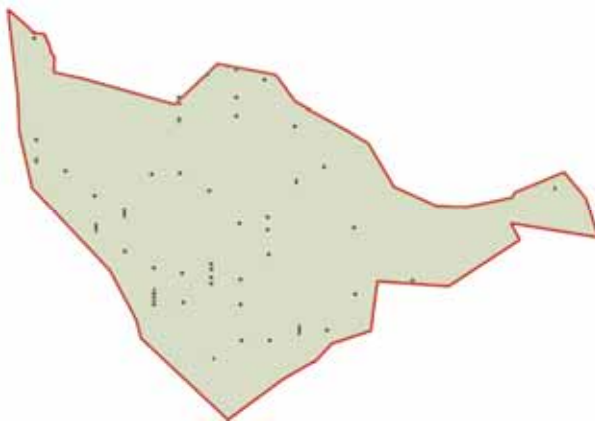
The flowerhead is up to 6 cm in diameter, at the ends of the main branch and side-branches. Each flowerhead has numerous purple to mauve flowers, 14-25 mm long, and can produce a single seed which is grey mottled, four-angled, wrinkled and about 4-5 mm long. The seed develops a pappus of fine toothed hairs about 10 mm long on top but this usually detaches at the time the seed is shed and it probably doesn't aid dispersal. The seed can remain viable for up to 8 years. Scotch Thistle may also spread very locally by root fragments cut up and transported by cultivation equipment provided soil moisture is adequate.

Scotch Thistle has a limited distribution across the reserve. There are approximately 1,150m² of thistle patches, and up to some 337 individual plants.

12. Paterson's Curse

Echium plantagineum L. is an annual herb which grows up to 120 cm high. It has several erect stems that arise from a stout taproot and large rosette of leaves at the base of the plant. The stems and leaves are covered in hairs that can cause skin irritation if touched. The rosette leaves grow up to 30 cm long and up to 8 cm wide, have a stalk and are oval to oblong in shape. The stem leaves are narrower and smaller than the rosette leaves and are stalkless or stem-clasping.

The trumpet-shaped flowers, up to 2-3 cm long, are pink in the bud and purple to blue when opened; occasionally white and pink flowers are seen. Seedlings have large, rounded, hairy cotyledons that are shortly stalked. The first true leaves are oval in outline, have a prominent mid-rib and are covered in long hairs.

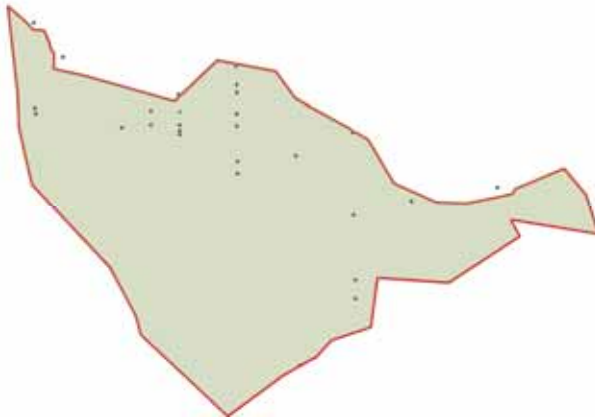


Infestations of Paterson's Curse, if left to maturity, can produce copious amounts of seed. Seed production of up to 12,000 seeds per m² in a single year has been recorded. Under dense infestations, seed banks of up to 30,000 seeds per m² have been recorded. Most seed falls from the plants at maturity but some remains on the plant. Seed is spread by water, especially where plants grow in riparian habitats and on terrain where erosion and runoff occurs. Contaminated soil, fodder, vehicles and the fur and manure of livestock are thought to be the primary vectors for transport of Paterson's Curse seed in Australia.

Paterson's Curse patches were not mapped during 2009, and so will be mapped in 2010. Paterson's Curse proliferates in open cleared areas, however, anecdotal evidence (Driscoll, per comm. 2010) is that after replanting woodland with eucalypt, acacia and other understorey shrubs it is out-competed by native grasses communities.

