enviroweed id

weed identification

ENVIRONMENTAL WEED TRAINING

CRC Weed Management Systems

Edited by

Kate Blood

Your name: ----------
Location: ----------
Date: ----------

ENVIRONMENTAL WEED

IDENTIFICATION COURSE NOTES

Environmental Weeds of Southern Australia

Edited by Kate Blood
Cooperative Research Centre for Weed Management Systems

Presented, sponsored and supported by:

CRC Weed management systems
Cooperative Research Centre for Weed Management Systems

Royal Botanic Gardens Melbourne

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City of Greater Geelong

TRAINING COURSES

These one-day courses look at environmental weed recognition and identification in different parts of southern Australia. They are sometimes supported with training on environmental weed management principles. These training notes are to be supported with the use of the SE Australian field guide *Environmental Weeds* by Kate Blood, or if in WA *Western Weeds*. There are other supporting local guides that may also be useful.

AIMS OF THE COURSE

- assist people to be able to recognise common, sleeper and potential weeds in southern Australia.
- influence more effective weed management through the correct identification of weeds.
- prevent the invasion of new weeds into southern Australia through the early identification and eradication of potential weeds.
- encourage the use of local and regional weed field guides and State Floras.

NOTE PREPARATION

These notes are adapted from course notes prepared by Kate Blood for the Alps Invaders courses conducted in December 1999. These notes have been put together by Kate Blood (Weeds CRC) with the following authors contributions:

- Kate Blood, Weeds CRC
- Ian Clarke, National Herbarium of Victoria

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- Ian Clarke (NHV) as co-author of *Name that Flower*

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Weeds CRC, Waite Campus, University of Adelaide, PMB 1 Glen Osmond, SA 5064, ☎ 08/8303 6590, crcweeds@waite.adelaide.edu.au

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- National Herbarium of Victoria, Melbourne (NHV)

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- Lisa Wright and Carmen Sporle, other administration staff at the Keith Turnbull Research Institute, Vic
- National Herbarium of Victoria, Melbourne including Ian Clarke, Jim Ross and Marco Duretto

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ABOUT THE AUTHORS & PRESENTERS

***Kate Blood**, Environmental Weed Education Coordinator, Weeds Cooperative Research Centre*

Kate is based at the Keith Turnbull Research Institute near Frankston in Victoria. She has written a field guide to the environmental weeds of SE Australia called 'Environmental Weeds' published in August 2001. She has been a principle player in the production and writing of the *Weed Navigator* and the draft national strategy on invasive garden plants *Garden plants under the spotlight*. Kate also runs a number of email discussion groups including *Enviroweeds* that has over 500 people around Australia and overseas communicating about problem plants. Kate has been working on environmental weed policy and education for 6 years, and in park and reserve management in Victoria for the previous 6 years.

***Ian Clarke**, Botanist, National Herbarium of Victoria*

Ian is currently one of the botanists staffing the *Plant Identification Service* at the National Herbarium of Victoria in Melbourne. After a variety of technical jobs, including with the Forests Commission of Victoria, Ian joined the Botany School of the University of Melbourne in 1974. From 1975 to 1990, Ian was associated with the Council of Adult Education in Melbourne tutoring in flowering plant identification. In 1987 with Helen Lee, Ian wrote *Name that flower*. It is now one of the prime references for the plant identification components of many botany, agriculture and horticulture courses, and has been reprinted numerous times.

Additional speakers:

Winter Weed identification Courses, Geelong Botanic Gardens, Vic, 22 & 23 June 2001:

***Kate Blood**, Weeds CRC.*

***John Arnott**, Curator, Geelong Botanic Gardens*

John is a recent addition to the Geelong Botanic Gardens having spent some 18 years at the Melbourne Zoo where he filled a number of technical and managerial roles. John joins the Geelong Botanic Gardens team at a time of significant developments for the gardens with the design, development and implementation of its challenging five-stage master plan.

Winter Weed Workshops, Kings Park, Perth, WA, 22 & 23 July 2001:

***Kate Blood**, Weeds CRC.*

***Bob Dixon**, Manager of Biodiversity and Extension, Kings Park and Botanic Garden*

***Neville Marchant**, Director, Western Australian Herbarium*

***Tim Woodburn**, Senior Research Scientist, and **Kathryn Batchelor**, Technical Officer, CSIRO Entomology, Floreat*

***Sandy Lloyd**, Technical Officer and Executive Officer State Weed Plan, Weed Science Group, Agriculture WA*

***Kate Brown**, Project Officer, Environmental Weeds Action Network, Perth*

PART ONE - NOTES

part 1 * notes

LET'S TALK ABOUT WEEDS...

Kate Blood, Weeds Cooperative Research Centre (adapted from coastal weed workshop notes published in 1996)

WHAT ARE ENVIRONMENTAL WEEDS?

- plants that invade natural ecosystems threatening indigenous biodiversity
- in other words, they are plants which can invade bushland & other vegetation

They:

- adversely affect natural regeneration of the vegetation
- affect the survival of indigenous plants & animals
- are one of the most serious nature conservation problems in Australia
- management of environmental weeds is the most crucial component of vegetation conservation

WHERE DO THEY COME FROM?

- overseas
- other parts of Australia

WHAT THREATS DO THEY POSE?

- they degrade the homes or habitat of indigenous plants & animals
- as a consequence, they contribute to the extinction of plants & animals (both locally and globally)
- they reduce indigenous biodiversity

HOW DO THEY DO THIS?

- they may compete with indigenous plants for light, nutrients, moisture, pollinators, and they smother and shade flora or crowd the soil etc
- they may prevent natural regeneration
- may change the movement of water both in the soil and in watercourses
- they may increase soil erosion by shading out ground plants which would normally hold the surface soil together
- may change the shape of the land eg. different grass types on coastal dune systems
- may introduce poisons into the soil which prevents other plants growing around them, or they poison animals
- may cause health problems for humans
- they can provide food and/or shelter for pest animals (and some indigenous animals)
- they may change water quality or characteristics, and habitat for fish and other aquatic animals
- can change fire behaviour by providing more fuel in summer
- can introduce foreign genes into local plant populations by cross breeding (hybridisation and gene swamping)

Hedera helix smothers trees and the ground flora

TYPES OF ENVIRONMENTAL WEEDS

Environmental weeds can be all shapes & sizes, and grow in all niches in an ecosystem. They can be:

- trees
- shrubs
- vines & creepers
- grasses
- herbs & succulents
- aquatic plants
- bryophytes (mosses and liverworts etc)

HOW DID THEY GET HERE & INTO THE BUSH?

There have been and continue to be many ways environmental weeds are introduced to Australia and into natural ecosystems. These include:

- deliberately introduced for utility or ornament for agriculture, forestry, land revegetation and horticulture etc
- accidentally introduced in contaminated agricultural and horticultural produce, in ballast, soils and with stock
- escaped from gardens, waste places, forests, parks and farms
- grown from dumped garden refuse
- transported by wind, water, birds, foxes, people and other animals etc
- sometimes, they have been mistakenly or deliberately used in revegetation projects

WHY IS IT SO EASY FOR THEM TO SPREAD?

- disturbance promotes many environmental weeds but is not essential for their spread
- seeds are very easily transported
- other plant parts can be transported such as bulbs, bulbils, tubers, corms, root parts, stems, branches and leaves
- many weeds are kept in check in their natural homes by pests and diseases - these are often missing in our environment

Most vegetation is constantly being disturbed by things such as burrowing and grazing animals, vehicles including trail bikes, pedestrians and fire. Other things such as floods and nutrient drift from adjoining properties or salinisation from rising water tables are also considered to be disturbances. For remnants, their high boundary to area ratio means that often the whole site is subject to the effects of disturbance through the 'edge effect'.

Sometimes, the removal of a "normal" disturbance pattern can also favour some plants. An example of this is the removal of fire from some areas making conditions favourable for the spread of plants such as sweet Pittosporum, Coast Wattle and Coast Tea-tree.

HOW ARE THEY SPREAD?

There are many vectors & dispersal mechanisms:

- wind
- water- particularly along drainage lines, watercourses, down slopes and by ocean currents
- animals including birds (internally and externally) - indigenous, domesticated and pest
- people
    - on clothing & shoes
    - on tools, machinery & vehicles
    - in contaminated soil
    - through the dumping of garden waste

Alstroemeria aurea can be spread in dumped garden waste

WHY IS IT IMPORTANT TO IDENTIFY THEM?

If we are to manage the natural ecosystems under our care as effectively as possible, we must manage the weeds. They are one of the most serious long-term management issues in natural ecosystems. The weed species will influence the treatment techniques and priority placed on that weed. We must know what they are in order to manage them.

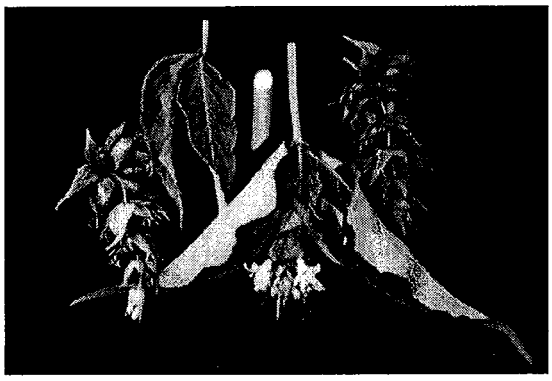
WHAT DO YOU DO WHEN YOU FIND A NEW PLANT?

Kate Blood, Weeds CRC

You're driving or walking along and you spot this bright pink thing out of the corner of your eye. You stop and go back. You haven't seen this plant before and you have no idea what it is. It doesn't look native and not like any native you have seen in the area in the last five years. What are you going to do?

This is the crucial moment! The moment when potentially a new rare indigenous plant is found that could raise the conservation status of the area... and the funding.... Or, it could be the moment when a new weed is found. A new weed to the area, the State or perhaps to Australia. You could be famous!

This is the crucial moment when you either keep walking and forget about it or you make a note of where it is and come back that afternoon with a camera and a plant press.



If you find *Leycesteria formosa*, what are you going to do?

Lets look at two possible scenarios:

Scenario one

The plant you have just found is a rare and threatened indigenous plant. If you keep walking and forget about it, it may struggle on and slowly reproduce or it could be wiped out by a cow that afternoon or by a rapidly advancing invasion of *Hieracium* or some other weed in two years time. If you bothered to confirm its identification (with the correct permit of course!) through the herbarium and its significance was recognised, it may have opened up a whole new interest in the significance of the area with subsequent improvements in funding and preservation efforts, not to mention the conservation of our indigenous biodiversity.

Scenario two

The plant you have just found is a serious weed that has never been found in Australia before. It is not even supposed to be in the country and is prevented from entry into Australia by the Australian Quarantine and Inspection Service. Woooaa! What a find!

If you keep walking and forget about it, chances are it may not be noticed again until it is quite a large infestation and satellite infestations have started popping up down stream. It is almost beyond containment and the rest of the area is threatened. It will cost huge dollars to do anything about it and the conservation status of the area has just gone down the toilet. You'd be left thinking, "I wish I had done something about it earlier".

If you bothered to confirm its identification through the herbarium and its significance was recognised, you would have started a whole train of events that would have activated a contingency plan. A priority would be put on its eradication, finding and addressing the source of the plant, educating others about its identification to look out for further infestations and saving huge resources and dollars in the longer term. As a bonus, you would have saved the conservation status of the area and conserved indigenous biodiversity. What a star!

As these two scenarios point out, the immediate action of the person finding a new plant can have huge ramifications on the future of the area. Don't just forget about it or throw the dried up plant specimen in the bin. Follow it through, learn from the process and potentially save indigenous biodiversity.

The rest of these notes will focus on what to do next to find out the name of a plant and if it is a weed, what to do next.

THE SHAPE OF A WEED - LIFE FORM

Kate Blood, Weeds CRC and Ian Clarke, National Herbarium of Victoria, Melbourne

Weeds come in all shapes and sizes from the tallest trees to the smallest herbs and mosses and everything in between. To assist people to recognise many weeds, looking at them by their size and shape can be very beneficial. We can group them according to whether they are a tree, shrub, climber or creeper, herb, bulb, grass, aquatic plant etc. These groupings are called 'life forms'. Below are some of these life forms, some of their characteristics and impacts and examples of plants in that life form found in southern Australia. Many of the examples that are used are pictured in *Environmental Weeds. A field guide for SE Australia* published by Cyril Jerram and Associates.

GRASSES & RUSHES

There is considerable variation within both groups. Sometimes the species are separated by fairly technical features but individual species are usually recognisable.

Rushes are usually tufted plants whose stems are usually "solid" (not necessarily hard, just not hollow – sometimes the pith is interrupted by small air spaces), and which often have brownish flowers that are individually recognisable (even though often tightly clustered). The word 'rush' is a common name loosely applied to various groups of plants, not always very closely related botanically. The families involved contain considerable variation.

Grasses can also be tufted but many species are spreading (producing some sort of runners, sometimes forming a sward). The stems are usually hollow (not including the nodes – where the leaf joins the stem) and the flowers are usually greenish and much reduced in structure and aggregated into small groups (called spikelets) which are the basic units (and usually the individually recognisable units) of the flowering shoots.

Grasses are one of the very common groups of plants worldwide. They are either annual (complete their life cycle in one year and then die) or perennial (their lifespan extends over several years). Their root system is fibrous making them able to hang on in very windy conditions such as in the alps or along the coast. Some are very small while others such as pampas grass are up to several metres tall. Many are spread by animal vectors on fur or internally through the gut. Some are spread by wind-blown seed, sometimes many kilometres, while others are spread by plant fragments being moved by water or people.

They compete for space with indigenous plants and often fill gaps needed by indigenous plants for regeneration. Some, like marram grass on the coast, can change the shape of coastal dune systems. They can also change fire behaviour in some areas by increasing the dry fuel load over summer.

Here are some examples of grassy weeds and rushes in southern Australia (fill in the common names):

Ammophila arenaria

Anthoxanthum odoratum

Briza maxima

Bromus catharticus

Cortaderia selloana

Dactylis glomerata

Eragrostis curvula

Holcus lanatus

Juncus effusus

Nassella trichotoma

Spartina anglica

HERBS & SUCCULENTS

Herbs are plants that don't develop a woody stem (excluding algae, ferns etc).

There are many smaller ground dwelling plants. Many are annuals growing to maturity in a season and setting their seed and then dieing. Perennial herbs are longer-lived and their lifespan may extend over several years. Herbaceous plants are often good gap-fillers jumping into and filling the spaces left by indigenous plants. Many are escaped garden plants spread by wind, people dumping garden waste or on roadside maintenance equipment.

For the purposes of this course, the bulbous types of plants are grouped together here with herbs. The bulbous plants are those that have underground storage organs such as bulbs, corms and tubers etc. Collectively, they are called *geophytes*. Many come from South Africa and have been introduced for ornamental purposes. In some situations, they can form very dense swards such as watsonia and montbretia. They compete above and below ground for space. Densely clumped corms etc underground can make it very difficult for indigenous plants to grow.

Succulents have fleshy leaves that are able to store nutrients and water so the plant can survive through extended dry periods.

Here are some examples of smaller weeds in southern Australia (fill in the common names):

Acetosella vulgaris

Allium triquetrum

Alstroemeria aurea

Aquilegia vulgaris

Chasmanthe floribunda

Cirsium vulgare

Conium maculatum

Coreopsis lanceolata

Crassula multicava

Crocosmia x crocosmiiflora

Digitalis purpurea

Echium plantagineum

Echium vulgare

Eschscholzia californica

Hieracium aurantiacum

Hypericum androsaemum

Hypericum perforatum

Hypochoeris radicata

Leucanthemum maximum

Marrubium vulgare

Trifolium repens

Verbascum thapsus

Verbascum virgatum

Watsonia meriana var. *bulbillifera*

Zantedeschia aethiopica

CLIMBERS & CREEPERS

Climbers are plants that use the support of other plants to climb upwards. Creepers tend to run along the ground and over low vegetation.

These are the smotherers and chokers of the plant world. They often strangle the plants they climb up or cause supporting plants to collapse under the climber's weight especially when wet after rain. They also compete for light, water, pollinators and nutrients. Climbers can form 'weed poles' when they completely smother a tree canopy. Those climbers that use wind dispersal to spread their seed are in a prime position for invasion on a windy tree top. Creeping plants smother ground flora and often prevent indigenous plants from regenerating. Sometimes, this group of plants is grouped with herbs or shrubs.

Here are some examples of climbing and creeping weeds in southern Australia (fill in the common names):

Anredera cordifolia

Aurujia sericifera

Asparagus asparagoides

Clematis vitalba

Dipogon lignosus

Hedera helix

Lonicera japonica

Passiflora mollissima

Tradescantia fluminensis

Vinca major

SHRUBS

There are numerous weedy shrubs in southern Australia. Many have originated from gardens. Shrubs are woody relatively long-lived plants. They have multiple trunks and branches, and are usually smaller than trees.

Shrubs are often able to form large swards shading the ground and smaller plants, and preventing the germination of indigenous plants including trees. They compete for light, water, pollinators and nutrients. They often provide shelter for pest animals such as rabbits and foxes. They also provide shelter and nesting sites for indigenous animals so their removal needs to be planned carefully. Their ability to form dense stands of the one plant to the exclusion of others can create biological deserts in some places.

