GUIDELINES FOR MONITORING WEED CONTROL

and recovery of native vegetation

Bruce Auld
NSW Department of Primary Industries

2009

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

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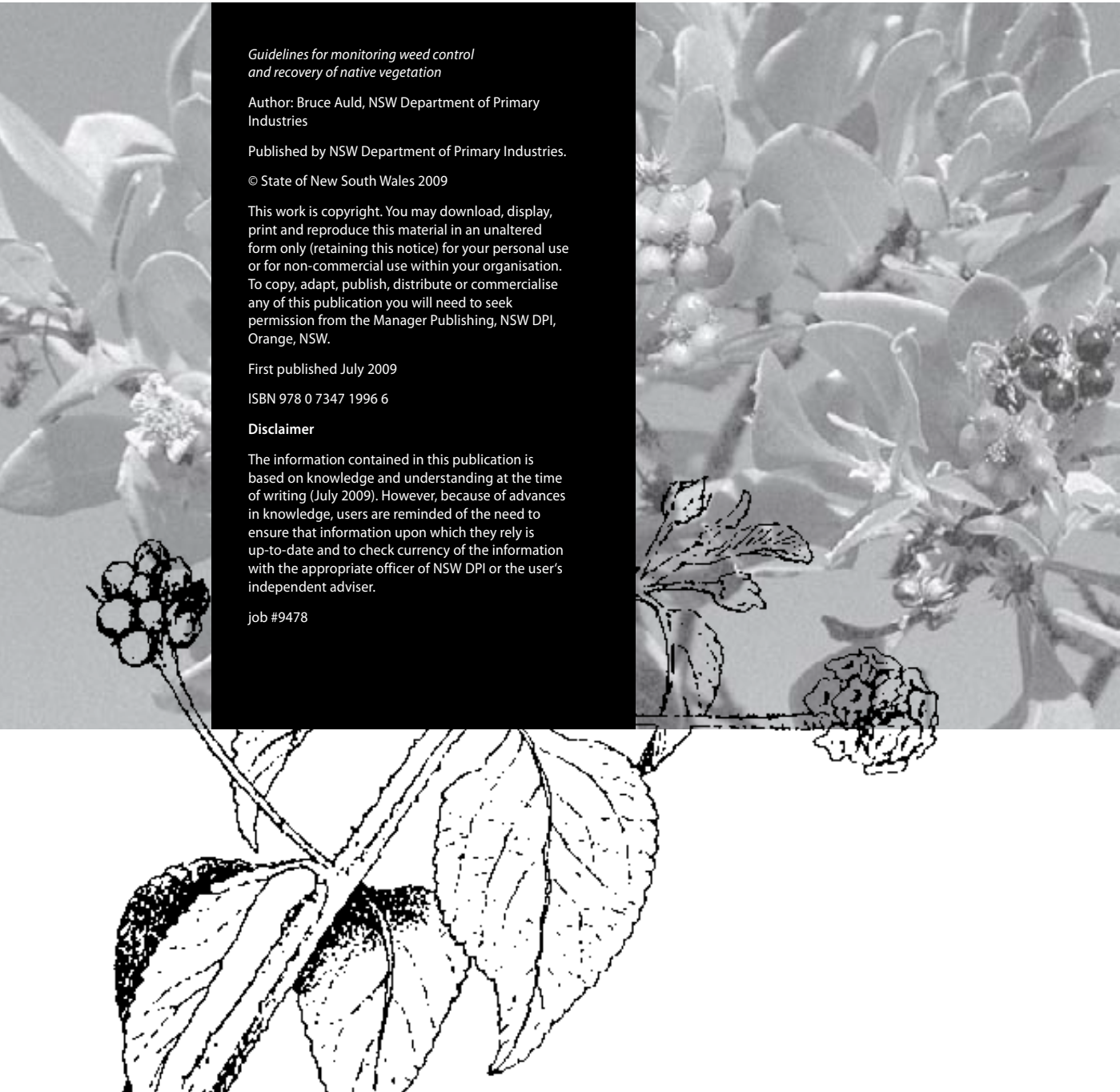

Guidelines for monitoring weed control and recovery of native vegetation

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Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (July 2009). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up-to-date and to check currency of the information with the appropriate officer of NSW DPI or the user's independent adviser.