13. Capeweed

Arctotheca calendula is an annual herb that germinates in autumn, grows as a rosette through winter and flowers in late spring to early summer, before dying off. Rosettes look similar to many other flat weeds, but can be distinguished by the hairy, very pale undersides of the leaves. Flowers are pale yellow daisy flowers with a black centre. Capeweed is most efficiently controlled in autumn.



Capeweed patches were not mapped during 2009, and so will be mapped in 2010. Capeweed has a limited distribution at The Pinnacle, and is mostly associated with vehicle and walking tracks.

14. Sorrell

Rumex acetosella is a slender upright rhizomatous perennial, 10-50 cm high. Plants bear either male or female flowers, or rarely both are on the same plant. Its leaves have a shortish stalk 5-15 mm long and a blade that is 2-7 cm long, usually elongated and spear-head-shaped (with basal lobes 15-25 mm long) or rarely narrowly oblong. The flowers are in loose clusters spread out along the upper half of the branches. Flowers are inconspicuous, with a stalk about as long as the flower and they have 6 greenish perianth segments (commonly called 'valves' in the docks). The fruiting heads become rusty-brown and conspicuous.



Sorrell usually germinates in autumn or winter. Plants flower spring to early summer, and produce numerous seeds, but can also spread rapidly vegetatively, at least locally, due to its extensive rhizome system. Sorrell is strongly competitive in low-growing pastures, crops and other disturbed sites, but it can be out-competed by taller, vigorous-growing pasture species. Its extensive rhizomatous system makes Sorrell difficult to control.

Sorrel is widespread throughout The Pinnacle (see **Figure 2**), generally in areas degraded by previous grazing, and in association with exotic grasses. It dominates some areas during flowering, and represents a significant ongoing threat to grassland biodiversity.

15. Exotic grasses and herbs

Exotic grasses and herbs at The Pinnacle include Wild Oats, Mustard Weed, Barley Grass, Rye Grass, Phalaris, Yorkshire Fog, Brome Grass, Cocksfoot, Perennial Ryegrass, Sweet Vernal grass, *Vulpia* spp, Quaking grass, *Poa annua*, Catsear, Fleabane, Fat hen. These species have arrived through various means including by land managers to improve agricultural production, unintentionally by wild and domesticated animals, or have invaded degraded areas.



These weeds are
widespread through-
out the Reserve
(see Figure 2).

Exotic grasses and herbs are distributed throughout The Pinnacle (**Figure 2**), representing a significant ongoing risk to The Pinnacle's biodiversity values. Due to the highly widespread nature of exotic grasses, the need generally for improved native grass management at The Pinnacle, and uncertainty surrounding restoration strategies, exotic grasses and herbs are a high priority for research into control methods.

Appendix 3: Restoring native grasses to the understorey of The Pinnacle

Introduction, background and justification

The widespread invasion of exotic grasses depletes native biodiversity. Exotic grasses contribute to reducing the number of bird species (Hannah et al. 2007; Maron and Lill 2005; Montague-Drake et al. 2009), reptile species (Jellinek et al. 2004) and invertebrates (Lindsay and Cunningham 2009). In the Australian Capital Territory, a number of woodland bird species are threatened with extinction. Additional threatened species most commonly associated with grasslands can also make use of grassy woodlands (ACT Government 2004).

The most widespread groups of weeds at The Pinnacle are the exotic grasses, along with sorrel and exotic clover species. This cluster of species likely represent the most profound environmental change throughout the park, both because they cover the majority of the area, and because they exclude most other native plants. They also represent a substantial barrier to the restoration of native fauna. Restoration of The Pinnacle therefore requires that this most widespread and difficult problem is addressed.

Native forbs are more likely to establish among *Themeda* swards than among exotic grasses (Smallbone et al. 2007). Increasing native plant biodiversity will therefore involve removal of exotic grasses and replacement with *Themeda* and native forbs, including addition of native seed (Prober et al. 2009). Prober et al (2005) suggest this may be achieved by mowing or burning exotic grasses in spring before they set seed. Reducing nutrient availability can also reduce the competitive advantage that some exotic grasses have over natives. In small scale experiments, nutrients have been reduced by addition of sugar or activated carbon (Kulmatiski and Beard 2006; Prober et al. 2005), and this resulted in reduced cover of exotics and increased cover of natives. Establishing *Themeda* may be a critical step in restoration because *Themeda* helps to manage seasonal nutrient availability and alters vegetation structure (Prober et al. 2005). It may be a key-stone species in grasslands (Prober et al. 2005).