Here are some examples of weedy shrubs in southern Australia (fill in the common names):

Berberis darwinii

Buddleja davidii

Calluna vulgaris

Chrysanthemoides monilifera ssp. *monilifera*

Coprosma robusta

Cotoneaster glaucophyllus

Crataegus monogyna

Cytisus scoparius

Erica lusitanica

Genista monspessulana

Ilex aquifolium

Leycesteria formosa

Ligustrum lucidum

Psoralea pinnata

Pyracantha angustifolia

Rosa rubiginosa

Rubus fruticosus aggregate

Ulex europaeus

TREES

To the human eye, trees are probably one of the most dominant plants in the landscape. They are woody usually with a single stem and may be quite tall. There are also many trees that have multiple trunks like the mallee eucalypts.

Due to their sheer size, trees take up a lot of space, resources and have impacts on the plants around them not to mention the wildlife in and under them. Some of the impacts of trees include shading the surrounding ground and indigenous plants, shading sunny habitat needed by animals, eg lizards and skinks that rely on sunbaking areas, competition for light, water and nutrients and competition for pollinators. Trees also provide roosting sites for many birds (both indigenous and pest). It is common to find a 'bird poo halo' under trees with prominent perching branches. Birds carry weed seeds from surrounding gardens or weed infestations, the seeds are deposited in their faeces and a halo of weeds germinate under the tree. Common examples include bridal creeper and berry producing shrubs such as firethorn, cotoneaster, privet and plums.

Here are some examples of tree weeds in southern Australia (fill in the common names):

Acer negundo

Acer pseudoplatanus

Ailanthus altissima

Celtis australis

Fraxinus angustifolia

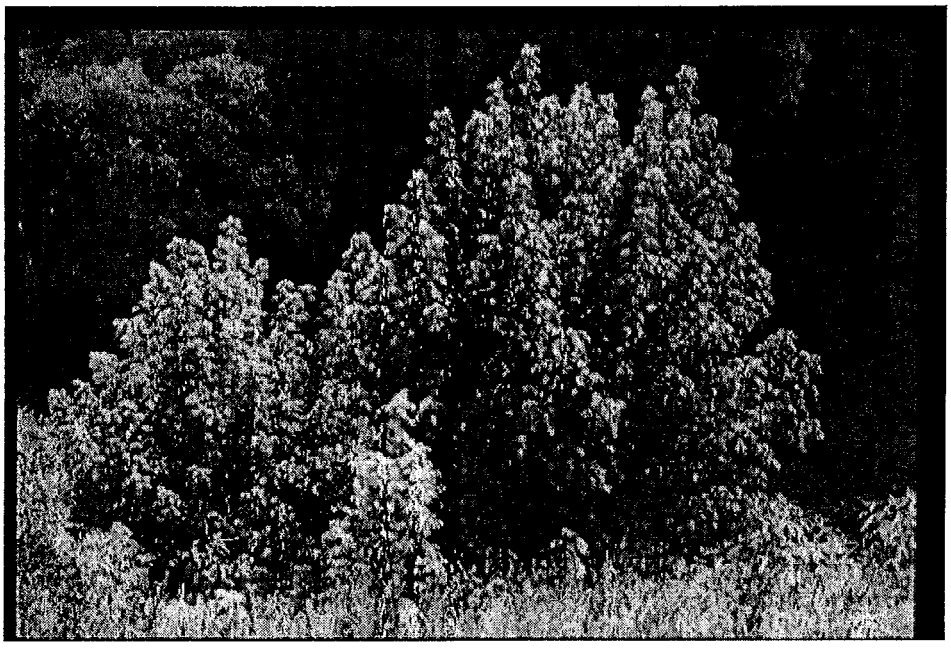
Pinus radiata

Prunus cerasifera

Robinia pseudoacacia

Salix spp.

Schinus areira



Acer negundo invading near Myrtleford, Vic

COMMON WEED FAMILIES

Kate Blood, Weeds CRC and Ian Clarke, National Herbarium of Victoria, Melbourne

These are just a few of the plant families represented across southern Australia. Plant families are like our families – they often have very similar characteristics amongst their members with enough differences to tell the individuals apart. Recognising some of the common features of plant families can help you work out the name of a plant that you are not familiar with. Many weed and plant books are organised by family. To find good descriptions of additional families, refer to: Clarke and Lee (1987 or subsequent reprints) *Name that flower*, Melbourne University Press, Melbourne. This has been the major reference used for the following information. Illustrations copied with permission of Ian Clarke.

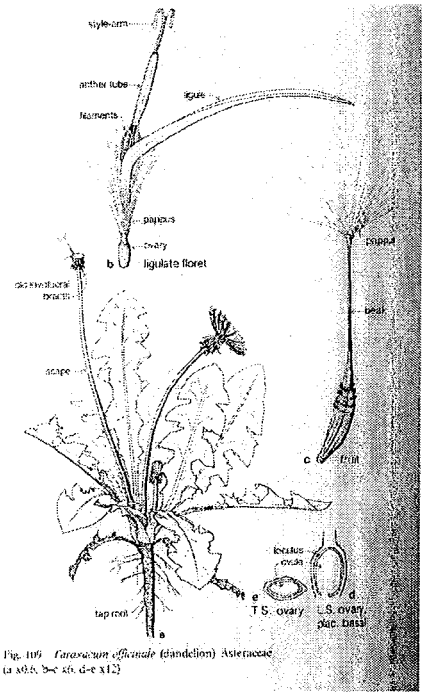
ASTERACEAE

Common features of the daisy family include:

- the 'flowers' are in fact clusters of lots of tiny flowers grouped together in a head
- the family typically includes lots of daisies, thistles and everlastings

The daisy family has many successful weeds because:

- many flowers act like one flower which gives them a very successful reproductive strategy
- they set lots of fruit
- they have nifty dispersal mechanisms such as pappus, and ornamentations including barbs, spines, hairs and scales
- many species are annual or biennial allowing them to reproduce quickly and respond to environmental conditions



Taraxacum officinale, illustration by Ian Clarke, *Name that flower* (1987)

This family includes (fill in the common names):

Achillea millefolium

Arctotheca calendula

Chrysanthemoides monilifera ssp. rotundata

Cirsium vulgare

Delairea odorata

Erigeron karvinskianus

Gazania species

Hieracium aurantiacum

Leucanthemum vulgare

Senecio angulatus

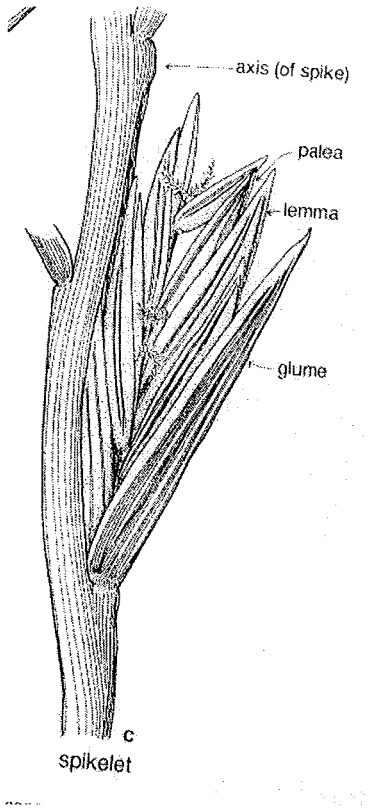
POACEAE

Common features of the grass family include:

- the flowers are small, and together with two enclosing bracts are known as florets
- one or more florets aggregated into spikelets – these are usually the most readily recognisable unit within the flowering shoot

The grass family contains many successful weeds because:

- they are wind pollinated and set lots of seeds
- many of them are annuals and are able to set seed in a short season



Lolium perenne, illustration by Ian Clarke, *Name that flower* (1987)

This family includes (fill in the common names):

Ammophila arenaria

Anthoxanthum odoratum

Arundo donax

Briza maxima

Bromus catharticus

Cortaderia jubata

Dactylis glomerata

Ehrharta calycina

Eragrostis curvula

Holcus lanatus

Lagurus ovatus

Nassella neesiana

Pennisetum clandestinum

FABACEAE

Common features of the pea family include:

- flowers are pea-shaped with 5 petals, 3 of which are free and 2 more or less united
- fruit is almost always a legume or pod that is dry at maturity and splits along both sutures to release the seeds
- the leaves are simple or compound usually with stipules (paired outgrowths at the base of the leaf) (some leaflets may be modified to form slender tendrils which twine around supporting structures)
- members of the family include herbs, shrubs, trees and climbers
- most members possess root nodules containing nitrogen-fixing bacteria which convert atmospheric nitrogen into nitrogenous compounds that the plant can use (as a consequence, weeds in the Fabaceae family often increase soil fertility assisting further weed growth)

This family includes (fill in the common names):

Chamaecytisus palmensis

Cytisus scoparius

Dipogon lignosus

Lupinus 'Russell hybrid'

Trifolium repens

Ulex europaeus

ROSACEAE

Common features of the rose family include:

- flowers are symmetrical, often showy, usually with numerous stamens
- some have thorns which are modified branches (*Crataegus* and *Prunus*) and some have prickles which are surface appendages (*Rosa* and *Rubus*)

As traditionally conceived, this is a large and variable family. Some authors (eg. NSW Flora) take a narrow view in terms of classification and recognise a number of segregate families eg Malaceae. The Victorian flora retains the broader, traditional view of one large family.

This family includes (fill in the common names):

Cotoneaster pannosus

Crataegus monogyna

Prunus laurocerasus

Pyracantha angustifolia

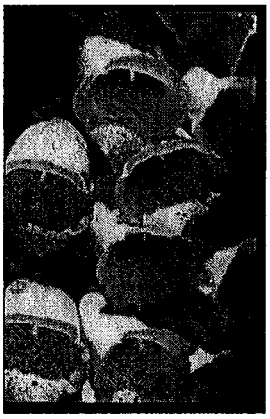
Rosa rubiginosa

Rubus spp.

SCROPHULARIACEAE

Common features of the foxglove and speedwell family include:

- the flowers are asymmetrical usually tubular and often showy
- they are mostly herbs



Digitalis purpurea

This family includes (fill in the common names):

Digitalis purpurea

Verbascum thapsus

Verbascum virgatum

ACERACEAE

Common features of the maple family include:

- leaves opposite (ie. in pairs at each node)
- fruitlets in pairs each with a wing forming a propeller-like structure

This family includes (fill in the common names):

Acer pseudoplatanus

Acer negundo

IRIDACEAE

Common features of the iris family include:

- mostly perennial herbs, the leaves forming a rosette or tuft and arise from a bulb, corm or rhizome
- leaves often linear and grass-like
- flower parts in 3s

This family includes (fill in the common names):

Chasmanthe floribunda

Crocosmia x *crocosmiiflora*

Gladiolus tristis

Ixia maculata

Romulea rosea

Sparaxis bulbifera

Watsonia meriana var. *bulbillifera*

JUNCACEAE

Common features of the rush family include:

- plants are often tufted, often appearing leafless
- flowers are small, often brownish or reddish brown, often in compact clusters
- the stem often appears to continue beyond the flower cluster (eg. *Juncus* spp.)

This family includes (fill in the common names):

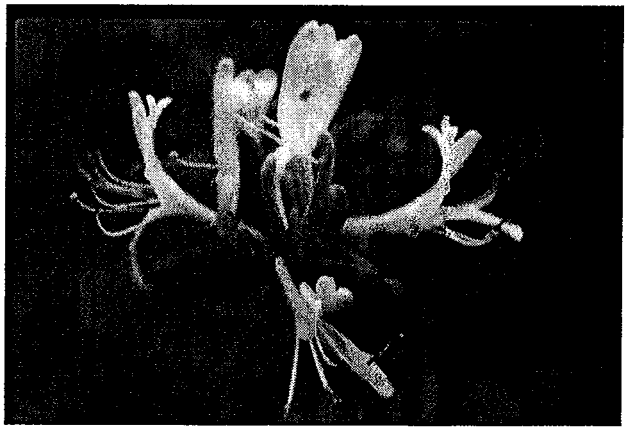
Juncus articulatus

Juncus effusus

CAPRIFOLIACEAE

Common features of the honeysuckle and viburnum family include:

- leaves usually simple, opposite
- petals united, flowers mostly asymmetrical



Lonicera japonica

This family includes (fill in the common names):

Leycesteria formosa

Lonicera japonica

GETTING THE *GIST* OF A WEED

Kate Blood, Weeds CRC

You drive past weeds every day of your life and occasionally, something stops you in your tracks. You may have only just caught a glimpse of it but you know it is out of character in the area. What is it that causes you to put the brakes on? What is going on in your brain that tells you it is different and worth looking at? It can all be explained by the 'gist' of a weed.

'Jizz' has been part of the language of birding for several years and is used to describe the essential characteristics of birds which enables them to be recognised instantly eg. the rose robin has a more flycatcher-like jizz than other red-breasted robins. There has been a lot of debate about the origins of the word *jizz* or *jiss*. Some say it came from 'GISS' which stands for general impression of size and shape. *Giss* was apparently used during the 2nd World War to train people to instantly recognise the difference between different types of planes so they didn't shoot down the wrong ones. The debate continues with lots of other suggested origins (see David McDonald's article 'The etymology of jizz' in *Canberra Bird Notes*, 21 (1), March 1996, pp. 2-11).

For the purposes of weeds, we will be content with using the word 'gist' to name the ability to instantly recognise individual weeds by their general impression of size and texture. It is the ability to recognise a weed just by the weed's general impression from a momentary glimpse at 100km an hour from a moving vehicle. The Macquarie Dictionary defines *gist* as the substance or pith of a matter; essential part.

Many of us scan road and track sides looking at plants while driving around. It is usually when a plant does not fit our long list of recognised plants that we stop and take a closer look. It is when the gist of a plant does not fit the hundreds stored in our mental databases.

Getting more familiar with a weed close up and then at a distance will help to cement the gist of that weed in your mind. What are some of those characteristics that give a plant its gist?

Flower color and shape are strong features along with the plant's general shape and form. An orange flowering Watsonia is easy to differentiate from a yellow flowering broom bush. Telling the difference between an orange flowering montbretia and an orange flowering watsonia can be more challenging. The flowering time sometimes helps. One similar looking weed may flower earlier than another.

So, when next you are hurtling along at a 100km/hr and you slam on the brakes because you saw something strange, that is just your subconscious working on the gist of a weed that is not in your mental database. Follow your intuition – stop and take a closer look. It may be a new weed that you can do something about then and there.

UNDERSTANDING PLANT NAMES

Ian Clarke, National Herbarium of Victoria, Melbourne

The 'scientific or 'botanical' name of a plant, called a binomial, always consists of two words (minimum), and there can only be one correct name. In contrast, common or vernacular names are not so restricted - there may be more than one for a particular kind of plant, they may contain one or a number of words, and the same common name may be used for more than one kind of plant. Common names include those often given by early settlers based on comparisons with known European plants eg. the Box trees and Blackwood based on physical features, or native names eg Waratah. The rules that govern the construction and application of scientific plant names are set out in the *International Code of Botanical Nomenclature* (ICBN).

In botanical names, the first word denotes the genus (plural genera) to which the plant belongs. This is equivalent to our surname. The second word is the specific epithet (equivalent to a first name), and together the generic name and the specific epithet constitute the name of a species.

eg. of a species name:	*Eucalyptus*	*globulus*	In this example, the genus is *Eucalyptus*.
	Generic name	specifc epithet	The generic name always begins with a capital.
			The specific epithet begins with a small letter

In many cases the endings of the generic name and the specific epithet will be the same ('us' in the above example). This is because botanical names are treated as Latin, and thus have gender (ie they are masculine, feminine or neuter) and follow the rules of Latin grammar.

Scientific plant names are are usually based on:

- botanical features eg. *Leptospermum,* referring to its slender seed
- ancient traditional names eg. *Salix,* an ancient European name for the willow
- names of people eg. *Banksia,* named after Sir Joseph Banks

In scientific literature a botanical name is often followed by the name(s), usually abbreviated, of the original author(s)of the plant name. This abbreviation is called 'the authority'. For the name *Eucalyptus globulus* the authority is Labill., an abbreviation for J.J.H. de Labillardiere, the name of a French botanist of the late 18th and early 19th centuries. In popular books authorities are usually omitted.

The same specific epithet can be used in more than one genus. Thus *Eucalyptus alpina* and *Grevillea alpina* are two totally different species that share the same epithet. If a botanist decides that a particular species is better placed in a different genus, the original epithet must be retained unless this would contravene the rules - eg, in the case where the epithet is already in use in the new genus.

The 'genus' and the 'species' are two of the lower ranks in the sequence that constitutes botanical classification. The main ranks are shown in the following list (there are many more!), using *Eucalyptus globulus* as an example. The most commonly encountered ranks are FAMILY, GENUS and SPECIES.

Kingdom	Plantae (plants)
Division	Anthophyta (flowering plants, angiosperms)
Class	Dicotyledones (dicotyledons, dicots)
Order	Myrtales
FAMILY	Myrtaceae (myrtle family)
Subfamily	Leptospermoideae
Tribe	-
GENUS	*Eucalyptus* (eucalypts)
SPECIES	*E. globulus* (blue gum)
Subspecies	*E. globulus* ssp. *globulus*
Variety	-

Species that are botanically similar are grouped into genera, similar genera into families and so on - the family Myrtaceae includes many other genera besides *Eucalyptus*, for example *Callistemon* (bottlebrushes), *Melaleuca* (paperbarks, honeymyrtles), and *Leptospermum* (teatrees). Not all ranks have to be used for a particular species; thus 'tribe' and 'variety' are not formally used in this case.