job #9478

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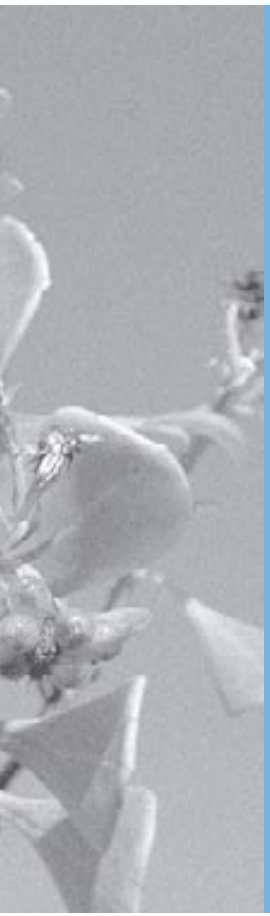

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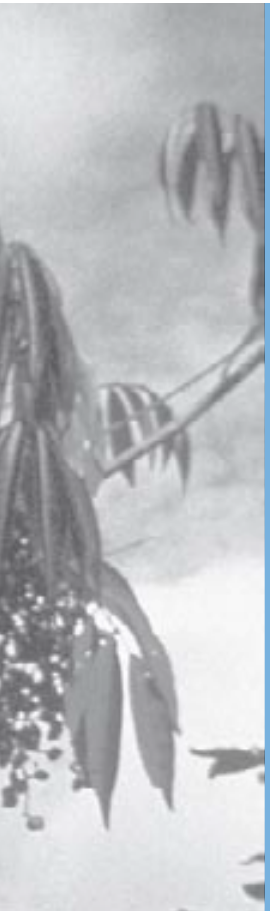
PREFACE

This booklet outlines some principles involved in monitoring the results of weed control and recording changes in vegetation following weed control. It is not intended to be the last word on the subject but rather an introduction to monitoring by simple methods. The NSW Department of Environment and Climate Change (DECC) has published detailed manuals for a three-tiered approach to monitoring bitou bush control and native plant recovery. These are being modified to produce comprehensive monitoring protocols with application to other weeds and native vegetation. These publications can be accessed via the DECC website: **www.environment.nsw.gov.au**

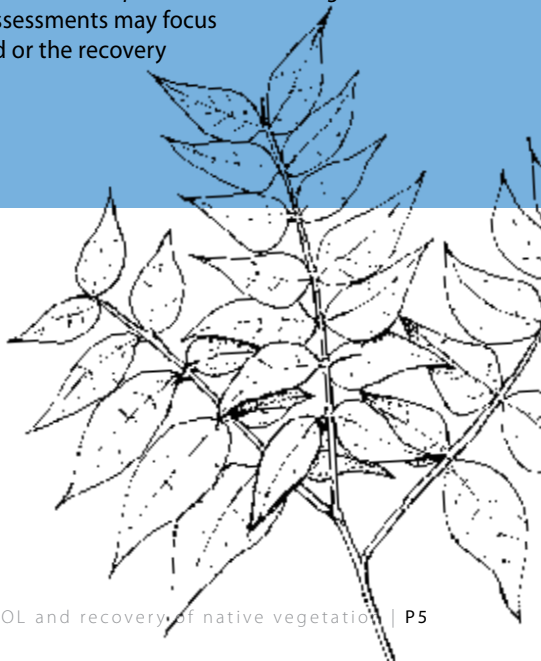
INTRODUCTION



Weeds have an impact on agriculture at farm, region and industry level. Newly invading species, weeds that are spreading and widespread established weeds are all important. Weed management may take the form of prevention of invasion, containment of spreading populations or control of widespread weeds to protect assets such as crops and pastures. Whatever the strategy adopted, it is important to assess the success of weed control in order to make the best use of time and money and to modify management programs as necessary.

Weeds also have a major impact on native plant communities and biodiversity throughout Australia. In recent years considerable time and money has been invested in weed management to conserve and protect areas of native vegetation and sites of high biodiversity value. However, the success of these weed management programs has rarely been assessed in any ordered or quantitative way. Moreover, any assessment programs that have been undertaken have usually been of short duration (one to two years). As weeds are a persistent problem requiring long-term commitment to address their impacts, and recovery of natural systems is often a slow process, monitoring over a number of years is necessary to properly assess the benefits of weed control and management.

