suppliers. The database is used primarily by Garden Centres as an aid to accounting, point of sales and stock control. A Master database of plant names is maintained at the Gardens from which two commercial databases have developed – a scientific version for education establishments, botanic gardens and agencies supplying technical information. This version includes over 55 000 botanical names, as well as botanical descriptions, line drawings, colour images, taxonomic bibliography, and list of international cultivar registration authorities. The nursery industry version of about 45 000 commercially available taxa is used for bar-coding and stock control, and as a wholesale Plant Finder for use by retail nurseries. Botanical names are cross-referenced to Plant Breeders Rights names, synonyms and common names: a list of trade marks used in the nursery industry is also included.

This database is the best source of cross-linked names in the industry and endorsed by the PBR Office; it is invaluable as a link between plants and suppliers and therefore could have an important part to play as an early-warning system for problem plants.

- MELISR (Melbourne Information Search and Retrieval)
  This is the database of all the National Herbarium collections. At the time of writing about 12% of 1.2 million specimens have been databased and sponsorship is being actively pursued to complete the task. This database of the State Botanical Collection carries more information than any other database in Victoria. Databasing priority is currently given to rare and endangered plants and loans to other institutions. Information on plants that are not databased can be accessed only through the labels on the specimens.

Suggestions for improving interdepartmental communication, curation and management of naturalized plants.

- Encouraging increased lodgement of voucher specimens – this would improve the Viclist entries and improve the comprehensiveness of a 'valuable' State resource.
- Recording potential weeds in the Greenlife Database™ thus alerting the nursery industry to potential environmental weeds (could be included as part of the 'Garden Thugs' campaign).
- Systematic and targeted weed collecting to improve the Herbarium records.
- Recording details of spot weed occurrences and making the information generally available by developing a rapid and effective 'weed alert' communication system with other organizations.
- Completing the Herbarium computer database of naturalized plants (which can generate distribution maps, search routines etc.).

Monitoring and evaluation of environmental weeds

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Introduction

The following is a brief discussion of some aspects of monitoring and evaluation, primarily from the point of view of assessing how well weed control techniques are working, but also including the monitoring of weed infestations that are not currently subject to control. Sometimes it can be hard to see the justification for monitoring activities when resources are urgently needed for implementation of control measures and when the extent or impact of the weed seems so obvious as to need no further investigation or recording. Despite this natural feeling there is often a case for formal monitoring to produce convincing evidence. Sites that have a well-documented record of weed density over a number of years, for instance, are likely to be considered favourably as early release sites for biological control agents because impact of the agent can easily be determined. Similarly, a statement that a new weed has expanded from scattered infestation of 3 ha to dense infestation of 10 ha and scattered infestation over 30 ha during the last five years is much more likely to support an application for funding of control measures than a vague, although entirely accurate, statement that the weed infestation is 'expanding rapidly'. Emphasis on quantifiable on-ground outcomes of weed control expenditure will inevitably lead to more monitoring to demonstrate that effective techniques have been properly applied.

Defining the question(s)

A monitoring program could have one or more of the following aims.

- Documenting presence/absence of particular weeds in a defined area (park, reserve, length of road).
- Defining present abundance of weed(s).
- Assessing change in weed abundance over some period of time.
- Determining which habitats are colonised by a particular weed.
- Associating change in weed abundance with some aspect of ecosystem change e.g. altered fuel load, changed abundance of native flora or fauna.
- Assessing effect of a weed control measure on abundance of weed and/or of native plants.
- Comparing different weed control measures in terms of cost, reduction in weeds or impact on native flora and fauna.

A clear idea of the aims is necessary before attempting to plan monitoring activities. For instance, if attempting to discover whether St. John's wort control adversely affects native wildflowers, the best time of year for assessment might be when spring-flowering species are most prominent; whereas if the intention was just to assess the effectiveness of St. John's wort control in the same plots the best time to monitor might be later in the year when final number and height of St. John's wort flowering stems could be recorded. An important consideration is the degree of precision that is required to answer the question. If attempting to determine the effect of a fire on the seed bank of a weed compared to no fire, is it really important to be able to detect a 5 or 10 % difference? A difference as small as this would, in practical terms, be unimportant and a sampling regime that could reliably detect differences only of 20% or more might be adequate. On the other hand, if investigating whether weed control adversely affected mature mountain ash a 5% death rate would be extremely important and monitoring sufficient to detect such small effects would be needed.

