fungicides, herbicides and insecticides on honey bee mortality, National Beekeepers Association of New Zealand, Horticulture and Food Research Institute of New Zealand, Client Report No. 1999/278, 16 p.

Heather, A.I.J, Shepherd, A.J. and Hollis, J.M. (1998). Losses of six herbicides from a kerb-and-gully pot road drain. Environment Agency R&D Technical Report P2-003/TR2, Soil Survey and Land Research Centre, Cranfield University, Silsoe, Bedford, UK.

Henion, J.D, Thomson, B.A. and Dawson, P.H. (1982). Determination of sulfa drugs in biological fluids by liquid chromatography/mass spectrometry/mass spectrometry. *Analytical Chemistry* 54(3), 451-6.

Kent, J.H. and Preston, C. (2000). Application and fate of herbicides in the environment. *In* 'Australian weed management systems', ed. B.M. Sindel. (R.G. and F.J. Richardson, Melbourne).

MacLeod, N.D. (2002). Watercourses and riparian areas. *In* 'Managing and conserving grassy woodlands', eds S. McIntyre, J.G. McIvor and K.M. Heard. (CSIRO Publishing. Collingwood).

Shepherd, A.J. and Heather, A.I.J. (1999). Factors affecting the loss of six herbicides from hard surfaces. Proceedings of the 1999 Brighton Crop Protection conference: Weeds, Brighton, UK, 15–18 November 1999. British Crop Protection Council, Volume 2, 669-74.

Wood, T.M. (2001). Herbicide use in the management of roadside vegetation, western Oregon, 1999-2000 – Effects on the water quality of nearby streams. US Geological Survey, Water-Resources Investigations Report 01-4065, 27 p.

Weeds in wild places – managing environmental compliance

Chris Knight, Managing Director, Land Management Systems Pty. Ltd., PO Box 1146, Mitcham North, Victoria 3132, Australia.

Introduction

Wild places abound. There was a time when wild places were 'out there', certainly not in capital cities or in the suburbs. An increasing awareness of the value of and an interest in Australian native plants (and animals) has heightened the perception of previously neglected pockets of land. Also, increasing urban density and suburban spread, industrialization and clearance for agriculture has brought into focus the realization that we are dealing with a finite resource.

A key component of most management processes is protection and prevention of weed spread and invasion. Agricultural chemicals (herbicides) have become almost an indispensable part of the process. However, although important, they are only one of a suite of options that is open to the creative manager.

More important than any one technique is the overall process. To this extent, native vegetation is no different to a wheat field. The manager must prescribe a regime, set the standards, objectives, timelines and monitor the success of the operation. This approach takes the bushland or parks officer into the realm of 'facilities management', a concept that many may find unpalatable.

Characteristics of wild places

Wild places, particularly within the urban spread, come in many dimensions. A small pocket of land around a utility asset, a nature strip development, linear corridors within largely developed areas and recreation areas can all potentially have equal significance to formally reserved state and national parks. The loss of diversity close to major urbanization or from agricultural land clearance has not only physically reduced the area of undisturbed native vegetation but also left only a relatively small source from which various threatened species can rebound. As such, these areas, however insignificant, may be worth the use of scarce resources to foster their protection.

The characteristics that define wild places assist in identifying the threats to their existence and the realistic management opportunities available. Because they are often ancillary to another primary land use, they may not be under intense management pressure in the their own right. However, they may be under indirect pressure from the management consequences of the primary use. As often extensive land parcels, their size may be disproportionate to the management resources allocated to their protection or operation. An even harder issue is often justifying any expenditure on protection measures. Apportionment of value on the organizations accounts maybe unpalatable, but unless they have notional financial or possibly social worth to an organization, then they potentially have no value. As a manager, how can expenditure be justified on an asset with no value?