In NSW, the Natural Resources Commission has established state-wide targets to protect our environment, including addressing the problem of invasive species such as weeds and feral animals. The Commission has recommended that *Actions should focus on protecting sites and systems as well as those species that are having the greatest negative impact on assets…*; thus assessments may focus on the management of a particular target weed or the recovery of desired vegetation or both.



MONITORING

Monitoring is the systematic collection, recording and analysis of observations over time. It provides a way of checking if the intended outcome of a management program is being achieved. Information such as *100 hectares of a particular weed was treated with herbicide*, or *$20,000 was spent on weed management at a high value biodiversity site*, tells us little about the success of weed control or the response of native species. Even after apparently successful weed control, reinvasion by weeds from buried seeds or other underground organs may occur before any native plant species occupy the area.

Monitoring is required to assess the effectiveness of weed management and the expected recovery of native vegetation following weed removal or suppression.

Without monitoring, we cannot learn about the impact of a management program or how it might be modified in the future, if necessary, for improved results.

In planning a monitoring procedure, we should consider the aims of the management program which is usually simply removal of weeds *and* an increase in native (or other desired) species. We must decide what to measure, how to measure and record it and the time-frame: the frequency of repeated measurements and the duration of the program. The monitoring procedure should be easily repeatable and not subjective, so that it could be done by different people over time.

PHOTOGRAPHY

Photographs are usually a quick and simple way to record general views of vegetation. Photopoints can be established so that the same area is photographed over time. This will provide a series of visual records of gross changes in vegetation but it will not produce the quantitative records preferred for monitoring.

It is possible to use images from photography and analyse them quantitatively but these need to be taken from a vertical position looking down to the ground. To achieve a large area in the field of view, the camera should have a wide-angle lens and must be high above the ground, for example, on a boom apparatus or aircraft.

MAPPING

An overall 'mud map' of a management site is essential. This should show the relationship of the site to access roads, tracks, compass orientation, general vegetation cover, any prominent features and the location of sampling sites within the area (Figure 1) The site's location could also be referenced using a GPS (Global Positioning System) receiver or Google Earth.

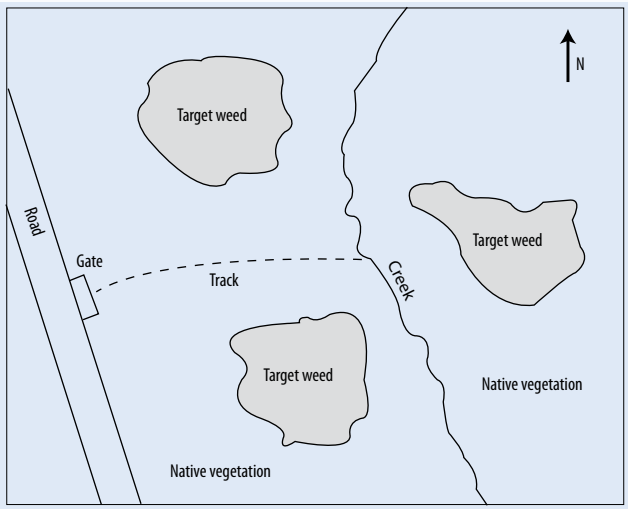


Figure 1. 'Mud map' of site.

Mapping an entire site accurately for weeds and native vegetation would not normally be attempted except for very small sites. So, maps would not usually form part of a quantitative monitoring program but could be used to indicate gross changes in vegetation cover, if updated over time.

MEASURING PLANT POPULATIONS

Estimating the abundance and distribution of different plant species is a specialised area of plant ecology. Here, it is simplified to the task at hand, where time and resources are usually limited.

Firstly, the area is *sampled* rather than attempting to measure everything over the whole site. The measurements are therefore *estimates* of the whole rather than a precise and complete record.

Secondly, measurements may be taken at *random points* on each visit or at *fixed points* that are revisited. While there are statistical reasons for choosing random points, revisiting fixed points provides greater confidence that changes have occurred over time rather than natural variation at the site.

The placement of fixed sampling points, however, can be random. This is suitable when a site is fairly uniform but this is rarely the case. Where a site has different habitats within it, such as woodland and grassland or different aspects, such as a south facing slope and a north facing slope, it is preferable to ensure that all the different areas are sampled. Completely random sampling, particularly with limited sampling points, may miss the areas of most interest (Figure 2). Spreading sampling points deliberately across an area is called *stratifying* the sampling (Figure 3). It is also usually advisable to do this when you are unsure whether an area is relatively uniform or not.