General considerations for monitoring and assessment schemes

Every monitoring program will have its own unique factors to accommodate and it is not possible to provide a formula to design good monitoring and evaluation. A wide variety of techniques may be useful in different circumstances including assessment of cover or biomass, counts of individuals, seed bank analysis, photographic records, seed production, growth rates or habitat use by native fauna. Textbooks on ecological measurements (e.g. Moore and Chapman 1986) and recent publications of similar studies may be consulted or expert advice sought.

There is a misconception that a high level of statistical knowledge is required to undertake or understand vegetation monitoring. In fact once a clear question has been decided on and the resources available and field conditions are known it is often not particularly difficult to devise a valid and easily understood scheme, with a little informed advice. The particular considerations for assessing impacts of weeds on biodiversity are discussed by Adair and Groves (1998) and this includes many points of more general relevance. Some of the points that should be considered whatever technique is chosen are mentioned below.

Choice of location(s) both of study areas and of plots, transects or other sampling unit within them is crucial. An important decision is whether to record in a wide or restricted range of situations or habitats. In the first case the results will be valid for a wide range of circumstances but the variability amongst locations makes it likely that only rather large and commonly occurring differences or changes will be detectable. On the other hand, restricting monitoring to selected highly uniform locations will make it easier to detect small changes or differences, but the results will strictly only apply to the particular narrow range of conditions that the monitoring included. If recording from a defined area the size of plot or quadrat should be appropriate to the vegetation being monitored; large tussocks, shrubs or trees require larger areas than small ground flora. Location of quadrats, experimental plots, photo points or individuals plants to be monitored should be random, or random within a defined range e.g. a random selection from all the blackberry bushes that are at least 1 m across and not more than 5 m from a creek. The amount of effort required for a monitoring or assessment scheme should be worked out at an early stage because if the resources are not available the questions addressed or the range of situations investigated will have to be reduced. If unfamiliar with a particular technique a timed trial run is desirable preferably with someone more experienced. Once decided on, techniques for monitoring changes over time should be thoroughly documented so that they can be applied consistently by different people. For the same reason, methods that rely on subjective personal assessments should be avoided. Repeated use of the same locations helps to distinguish genuine changes over time from spatial variation within the study area. Nevertheless, if the act of recording data at a location unavoidably and substantially changes it (e.g. cutting access paths in dense shrub cover) then re-use of the same locations may be inappropriate. Data should be protected from accidental loss by ensuring that both electronic and printed versions are maintained and copies lodged elsewhere. Time allocated to a monitoring program should allow for data checking, resolving anomalies with previous data, making some assessment of emerging trends and if necessary updating old records to new hardware or software when computer systems change. Where possible results should be publicised and displayed so that maximum use is made of them.

Staff changes, altered funding and management priorities and the often repetitive nature of monitoring activities tend to reduce recording of long-term data. Nevertheless, records over a period of years are vastly more useful to weed science than once-only surveys of the conditions at a particular moment. Understanding of many weeds and development of effective management of them is restricted by ignorance of very basic characteristics of their populations, making this an area of science where relatively small inputs by people without high levels of technical expertise or access to sophisticated technology can be of great value.

Special considerations in assessing impact of biological control agents

More information on this subject is contained in Farrell and Lonsdale (1997). The purpose here is to provide some pointers to those who may become involved in such work and to provide an indication to others of why it is often difficult to obtain precise information on what a biological control agent has achieved. Biological control impact often varies from year to year so that it may be many years after the initial release before researchers can be confident that they have a reasonable idea of whether and by how much the weed will be reduced. Different environments will lead, in many cases, to different impacts, so studies should always be conducted at multiple sites.

The simplest assessment is to record weed density, seed production, growth rate or other relevant measures, release a biological control agent then record again. Without good information on the pre-biological control weed population, normal year-to-year fluctuations may be confused with biological control effects. If good information has been collected on the weed in previous years then a decline to below levels seen before may be a convincing indication of biological control effect, especially if repeated at a number of sites. Nevertheless, all the sites may, for instance, have been affected by a drought that would have caused a decline in the weed regardless of biological control.

A better approach is to compare sites with biological control agents with other nearby sites that are similar but lack the agent. Some of the agents that disperse relatively slowly may be manageable in this respect but if the no-agent area is to be truly comparable with your test area it should be fairly close, and that could mean that the agent arrives there before its full effect at the original release point becomes obvious. Excluding a biological control agent from one part of an infestation (or better, several places) and comparing the weed performance with the surrounding area that has the agent can work and I am involved in two such trials. Chemical exclusion is usually the only practical method but has some problems. Agents that breed quickly or disperse readily during a large part of the year may require frequent insecticide spraying to keep them out, which is expensive, or the use of very persistent chemicals, which may not be environmentally acceptable. The water used in frequent applications may itself cause a growth response, so it may be necessary to spray with-the-agent plots with the same amount of water. Pollinating insects could be killed or deterred by the insecticide so that without-agent plots set fewer seeds. If other insects besides the agent of interest attack the weed it may be impossible to separate their effects. Nevertheless, agent exclusion plots can be valuable and also good as demonstrations if they show up as patches of healthy weed surrounded by insect-ravaged weeds.