And finally, as areas of natural vegetation significance, it may be difficult to define a management regime. In prescribing objectives or outcomes we can only work on historical change and not what will or could have evolved naturally. A common feature of vegetation evaluation for quality or degradation is the assessment of condition relative to pre-European colonization. This is only a best guest and pegs all values at a past status. The use of heavy machinery has hastened the pace of change and increased the pressure many areas would have experienced naturally. This does not mean just accepting that species or ecosystems present 200 years ago is all that should be aspired to or accepted.

Process

More important than any specific technique is the overall management process that is established. Without in-depth thought being given to all the factors, weed control measures will flounder, waste resources and increasingly drain staff and management time as the problem spirals through Band-Aid approaches to its resolution.

Use of a structured approach provides definition of the type and magnitude of the overall problem, allows formal allocation of resources, is an integral part of a strategic management program, allows setting of targets and measurement of progress. The process consists of the five elements below:

- Area and asset type.
- Standards.
- Audit.
- Management type.
- Threats and other issues.

Each of the elements is a topic in its self, however; only chemical weed control (as a management type) and audit will be focused on in-depth.

Area types

The nature and characteristics of a property will provide its own opportunities, threats and challenges to its orderly management. As an initial step, it is worth defining the 'lay of the land'. The characteristics (and use pattern) of an individual property or as an overall land class, may be the most significant features that determine the likely areas of weed invasion risk, the type of works required and limitation to its operational use.

There are any numbers of ways of characterizing large parcels of land. While it is tempting to rely just on geological forms alone, the greatest sources of weed invasion and spread have been through human activity and the structures that we form to services our day-to-day requirements. As such, the following five broad area types or classes were identified:

- Linear corridors.
- Other utility.
- Indigenous (terrestrial) – undisturbed and harvested.
- Riparian.
- Marine – coastal and subsurface.

Each area type has particular characteristics and use patterns, desirable features to be protected and inherent problems. Within each classification, further subdivision is possible and would be of value to managers working in one specific class. Knight (1999) highlighted the disproportionate boundary to area ratio of linear corridors compared to the more usual roughly square property allotment. The consequence for the manager of linear corridors is that they potentially face a significantly higher level of potential outside weed invasions from their neighbours, or if weeds are not controlled in the corridor, can impact on a huge number of other adjoining properties.

Standards

Use of operational standards is central to any management system. Without clear definition, a manager will have little concept of whether they are achieving meaningful results, underspending on asset protection or wasting resources on unnecessary works.

Use of contractors either for components of, or in a fully outsourced management regime requires some understanding of standards to be achieved. Many outsourced vegetation management contracts are worth millions of dollars. Without a definition and understanding of standards, the outsourcing organization will not be able to firstly judge the success of the contract and importantly will have difficulty enforcing its terms, if the guiding standards and required outcomes are poorly defined or non-existent. In a fully audited management system, apart from providing 'the big stick' to control the service provider, standards also allow for the meaningful costing of the required service level, adjustment of such, up or down and the identification of additional or future works.

Appropriate service levels can be relatively easy to define, but care is warranted as they have cost implications. Weed control in a garden bed could be defined simply as '*Weeds are removed before they reach a height of 50 mm and/or a diameter of 50 mm at any time*'. This defined the asset managers tolerance to weed invasion of the asset but with a realistic view to cost control.

On a number of occasions, attempts at specification by various parties from municipalities to professional consultants have evidently been more of a wish list by the outsourcing organization rather than a careful definition of what is required and what can be afforded. It is important that the asset manager thinks through the sensitivity of the asset to weed invasion, timing (response) issues and the appropriate resourcing level to achieve such.

Audit

Use of asset audits have five important benefits to the managing organization, they:

- Provide a performance measure to a defined standard.
- Assist in determining whether value for money is being provided.
- Is an opportunity to review the appropriateness of the standard used.
- Protects the asset from decline.
- Provides a permanent historical site record rather than hearsay.