Another reason for the deliberate positioning of sampling points might be to focus on a particular area of interest such as the edge of a weed infestation to check whether it was expanding or receding, rather than sampling the whole area (Figure 4). However, this will not provide any information about the possible invasion by weeds into other parts of the site.

MEASURING PLANT POPULATIONS

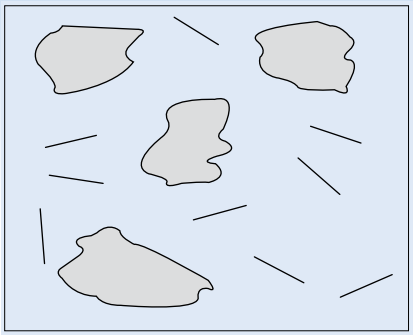


Figure 2. Placing sampling lines or points at random may not provide information from areas of interest (weeds represented by four patches).

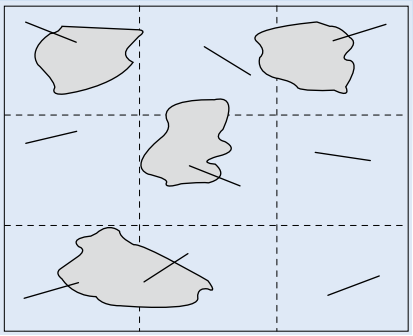


Figure 3. The area has been divided or 'stratified' into equal parts to ensure greater coverage from a limited number of sampling points.

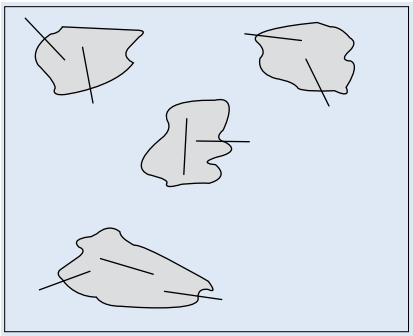


Figure 4. Deliberate placing of sampling points on areas of most interest. This will not provide any information about possible invasion of weeds into other parts of the site.

WHAT TO MEASURE?

Cover

Estimating the abundance of different plants is often most conveniently done by measuring their *ground cover* which is the perpendicular projection of aerial parts of plants on to the ground (Figure 5); for a given area this is often measured as a percentage of the whole area. Cover is a particularly suitable measure to use for shrub-weeds such as lantana and blackberry or any species where it is difficult to distinguish individual plants. Because shrubs may overlap plants growing closer to the ground, the total percentage cover of vegetation over an area may be greater than 100% (Figure 6).

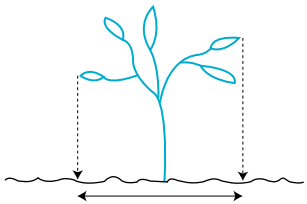


Figure 5. Ground cover of a plant indicated by the horizontal arrowed line.

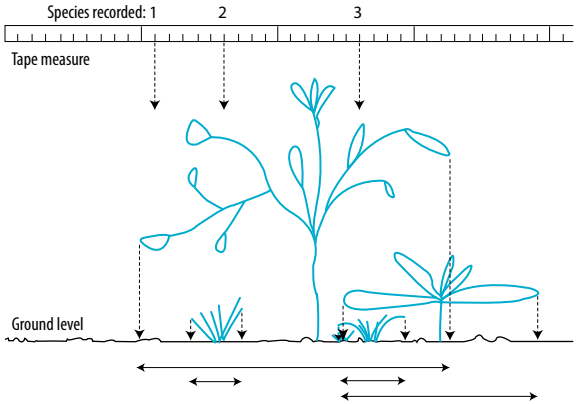


Figure 6. Overlapping vegetation means that total ground cover is often more than 100%. Three different sampling points indicated on the tape measure, used as a line-transect, will record either one, two or three plants.

WHAT TO MEASURE?

To simplify estimates, classes of cover are often used which extend over ranges.
A simple set of five cover classes is shown in Table 1.

A diagrammatic representation of some percentage cover examples is shown in Figure 7. It is difficult to visually estimate percent cover when it is between 50 and 100% and management is unlikely to vary for a weed if it has 50% or greater ground cover.