The names used in the list for the groups of higher rank are taken from a recent text (Raven, 1981) and represent one current view. There is considerable debate about the limits of these groups and the names that should be applied to them. For example, the fungi are no longer considered to be part of the plant kingdom but are placed in a kingdom of their own. In the new *Flora of Australia* series, following the American botanist Arthur Cronquist's classification, the flowering plants are called 'Magnoliophyta', the dicots 'Magnoliopsida', and the monocots 'Liliopsida'. The traditional names for some groups, for example the gymnosperms, angiosperms (flowering plants), monocots, and dicots, remain very useful for practical purposes.

The endings of the names of the higher ranks are standardized. The names of orders end in '-ales'. The names of families end in '-aceae', although for eight of these there are alternative names that are sanctioned by long use:

traditional name	**recommended name**
Compositae (daisies)	Asteraceae
Cruciferae (cabbages)	Brassicaceae
Gramineae (grasses)	Poaceae
Guttiferae	Clusiaceae
Labiatae (mints)	Lamiaceae
Leguminosae (legumes)	Fabaceae
Palmae (palms)	Arecaceae
Umbelliferae (carrots)	Apiaceae

Sometimes the Leguminosae are split into three smaller families (a procedure followed at the National Herbarium of Victoria, MEL). In this case the name Fabaceae is used for one of these smaller families, and in this sense it is a recommended alternative for the older name Papilionaceae (peas). The other two segregate legume families are the Mimosaceae (wattles) and the Caesalpiniaceae (sennas and cassias).

For our purposes, we are chiefly interested in knowing what grows in our area so that we can sort out weeds from indigenous plants, and plan weed management and revegetation programs. Our main interest will be at the genus and species level, though a broader understanding of families will give us a basis for identifying plants we are not familiar with.

WRITING PLANT NAMES

Here are some guidelines for correctly writing plant names taken from *Plant names* by Peter Lumley and Roger Spencer (1995), Royal Botanic Gardens, Melbourne.

SPECIES

The species is the basic unit of classification. When someone asks for the name of a plant the answer is usually a species name. As we have seen, the species name is a binomial - the name of the genus followed by a specific epithet - for example *Agrostis capillaris.*

FAMILY

Closely-related genera are grouped together into a family. You can recognise them easily because they all have the ending -aceae (meaning 'resemblance').

GENERIC NAME (the name of the genus)

This is written with a capital first letter and italicised: *Alstroemeria*

SPECIFIC EPITHET

This is written with a lower case first letter and italicised: *aurea*

SPECIES NAME

The specific epithet and species name are not the same thing. The specific epithet, when combined with a generic name, constitutes the name of a species:

Alstroemeria aurea

If the species name is used repeatedly in a piece of writing, the generic name may be abbreviated to a capital letter and full stop (eg *A. aurea*) unless it begins a sentence or is used for the first time in a paragraph. There should also be no confusion with the names of other plants mentioned.

'Species' is written and pronounced the same way in both singular and plural.

SUBSPECIES

It is recommended that subspecies be designated by the abbreviation 'subsp.' although 'spp.' is also acceptable. The abbreviation for 'subspecies' is written with a lower case first letter and is not italicised:

Eucalyptus globulus subsp. *pseudoglobulus*

VARIETY

Designated by the abbreviation 'var.' which has a lower-case first letter and is not in italics:

Diuris punctata var. *alba*

HYBRIDS

Hybrids between two species are indicated by inserting a hybrid sign (x) between the species names of the two parents.

SYNONYMS

Synonyms are outdated or 'alternative' names. Unfamiliar new names are best accompanied by their old names, so that people are not confused by the new name. The synonym may be strictly a prior botanical name or, occasionally, a name of no botanical standing or a frequently-used misspelling. The usual way of doing this is to put the old name in brackets with 'syn.' in front of it although the 'syn.' is sometimes omitted.

Lophostemon confertus (syn. *Tristania conferta*)

COMMON (VERNACULAR) NAMES

There is no universally accepted way of writing common names. However, the following is generally recommended:

- For a name used in a general sense covering a group or genus (eg bottlebrush, conifer, oak) start with a lower case letter; this also applies to botanical names used in a general sense eg banksias, camellias and acacias.
- If one particular species or plant is referred to then we suggest that you use capitals for the first letter of all words, except when there is a hyphen between two words:

  River Red Gum; Lemon-scented Gum

Some publishers use lower case letters for all common names. This can lead to confusion as to what exactly constitutes the common name in a piece of text. What, for instance, is the common name in the sentence: 'In the centre of the garden was a red flowering gum'?

UNCERTAIN NAMES

When there is an element of doubt about the identification of a plant a question mark is put in front of the full name.

?Davidia involucrata
Meaning: this is perhaps *Davidia involucrata.*

When the genus is known but there is some uncertainty about the species a question mark is put in front of the specific epithet.

Pinus ?aristata
Meaning: this is a *Pinus* species, possibly *P.aristata.*

If only the genus is known then it is conventional to write the abbreviation 'sp.' for the specific epithet:

Callistemon sp.

The plural of sp. is spp., thus:

Melaleuca spp.

REMEMBERING NAMES

Naturally, the more you use plant names the sooner they will become second nature. By reading weed and gardening books, and sometimes visiting nurseries you will soon become familiar with many of the common weeds (remember that many are escaped garden plants). It is generally the first sight of a botanical name that disconcerts people. We all cope well with the familiar *Chrysanthemum*, which is a word with quite a complicated construction, but feel unsure when confronted with *Chionodoxa:* if it is an unfamiliar word we are suddenly lost. Practice is the key.

Being able to pronounce a name will help you to remember it too. Learning some Latin and Greek words will also help.

Learning plant names is a little like being a teacher at the first day of school faced with a large audience of new students. You tend to remember the trouble-makers first, followed by the good achievers and then the rest. Over time and with regular exposure to the plants or in plant books, you will gradually remember them.

FURTHER READING

Greuter, W. *et al* (eds) (1988) *International code of botanical nomenclature*. International Association of Plant Taxonomy, Utrecht. Part of the series, *Regnum Vegetabile* - Vol. 118.

Jeffrey, C. (1973) *Biological nomenclature*. Edward Arnold, London.

Lumley, P. & Spencer, R. (1990) *Plant names. A guide to botanical nomenclature*. Royal Botanic Gardens, Melbourne.

Raven, P. H. *et al* (1981) *Biology of plants*. 3rd ed. Worth, New York.

"HOW DO YOU TELL THE DAMN THINGS APART?"

Kate Blood, Weeds CRC

IDENTIFICATION VERSUS RECOGNITION

Weeds can be identified through a formal identification process such as having it identified at a herbarium, using a botanical key or comparing it to already identified pressed specimens or photographs. The other option is to be able to recognise it based on memory from previous experience. Managing natural environments with the intention of reducing weeds requires managers at some point to have identified those weeds so that they can be recognised later. The diagram over the page (by Ian Clarke) illustrates the process for identifying plants.

Why is it important to accurately identify a plant?

- To differentiate between an invasive and an indigenous plant
- It will influence the treatment method used for a weed
- It will influence the management approach used in an ecosystem and the management priority given to it
- It may also influence the level of funding available

To identify a weed, you either need some botanical knowledge or have access to others who have botanical skills such as botanists at a herbarium.

Here are some options for identification and remember that plants are easier to identify when they are in flower:

Identify it yourself using:

- books and brochures (see the *Weed Navigator* and the 'further reading' section at the back of these notes)
- botanical keys
- herbarium specimens (see below) etc

Seek advice from others including:

- Local or State/Territory government staff
- local volunteers and people in the community

Hire someone to identify the weeds for you:

- botanists
- consultants

Specimens and Herbarium identifications

- collect, press and dry specimens (preferably when they are flowering) – follow the instructions elsewhere in these notes
- specimens can be sent to your State/Territory Herbarium (sometimes a fee will be involved)
- or use the identification room at the Herbarium to identify plants yourself
- create your own herbarium for future reference using dried specimens, photocopying fresh specimens or photographs

To recognise a plant by its 'gist' (see section earlier in notes), it is particularly useful to observe the following characteristics:

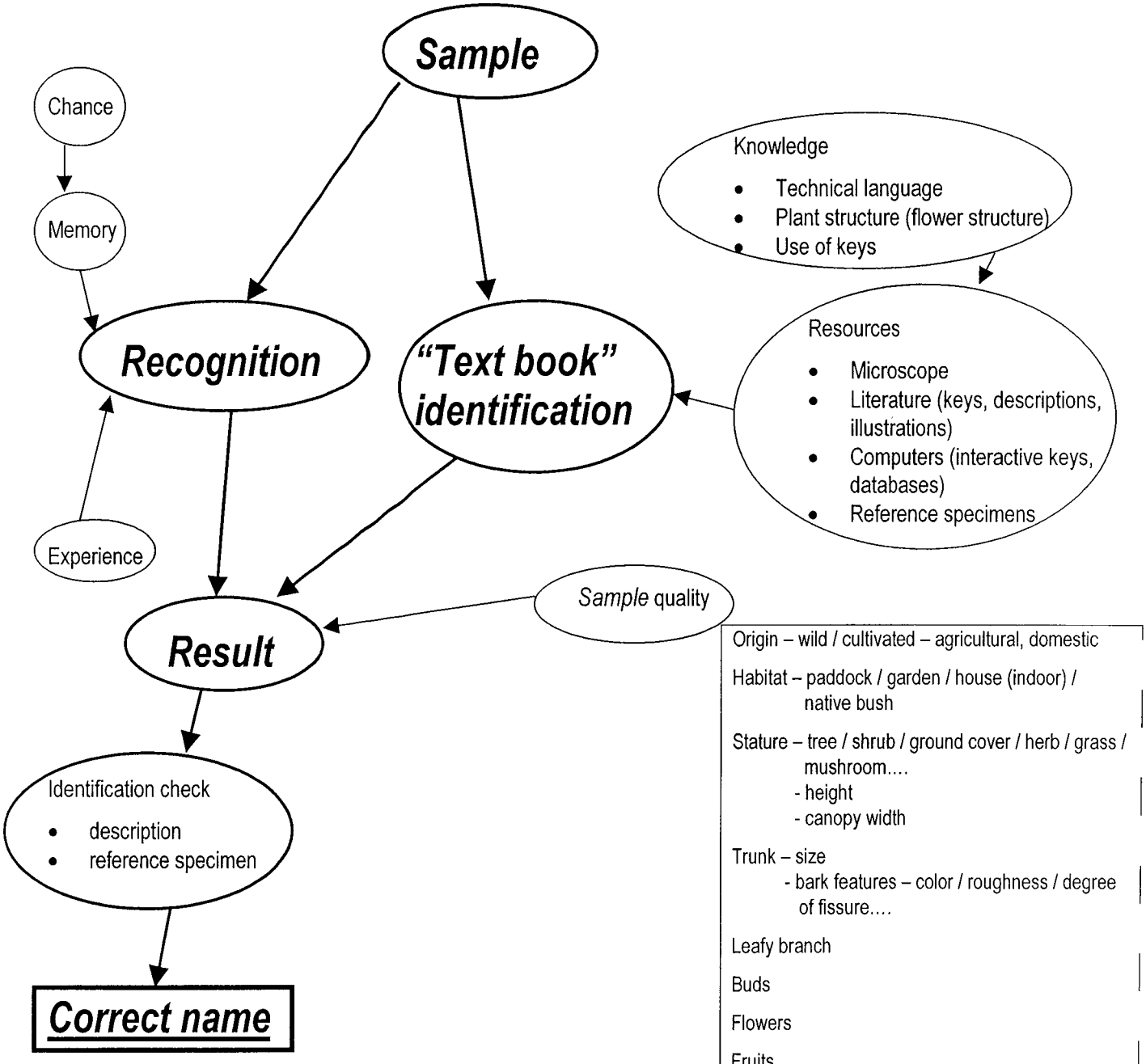
1. Growth habit – eg. upright, spreading, prostrate
2. Color of the flowers and leaves
3. Flower type and shape
4. Leaf shape
5. Unique features such as unusual seed pods, bark, smell of leaves when crushed
6. Height

Remember that if in doubt about a plant's identity, don't pull it out!

FLOWERING PLANT IDENTIFICATION

Ian Clarke, National Herbarium of Victoria

WHAT'S THE PROCESS?



BOTANICAL KEYS

Ian Clarke, National Herbarium of Victoria, Melbourne

A Botanical Key is a methodical way of identifying plants. The user works step by step through a series of statements describing plant features, gradually narrowing the range of possibilities until an answer is reached. This answer should then be checked against an accurately named specimen, and/or a description and illustration.

TYPES OF KEYS

There are two types of keys commonly encountered - bracketed and indented. They are similar in basic ingredients, differing mainly in layout.

bracketed keys

These are made up of pairs (couplets) of mutually exclusive statements. Each statement is called a lead. The statements are mutually exclusive because the conditions described in each one positively exclude those described in the other eg:

Petals five, red; ovary inferior; leaves opposite.....

Petals four, white; ovary superior; leaves alternate.....

Clearly a plant that matches one of these leads cannot simultaneously agree with the other. The conventional way of constructing the leads is to begin with a noun, qualify it with adjectives and/or dimensions etc and separate one or more of these phrases within the lead with semi-colons.

Sufficient couplets (ie pairs of leads) are included in sequence in the key to accommodate the range of taxa (families, genera, species, etc.), and possible variations within these taxa, that the key is intended to cover. The variability of some groups, particularly the higher taxa such as families, usually means that each will 'key out' more than once.

	DICOTYLEDONS	
2	Flowers with at least one perianth whorl	3
	Flowers lacking perianth	820
3	Either one or both perianth whorls fused into a cap	4
	Perianth segments not fused into a cap	10
4	Leaves invested with peltate scales	Himantandraceae
	Leaves glabrous or, if indumentum present, not of peltate scale	5
5	Leaves gland-dotted	Myrtaceae
	Leaves not gland-dotted	6
6	Leaf base sheathing	Epacridaceae
	Leaf base not sheathing	7
	↓	
925	Leaf margins entire	926
	Leaf margins serrate	Bromeliaceae
926	Perianth segments all similar in texture and colour	927
	The two perianth whorls different in texture and/or colour	Bromeliaceae
927	Flowers in umbels, rarely solitary on a leafless scape	Liliaceae
	Flowers in simple or compound racemes	928
928	Leaves narrow, up to 20cm long, arising from an underground rhizome	Liliaceae
	Leaves thick, fibrous, up to 2m long, in tufts at base or apex of trunk-like stem	Agavaceae

Part of a bracketed key to Australian plant families from *Flora of Australia* vol. 1, p. 113.

indented keys

Again, these are made up of couplets of mutually exclusive leads but the leads of each pair are not necessarily in close proximity and may be separated by many pages of the key. The leads belonging to one couplet are indented to the same degree from the left hand margin, are usually identified in an unambiguous way (eg A and AA, B and BB, or 1. and *1., 2. and *2 etc), and should begin with the same noun.

1. Capitula in a dense elongated panicle.
    2. Biennial with a basal rosette; leaves white below, dark-green above ..... *G. spicatum*
    2. Annuals without distinct basal rosettes; leaves similarly green and hairy on both surfaces.
        3. Pappus bristles free..... *G. polycaulon*
        3. Pappus bristles joined at the base..... *G. subfalcatum*
1. Capitula in a dense globose head.
    4. Leaves white - or grey-woolly on both surfaces.
        5. Leaves oblanceolate..... *G. diamantinense*
        5. Leaves narrowly oblong to linear..... *G. indutum*
    4. Leaves white-tomentose below, green and glabrous to cobwebby above.
        6. Annual; bisexual floret solitary in each capitulum..... *G. sphaericum*
        6. Stoloniferous perennials; bisexual florets 3 or more in each capitulum.
            7 Rosette of basal leaves prominent and alive at flowering time.
                8. Head with 2-9 capitula; flowering stem 2-10 cm long..... *G ensifer*
                8. Head with 10-20 capitula; flowering stem 10-30 cm long..... *G gymnocephalum*
            7. Rosette of basal leaves small, dead at flowering time..... *G. involucratum*

Indented key to species in the genus *Gnaphalium*, *Flora of South Australia* vol. 3., p 1516.

USING KEYS

1. **Bracketed keys** - beginning at couplet one, read both leads. Choose the one which best fits the plant material at hand. Note the number in the right hand margin of the chosen lead. This identifies the couplet to which you should proceed. Continue with this process - reading both leads, choosing one, proceeding to the number indicated by the chosen lead, until an answer is give instead of another couplet number. Check that the answer is correct by comparison with an accurately named specimen, description and/or illustration.
2. **Indented keys** - the procedure is similar in principle to the above, but first locate the two leads belonging to couplet 1 - they may or may not be on the same page. Read both. Choose one that best fits. Having chosen one, the next lead is that directly below. Find the opposing lead which makes up the couplet. Chose one. Having chosen, the next lead is the one directly following. Proceed in this manner until an answer is given in the right hand margin of the lead. Check the answer as before.

CAUTIONARY NOTES ETC.

1. Key writers are human, therefore keys are fallible. But the mistake is more often the user's - either in the path taken through the key or in interpreting the plant structure.
2. Read both leads before choosing - one should match best, one should not.
3. Record the numbers of the couplets indicating your path through the key so back-tracking to find errors is easy. Mark any couplets where the choice was difficult so the other alternative can be tried if necessary.
4. Note the possibility of more than two leads per 'couplet'. This is not particularly desirable, but not uncommon. Choose the one best fit.

COLLECTING WEED SPECIMENS

Ian Clarke, National Herbarium of Victoria, Melbourne

INTRODUCTION

It is really important to send weed specimens to your State/Territory herbarium. When a specimen is sent to the herbarium, they are pressed and dried (if not done already) and treated for insects (insects which may eat and damage the specimen are killed when the specimens are frozen). The plant is then identified by a botanist and its details entered on the herbarium's database. If the plant is a weed, it is recorded as naturalised. If it is a new or emerging weed, the appropriate government officials are notified so that action can be taken to stop the weed spreading further.