It's at this point that the initial comments about the notional value of Wild Places start to have relevance. Why go to the trouble of setting management standards and establishing an audit regime for an asset that has little value, as to do so involves allocation of additional resources and scarce personnel time? Assets are only protected to this level when:

- They involve significant cost to establish – such as design changes to an engineering project to accommodate environmental compliance.
- A major commitment to ongoing funding was made – such as a parks and gardens outsourcing.
- Damage or compromise of their value has significant risk to the managing organization or individual – such as protection of national or international declared sites or as a key part of a quality accreditation program.
- Protection and or presentation of the assets is central to the managing organization's image – such as formal gardens at the headquarters of most large organizations or as part of a core client leasing agreement.

Having established appropriate standards, they must be applied to the asset in a meaningful way. Table 1 shows a small selection of results from an audited asset, in this case formal gardens. The overall asset consisted of seventeen distinct areas rather than the nine shown. Each area was allocated one or more of five standards, which were and are routinely audited. Audit frequency and the rating method were the final decisions to be made.

Audit frequency is important, as it is central to the protection and a timely response to asset protection and decline, as well as auditor costs. In the natural realm; seasons, growth stages, anticipated servicing frequency and major property changes impacting on the asset can be used to establish an audit regime. Managing weeds, a monthly schedule is quite possible for some types of assets, for others, possibly several times over spring and summer may suffice. The three results shown in Table 1 were of sequential assessments. The first was a programmed and routine inspection, the second was an unplanned additional visit made following a report of asset decline in two areas – and hence the second auditor's attention to the reason for non-conformance. The entire property was further audited a week after the October 6th visit to ensure that the standards had been re-established. In some areas they had, but had declined elsewhere to an unacceptable level, which resulted in a contract non-conformance. Given that the initial non-conformance was immediately rectified, no penalty was imposed. However, a second unexplained non-conformance would quite likely lead to contract cancellation.

Table 1. Monthly audit result.

Area No.	1	2	3	4	5	6	7	8	9	Comments and action required
15th Sept	3	3	3	2	2	4	2	3	2	Auditor KN – had serviced shortly after audit. Small tea-tree split – instructed to clear away 30/9/02
6th Oct		4						4		Auditor CK – casual observation of long grass Area 5 and large weeds. Due for service 4/10 but delayed by truck breakdown to be done 8/10 – confirmed on site.
13th Oct	1	1	1	4	1	4	2–3	4	2–3	Auditor CK – Beds have large weeds look sprayed but still out of spec. Non-conformance raised for two areas.

Choice of a rating technique is crucial. It must have relevance to the asset or the threat posed by, in this case, weeds. As a management tool, it must alert the supervisor to asset decline and be rigorous enough to withstand legal cross-examination where contract penalties are to be applied or contract cancellation is probable. The person undertaking the audit must be competent and fully understand the natural invasion forces at play (weed germination, vegetative invasion and seed production, as well as the sensitivity of the protected asset). The assessment area can be the whole section of a property or a small component such as a quadrat of series of quadrats.

Assessment methods are as varied as the imagination of the auditor but typically include the following techniques:

- Ratings or scores.
- Percentage ground cover.
- Leaf area index.
- Biomass.
- Seed count / viability.
- Germination count.

Ratings, if appropriate, are the easiest, are fast, and given auditor experience, can be sufficiently consistent for statistical analysis. In Table 1, a one to four rating systems was used to assess all five standards and had the following interpretations:

- 1 = area at or exceeds requirement
- 2 = area generally meets specification with minor deviation
- 3 = area exceeds tolerances
- 4 = area does not comply with standard
- N / A = changed conditions out of contractors control

A one to four system was used in this case as the assessments were relatively uncomplicated and could be readily associated with an expected response time. For instance, when an area was rated as a 'four' then a response within two days was expected to return the area to the required standard.