Regularly assessing both the weed and density of the biological control agent along a line away from the release point would seem to be a useful approach. In principle the weed density at each point will decrease, with the ones closest to the release site decreasing first and the decline correlating with the observed arrival of the agent. There are some important drawbacks to this approach. Biological control agents are often released in the densest available patch of the weed, and having selected the best stand of weed to start with the initial release point may remain weediest, despite the agent. Agents may also move discontinuously rather than dispersing regularly away from the release point, leaving points closer to the release unaffected. Density of the biological control agent may not always be a good indication of its impact. Chrysolina beetles, for instance, feed on St. John's wort as a front quickly moving from plant to plant. The impact of the agent would then often depend on the density of beetles that had been there some time before, rather than the density on the day of survey.

Despite the difficulties it is essential that the impact of biological control agents are properly measured if further introductions are to be justified.

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Panel discussion – "50 years from now…."

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Emma Blood, a typical Biosecurate working for and shareholder in the Australia Pacific Biosecurate Company, is on her way to work. It's the year 2049.

Australian and New Zealand governments sold off their conservation departments years ago because they couldn't make money from them. But the community realized that conservation was good business and so formed their own company. As a consequence, the staff are all highly trained and motivated shareholders.

Emma is going to the office in her English ivy sap-fuelled vehicle (that's how the company made their profit!). She listens to the daily VEB (Virtual Enviroweed Bulletin) on the way. Today's bulletin includes a report about an attempted breach of border quarantine controls. A foolish tourist tried to bring in some plant seeds for relatives but the LCI (Living Cell Identifier, a bit like an X-ray machine) at the teleport centre spotted them in a bag. Emma is amazed that people still bother trying to get things through.

Not only did the LCI sense the living cells, it also identified the genetic material as *Mikania*, a plant removed from the permitted list back in 1999.

The next item in the bulletin is the finding of St. John's wort in a garden two towns away. Although banned from cultivation by national legislation 50 years ago, some people still grow it in ceiling cavities and household wardrobes under grow lights. This is because they believe that it can cure depression naturally (scientists made a more effective and safer synthetic alternative 45 years ago).

Emma looks out the vehicle window at her local nursery. The owners are loading this weeks promotional signs about 'Butter glory broom' – the sterile plant that's safe for the garden and the environment (one of hundreds genetically developed each year by the lucrative nursery industry) catering to gardeners with 55% more recreational time than 50 years ago.

Emma smiles at the garden thug freezone sign on the nurseries front gate. Her great aunt helped sell the concept to nurseries and the gardening media 49 years ago.

Emma's first task for the day is to book in her local events into the global Weedbuster Week web site calendar.

Her second task is to biotether an old infestation of horsetail (or Equisetum) at the Geoff Carr Memorial Orchid Reserve at Anglesea (strangely Equisetum infestations are only still found in Victoria). Despite spreading rapidly, the infestation has been left until sufficient indigenous replacement seed was harvested and treated with Sureseed. This coating ensures 99% seed establishment when sown.

The biotether method, developed 15 years ago at the Keith Turnbull Research Institute, revolutionized global weed management. A hovercopter hovers over the centre of an infestation. The biotether scans for the matching programmed genetic material (e.g. for a specific weed). Once located, the biotether delivers a laser that neutralizes every living cell in the plant including the seed in the soil. This prevents the plant from growing further or reproducing. This allows revegetation to take place over a timed period without risk of soil erosion and other problems.

The biotether and the production of genetically manufactured biocontrol agents put the herbicide companies out of business in three years because they wouldn't explore other technologies.

Another job today includes the finishing touches to the latest virtual weed walk that people can download from the internet and test in their own living rooms. This compliments the VWIS (Virtual Weed Information System).

At the end of the day, Emma's last task is to sign a permit for a local plant breeder allowing them to send a tissue culture of a sterile Eucalypt overseas. This is part of the Heidelberg Convention signed by 30 countries in 2009 preventing countries exporting potentially invasive plants to other countries.

– END –

NOTE: Discussion sessions from this forum, along with any late papers, will be published on the internet by the Weed Science Society of Victoria at www.vicnet.net.au/~weedsoc