These are the basic standards needed by the Herbarium to ensure good quality specimens are received for identification and/or lodging as vouchers (standard reference specimen upon which the name of the plant is based). There are a number of good reasons for sticking with these standards:

- Specimens take time and resources to collect. It saves the Herbarium lots of time and money to keep specimens received from outside sources and it's a much more efficient way of expanding the initial collection.
- Quality specimens greatly enhance the value of the herbarium collections for scientific research.
- Identification of specimens can be a time consuming process. Quality specimens are invariably quicker to identify. At present there is a charge levied for this service. Where the Herbarium receives compensation in the form of quality specimens, charges may be waived.

GOOD SPECIMENS MAKE A DIFFERENCE

The quality of herbarium specimens need to be addressed in two areas - the plant sample itself, and the accompanying documentation which will form part of the Herbarium's database and be used to prepare the specimen label.

Plant samples - if at all possible (bearing in mind conservation values, availability, etc.)

Samples should:

- Be representative of the plant - include as much 'information' as possible - leafy stem(s) with flowers and fruits, juvenile leaves, bark etc
- Be representative of the population.
- Be chosen to reasonably fit on a standard herbarium mounting sheet when pressed (about the size of a page of the *Herald Sun* newspaper).
- Be either: pressed and dried, or sent fresh and despatched early in the working week.

Documentation - information accompanying the sample should be as complete as possible. The locality should be sufficiently detailed to allow the population to be relocated. Additional notes should fill in any details about the plant not obvious from the sample. See the accompanying *Field Note Book* form (after this section) for prompts as to the type of information required. The format presented on the form matches the data input screen of the Herbarium database and should be followed closely.

TIPS FOR COLLECTING GOOD SPECIMENS

Much of the following information comes from the booklet by David Albrecht entitled *Collecting and Preserving Herbarium Specimens* (1993) available at the National Herbarium of Victoria.

Good quality herbarium specimens accompanied by full field notes are almost as good a source of information as the original living plant. They provide important research material and a permanent voucher validating the occurrence of a species at a locality at a given point in time. Specimens can be re-examined if there is a dispute over the identity of the record. It is also helpful in groups of plants that have undergone review with subsequent changes of names, for example, in a species that were once thought to be widespread and variable but are subsequently divided into two or more species.

Ensure that you have the correct authority and permits if required for collecting in protected areas. Generally, Permits are not required to collect weeds but it is always better to check first with the relevant authorities.

Prior to collecting specimens, it is good practice to carefully examine the population size and the degree of variation exhibited by the plant. It will also enable you to collect material that is representative or shows the range of variation within the population.

Specimens should be as complete as possible and for vascular plants (excluding ferns and fern allies) consist of flowers and/or fruits, as well as a piece of stem (when present) bearing typical healthy leaves. In the absence of open flowers, flower buds should be included. In the case of herbaceous plants (other than orchids) specimens should also include underground storage organs, stolons, rhizomes, and/or roots.

When collections consist of specimens from more than one plant this should be recorded.

Collectors should be wary of cryptic features of some plants. An example is separation of the sexes, where male and female flowers occur on the same or separate plants. In such cases endeavour to collect both female and male specimens. Another example is leaf dimorphism, where juvenile leaves may differ from adult leaves in characters such as size, shape, degree of lobing and colour. If leaf dimorphism is observed, the collection should include specimens that show this feature.

Here are some tips on what to collect and record for particular weedy plant families:

Iridaceae - Underground parts. Flowers in spirit (especially genera with flowers that wither rapidly).

Juncaceae - Rhizomes, record colour of leaf sheaths and stems (leafless *Juncus* spp.). Mature fruits. Flowering material is of little value.

Liliaceae - Underground parts, eg tubers or corms. Colour of floral parts is important for some. Note that tubers are sometimes at the end of roots rather than near rootstock.

Orchidaceae (only collect weedy species) - Record floral colours and scent. Flowers in spirit are important. Colour transparencies are desirable. Fruits are of little value. Indicate whether leaves were present at the base of flowering stems.

Poaeae - The whole plant, including underground parts. For large tussocks, at least two or three flowering stems with leaves and roots. Indicate whether the plant was easy to uproot (usually indicating an annual life form) or difficult to uproot (usually indicating a perennial life form). Try to ensure that inflorescences are not too young. Optimal material is post-anthesis (stamens and styles withered in most florets) but before the grain is ready to drop.

Asteraceae - Mature fruits.

Boraginaceae - Mature fruits.

Brassicaceae - Mature fruits.

Epacridaceae - Record mature fruit colour in taxa with fleshy fruit. Note that some taxa are functionally dioecious (different sexes on different plants) (eg *Monotoca*).

Euphorbiaceae - Mature fruits (seeds). Note that plants are monoecious (different sexes in different flowers but on the same plant) or dioecious.

Fabaceae - Mature fruits are important in some taxa (eg *Lotus* and *Trifolium*).

Fumariaceae - Mature fruits.

Lamiaceae - Record smell of crushed leaves. Flowers in spirit are useful.

Malvaceae - Mature fruits.

Oxalidaceae - Record flower colour. Underground parts. Mature fruits.

Papaveraceae - Record flower colour. Mature fruits.

Pittosporaceae - Mature fruits are needed in some taxa.

Plantaginaceae - Record life form. Root system. Mature fruit.

Polygonaceae - Mature fruits.

Ranunculaceae - Underground parts. Mature fruits.

Rosaceae - Mature fruits. For *Rubus fruticosus* sp. agg., material from both first year (usually non-flowering) canes and flowering canes. Remove petals from a flower and place on Magic Tape and mount on a small piece of white card.

Salicaceae - It may be necessary to collect from the same tree when flowering in spring and again when in full leaf in summer. Leaves should be collected from branch systems that have borne flowers the current season and not the vigorous sterile shoots arising from near the base of the plant.

Scrophulariaceae - Record flower colour and place some flowers in spirit. For *Euphrasia*, life form and habit should be recorded. Mature fruits are important in some taxa (eg *Veronica*).

Solanaceae - Mature fruits (also record colour).

Urticaceae - Record life form. Beware of stinging hairs. Note that some taxa are dioecious.

Volaceae - Record flower colour. Flowers in spirit are useful.

FIELD NOTES

Even though a specimen may have been well collected and carefully prepared, it will be of negligible scientific value and in some cases impossible to confidently identify unless accompanied by basic field notes.

Field notes should be made at the time a specimen is collected. It may seem a tedious procedure but it ensures the accuracy of the information accompanying specimens. If you anticipate collecting more than a few specimens it is advisable to purchase a collecting book from your State/Territory herbarium to keep the notes in order. Collecting books also have the advantage of providing various prompts (eg. Location, date of collection) which assist in the methodical recording of data. If a collecting book is not used, field data should be recorded on a sheet of similar format to that in State herbarium's collecting books, to ensure that all relevant data are recorded. Carbon paper can be used to produce duplicate copies of each field label, one of which can be retained by the collector for their records and the other submitted to State herbarium with the specimen.

If the notes recorded in the field are legible they can be lodged at the herbarium in their original form, if not they should be neatly transcribed. Once lodged at the herbarium the data on the field labels is entered onto the Herbarium's data base, which also generates high quality herbarium labels on archival paper. The labels are then mounted on to herbarium sheets with the corresponding specimens.

It is encouraged that collectors use collecting numbers, as this makes the specimens more simply referred to in correspondence, annotated species lists and in published works. At the time of collection, attach to each separate specimen/collection a tag with your initials and a number, and enter notes in your collecting book under the same number. Jeweller's tags are ideal for this purpose and are readily available from many stationery shops.

Labels and tags should be written with water-proof ink or pencil not biro. If additional material such as photographs, propagation material or spirit material is taken, they should also be assigned the same collection number. A simple sequential numbering system should be used. Numbering should proceed with consecutive numbers from 1 onwards for the rest of the collector's life.

Collectors should endeavour to record all of the following details:

i) *Field identification* - eg. *Poa tenera*. Leave vacant if the name of the plant is not known. An asterisk (*) prefixing the name denotes that the taxon is considered to be introduced to the collection site. If the collection is made from a cultivated plant this should be noted. It is also helpful to provide the authority and family; these can be found in your State/Territory Census eg Ross (2001). *Census of the vascular plants of Victoria* (6th). Royal Botanic Gardens, Vic.

ii) *Location* - The details should be written in plain words and be as precise as possible to enable others to relocate the population if necessary. The conventional format for recording locality is: state, general position in the state (eg. East Gippsland, Mallee), distance and direction from a well known landmark, town or road intersection. The use of the Natural Regions of Victoria as described by Conn (1993) in Volume 1 of the *Flora of Victoria* is strongly recommended.

Recording the altitude, latitude and longitude (and additionally the Australian Map Grid reference if desired), and minor grid is particularly useful for our purposes. With the exception of minor grids, these details can be extracted directly from topographical maps.

Latitudes, longitudes and altitudes can now be determined by means of an electronic position finder called a Global Positioning System (GPS) which uses many satellites to accurately establish a locality.

When the relocation of a population is particularly important, such as in the case of a new weed or rare or threatened species, an annotated photocopy of a map is a valuable adjunct.

iii) *Collector details* - Collectors name, collection number and date of collection eg C. Coles 2701 14 Apr 1991. To avoid confusion, it is preferable to indicate the date in the same form as it will appear on the label eg 14 Apr 1993, 17 May 2010. It is important to indicate the century.

iv) *Determination* (det.) - The name of the person who identified the specimen and date of determination.

v) *Features not apparent from pressed specimen* - such as size and habit, presence of underground organs, bark type, colour, texture and smell of leaves, flowers and fruits.

vi) *Habitat and ecology* - eg landform, soil type, vegetation type, disturbance history if apparent, frequency and a short list (usually 3-6 species) of adjacent species or dominants in the various strata of the vegetation.

vii) *Weeds* - For non-indigenous species, collectors should note whether the plants are naturalised (reproducing) at the collection site. If a seed reproducing species in naturalised at a site it is usually possible to find seedlings during the time of the year when germination would be expected. However, it is sometimes difficult to tell whether a plant is truly naturalised or whether it would not persist without fresh introduction (so-called 'casuals'). This is particularly

the case with vegetatively reproducing species and species that require a major event (such as fire) to stimulate seed germination. Such species require monitoring sometimes over a period of many years, to determine whether they are truly naturalised.

If time permits, other useful information that could be recorded includes area of infestation (ha), an estimate of the number of plants in the population, possible means of introduction and evidence of active management efforts.

viii) *Miscellaneous* - If the following applies it should be noted on the label:

- If specimens were gathered from the ground beneath a plant rather than being taken directly from the plant (avoid this if possible).
- If the specimens of a collection were taken from more than one plant.
- If a collection possibly consists of more than one taxon or a hybrid.
- If a photograph, transparency, spirit collection or other ancillary material is included in the collection.

FORWARDING SPECIMENS BY MAIL

Weed specimens being sent to a herbarium should be forwarded by mail in a pressed and dried state. Each specimen/separate collection and its accompanying label should be placed within two interlocking dry newspaper sheets. Any loose material (such as fruits) that could slide out of the newspaper wrappers during transit should be placed in an envelope clearly labelled with the collector's name and collection number. If the envelope is not too bulky it should be attached to the newspaper folder. Sheets can be stacked on top of the other and then sandwiched firmly between two pieces of cardboard. Uneven packing can be stabilised with empty newspaper layers used as padding. The parcel can then be wrapped in firm textured paper or placed within a large envelope or box.

In certain circumstances (generally when specifically requested), specimens can be sent in the fresh state. Each specimen should be clearly labelled and wrapped in damp newspaper (or tissue paper in the case of fragile flowers such as orchids) within a plastic bag. Fresh specimens should be sent post haste early in the working week, as they can deteriorate beyond recognition if caught in the mail for a prolonged period.

To avoid the time and expense involved in returning specimens forwarded for determination, collectors should retain a duplicate set of specimens so that the list of determinations received from the herbarium can be matched up with the corresponding specimens.

Specimens should be accompanied by a covering letter and sent to the addresses below.

FURTHER INFORMATION AND CONTACT ADDRESSES

The information in this chapter is a very brief summary. The booklet by David Albrecht entitled *Collecting and Preserving Herbarium Specimens* (National Herbarium of Victoria, 1993, is currently being reprinted and should be available for about $15) provides much useful further information.

Ensure that you have the correct authority and permits if required for collecting in protected areas. Generally, Permits are not required to collect weeds but it is always better to check first with the relevant authorities.

Specimens should be forwarded to:

NSW	Identification Service, National Herbarium of NSW, Royal Botanic Gardens, Mrs Macquaries Rd, SYDNEY, NSW 2000, Ph 02 9231 8111
SA	State Herbarium of South Australia, Plant Biodiversity Centre, PO Box 2732, Kent Town, SA 5071, Ph 08 8222 9307
Tas	Tasmanian Herbarium, GPO Box 252-04, Hobart, Tas 7001, Ph 03 6226 2635 *or Weed Alert Network via ph 1300 368 550*
Vic	Identification Service, National Herbarium of Victoria, Birdwood Ave, SOUTH YARRA, Vic 3141 Initial contact for clarification of any points may be made by phone on 03 9252 2300
WA	Western Australian Herbarium, Locked Bag 104, Bentley Delivery Centre, WA 6983, Ph 08 9334 0500
National	Australian National Herbarium, Centre for Plant Biodiversity Research, CSIRO Plant Industry, Black Mountain, ACT (GPO Box 1600, CANBERRA, ACT 2601), Ph 02 6246 5108

Recording sheet:

Family:

Genus: Species:

Authority:

Infraspecific name & authority:

Determined (identified) by:

Collector:

[1]Collector's specimen number:

Date of collection:

Additional collector(s):

Location

State:

Altitude:

[2]Minor Grid: [3]AMG:

[4]Latitude: Longitude:

[5]Natural Region:

[6]Specific:

Habitat

Vegetation Type:

Associated Species:

Landform:

Soil Type:

Features

Habit:

Bark Type:

Leaves:

Flowers:

Fruit:

Notes

Frequency:

Additional Notes:

*Vital information categories are underlined. All others are highly desirable for a well documented specimen, but simply leave blank if information not known.

1. It is desirable that collectors number their specimens sequentially from 1 onwards.
2. Standard Victorian plant distribution mapping grid of Churchill and De Corona (1972).
3. Australian Mapping Grid from 1:100,000 topographical maps. Please indicate full northing (7 figures) and easting (6 figures) as well as map number, which allows conversion to latitude and longitude by computer.
4. Lat. and long. to the nearest minute is acceptable, more accurate is useful. If a GPS reading is used this source should be stated.
5. See endpapers of *Flora of Victoria* vol. 2.
6. Distance and direction from known town or landmark, distance from local identifiable feature, and particular site information.

WHAT IS A HERBARIUM?

National Herbarium of Victoria, Melbourne

NATIONAL HERBARIUM

In Victoria, the State Botanical Collection is housed in the National Herbarium of Victoria, and consists of more than one million dried specimens of plants, algae and fungi from Australia and around the world. The Herbarium also maintains a rich and diverse collection of botanical books, manuscripts and works of art. Other States have a comparable herbarium. The Australian National Herbarium is located in Canberra.

WHAT IS THE HERBARIUM?

The National Herbarium of Victoria, is the Victorian State Government's major centre for botanical studies in plant identification and classification, and for ecological surveys of the State's vegetation.

An herbarium (plural, herbaria) is a collection of preserved plants arranged for reference and study. Victoria's collection of more than one million preserved specimens is the largest in Australia and contains specimens of most Australian flowering species. It is particularly rich in those plants which occur in Victoria. There are also numerous specimens of cultivated plants and weeds from most countries. Flowering plants form the greatest part of the collection but other plant groups such as algae, mosses, lichens and ferns are well represented.

Most herbarium specimens are preserved by pressing and drying. Once pressed, they are mounted on sheets of stiff white paper with a label bearing the name and description of where the plant was found, when, by whom and any other relevant information. The sheets are stored in flat folders, boxes or envelopes, which are arranged for easy access in large cupboards. Some delicate plant parts may be preserved in spirit and some are mounted whole on microscope slides.

THE FUNCTIONS OF THE HERBARIUM

The Herbarium is a source of detailed information about plants and plant communities. Herbarium specimens are one of the basic tools used by plant taxonomists who describe, identify and classify plants. The specimens are also important to plant ecologists who investigate the interaction of plant species with one another and with the environment.

Herbarium specimens are a unique form of stored information. Unlike catalogues, card indexes or computer records, they are actual pieces of biological material which provide the basic information on vegetative, reproductive and anatomical features of plants. Collectively, the labels of specimens provide distribution and ecological data and sometimes economic and ethno-botanical information (ethno-botany is the study of the use of plants by different cultures).

Certain herbarium specimens (known as 'Type specimens') are vouchers (standard references) upon which the name of a plant is based. Specimens of uncertain identity can always be compared with the Type specimen where there is doubt about the application of a name. The National Herbarium of Victoria contains several thousand Type specimens. When detailed examination of specimens, with associated field work, shows that some plants cannot be matched with examples of known species, then these plants may warrant recognition as a new species. A complete botanical description with drawings is then made and an appropriate scientific Latinised name is chosen. The description is then published in a scientific journal to conform to the principles laid down in the *International Code of Botanical Nomenclature*.