Although grassy woodland restoration remains in an experimental phase, research led by Susan Prober has provided some promising leads. Given this, The Friends aim to adopt a research approach to better understand how to restore the native understorey of The Pinnacle.

We will use a small-scale experimental approach to trial a limited number of treatments but with substantial replication to ensure that we have adequate statistical power to make robust inferences. Our core actions are to reduce weed cover and weed seed banks, reduce competitiveness of exotic grasses by reducing nutrients, and add native grass seed to all treatments. We expect that reducing weed cover and seed banks will require substantial effort, so rather than apply single treatments, we will apply a combination. To reduce the prevalence of exotics we will (1) burn in autumn to stimulate germination of weed seed; (2) in spring spray herbicide to kill germinating and resprouting weeds; (3) in spring/summer slash any weeds that continue to grow and flower. Although repeated burning at short intervals may be

detrimental to native species (Prober et al. 2008), our burn treatment is designed to be detrimental to exotic species and is only applied once during the experiment.

To reduce nutrients, we will add sugar at the same rates as used by Prober et al. 2005. We will seed plots with a range of native species to maximise the opportunities for natives to establish across a range of conditions. The mix will include *Themeda*, and depending on availability, *Stipa*, *Danthonia*, *Bothriochloa macra* and *Microlaena stipoides*. These seeds will be sourced using Greening Australia CR recommended provenance boundaries, and also consider the genetic structures of native grasses which generally make them more robust to provenance issues.

We will explore the effects of the treatments in three different weed contexts: exotic grasses, exotic grasses with saffron thistles and, exotic grasses with *Verbascum*. Saffron thistles and *Verbascum spp.* occupy large, but mostly non-overlapping areas of The Pinnacle. The different distribution of thistles and *Verbascum* partly reflects disturbance history, but also likely reflects soil properties. *Verbascum spp.* dominate in rockier areas of The Pinnacle, while Saffron Thistles prefer low-nutrient sites (Department of Primary Industries 2007). If these two weeds can be reduced using the same treatments as used for exotic grasses, then substantial resources may be saved by avoiding treatment of those individual species. In addition by stratifying our experimental effort among these three distinct communities (and soil conditions), we will learn more about how widely successful our treatments are likely to be.

Fencing to exclude kangaroos or rabbits is not currently factored into the experiment. After 2010 we will have completed rabbit surveys and Parks ACT will have implemented rabbit control. We will understand more about the likely threat to germinating plants from herbivores before year 2 of the experiment when native seeds are sown. The possible importance of fencing will be ascertained after year 1.

Our initial experiment is planned to run for four years. This includes comparing pre-treatment for one year with two years of pre-treatment, and two years of post-treatment monitoring. Although we anticipate that the project will continue for some years after the initial four, our main findings at that time will strongly determine the subsequent course of action. Options at that time may include continuing to monitor without additional treatment, formulation of additional treatments, or application of very successful treatments to larger, and more diverse areas.

Questions addressed using this experiment.

Can the cover of exotic plant species be substantially reduced and native plant species substantially increased by manipulating nutrient levels, or exotic cover and seed? (by substantial, we mean >75%).

Does the response of native and exotic plants to the treatments relate to the presence of the widespread weeds, Thistles and Verbascum?

Does two years of weed control enable native grass to re-establish faster than one year of weed control?

By answering these questions we will discover if native grassland at The Pinnacle can be restored using treatments that have shown promise in similar grassy woodlands.

Experimental design.

Each of three underlying weed combinations (exotic grass, exotic grass + thistles, exotic grass + verbascum) have four treatments and one control, for a total of five **plots** per experimental **block** (ie, a block is a cluster of five 5 x 5m plots).

Tree cover standardised within block.

Three blocks for exotic grass.

Three blocks for exotic grass + thistles.