Management types

The choice of management type or control techniques often comes down to personal preference, available expertise and funding. Agricultural chemicals (herbicides) provide a number of powerful and persuasive benefits. They are however only one of a number of options available. While the use of herbicides will be discussed in particular, prior to making any selection of control tool, it is important that the decision is worked through so as to consider:

- The nature of the target plant – most sensitive time or times when particular control approaches will be effective.
- Sensitivity of the surrounding environment to the control technique – control risks.
- Timing of the weed species greatest impact on desirable species or when the native species are at greatest risk.
- Ability to implement a technique from both a financial and expertise level.
- Other undesirable consequences that a particular technique may have.

The above decision process will be compounded by the complexity of multiple species and any similarity between the nature of the weed species and the desirable species. Given such complexity, only a very small window of opportunity may be available for any one technique. To overcome such an obstacle, an assessment of the sensitivities of both weed and desirable species may require a combination of several techniques at similar or different timings in the growth cycle.

In addition to agricultural chemicals key alternative options available are:

- Fire – thermal properties and significant physical destruction of above ground plant tissue.
- Thermal – predominantly steam producing variable above ground destruction and generally with limited subsurface thermal properties.
- Slashing – physical cutting of above ground plant structures – may be inappropriate in many situations.
- Cultivation – physical disturbance of the whole plant generally with agricultural machinery but would also include hand pulling.
- Biological – release of host specific insect or disease agents – typically suited for large scale and areas of difficult access.
- Cultural – alteration of the weed specie's environment – i.e. light, water, sunlight and temperature regimes, crowding and nutrition.
- Grazing – various domestic animals, particularly goats, will target some weed species and may be of benefit if roaming and plant selection can be controlled.
- Minimalist control – not a control technique but more a mindset, where, for whatever reasons, only a strategic targeting of the most crucial issues, is possible. This approach has only short-term suitability until a complete program is developed.

Agricultural chemicals are a key management tool and define a specific approach. It is hard to imagine undertaking bushland works without some level of reliance on several key herbicides. However, as with all the techniques listed above, they have pros and cons, which must be recognized and allowed for in any management and programming plan. The following were identified for chemical weed management:

Advantages

- No physical disturbance
- Fast – timing important
- Long control
- Own labour / equipment
- Contractors often available
- Comparable cost

Disadvantages

- Need trained staff
- No single herbicide
- Environmental risk
- Contractor availability
- Off-target damage – suitable treatments

Threats and other issues

No system can work in isolation of a variety of outside issues, threats and distractions. Unfortunately, at times, the 'other issues' can become bigger than the protection of the primary environmental asset. As managers, it is worth considering these when a project is commenced or address them as they develop.

- Poor planning – '*fail to plan, plan to fail*'
- No follow-up – the weeds **will** be back, either next year or in the same season.
- Land type – the physical nature of the asset, its soil type, water bodies and vegetation cover will present specific challenges to be factored in.
- Adjoining activities – upstream or over the fence issues / management practices.
- Own activities – colleagues and their operational roles may be your most difficult audience to convince and curtail.
- Politics – organizational priorities
- Volunteer management – everyone loves the family tree planting day but how many will come in the middle of winter for weed pulling?
- Legislation – what relevance?
- Stakeholders – outsiders with an interest in your operation or the impact it will have on theirs.
- Insurance – or lack of it
- Information – where do you get it?
- Budgets – always an issue.

Conclusion

Wild places abound but are a finite resource. The impacts on their integrity require a planned and adequately costed response. Protection and prevention from weeds is a key responsibility. Herbicides are central to most management plans, but should be viewed only as one of a suite of equally valid options.

Weed management can involve a lot of 'grunt', both physically and in commitment to resolving the problem. While it is tempting to focus on fixing the problem at hand, it is more important (in the long run) to recognize and establish an overall process. Facilities management can provide guidance, as in such a commercially orientated arena, vegetation management is specified, measured, costed and the client / service provider relationship is clearly defined through legal necessity.

Reference

Knight, C. (1999). Roadside and linear corridors – a strategic approach to management. Proceedings 12th Australian Weeds Conference, Hobart, pp. 102-3.