The specimens provide a permanent record of the plants growing in a particular area at a given time. This information can be used to detect natural or induced changes in the composition of plant communities. Monitoring these communities often leads to the recognition of plants becoming rare, vulnerable or endangered. Once this situation is recognised, the first step towards conservation of the species can be taken. It also assists with the monitoring of new weed incursions.

PLANT IDENTIFICATION AND INFORMATION SERVICE

Thousands of plants are identified annually through this service. Routine identifications are made by keying out the specimens and comparison with a reference collection of plants that are cultivated, native or naturalised in Victoria. The more unusual require verification by comparison with the main collection. The service is widely used. For example, veterinarians investigating stock poisoning, doctors studying allergies, naturalists and gardeners are all regular visitors.

MAKING YOUR WEED COLLECTION

Much of the following information comes from the booklet by David Albrecht entitled *Collecting and Preserving Herbarium Specimens* (1993) available at the National Herbarium of Victoria.

WHAT IS A REFERENCE COLLECTION?

State herbaria are the major repositories of preserved plant specimens, housing millions of specimens from all regions of the world. Other smaller collections exist in the hands of private individuals, government or university departments and are established primarily as a reference for plant identification, or in the case of students, as a component of a biological science course. Such collections are usually called reference collections or reference herbaria.

Establishing and maintaining a reference collection is very time consuming and before starting such a project one should be certain that it is really necessary. Only accurately identified specimens should be included in a reference collection, and if there is doubt over the correct identity of a specimen it should be checked at your State herbaria. Here is some information on establishing your own collection.

METHODS OF PRESERVATION

PRESSING

Ideally, specimens should be pressed immediately after collection. If they can't be, the specimens should be placed in plastic bags (or for small delicate plants sealable wide-mouthed plastic containers) to prevent desiccation and pressed at the earliest opportunity. Some species will remain in fairly good condition for up to a day or more if kept cool (refrigerate if possible) and protected from bumps.

If field notes are recorded at the time of collection and specimens are numbered prior to placing them into plastic bags, there should be little confusion (over details such as locality) when it comes to pressing them. If there is insufficient time to follow this procedure, specimens should be placed in separate, clearly labelled plastic bags for each habitat or locality.

It is advisable to remove soil from the root-system of specimens (such as by washing) before rather than after pressing as there is less damage to the specimen.

A plant press is a necessity for satisfactory pressing and drying of specimens. A press consists of an outer pair of end-frames or 'woods', thick smooth-sided cardboard with a transverse corrugated centre, newspaper, and two lengths of rope or straps.

The end-frames for a 'home-made' press can be made from suitable slats of timber nailed, glued or bolted together to form a lattice with the overall dimensions of c.45cm x 30cm. Alternatively, sheets of plain masonite or chip board can be used but holes should be drilled in each to facilitate air circulation. Cardboard can be obtained by dismantling firm textured cardboard boxes and cutting them into sheets the same dimensions as the end-frames. Folded newspaper is preferable to blotting paper, as the latter tends to hold moisture for too long and is an unnecessary expense. Avoid using paper with a glossy surface as its absorptive capacity is poor.

To assemble a press, place each specimen inside a folded sheet of newspaper and arrange it carefully, as its disposition at this stage will largely determine its ultimate appearance. Ensure that wilted leaves are straightened and that some of the leaves are pressed with their underside upwards. When placing these sheets in a press, each should be separated from the next by a sheet of cardboard, to assist air circulation through the press. A sheet of firm foam in addition to the cardboard can also assist drying.

When all specimens have been prepared, moderate pressure should be applied by pulling tight ropes or straps surrounding the end-frames. Excessive pressure will burst and squash soft parts, while inadequate pressure allows the material to wilt, wrinkle and curl within the press. Field labels can be inserted into the newspaper folder when the specimens are being prepared for pressing, or after the specimens are dry.

Spiny plants - (eg *Lycium* (Boxthorn)) Prior to pressing, the specimen can be placed beneath a wooden board and subjected to the weight of the collector. This method will prevent the spines from tearing the newspaper when the plant is pressed.

Bulky or bushy specimens - Bulky specimens such as Banksia flower spikes, large bulbs, thistle heads or densely tufted plants can be cut in half lengthways before pressing. It may be necessary to completely remove very bulky organs that are impossible to press (eg pine cones). These

should be placed in a labelled paper bag or envelope and re-united with the dried specimen later.

Long specimens - Many graminoids (eg grasses, rushes and sedges) are longer than the standard herbarium sheet, and as it is important to press the entire length of at least a few flowering stems. The specimen should be bent once, twice or more in the shape of V, N or M. Endeavour to bend each stem around the other as the resultant pressed specimens are flatter and are more easily mounted. If the material is exceptionally large a portion from the base with leaf sheaths and blades, and the inflorescence should be pressed. When specimens are selectively pruned for pressing it is important to note the overall length of the specimen.

DRYING

Moisture should be withdrawn from pressed specimens at a fairly rapid rate as it results in better quality specimens, particularly with respect to colour. However, if drying is too rapid specimens become brittle and readily drop their leaves. Large herbaria have drying cabinets with forced circulation of warm air, which accelerates drying and overcomes the need for regularly changing newspaper folders. The options available to those without access to driers include placing the press in the sun, beside a fire (but not too close, as excessive heat will turn specimens brown), on the roof racks of a moving vehicle, or in some other warm, well ventilated position.

The moisture level within the press should be checked and newspapers changed as often as necessary, particularly during the first few days of pressing. If mould develops it can be killed by brushing with methylated spirits. Mould is usually indicative of inadequate drying conditions.

The press should also be examined regularly for tightness, as undue distortion or shrivelling can result if the press is too loose. When specimens are fully dry they are generally rigid and do not feel cool, or droop at the extremities when lifted from the newspaper folder. As the original water content of plants and drying conditions vary considerably, no exact guide can be given as to how long the specimens will take to dry. However, in general most plants should be dry in one to two weeks.

MOUNTING SPECIMENS

Pressed plant specimens should be stored in a cool, dry place and inspected regularly for insect damage. Holes in leaves and petals, and fine dark granular droppings are evidence of insect damage. To prevent insect damage, pressed and dried specimens (excluding marine algae) should be frozen in a deep freezer at about -17°C for 48 hours or longer prior to incorporation into a reference collection and then periodically afterwards. Mothballs or flakes of napthalene can be placed amongst specimens to discourage insect predation but regular freezing (every six months or so) may overcome the need to resort to this measure.

Much more information is available in the booklet by David Albrecht entitled *Collecting and Preserving Herbarium Specimens* (1993) available at the National Herbarium of Victoria.

NEW AND EMERGING WEEDS

Kate Blood, Weeds CRC

SLEEPERS AWAKENED

There are many new and emerging weeds lurking in or near our natural areas. New and emerging weeds are defined as "newly recorded or recognised plant species or taxa of known or potential weediness with detrimental impact on specific environments".

Some may be 'sleepers' sitting there not really spreading much waiting for the ideal situation to start expanding. That 'ideal situation' may be a change in the local climate such as a drought or higher than average rainfall or perhaps the greenhouse effect. Other forms of disturbance that may favour new weeds include bushfires, a new road or human development, a change in the drainage patterns, maybe a new pest animal in the area that digs holes in the ground or an increase in the rabbit population. Disturbance usually favours the establishment of weeds but is not always essential for them to establish and spread.

Sleeper weeds are defined as "invasive plants that have naturalised in a region but not yet increased their population size exponentially".

Another term often used in discussions about these new weeds is 'incursion'. Incursion essentially means a new entry of a weed into Australia that has not been here before.

DISTURBANCE

An example of a common disturbance in natural areas is the building of roads and structures such as buildings. These require the earth to be moved and disturbed opening up ground for weeds to germinate. The compaction of the ground by vehicles and equipment may make it harder for indigenous plants to regrow and favour the weeds. As the ground is moved, drainage is usually altered and more run-off may be directed into a smaller area. This increase in localised water, usually accompanied by an increase in nutrients, can favour weed growth. It is common to see a flush of weeds growing down-slope from houses or alpine resort areas.

HOW WEEDS SPREAD

Even in more remote areas not immediately adjacent to developed sites, weeds can be introduced and spread. Plants may escape from gardens, forestry, crops or pastures and be carried many kilometres by wind, water or birds. A new weed can also be brought in on contaminated machinery or vehicles used for patrols, recreational access or fire management. They can even be brought in on clothing and boot laces of bushwalkers and workers. Stock such as sheep and cattle are good vectors as are horses used for trail rides. There are also the indigenous and pest animals and birds that carry seeds, including introduced deer which spread Himalayan honeysuckle (*Leycesteria formosa*) at Mt Buffalo NP in Victoria.

LEARNING FROM OVERSEAS

We can be aware of the plants that have the potential to invade by studying other areas in Australia or overseas that have similar characteristics and climate. An example is New Zealand. A very serious weed in the high country of the north island of NZ is Heather or Ling (*Calluna vulgaris*) from Scotland. At Tongarriro NP, Heather covers thousands of hectares. It had an unusual introduction to the park – a caretaker from Scotland many years ago used to walk around with a pouch of Heather seeds spreading them around so that it would look more like his home country! The plant is now a huge problem. It is assumed that caretakers or Rangers here in Australia would not do the same thing. However, many of our indigenous and pest animals are doing the same job of spreading seeds into natural areas from adjoining properties, gardens and roadsides.

The wind too can do the same task. Another serious threat to our alpine areas is *Hieracium* or Hawkweed. This small daisy plant is widespread in New Zealand and a priority weed. It produces lots of tiny seeds that are spread by the wind. The species *Hieracium aurantiacum* has been found in a resort garden at Falls Creek in Victoria. It has now spread along at least one of the local roads. It can be purchased from a number of nurseries in Australia.

When a new weed is found, depending on its invasive potential, priority should be placed on its removal. It is far cheaper and easier to remove a weed when it is a single or small number of plants rather than when it covers a 100 ha.

MORE INFORMATION

There are a number of articles worth reading in the appendix of these notes that outline the processes of what happens next in more detail.

WHAT NEXT?

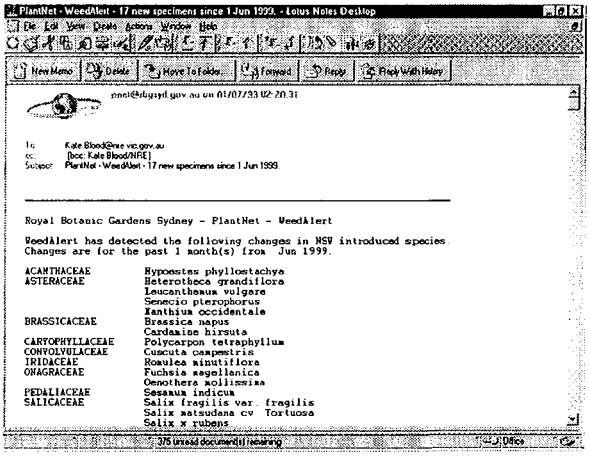
Kate Blood, Weeds CRC

SHARING INFORMATION

Once a plant has been identified, the next task is to decide how to manage it. You may have to ignore it because you don't have enough resources or there are higher priorities elsewhere. These are not always easy or pleasant decisions.

If you have the resources to do something, the level and type of action will be determined by the level of resources available, the priority of the weed and the priority of the area in which it occurs. The purpose of the area being managed will also influence management decisions. The whole management side of things is potentially another future workshop. In the mean time, there are networks of people who share information on such issues. There is an email discussion group in Australia called *Enviroweeds*. If you wish to subscribe for free, contact owner-enviroweeds@majordomo.nre.vic.gov.au to be joined up.

State herbaria are improving their notification systems for new weeds. The National Herbarium of NSW has an email system called *WeedAlert*. Monthly email bulletins are issued to notify which plants have been recorded for the first time as naturalised or have changed their distribution. Here is a *WeedAlert* bulletin:



Royal Botanic Gardens Sydney - PlantNet - WeedAlert

WeedAlert has detected the following changes in NSW introduced species
Changes are for the past 1 month(s) from Jun 1999.

ACANTHACEAE	Hypoestes phyllostachya
ASTERACEAE	Heterotheca grandiflora
	Leucanthemum vulgare
	Senecio pterophorus
	Xanthium occidentale
BRASSICACEAE	Brassica napus
	Cardamine hirsuta
CARYOPHYLLACEAE	Polycarpon tetraphyllum
CONVOLVULACEAE	Cuscuta campestris
IRIDACEAE	Romulea minutiflora
ONAGRACEAE	Fuchsia magellanica
	Oenothera sellowiana
PEDALIACEAE	Sesamum indicum
SALICACEAE	Salix fragilis var. fragilis
	Salix matsudana cv Tortuosa
	Salix x rubens

There are many groups and organisations that share information such as weed societies and conservation groups (eg. Indigenous Flora and Fauna Association). Many of these are listed in the *Weed Navigator* published by the Weeds CRC and available by calling 08 8303 6590 or at email crcweeds@waite.adelaide.edu.au

The Tasmanian Weed Alert Network has a quarterly newsletter called *Spotter* which contains lots of useful information on new potential threats, incursions and new weed infestations in Tasmania. Contact Editor, Cindy Hanson at Cindy.Hanson@dpiwe.tas.gov.au

It is important to continue raising awareness about weeds in your local area. Let your colleagues, family and friends know about the problems. Let them know how they can start in their own backyards by replacing invasive garden plants with safer alternatives. Encourage them to dispose of their garden refuse responsibly through local council rubbish collection or by taking it to the tip, not dumping it over the back fence or in the bush.

Try and get local groups involved in national Weedbuster activities especially each year in October. There is a whole network of people around Australia working together to stop weeds in their tracks. You can access expertise and a whole range of information material and merchandise that can be used at events and activities through out the year. More information can be obtained on the web at www.weedbusterweek.info.au or by calling your State/Territory coordinator (call Conservation Volunteers on 1800 899 444 for details).

WEED CALENDAR

When in the field, it is a good idea to keep notes of which weeds are flowering and seeding and when. Developing a weed calendar can be very useful for planning weed mapping (they are easier to see and recognise when flowering), treatment activities and restricting recreational access (eg to prevent seeds being spread on vehicles of bushwalking equipment etc). A weed calendar will help you match your work force, equipment and training with the work to be done each month.

WEED PREVENTION

some hints for weed prevention

Kate Blood, Weeds CRC

Here are some brief hints on preventing weeds being introduced, establishing and spreading in your area:

NO NEW WEEDS!

- prevent new weeds coming into Australia – let travellers know about quarantine restrictions, encourage plant importers to go through the correct quarantine procedures, avoid ordering plants over the internet from overseas or through mail-order

KEEP CLEAN AREAS CLEAN

- minimise disturbance in uninfested areas to reduce the chance of weed establishment - disturbance assists weed establishment and growth but is not essential
- ensure equipment entering any area is checked and cleaned of all potential soil and plant material including seeds
- educate bushwalkers, recreational vehicle drivers, horse riders etc about weeds and how to avoid spreading weeds on vehicles, clothing and equipment

WHERE DO THEY COME FROM?

- consider where weeds come from? - look over the fence or road, upstream and upwind
- address the sources of weeds otherwise effort put into management will be wasted due to reinvasion
- this may include community awareness and education programs for gardeners, recreationalists, nurseries and garden centres, tourists and farmers

HOW DID THEY GET THERE?

- consider the role of wind, water, people planting for "beautification", soil movement, dumped garden refuse, clothing and shoes, vehicles, equipment, birds, foxes, deer and other animals as vectors or spreaders of weeds
- address vectors of weeds where possible
- consider removal of introduced grazing animals as potential vectors
- manage introduced vectors of weeds such as foxes, wild dogs, rabbits, deer, pest birds
- reconsider the species used for soil stabilisation, and the use of hay as mulch or water run-off mitigators

WHAT CAN I DO?

- improve weed hygiene by regularly cleaning tools, equipment, vehicles, clothing and shoes
- have you looked at your own backyard lately? – consider replacing invasive garden plants
- protect areas from disturbance through good site management – use fencing effectively, define visitor access tracks, consider using wind barriers where appropriate to catch weed seed and protect soil, use indigenous plants of local provenance for revegetation, avoid moving contaminated soil, minimise disturbance during construction activities, carefully plan changes to drainage
- notify adjoining land managers of new weeds or new invasions of existing weeds so joint action can be taken
- be alert at all times and watch for weeds especially new weeds – act fast and nip them in the bud!

Documents such as *Guidelines for preventing the spread of weeds* (1998) by Leigh Dennis of NRE, Vic have more ideas.

WHERE TO FIND INFORMATION

Kate Blood, Weeds CRC

These are some of the many locations where you can obtain weed and related plant publications. They are grouped by geographic location but many will have publications relevant for areas beyond their home State/Territory. Many retail bookshops increasingly stock weed and plant books. Try looking in the gardening section. Also try government department bookshops listed in the *Weed Navigator* available from the Weeds CRC listed below.