Three blocks for exotic grass + Verbascum.

treatment combination	Yr 1 weed control	Yr 2 weed control	Yr 1 fire	Yr 2 fire	+ Carbon	+ Native seed	Reps
Exotic grasses							
control							3
1yr control		X		X		X	3
+ carbon		X		X	X	X	3
2 yrs control	X	X	X			X	3
+ carbon	X	X	X		X	X	3
+ Saffron Thistles							
control							3
1yr control		X		X		X	3
+ carbon		X		X	X	X	3
2 yrs control	X	X	X			X	3
+ carbon	X	X	X		X	X	3
+ Verbascum							
control							3
1yr control		X		X		X	3
+ carbon		X		X	X	X	3
2 yrs control	X	X	X			X	3
+ carbon	X	X	X		X	X	3

X=action implemented, Reps = no of replicates

Implementation and treatments.

Slash: remove all exotic plant flowers and fruits before seed set. This may require that plots are slashed twice during spring. (approx 900m² for the treatments plus 864m² as a 2m buffer around the plots)

Herbicide: Apply general herbicide (glyphosate) to plots twice, including early and late spring. (900m²)

Carbon: Apply 12.5kg of sugar per carbon plot (0.5kg sugar/m², Prober et al. 2005), two weeks prior to seeding with natives, and 3 months after initial sugar application. This is timed to favour establishment of *Themeda* and other grasses during the period in which the exotics have been reduced.

Burn. Burn exotic grasses and other weeds to eliminate seed sources.

Soil nutrient measurement. To minimise costs, from each of the nine blocks randomly sample one +carbon treatment, one no carbon treatment. For each selected plot take 10 small soil cores (3cm x 3cm) and bulk together for the plot. Total of 18 soil samples per time period in years 1-3.

Timeline

Year 1

Only the two-year pre-treatment plots are applied in the first year so that the one and two-year pre-treatment plots have their carbon and native seed applied in the same year (year 2). This ensures that our pre-treatment duration treatment is not confounded by differences in rainfall etc between years.

- 1) Select experimental blocks using GIS.
- 2) Mark plots in field using GPS and small steel droppers.
- 3) Measure all plants in each plot (% cover and count/estimate of abundance of native species and exotic species).
- 4) Assess soil nutrient status of selected plots.
- 5) Implement fire, herbicide and slash treatments for the TWO YEAR pre-treatment plots.
- 6) Assess risks posed by herbivores and determine if fencing is needed.

Year 2

- 1) Measure all plants in each plot.
- 2) Implement weed control in all plots (only burn the one-year treatment, slash and herbicide both one and two-year treatments, add carbon to appropriate plots, add native seed, reapply carbon).
- 3) Assess soil nutrient status of selected plots after all carbon treatments applied.
- 4) Monitor plots at least monthly, record germination and signs of losses to herbivore.

Year 3

- 1) Measure all plants in each plot.
- 2) Assess soil nutrient status of selected plots.

Year 4

- 1) Measure all plants in each plot.
- 2) Appraise progress towards native grassy establishment. Revise treatment combinations to consider next phase.

Equipment and consumables

Item	Cost
180 small metal droppers (mark each corner of 5 plots in 9 blocks. 2m spacing slashed between plots to reduce seed-flow back into plot). \$4 each,	\$720
9 kg of native grass seed (Themeda as example, to cover 4 plots/block, 9 blocks, 900m ² , \$800/kg seed, 10g seed per m ² ,	\$7,200
450 kg sugar (12.5kg/plot, 2 carbon plots/block, 9 blocks, two applications) = 450kg. Available in bulk for around \$700/tonne + transport. Alternatively, white sugar is \$1.65 for 2kg at Aldis.	\$371
2 litres herbicide (3 litres diluted herbicide will cover one plot, 1litre undiluted makes 50 litres (conservative), 36 plots to cover twice, need 108 diluted litres/yr = about 2 1litre herbicides)	\$30
Brush-cutter	\$250
GPS for mapping sites	\$270
Soil nutrient analysis. \$50/sample. 18/year, 3 years.	\$2,700
TOTAL COST (equipment and consumables)	\$11,541

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