Table 1. A set of possible classes for vegetation

1	0
2	0–5
3	6–25
4	26–50
5	51–100

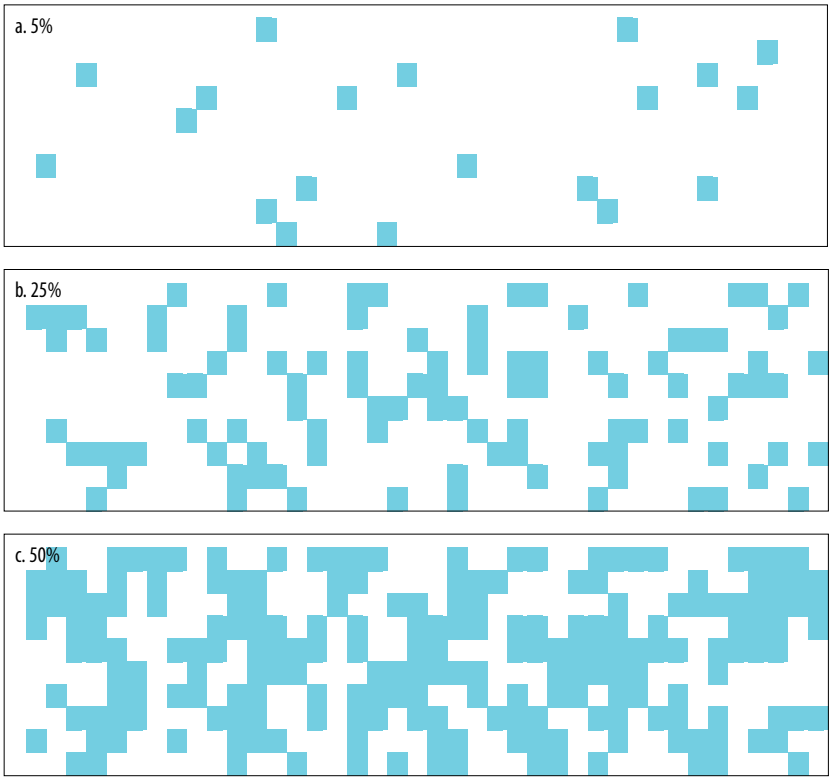


Figure 7. Shaded areas represent percent cover.

WHAT TO MEASURE?

Sampling areas are usually 4-sided and referred to as quadrats. They are commonly rectangular as this shape has been found useful to characterise vegetation. However, circular plots are sometimes used.

Measuring or estimating cover becomes easier the narrower the rectangle is: long narrow rectangular sampling areas are referred to as transects. The width of a transect can be reduced to a single line: a line-transect. Using a tape measure stretched between two fixed points as a line-transect is a convenient way to estimate cover of different species as lengths along the tape (Figure 8). Several paired, fixed points can be established, for instance using steel pegs, say 10 m apart, as end-points for the transects.

Figure 8. Using one edge of a tape measure to estimate the percent cover of flatweed or cat's ear amongst grass and plant litter.

WHAT TO MEASURE?

Another approach is to reduce the sampling area to a *point*. In this case, the plants that occurred at certain fixed points along a line-transect would be recorded (Figure 9). This might be every 20 cm, so that for every 10 m transect there would be 50 sample points.

A variation of this method is the step-point method where the plants in contact with the toe of your boot are recorded as you take each step. These steps can be along a fixed path which acts as a line-transect (Figure 10). While this is a quick and simple method it does not have the precision of the tape measure to revisit the same points.

Another variation is to establish small quadrats to sample at fixed points along a line-transect. The percentage cover of different plants in each small quadrat is then estimated visually, sometimes using a square divided with cross-wires.

In general, the more transects or sampling points, the greater the precision of estimates of cover. However time and other practical considerations will usually limit the number of samples.

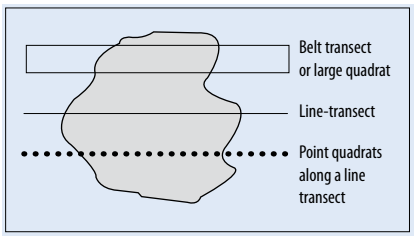


Figure 9. Three different types of sampling methods: rectangular quadrat or transect; line-transect; point 'quadrats' along a line-transect.

Figure 10. The step-point method using the toe of your boot as the point to sample as you walk along a transect.

WHAT TO MEASURE?