BOOKS AND PUBLICATIONS

ACT

Botanical Bookshop
Australian National Botanic Gardens visitor centre, Black Mountain, ACT
PO Box 351, JAMISON CENTRE, ACT 2614
Ph 02 6257 3302, fx 02 6247 1947
Web site: www.anbg.gov.au/anbg/bookshop

NSW

Florilegium
PO Box 644, ROZELLE, NSW 2039
Ph 02 9571 8222, fx 02 9571 8333
Email: florileg@ozemail.com.au

Gardens Shop
Royal Botanic Gardens, Mrs Macquaries Rd, SYDNEY, NSW 2000
Ph 02 9231 8125, fx 02 9251 6132

Sainty and Associates
Box 1219, POTTS POINT, NSW 2011
Ph 02 9332 2661, fx 02 9331 5372
Web site: www.sainty.com.au

SA

Weeds CRC
Waite, University of Adelaide, PMB 1 GLEN OSMOND, SA 5064
Ph 08 8303 6590, fx 08 8303 7311
Email: crcweeds@waite.adelaide.edu.au

VIC

CSIRO Publishing
PO Box 1139, COLLINGWOOD, Vic 3066
Ph 03 9662 7500
Web site: www.publish.csiro.au

Gardens Shop
Herbarium Building, Royal Botanic Gardens, Birdwood Ave, SOUTH YARRA, Vic 3141
Ph 03 9252 2341, fx 03 9252 2350

NRE Information Centre
Department of Natural Resources and Environment, 8 Nicholson St, East Melbourne, Vic
PO Box 500, EAST MELBOURNE, Vic 3002
Ph 03 9637 8325
Email: infocentre@nre.vic.gov.au

RG & FJ Richardson
PO Box 42, MEREDITH, Vic 3333
Ph & fx 03 5286 1533
Email: richardson@weedinfo.com.au
Web site: www.weedinfo.com.au

ENVIROWEEDS email discussion group

Get in touch with over 500 people interested in environmental weeds in Australia and overseas. It is a free service and you receive regular bulletins and can share information with people all over the country. To subscribe, send an email to Kate.Blood@nre.vic.gov.au

To send a message to the group (you have to be subscribed first), send it to: enviroweeds@majordomo.nre.vic.gov.au

HOT WEED WEB LINKS

- All your weed information on the web. Start here for hotlinks around the globe:

  http://www.agric.wa.gov.au/progserv/Plants/weeds/links.htm

- Weeds of National Significance (WONS) and noxious weed lists:

  http://www.weeds.org.au

- Get involved in national Weedbuster campaigns: www.weedbusterweek.info.au

GARDEN THUGS

Over 900 invasive garden thugs (garden plants that have escaped to become weeds in natural or farming systems) have been identified in Australia. Many are still in gardens and available from nurseries, garden centres and over the internet. A draft national strategy on invasive garden plants called 'Garden plants under the spotlight' is available from Kate.Blood@nre.vic.gov.au. The Nursery and Garden Industry, Australia has published their short list of garden thugs at www.ngia.com.au

BEST PRACTICE MANAGEMENT GUIDES AND WEED NOTES

The Weeds CRC have published a series of best practice management guides on various environmental weeds. These guides combine the current research with practical management solutions for the field. Guides are available on broom, blackberry, bridal creeper, boneseed, bitou bush, St John's wort, horehound. See the Weeds CRC web site for more information. Most government departments publish their weed or pest plant notes on their web sites. See the *Weed Navigator* for more details or hot link from the Weedbuster web site above.

UNDER CONTROL

'Under Control' is a newsletter on pest management published regularly by the Keith Turnbull Research , Vic. To join the free mailing list, contact the Editor Ian.Faithfull@nre.vic.gov.au or call 03 9785 0111.

NEW FIELD GUIDE

The Weeds CRC and Cyril Jerram and Associates have published a new field guide on environmental weeds in south eastern Australia in August 2001. The guide will be field friendly and cover over 170 weeds with color photos. Written by Kate Blood, the guide looks at the weed characteristics, where they come from, where they invade and ecology information. Contact the Weeds CRC or see their web site for more information.

OTHER FIELD GUIDES

There are a growing selection of field guides and publications to assist with weed identification. Many are listed in the *Weed Navigator* and subsequent issues of the email delivered *Enviroweed Bulletin*. In WA, use *Western Weeds*. Ask your local Council for regional guides, many of them free.

FURTHER READING...

This is only a small number of references. The *Weed Navigator* has lots more including field guides and floras. Contact 08 8303 6590 to order a copy.

Adair, R. J. (1995) The threat of environmental weeds to biodiversity in Australia: a search for solutions , **in** Bradstock, R. A., Auld, T. D., Keith, D. A., Kingsford, R. T., Lunney, D. and Sivertsen, D. P. (eds.) *Conserving biodiversity: threats and solutions.* Surrey Beatty & Sons, pp. 184-201.

Albrecht, D. (1993) *Collecting and preserving herbarium specimens.* Royal Botanic Gardens, Melbourne.

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GLOSSARY...

alien or exotic	not indigenous; introduced from another region or country; the terms are used interchangeably; exotic often implies from overseas
annual	a plant that completes its life cycle within one year from germination to fruiting and then dying
authority	the author of a botanical name
biodiversity	contraction of biological diversity
biological control	control of pests by use of their organisms, such as predators or pathogens, or their products
biological diversity	the variety of life forms: the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form
casual	one of the stages leading to naturalisation; the plant requires constant reintroduction as it will not persist or become naturalised; the other two stages towards naturalisation are adventive and established
community education	involves the communication of information, ideas, concepts, values, attitudes and skills to and between members of the community
confirmation	acceptance of the existing determination by a person with a specialist knowledge of the particular group
corm	a solid, reduced, underground stem of one year's duration, with thin leaf bases attached to the surface. The next season's corm forms on to of the older one
determination	ascertaining the correct name for a specimen; identification
dioecious	with male and female sex organs on separate plants
dispersal	process by which seeds, or other reproductive units, are carried away from the parent plant
dormancy	a special condition of arrested growth in which a plant and such plant parts as buds and seeds do not begin to grow without special environmental cues
ecology	the science dealing with the relationships between organisms and their environments, including its practical application
ecosystem	the organisms in a community plus the associated abiotic (non-living) factors with which they interact
education	provision of detailed materials and programs designed to assist interest and education groups
endemic	restricted to a specified region or locality
environmental weed	plants that invade natural systems threatening indigenous biodiversity; they usually adversely affect natural regeneration of the vegetation and affect the survival of the indigenous flora and fauna
extension	the taking out of information from research to traditionally farmers, to be used in improved management techniques of weeds
feral	domestic gone wild
flora	(1) all the plants growing in a certain region or country; (2) an enumeration of them, generally with a guide to their identification
habitat	the environment of an organism; the place where it lives
herbarium	a scientific collection of dried and pressed plant specimens
identification	the act of identifying
identify	to recognise or establish as being a particular person or thing
indigenous	the indigenous flora of Victoria is taken to be that which evolved here or migrated by long distance dispersal before European settlement
information	provision of details on environmental weed identification, biology and management, weed regulations etc, both prior to and during environmental weed management programs

interpretation	can be considered a special form of community education. It is primarily on-site and site related, and it offers first-hand experiences. It involves the communication of feelings and relationships as well as facts
introduced	a plant that has been brought accidentally or deliberately to a site since European settlement (maybe from overseas, inter-State or other parts of Victoria)
life form	a descriptive term that combines morphological and life history features of a plant
monoecious	having male and female flowers on the same plant
native	use of this term usually implies native to Australia. In a Victorian context, native could mean a plant that is indigenous to Western Australia or another part of Australia or Victoria. If the plant is not indigenous to a specific area of Victoria, then it is considered to be introduced ie. it has expanded its natural geographic range under human influence since European settlement. The use of this term can be confusing and it is preferable to use the terms indigenous and introduced.
naturalised	capable of reproducing and sustaining populations without the input of resources or direct intervention by humans; a taxon not indigenous to an area but now freely reproducing in well established populations
noxious	declared as noxious under legislation
ornamental plant	a plant grown for aesthetic value
perennial	a plant with a normal life span of more than two years
potentially threatening process	a process which may have the capability to threaten the survival , abundance or evolutionary development of any taxon or community of flora or fauna
propagule	a plant part or plant organ capable of producing a new plant; includes seeds, spores, bulbils, stem fragment etc
recognise	to know again; perceive to be identical with something previously known
rhizome	an underground stem, usually growing horizontally; in ferns, used more generally to include prostrate, creeping and short erect stems below or just above the ground
seed-bank	reservoir of viable seed in soil capable of remaining dormant for some time, and usually germinating after disturbance
species	groups of individuals, or populations of individuals, which share common features and/or ancestry, generally the smallest group which can readily and consistently be recognised; often, a group of individuals capable of interbreeding and producing fertile offspring
stolon	a more or less horizontal stem growing above ground, producing roots and sometimes erect shoots at the nodes
succulent	a plant having juicy or watery tissues
taxon/taxa (plural)	a group or category in a system of classification eg species
taxonomy	the science of the classification of organisms
taxonomy	the science of the classification of organisms
tuber	an underground storage organ formed by the swelling of an underground stem or root (the latter sometimes called a tuberoid)
voucher	a specimen preserved and stored to substantiate recorded observations, and to which future reference may be made
wilding	an escape from cultivation

A number of references have been used to compile this glossary. They include: Walsh & Entwisle 1994, Albrecht (1993), Cronk & Fuller 1995, Beattie 1995, Parsons & Cuthbertson 1992, Carr 1993, Carr *et al.* 1992, Meagher 1991, NPS interps manual 1995 and the 1998 Macquarie Dictionary.

abbreviations

AALC	Australian Alps Liaison Committee
AAnp	Australian Alps national park
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific Industries Research Organisation
ed	editor
FFG	Flora & Fauna Guarantee
ha	hectare
ICBD	International Code of Botanical Nomenclature
IFFA	Indigenous Flora and Fauna Association
KTRI	Keith Turnbull Research Institute, Frankston
NHV	National Herbarium of Victoria
NRE	Department of Natural Resources and Environment (formerly CNR)
RBG	Royal Botanic Gardens
sp.	species (singular)
spp.	species (plural, more than one)
subsp., ssp.	subspecies
Vic	Victoria

NOTES...

PART TWO - ACTIVITIES

part 2 * activities

PART 2 - ACTIVITIES

CONTENTS

PART TWO - ACTIVITY SHEETS

MAKING A BOTANICAL KEY

GO TO IT!

WEED DESCRIPTIONS

The following pages provide space for you to collect specimens and information about weeds that interest you. Place a small plant specimen or draw a picture on each page, record its name and other information and then record in you own words a description that you will remember.

To ensure your book does not go mouldy, place sheets of newspaper between the pages with specimens and press flat under a phone book or other books for a couple of weeks. Change the newspaper every few days during that period. Remove newspaper once the specimens are dry.

Use these notes in conjunction with the SE Australian field guide *Environmental Weeds* or the West Australian guide *Western Weeds*.

botanical name		place your specimen or hand drawing here:
common name		
family		
life form *(may be more than one)*	☐ tree, ☐ shrub, ☐ climber/creeper, ☐ herb ☐grass, ☐ bulb etc, ☐ aquatic, ☐ other:	
origin		
distribution		
reproduction	☐ seed, ☐ bulbs etc, ☐ stems, ☐ other:	
spread by	☐ wind, ☐ water, ☐ animals, ☐ people, ☐ other:	
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PART THREE - APPENDICES

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PART 3 - APPENDICES

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PART 3 - APPENDICES

SLEEPER WEEDS

Richard Groves
CSIRO Plant Industry & CRC Weed Management Systems
GPO Box 1600, Canberra, ACT 2601

Abstract I define sleeper weeds as those invasive plants that have naturalised in a region but not yet increased their population size exponentially. They thus fall between recent incursions and major weeds of national significance and represent a numerically large proportion of the total introduced flora of Australia. Some ecological factors which interact to determine status as a sleeper weed are discussed using Australian examples; two that seem to have most predictive value are time from naturalisation and re-location to a more favourable site. I conclude that sleeper weeds, one of the three major categories of weeds, require enhanced attention from research scientists and resource agencies so that overall weed impact in Australia can be reduced.

INTRODUCTION

A plant population goes through certain phases as it increases in numbers - it is introduced to a new site, it establishes and becomes naturalised, it increases in numbers slowly and, after a period of time, its rate of increase becomes higher until some factor in the environment limits further increase. This limiting factor may be imposed either naturally or as a result of human intervention (some form of management), after which the rate of population increase slows (Figure 1). A few naturalised plant species increase exponentially almost immediately after arrival and become major weeds. Most naturalised plant species, however, increase initially only to a limited extent, after which they show no further apparent population increase in their new environment for many years. Only after an extended period of time does the rate of population growth for such species increase and they begin to interfere with human activities in some way. These so-called 'sleeper' weeds comprise a numerically large subset of the invasive biota of Australia, and little is known about them at present.

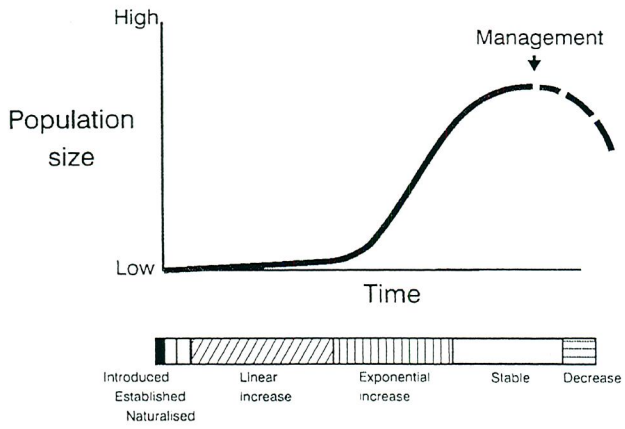

Figure 1. Phases in the population increase of a weed. Sleeper weeds are those invasive plants showing a low rate of increase in population size, i.e. they occupy the time period between naturalisation and the start of a high rate of increase in population size

ECOLOGY OF SLEEPER WEEDS

Elsewhere (Groves 1999), I have discussed several biological and ecological attributes of sleeper weeds that may influence the time between naturalisation and rapid population increase, and hence 'sleeper weed' status. These factors include the favourability of the arrival site for establishment of a population, the possession by the species of biological attributes enabling its persistence at a particular site and the species possibly being pre-adapted to the ecological conditions of the 'new' site. But two factors seem to be especially important in determining sleeper weed status, viz. time from naturalisation and re-location of a naturalised species to a more favourable site, each of which I shall discuss separately but in each case using the European genus *Hieracium* as my example.

Time from naturalisation Scott and Panetta (1993) investigated the status of some southern African plants that have become agricultural weeds in Australia over the last 150 years. Of a number of predictor variables they looked at, the longer the time from introduction (correlated with time from naturalisation?), the more likely it was that the species became an agricultural weed in Australia. Species introduced most recently (since 1950) had weed ratings that could not be predicted. Sleeper weeds include not only agricultural weeds, however, and it is noteworthy that Scott and Panetta found no variable (even a long time from introduction) to be a suitable predictor of non-agricultural weed status.

At least 260 species of *Hieracium* have been described for Europe, togather with many subspecies, apomictic lines and hybrids (Sell and West 1976). In Australia only one *Hieracium* species (*H. aurantiacum* L., syn. *H. brunneocroceum* Pugsley?) is known to be naturalised, with populations currently present in Tasmania (Curtis 1963) and Victoria (Groves, unpublished). In New Zealand, nine species of the genus and one naturalised hybrid occur currently and their known times of naturalisation are given in Table 1. The most invasive species in New Zealand at the moment is the one that naturalised earliest, viz. *H. pilosella* L.

The fact that the *Hieracium* species that naturalised first and over a century ago in New Zealand is now the most weedy bears out the conclusion of Scott and Panetta (1993) for agricultural weeds of southern African origin. Whilst some of the other *Hieracium* taxa present in New Zealand are also considered as weeds, can some of the more recent arrivals be regarded as sleeper weeds that will become major weeds over time? At two sites in southeastern Australia *H. aurantiacum* seems to be a garden escape that is behaving currently as a sleeper weed. When will it become a major weed of subalpine grassland areas in this region? What is limiting its current low rate of population increase? What will change with time?

Table 1. *Hieracium* species and their dates of naturalisation in Australia and New Zealand (from Curtis 1963 and Webb *et al.* 1988 respectively)

Taxon	Date of Naturalisation
Australia	
H. brunneocroceum (syn. *H. aurantiacum* ?)	1963
New Zealand	
H. pilosella	1878
H. sabaudum	1904
H. aurantiacum	1911
H. praealtum	1924
H. argillaceum	1940
H. caespitosum	1940
H. murorum	1940
H. lepidulum	1946
H. pollichiae	1988
H. x stoloniferum	1988

Re-location to a more favourable site The history of spread of *H. pilosella* in the South Island of New Zealand (Groves 1999) suggests that for about 80 years it behaved as a sleeper weed in South Canterbury. The species increased its rate of population growth only when it was re-located to the montane grasslands of the Mackenzie Basin, where over the last 40 years it has become a major pasture weed. In a manner similar to that evidenced by *H. pilosella*, the two populations of *H. aurantiacum* in southeastern Australia may be behaving as sleeper weeds until their re-location to sites more favourable for rapid population increase. Thereafter *H. aurantiacum* could become yet another aggressive rosette weed of major significance to Australian pastoral regions.

One Australian example which definitely shows a pattern of significant increase in population size as a result of geographic re-location is *Mimosa pigra*. This species is known to have been planted in the Darwin Botanic Garden since at least 1891, and probably earlier (Miller and Lonsdale 1987). It was naturalised only in the Darwin area as a sleeper weed until 1952 when material was re-located to an inland site at the headwaters of the Adelaide River. Its water-borne seeds could then spread down-river to the floodplains where it is currently one of northern Australia's major weeds of seasonally flooded wetland areas.

The two ecological factors I have discussed above will interact, as is obvious from the example of *H. pilosella*. Clearly, naturalised plants that have been in Australia for a longer period will have had a greater chance or time to be relocated to more favourable conditions that will forster their further spread. These two factors will also interact with other ecological factors such as rate of spread and the availability of dispersal vectors. Just as there seems to be no one attribute or set of attributes characteristic of invasive plants overall, neither does the subgroup of sleeper weeds necessarily have attributes in common. Rather, there seems to be a range in response of sleeper weeds to new geographic and ecological situations, knowledge of which is limited by the paucity of examples available at present and the inadequate documentation of the history of introduction and spread of other potential examples.

RESOURCE CONSIDERATIONS

The majority of resources for weed control (in terms of both money and time) in Australia goes towards reducing the impacts of major known weeds of cropping and grazing lands. Such weeds reduce the value of production, often in a direct way, and their costs to the community can be calculated and compared with the benefits of controlling those weeds. Benefit/cost ratios for control programs are often shown to be highly favourable, a situation that further promotes flow of resources to this category of weed. Less resources are directed currently at managing weeds invading natural vegetation, partly because the impact of such weeds is largely indirect in monetary terms and is more difficult to assess economically, especially those aspects related to biodiversity loss. A small but significant level of resources is also spent controlling, and even attempting to eradicate, some recent incursions in those cases where the species is known to be weedy outside Australia, such as the recent examples of *Chromolaena odorata* and *Kochia scoparia* var. *scoparia*.

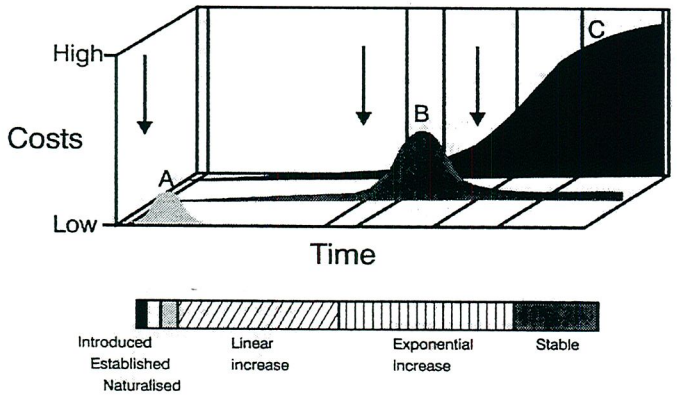

Figure 2. Costs of undertaking an eradication program on a recent incursion (A) relative to those for control at either an early (B) or a late (C) phase of a plant invasion (from Figure 4 of Williams 1997).

Williams (1997) showed diagrammatically the relative costs (both in monetary terms but also in terms of the presumed environmental costs) of limiting weed populations at three different phases of the invasion process (Figure 2). The costs for eradicating a new incursion (A) are less than those associated with controlling it when it is already widespread geographically (B), although the total population may be limited and much less than when its rate of population size has increased and it has acquired the status of a major weed (C). The costs of eradicating or controlling sleeper weeds lie somewhere between (B) and (A), presumably.

Csurhes and Edwards (1998) considered a total of 289 weed species that were in the early phases of invasion, of which 274 were definitely introduced to Australia. Of the latter total, 119 species were not known as environmental weeds outside Australia. Csurhes and Edwards then took a subsample of 30 of the 155 species known to be weedy outside Australia and assigned each species a relative probability of eradication; they found that 10 species had a 'high', 5 a 'medium' and 15 a 'low' probability of eradication. Their predictions refer mainly to environmental weeds and not to known weeds of agricultural systems.

Many of the 274 species considered by Csurhes and Edwards (1998) seem to fall into the sleeper weed category as defined in this paper. Others are not yet naturalised and may not therefore comply with my earlier definition. Their 10 introduced species known to be weedy outside Australia and predicted by them to have a high probability of success for eradication would be a useful short list on which to start limiting the number of non-naturalised sleeper weeds in the Australian introduced flora. Taxa on this short list include *Acacia* spp. (especially *A. catechu, A. karroo, A. sieberiana*), *Aloe ferox, Clerodendrum* spp. (though *C. chinense* is not yet known to be naturalised in Australia), *Miconia calvescens, Mikania* spp., *Myrica faya, Mimosa dulcis, Rhus radicans* (the latter three not yet known to be naturalised, though grown in some Botanic Gardens in Australia), *Sesbania punicea* (not naturalised but probably still in some private gardens in Australia) and *Ziziphus mucronata* (as one plant in Melbourne Botanic Gardens). Whilst some success may already have been attained in Australia with controlling and/or eradicating *Acacia karroo* and *Mikania* spp., eradication of the other taxa specified by Csurhes and Edwards seems an urgent priority for Australian land managers. Certainly, most of them meet the conditions for eradication as specified by Williams (1997).

At present, almost no resources are allocated for the eradication of sleeper weeds, and certainly not on a national basis. Logically, however, a limited amount of money and time spent when a weed population is small and confined geographically should yield considerable benefit in that the overall cost of controlling that weed will be much less than when the same weed has increased significantly in population size and distribution (Figure 2). This is the same logic, after all, that is applied to the allocation of scarce resources to control or eradicate recent incursions of weeds of already known agricultural potential. The different situation with sleeper weeds presumably arises because their potential to multiply and affect human values is less simple to predict as that for recent incursions of known agricultural weeds.

The deficiency in programs targetting sleeper weeds needs to be addressed if the overall impact of weeds on Australian land systems is to be reduced. Bureaucratic structures are in place to allocate resources and to implement management of weeds of national significance and of recent incursions. No such resources or structures exist at present, however, to reduce the present or future impact of sleeper weeds. Perhaps it is time for this numerically large third class of weeds to receive more attention from all sections of the weed management community, including those who allocate already scarce funds on a national basis. Involvement of the nursery industry seems essential, because many sleeper weeds (including *H. aurantiacum* in New South Wales - see Dellow and Groves, these Proceedings) are still being sold and actively promoted by members of that industry.

CONCLUSIONS

There is a spectrum of responses to new environments shown by plants introduced to Australia from elsewhere. There appear to be no hard boundaries between the biological attributes shown by unsuccessful arrivals, by naturalised but localised plants and those shown by major invasive weeds which are currently characterised by large population sizes and extensive distributions. Sleeper weeds fall somewhere between those recent incursions with a high invasive potential known from their behaviour in other regions and the species that have already become major weeds of national significance.

Sleeper weeds are thus an important and hitherto-overlooked third category of invasive plants that have been little studied to date but for which benefit/cost ratios of eradicating or containing

them may be highly favourable. They comprise an unknown but probably numerically large proportion of the introduced flora of Australia and are worthy of an enhanced level of study and research funding. The benefit/cost ratios arising from an eradication program for a recent incursion may be considerable in the short term, as in the case of *Chromolaena odorata* in northern Queensland. The benefit/cost ratios from more effective control of some major weeds of agricultural and natural ecosystems may be higher and even longer term. Control or eradication of the intermediate, third category of invasive plants we call sleeper weeds may also be highly cost-effective in the medium- and long-terms (Figure 2).

The important category of sleeper weeds cannot continue to be overlooked by weed scientists and funding agencies in Australia if we wish to avoid an inexorable increase in the number of major weeds and the resources spent on their control in the future. The subject is too important to have been overlooked nationally for so long!

ACKNOWLEDGMENTS

Much of the material discussed here was first presented in more detail elsewhere (Groves 1999). I thank Stephen Dempsey, BRS, for permission to reproduce this shortened version to a wider audience, and Cheryl McRae and Graeme Evans, BRS, for their earlier invitation to publically face the challenges posed by sleeper weeds nationally. Peter Williams (NZ Landcare Research, Nelson) willingly gave permission to re-use some of his published material on weed ecology and management. John Vranjic commented helpfully on a previous draft of this material.

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THE AUSTRALIAN QUARANTINE AND INSPECTION SERVICE WEED RISK ASSESSMENT SYSTEM FOR NEW PLANT IMPORTS: ITS DEVELOPMENT AND IMPLEMENTATION

Eve Steinke
Plant Quarantine Policy Branch, Australian Quarantine and Inspection Service,
GPO Box 858, Canberra, ACT 2601

Abstract The Australian Quarantine and Inspection Service (AQIS) regulates the importation of plants into Australia to minimise the risk of introducing exotic weeds. AQIS operates on the principle of managed risk, utilising decision making processes consistent with relevant international trade agreements and standards to identify risks and management options. The objective is to protect Australia's agricultural industries and the natural environment by managing any disease or weed risks within an appropriately conservative quarantine framework, whilst still permitting import of benign and desirable plants.

In 1997 AQIS introduced a new system for screening new plant imports to reduce the levels of exotic weed pests entering and establishing in Australia, based on the principle of a permitted list of plants. This paper describes the operation and implementation of the process that AQIS adopted, and discusses the development of the policy underpinning the process.

INTRODUCTION

Effective plant quarantine is important for the protection of the biodiversity of the natural environment and Australia's agricultural industries. Infestation of agricultural systems has the potential not only to incur costs in controlling pests and losses in production, but also to restrict access to export markets, if the pest has the potential to contaminate the marketable product.

Australia's policy on the operation of plant quarantine has traditionally focused on preventing insect or disease entry with plant imports. The only exceptions were a small number of plants known to be major agricultural pests elsewhere and some environmental weeds, listed in Proclamations enacted under the *Quarantine Act, 1908*.

The introduction of the Hazard system in 1990 to identify potential weeds was recognition of the need for a more comprehensive screening of imports (Hazard, 1988). The Hazard system utilised 14 questions relating to a plant's weed history and known weedy relatives, with a focus on weeds of agricultural systems. Although the Hazard system was an improvement on the system of *ad hoc* assessment, basing the assessment on known weediness was a major limitation of the system. Experience has shown that many plants that have become weeds in Australia have not been recorded as weeds overseas. Prickly pear (*Opuntia* spp.) and bitou bush (*Chrysanthemoides monilifera ssp rotundata*) are two well known examples of plants which are, at worst, minor pests overseas, but became serious weeds in Australia. As most recorded weeds are weeds of agricultural systems the Hazard system was also limited in its ability to identify environmental weeds.

Increasing recognition of the importance of environmental weeds, and Australia's obligations under international treaties to use scientifically based risk assessment systems, led AQIS to participate in 1994 in a joint initiative led by the Australian Plant Industries Committee to examine screening protocols for plant introduction (Panetta *et al*, 1994). The resulting workshop "Screening plants for weediness" was the first step towards a new system.

DEVELOPING A NEW WEED RISK ASSESSMENT SYSTEM

The major considerations in the selection of the new system can be divided into three categories:

1. the policy of the incumbent government;
2. Australia's domestic legislation relating to quarantine and the environment; and
3. Australia's international obligations relating to trade and the environment.

Government policy and quarantine in the 1990's

(a) *The National Weeds Strategy* In 1991 the Commonwealth, State and Territory ministers responsible for agriculture, forestry and the environment agreed in principle to develop a National Weeds Strategy (NWS). The NWS came into operation in 1997 when it was funded by the Natural Heritage Trust, a body established by the

federal government to distribute funds to projects directed at developing sustainable agriculture and protecting biodiversity.

The first goal of the NWS was the prevention of the development of new weed problems. The NWS provided funding to AQIS to implement a new screening process able to identify potential weeds of all ecosystems including agricultural, rangeland, bushland and aquatic systems, to be applied to all new plant imports (ARMCANZ, 1997). This funding was critical in both the development and implementation stages of the new WRA system.

(b) *The Nairn Review* A comprehensive review of Australian quarantine was undertaken in 1996, chaired by Professor Malcolm Nairn. The review produced a number of recommendations relating to the overall conduct of quarantine, including the need to:

1. engage industry, government and the general public in a partnership approach to quarantine;

2. take greater account of environmental considerations;

3. increase the quarantine resources devoted to plant issues;

4. recognise that quarantine is a continuum including pre-border, border and post-border activities; and to

5. conduct risk assessment in a way that allows industry and the general public to have their views considered, and that is transparent, scientifically based and allows for appeal on process (Nairn *et al.*, 1996).

A report funded by the review found that the increasing rate of plant naturalisations, with over 290 plants naturalising in the past 25 years (Groves, 1997), was a major source of concern. Over 65% of these plants were deliberately introduced for horticultural purposes. The review supported the introduction of a system based on a model for determining weediness of new plant introductions developed by Pheloung (1995), which was based on risk analysis principles including the use of a permitted list as the basis for approvals.

The endorsement and funding for the implementation of many of the recommendations made by the review reflected a rise in the government's perception of the importance of quarantine issues.

The legal basis of quarantine in Australia

(a) The Quarantine Act The *Quarantine Act, 1908*, defines quarantine as "measures for the inspection, exclusion, detention, observation, segregation, isolation, protection, treatment, sanitary regulation and disinfection of vessels, installations, persons, goods, things, animals, or plants, and having as their object the prevention of the introduction or spread of diseases or pests affecting human beings, animals, or plants." The Act makes no distinction between diseases and pests of agriculture and those of the environment.

As mentioned previously, until recently all plants not expressly prohibited were permitted import as seed. Prohibited plants were listed in proclamations subordinate to the *Quarantine Act, 1908*. In 1998 a new proclamation under the Act introduced a permitted list for plant imports. All plants not on the permitted list are now prohibited. To import a species not on this list an import application must be completed, and the weed risk of the plant assessed using the WRA system and found to be manageable.

Decision making based on import risk analysis under the *Quarantine Act 1908* must conform with international trade standards and the relevant provisions of domestic environmental legislation and related arrangements dealing with environmental impact assessment, protection of Endangered Species and protection of World Heritage areas and the National Estate.

(b) *Environmental law and quarantine in Australia* Prior to the passing of the *Environment Protection Biodiversity Conservation Bill* in June 1999, the *Environment Protection (Impact of Proposals) Act 1974* (*EP(IP) Act*) was the environmental legislation most directly relevant to the operation of quarantine risk assessment processes, effectively encompassing the requirements of Australia's other environmental legislation. The object of the *EP(IP) Act* was to ensure that matters affecting the environment to a significant extent were fully examined and taken into account in the making of decisions and recommendations by the Australian Government and its authorities. For the purposes of quarantine, if the Department of Environment and Heritage advised AQIS that its' import risk assessment processes adequately covered environmental issues then there was no need to invoke the processes under the *EP(IP) Act*.

The Department of Environment and Heritage has endorsed the AQIS WRA process, allowing assessments to be made without invoking the EP(IP) processes. Although the *Environment Protection Biodiversity Conservation Bill* will replace this Act, it is unlikely that the new legislation will affect the processes for the weed risk assessment of new plant imports outlined here.

International obligations and quarantine

(a) Trade agreements Australia is a signatory to the International Plant Protection Convention (IPPC). This convention aims to prevent the transfer of organisms that will harm agricultural systems. The IPPC administers the International Standards for Phytosanitary Measures (ISPMs) which outline various plant quarantine methodologies developed by the contracting parties. Australia is also a signatory to the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS agreement).

The SPS agreement addresses measures to protect human, animal or plant life or health from risks arising from quarantine pests (WTO, 1994). The SPS agreement recognises the ISPMs set by the IPPC as the relevant international standards. SPS measures must be:

- applied only to the extent necessary to protect human, animal or plant life or health;

- based on scientific principles and not maintained without scientific evidence; and

- not applied in a manner which would constitute a disguised restriction on international trade.

In order to assist this task the IPPC has developed guidelines for risk analysis (FAO, 1995). These guidelines include a definition of a quarantine pest that must be used: 'A pest of potential national economic importance to the area endangered thereby and not yet present there, or present but not yet widely distributed and being officially controlled' (FAO, 1997).

(b) Environmental agreements Australia ratified its membership of the Convention on Biodiversity in June 1993. The Convention on Biodiversity is a framework for global action to conserve and sustainably use biological diversity. Its requirements include measures for *in situ* conservation, which is the conservation of ecosystems, natural habitats and species in their natural surroundings, and involves control of alien species and genetically modified organisms (UNEP, 1992).

The guidelines for implementing the requirements of the Convention on Biodiversity are still being developed. However the environmental concerns specified in the Convention on Biodiversity were considered when selecting a WRA system, in order to minimize any conflict between the eventual guidelines and AQIS policy.

THE AQIS WRA SYSTEM

The AQIS WRA system is a three tiered system. The first tier determines whether a plant is already naturalised in Australia, and not officially controlled, or on a list of permitted plant imports. Plants that are not already present or permitted proceed to the second tier. The second tier is based on the Pheloung model (Pheloung, 1995; Walton *et al*, 1998), and consists of a questionnaire which evaluates the weed risk of plants using 49 questions about the plants' biology, climatic preferences, reproductive and dispersal methods, and known weed history. The questionnaire is designed to identify weeds of natural and agricultural systems. Depending on the score generated importation of the plant is permitted, rejected or prohibited pending 'further evaluation'. Plants that require further evaluation proceed to the third tier of assessment.

The questionnaire was calibrated using 370 species already introduced to Australia. With this calibration the AQIS WRA accepted no serious weeds, only 16% of the minor weeds, and rejected 7% of the non-weeds. Twenty-nine percent of the species required further evaluation (Pheloung, 1996).

A process for assessing plants in the third tier is necessary because the international standards for quarantine risk assessment which AQIS follows are based on the principle of 'manageable risk'. Risk analysis seeks to reduce the possibility of harmful organisms entering by identifying risks and determining how they can best be managed. The objective of third tier trials will be to quantify an otherwise unknown risk, and assess the effectiveness of potential management options.

An assessment process for the third tier is currently being developed. Plants enter the third tier because insufficient information exists in the literature, they cannot be assessed by the WRA questionnaire, or they are genetically modified organisms (GMO's) which are considered to have changes that will affect their weed potential. The process is being designed to integrate with other assessment procedures that GMO's must undergo before they are released, to avoid duplication of effort.