Plant numbers

In some cases it might be more appropriate to count or estimate *individual plant numbers* in a quadrat or along a transect rather than use cover; for instance, for grass species that form distinct tussocks. Plant numbers are usually expressed as density per some unit of area e.g. per square metre. Again, estimates can be simplified by establishing classes of density: for instance 'low' less than 3 plants/ sq m; 'medium' 3–10 plants/sq m; 'high' greater than 10 plants/sq m; the appropriate numbers for the density classes would vary greatly depending on the size of individual plants.

A problem with counting individual plants is that plants of different sizes and ages might be counted as equivalent. This can be overcome by having different age classes of plants: e.g. seedlings, non-reproductive or juveniles and mature (flowering or fruiting) plants.

Equipment

The most basic set of equipment to mark quadrats or transects includes steel pegs or posts, depending on the height of the vegetation, a tape measure and a recording folder or book. A compass may be useful too (Figure 11). With one established fixed point at a site, several others can be located (and found again) with a tape measure and compass.

Recording list

A very basic form of monitoring would be to record, over time, the % cover or densities of:

Target weed(s)

Other weeds

Native plants

(see Table 2, page 16 and Appendix 1)

Figure 11. Basic equipment for monitoring: steel pegs or posts; tape measure; recording book or folder; compass (plus pen and hammer).

WHAT TO MEASURE?

However, as well as familiar plants, there will be unknown species and other forms of ground cover such as plant litter as well as bare areas that, ideally, should also be recorded. A more comprehensive monitoring list is:

Target weed(s)

Other weeds

Native plants

Unidentified plants

Plant litter

Bare areas

Other (e.g. rocks)

There may be specific native plant species that should be recorded at some sites (e.g. a threatened species) and several weed species might also be specified. In addition seedlings, juvenile (non-reproductive) plants and mature plants could be recorded separately for certain species (see Table 3, page 17). Identifying seedlings is often difficult and these may often fall into the unidentified plants category.

For rare or threatened species, recording the position of, or tagging, individual plants or groups may be required. However care should be taken not to make them more vulnerable to tampering or removal.

Timing

An initial measuring and recording of vegetation before any weed control has taken place is critical. Without this, there is no evidence from which to judge the success or otherwise of the management program. A visit sometime after the initial weed control treatment (say, two to six months, depending on the weed) is desirable to specifically check on the efficacy of the weed control method. Standing dead plants could be recorded as such or as litter. Subsequent visits should be approximately annual if possible and may be made to coincide with flowering times of plants that are otherwise difficult to identify. Visits could also be in different seasons to take account of seasonal annual plants (e.g. winter grass in winter; Bathurst burr in summer).

RECORDING SYSTEM

A recording system should be set up so that it can be used by different people. For field visits, this might be a purpose designed form (see Appendix 1) in a folder with the mud map. Results from a very basic form of monitoring and recording are presented in Table 2. (Monitoring should continue beyond one year.)

Table 2. Changes in percentage cover of vegetation over time

VEGETATION	PERCENTAGE COVER		
DATE	BEFORE WEED CONTROL	3 MONTHS LATER	ONE YEAR LATER
Target weed	55	10	5
Other weeds	10	15	15
Native vegetation	45	45	75

If cover classes were used these could be represented by using the mid-point of each cover class; for example from Table 1 these mid-points would be 3, 16, 38 and 76%. Alternatively, the class numbers could be used.

Figure 12. Using a tape measure attached to steel posts as a line-transect to record the cover of blackberry in a woodland remnant.

Figure 13. Records of tree canopy cover can also be recorded by looking up at points along the line-transect.

RECORDING SYSTEM

Results from a more comprehensive monitoring (see Appendix 2 and 3) are presented in Table 3. This could also include specific native species of interest.

Table 3. Changes in vegetation over time

VEGETATION			PERCENTAGE COVER		
GROUP	SPECIES	AGE CLASS	BEFORE WEED CONTROL	3 MONTHS LATER	ONE YEAR LATER
Target weeds	Blackberry		40	20	5
	St John's wort		15	10	2
	Black thistle		5	0	0
Other weeds			5	3	2
Native plants	Yellow box	Seedlings	0	2	3
		Juveniles	0	0	1
		Mature trees	5	5	5
	Other trees		0	0	0
	Shrubs		5	5	20
	Grasses		7	15	30
	Other plants		3	10	15
Unidentified plants			5	7	10
Plant litter			2	4	8
Bare areas			0	15	5
Other			3	7	3

RECORDING SYSTEM

The field recording form should allow space for commentary on such things as:

- Control method used e.g. herbicide rate, volume of water used, date applied;
- Response to control method e.g. 'lantana dying; some yellowing on banksia leaves';
- Any disturbance to the site e.g. rabbit invasion; fire;
- The condition of the vegetation e.g. 'several mistletoes on white box trees'
- Any replanting e.g. '400 *Acacia dealbata* seedlings planted – see map for location'.

All field recording forms should be retained together in a folder or other safe location so that they can be referred back to for comparative purposes at a later date.

Observations of cover and density could later be entered onto a spread sheet, such as Microsoft Excel, to keep records over time. Graphing changes in vegetation over time will give a clear, quantitative picture of the impact of weed management in summary form.

CONCLUSION

The line-transect method, using a tape measure or marked cord, with fixed sampling points along it, is probably the most widely useful technique to measure changes in vegetation. It is objective, relatively simple and fast. Stratifying transects across a site is usually advisable. Sample field recording sheets for line-transects with 30 sampling points are shown in the appendices. Several line-transects should be established at each site and recordings made on each visit to a site.

No matter what method is used, the longer the monitoring period (in years), the more likely the changes and trends that are observed, are meaningful.

ACKNOWLEDGEMENTS

Many thanks to the following colleagues who provided helpful comments on drafts of this booklet: Warwick Badgery, Sean Brindle, Adam Hook, Cilla Kinross, Judy Lambert, Neville Schrader, Brian Sindel, Dale Stringer. Thanks also to Stephen Johnson and Scott Charlton for checking the final manuscript.

This project was funded by *Catchment Action NSW.*

APPENDIX 1. Sample format for a simple field data sheet for 30 point samples along 10 line-transects recording only target weeds, other weeds and native vegetation

SITE NAME:																																			
																																	DATE:		
RECORDER ID:		PRESENCE (X)																															COVER		
TRANSECT NUMBER	VEGETATION	POINT NUMBER																															TOTAL	%	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30				
1	Target weed(s)																																		
	Other weeds																																		
	Native vegetation																																		
2	Target weed(s)																																		
	Other weeds																																		
	Native vegetation																																		
3	Target weed(s)																																		
	Other weeds																																		
	Native vegetation																																		
4	Target weed(s)																																		
	Other weeds																																		
	Native vegetation																																		
5	Target weed(s)																																		
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8	Target weed(s)																																		
	Other weeds																																		
	Native vegetation																																		
9	Target weed(s)																																		
	Other weeds																																		
	Native vegetation																																		
10	Target weed(s)																																		
	Other weeds																																		
	Native vegetation																																		

APPENDIX 2. Sample format for more detailed field data sheet for 30 point samples along one line-transect

SITE NAME:			TRANSECT NUMBER:			RECORDER ID:			DATE:		
VEGETATION			PRESENCE (X)							COVER	
GROUP	SPECIES	AGE CLASS	POINT NUMBER							TOTAL	%
			1	2	3	4	5	6	7		
Target weeds											
Other weeds											
Native plants											
Unknown plants											
Plant litter											
Bare areas											
Other											
Other site notes:											

8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

APPENDIX 3. Completed field data sheet from Appendix 2

SITE NAME: CABONNE CREEK RESERVE																																									
			TRANSECT NUMBER: 9																			**RECORDER ID:** A. SMITH												**DATE:** 29/9/09					
VEGETATION			PRESENCE (X)																																	COVER					
GROUP	SPECIES	AGE CLASS	POINT NUMBER																																	TOTAL	%				
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30									
Target weeds	Blackberry						X	X	X	X	X	X														X	X	X	X				10	33							
	St John's wort																X	X															2	7							
	Black thistle																												X	X			2	7							
Other weeds											X	X	X											X						X	X	X	7	23							
Native plants	Yellow box	Seedlings																														X	1	3							
		Juveniles																															0	0							
		Adults	X	X																													2	7							
	Other trees																																0	0							
	Shrubs																	X	X	X	X	X	X										6	20							
	Grasses					X																											1	3							
	Herbs																								X								1	3							
Unknown plants							X	X	X			X												X	X								6	20							
Plant litter			X	X															X	X													4	13							
Bare areas					X										X																		2	7							
Other	Rock															X																		1	3							
Other site notes: Rabbit burrows adjacent.																																										

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