It is intended that the third tier process will allow for glasshouse trials to gather information not present in the literature. Field trials under strict quarantine may also be permitted if the WRA questionnaire assessment is indeterminate, significant potential economic benefits may result from using the species, and an effective control measure has been demonstrated. Potential pasture species are likely to fall into the latter category because they are selected for characteristics such as drought tolerance and ability to grow in low nutrient soils. These characteristics are scored in the WRA questionnaire as contributing to the ability of a plant to become a weed problem. However, unless the plant is a known weed elsewhere, those characteristics would not necessarily be sufficient to consider the plant a significant weed risk in Australia.

The cost of the standard weed risk assessment (tier two) is being borne by the government, not the importer, as it is considered a component of the governments' service obligation to the community. The costs for the third tier assessment of a species will, however, be borne by the importer.

CONCLUSION

In developing a new WRA system AQIS was required to balance conflicting needs. It was necessary to develop a transparent and scientifically valid system that would allow new (safe) imports, protect industry and the environment, be consistent with domestic regulations and meet Australia's international obligations.

The system chosen continues to permit imports while utilizing a transparent and scientifically valid risk assessment process as required under the SPS agreement. Evaluation of the system showed that it should exclude all major weeds, whilst still permitting the majority of non-weedy plants, thus both permitting import and protecting industry and the environment.

ACKNOWLEDGMENTS

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FIELD SCREENING TECHNIQUES TO ASSESS NEW CROP WEEDS

John Virtue[1] and Paul Thomas[2]
[1]Animal and Plant Control Commission (APCC), GPO Box 1671, Adelaide, SA 5001
[2]Centre for Integrated Catchment Management, Univ. of Western Sydney, Richmond, NSW 2753
(formerly APCC)

Abstract Early action to contain the spread of serious new weeds will minimise the long-term costs of impact and control. Identifying such weeds is difficult, and comparative field screening was done to determine if serious crop weeds could be distinguished from minor crop weeds and non-weeds. Thirty-nine crucifer species (Brassicaceae) were tested. Measurements of germination, seedling survival and seed production were used to develop a simple measure of the finite rate of increase, *R*, within a winter wheat crop. Most crop weeds had positive rates of increase ($R > 1$) and most garden plants and non-crop weeds were unlikely to persist ($R < 1$). Strong performing species included *Sisymbrium orientale* L., *Raphanus raphanistrum* L. and the new weed *Chorispora tenella* (Pall.) DC.. Crop species had low or negative rates of increase, provided that germination in the first month was ignored. The field screening approach shows promise for assessing recently naturalised species as potential crop weeds. However, refinements need to address persistence of perennial species, soil type preferences and selection of germination periods.

INTRODUCTION

An average of 12 new plant species are found naturalised in Australia each year (Groves and Hosking 1998) but only between 5% and 20% have the potential to become weeds of significant economic and/or ecological impact (Williamson and Fitter 1996). Early containment of serious new weeds is cost-effective, avoiding the much greater, long-term impact and control costs if such weeds were to become widespread. There is a need for relatively simple yet accurate techniques to identify and prioritise the serious weeds amongst the recent naturalisations.

Rigorous assessments of invasiveness have been achieved by comparing groups of related species in a specific ecosystem (Mack 1996). This paper reports on a field comparison of crucifers (Brassicaceae), which aimed to rank species according to their risk as crop weeds. The focus on crucifers was initially detailed in Virtue (1996). Parker and Kareiva (1996) recommended the finite rate of increase (λ) as the most appropriate measure of risk of invasiveness of plant species. It compounds plant performance throughout the life cycle and is biologically meaningful.

Germination, seedling survival and seed production in a wheat field were measured for a selection of known crop weeds, non-crop weeds, crop plants, garden plants and new species. Data presented is preliminary, covering one time of sowing, excluding seed dormancy and dispersal measurements, and averaging multiple seedlots for some species.

MATERIALS AND METHODS

Seed of 39 crucifer species (Table 1) were obtained in summer 1996-97, from naturalised populations in South Australia (SA), interstate seed collections and commercial seed suppliers.

Seed viability Seeds were germinated in petri dishes on moist filter paper. There were fifty seeds per dish, with two dishes per seedlot. Seeds were incubated at 25°/15°C (12h/12h) for three weeks. Seeds were in darkness for the first week, and had light at 25°C for the latter two weeks. Ungerminated seeds were then incubated at 15°C in darkness for a further week. The different light and temperature regimes provided a range of conditions to promote germination. Seeds that rotted during the germination test were considered non-viable. Viability of ungerminated seed was tested using tetrazolium stain. For some species with poor germination, tests were redone after removing indehiscent pods surrounding seeds or after a period of chilling.

Field germination The number and timing of germinations were examined at Roseworthy, SA. The soil was an alkaline sandy loam. Seeds were sown in lots of 100, with two to six replicates (replicates were completely randomised and rain prevented the sowing of all replicates for some species). Seeds were sown in the week of 12th May 1997. The first autumn rains occurred on 17th May. A hoe was used to make six furrows (depth 2 cm, width 15 cm, length 3 m), 0.5 m apart. The furrows were filled with topsoil that had been steamed to kill existing weed propagules, and weedmat was placed between them. The topsoil was smoothed, and 100 cell, square grids were placed along the rows. The grids were clear plastic

may include weed management plans, and contract arrangements with Parks Victoria for on-ground management of parks. These plans are strategic in nature and don't really get down to the operational requirements for dealing with weeds.

Flora and Fauna Guarantee Act 1988
This Act provides for the conservation of Victoria's flora and fauna, using various mechanisms for the conservation, management and control of flora and fauna and potentially threatening processes.

'Invasion of native vegetation by environmental weeds' is listed as a potentially threatening process. Some Action Statements for threatened species include measures to control weed invasion.

Enforcement
Under the Catchment and Land Protection Act 1994 the Department of Natural Resources and Environment conducts a substantial enforcement or compliance program. This is directed to priority species in each area and provides support to community groups which are undertaking planned, co-ordinated action. Although the major focus is on protecting the productive value of private land, a number of environmental weeds are targeted in each region. For example boxthorn and furze (gorse) are targeted in the north-west, serrated tussock and furze in the south-west, blackberry St. John's wort and English broom in the north-east and blackberry, furze and English broom are targets in Gippsland.

Achievements of the Compliance Program in 1998–99 were:

- 87% compliance rate for landowners dealing with priority weeds,
- 13 771 properties covering over 1 million hectares were inspected,
- over 10 000 landowners were contacted,
- 344 Land Management Notices and 1119 Directions were served on landowners requiring action to be taken,
- 11 landowners were prosecuted for failing to undertake the required weed control.

A commitment has been made to continue and expand the Enforcement Program in the 1999–2000 financial year.

A Weedwatch project has just commenced under the Weeds Initiative and will develop co-operative mechanisms to stop the spread of weeds through the nursery, aquatic and seed trades.

Preventing the introduction of potential new weeds to Australia

Paul Pheloung, Australian Quarantine Inspection Service, GPO Box 858, Canberra, ACT 2601, Australia.

Introduction
New species and varieties of plants have been brought into Australia continuously since European colonization. While a proportion of these are beneficial and contribute to the quality of Australian life, a similar proportion have naturalized and become weeds of production or the natural environment. The demand to import new plants continues; in a global environment of free trade and easier access to novel plants, this demand is likely to continue to grow.

Eradication of weeds can be very expensive and is unlikely to succeed unless the infestation is detected at a very early stage. Containment and control are also costly and the cost persists indefinitely. The costs involved in identifying potential new weeds and denying their entry to Australia are very small by comparison.

The National Weeds Strategy (NWS; ARMCANZ 1997), which was formally implemented in 1997, identified the development and introduction of measures to exclude new weed introductions as a primary goal. A review of Australian quarantine (Nairn *et al.* 1996) made similar recommendations. In recognition of this, and with funding support from the NWS, the Australian Quarantine and Inspection Service (AQIS) has implemented a process to screen plant introductions for potential weeds.

Barrier agencies
Barrier agencies include customs, immigration and quarantine. The Australian Customs Service is the primary custodian of the international barrier, recording and regulating trade, imposing tariffs and policing contraband such as drugs, firearms and protected wildlife.

The role of quarantine is to regulate international trade and movement of people with the object of preventing the introduction, establishment or spread of diseases or pests affecting people, animals, or plants. AQIS is the Commonwealth provider of this function.

AQIS aims to achieve two outcomes through the services it provides. They are:

- improved market access opportunities for Australian food and other agricultural products; and
- protection of Australia's animal, plant and human health and the environment.

The role of AQIS is further described in the current Corporate Plan (www.aqis.gov.au). Although AQIS traditionally has focused on protection of plant health in production systems, the second outcome clearly identifies protection of the environment as part of the overall scope.

Trade vs. risk
Quarantine risk can only be eliminated by eliminating all trade, tourism and other movements across Australia's international borders. As Australia is largely dependent on trade and tourism for the quality of life Australians enjoy, AQIS imposes conditions on imported commodities to manage the quarantine risk and achieve an appropriate level of protection for animal, plant and human health and the environment. Appropriate level of protection refers to the need for consistency, net benefits over costs associated with a trade activity and the diminishing returns of additional measures to further reduce risk.

As a member of the World Trade Organization (WTO), Australia is committed to an open international trading environment. AQIS applies a conservative approach to the management of quarantine risks, but must justify the conditions and restrictions the Commonwealth imposes on the grounds of sound quarantine risk or be accused of erecting economic barriers to the detriment of traders seeking to buy or provide a cheaper or novel product.

Determining the quarantine risk of new plants requires scientific knowledge that may not be available. The precautionary principle in essence states that, in the absence of scientific information necessary to assess risk, the risk should be avoided, that is, the import should not be allowed.

The Sanitary and Phytosanitary (SPS) agreement between WTO members (WTO, 1994) allows for restrictions on trade where such trade can lead to adverse affects on plant health. The agreement requires a sound and clear technical basis for such restrictions. While the precautionary principle requires scientific data to justify trade, the SPS agreement requires such data to justify restrictions on trade.

AQIS must find an appropriate balance to achieving these principles and has implemented the Weed Risk Assessment system to do this.

The policy
AQIS has adopted a three tiered *permitted list* approach to managing the risk of proposed new plant introductions becoming weeds in Australia. Details of the system have been described elsewhere (Pheloung 1995, 1996, Steinke and Walton in press) but are outlined here.

The permitted list
In June 1998, the Proclamations to the 1908 Quarantine Act were revised into one document that includes Schedule 5, the list of Permitted Seeds. Seed of plants included on this list may be imported subject to inspection to ensure freedom from soil, insects, contaminant seeds or other material of quarantine concern (other propagating material may have conditions to address the risk of associated pests and disease). This list currently contains 5700 plant taxa.

All plant species not on the permitted list are prohibited entry into Australia, except where AQIS issues a permit to import. AQIS does not issue permits to import for assessed weeds or for unassessed taxa. However, permits are required for many crop species that require growth in quarantine. This includes species that are not necessarily weeds but potential carriers of disease. For example, *Triticum* (wheat) and *Eucalyptus* are not on the permitted list because they have the potential to introduce seed-borne diseases and consequently imports require treatment and growth in quarantine.

The permitted list is added to as proposed new plant introductions are assessed to be of low weed risk.

The Weed Risk Assessment (WRA) system
The WRA system is a scoring system used to determine weed potential based on existing knowledge of proposed new plant introductions (Table 1). The questions relate to knowledge of the status of the plant as a weed outside of Australia, climatic preferences, undesirable attributes, growth, reproductive and dispersal attributes. The system includes consideration of attributes that make a plant less weedy. Not all questions need to be answered in order to generate a result.

An attempt was made to include and identify attributes that contribute to the risk of a plant becoming an environmental weed. This is shown in Table 1 by the letter 'E' in the left hand column. 'A' denotes attributes that have agricultural significance and 'C' denotes attributes relevant to both sectors. The score is partitioned on this basis. In the example shown, *Asparagus asparagoides* (bridal creeper) has a much higher environmental score partition, consistent with the fact that this plant is essentially a weed of natural environments.

The system was designed so that the score produced would be a measure of its weed potential. A calibration process using a complete spectrum of 370 weeds, non-weeds and useful plants already present in Australia, was used to convert the score to one of three outcomes, reject, accept or further evaluate (Pheloung 1995). The WRA is reasonably reliable in rejecting weeds while accepting non-weeds, but to minimize the proportion of incorrect outcomes (rejecting non-weeds or accepting weeds), a proportion fell within the intermediate category of 'further evaluate'. From a quarantine standpoint, and in accordance with the precautionary approach, plants falling into this category are not permitted entry unless a more detailed examination of the biology satisfactorily resolves the concern.

AQIS adopted the WRA formally in 1997 as part of the three tiered process to assess new plant introductions.

The three tiered process
AQIS's three tiered system to screen proposed new plant introductions for weed potential is illustrated in Figure 1.

Tier 1 A client wishing to import a plant advises AQIS who determines if the plant is listed on the schedule of permitted seeds or has previously been assessed. The taxonomy is also checked to determine if the name given is correct or is a synonym of a previously dealt with species.

Tier 2 WRA is undertaken on taxa that are not on the permitted list and have not previously been examined by AQIS. Accepted species are added to the permitted list and AQIS keeps a record of species rejected by WRA to prevent repeat assessment. The client is advised of species requiring further evaluation and in some cases may be able to supply additional information that leads to a definitive WRA outcome. Up to this point, AQIS bears the cost of assessment.

Tier 3 Species requiring further evaluation must be assessed in greater detail, at the client's expense. An assessment protocol involving further experimentation either offshore or onshore under quarantine supervision and possible cost benefit analysis is being developed in consultation with stakeholders.

Performance
Over an 18 month period of operation of the three tiered system, AQIS has undertaken WRAs on 478 applications to import new plants – this just represents those applications that progressed to the second tier. Table 2 shows the outcomes. The majority of species (64%) were accepted and the WRA was unable to reject or accept 15%, which is a marked improvement on the 30% that fell into the 'further evaluate' category during calibration of the system.

Critical factors leading to rejecting a taxon varied from evidence of weedy behaviour in other parts of the world to biological attributes of reproductive capacity and dispersal mechanisms. Because of the uncertainty of prediction, many (possibly all) of these taxa may not, given the opportunity, become significant weeds in Australia. Nevertheless, there is a significant risk that at least some would become important weeds and the combined cost of assessment is negligible in comparison to the costs associated with just one such introduction.

Operational considerations
The three tiered screening system depends on understanding and co-operation from importers of plants.

- Inspectors generally must assume that the material is correctly described because the capacity within Australia to taxonomically identify exotic material, particularly seed, is very limited.
- Seeds are compact and easy to bring into Australia undetected, either deliberately or through ignorance of quarantine requirements. Plants are available via international mail order, through printed catalogues or via the internet. Small parcels may pass through the mail exchange undetected, particularly if the label gives no indication of the contents. The risks from entry through the mail or on a person can only be met by a combination of increase in specific resources, community awareness and penalties. AQIS is currently undertaking an information campaign intended to address community awareness. Additional resources following the Quarantine Review resulted in a substantial increase in interceptions of items in the mail posing a quarantine risk (from 10 000 to 50 000 p.a.). A large proportion of these are plant material or seed of unknown identity.
- Weeds can also be introduced as contaminants of other imported commodities such as commercial seed for sowing or consumption, on used machinery, dirty ships and shipping containers, or travellers clothing. Effective inspection protocols are essential to manage this risk. AQIS is examining the inspection and sampling protocols currently in place to manage the risk of contaminants in imported commercial seed.

Table 1. The Weed Risk Assessment Scoring Sheet with answers for *Asparagus asparagoides*. Details of the scoring process are given in Walton *et al.* 1998.

Botanical name:	*Asparagus asparagoides*			Outcome: Accept <0 Evaluate 0–6 Reject >6	Reject
Common name:	Bridal creeper			Score: (Ag = 12; Env = 20)	22
Family name:	Asparagaceae			Your name:	PCP
History/Biogeography					
A	1	Domestication/	1.01	Is the species highly domesticated? If answer is 'no' got to question 2.01	N
C		cultivation	1.02	Has the species become naturalized where grown	
C			1.03	Does the species have weedy races	
	2	Climate and	2.01	Species suited to Australian climates (0–low; 1–intermediate; 2–high)	2
		distribution	2.02	Quality of climate match data (0-low; 1-intermediate; 2-high)	2
C			2.03	Broad climate suitability (environmental versatility)	Y
C			2.04	Native or naturalized in regions with extended dry periods	Y
			2.05	Does the species have a history of repeated introductions outside its natural range	Y
C	3	Weed	3.01	Naturalized beyond native range	Y
E		elsewhere	3.02	Garden/amenity/disturbance weed	Y
A			3.03	Weed of agriculture/horticulture/forestry	
E			3.04	Environmental weed	Y
			3.05	Congeneric weed	N
Biology/Ecology					
A	4	Undesirable	4.01	Produces spines, thorns or burrs	N
C		traits	4.02	Allelopathic	N
C			4.03	Parasitic	N
A			4.04	Unpalatable to grazing animals	
C			4.05	Toxic to animals	N
C			4.06	Host for recognized pests and pathogens	
C			4.07	Causes allergies or is otherwise toxic to humans	N
E			4.08	Creates a fire hazard in natural ecosystems	Y
E			4.09	Is a shade tolerant plant at some stage of its life cycle	Y
E			4.10	Grows on infertile soils	Y
E			4.11	Climbing or smothering growth habit	Y
E			4.12	Forms dense thickets	N
E	5	Plant type	5.01	Aquatic	N
C			5.02	Grass	N
E			5.03	Nitrogen fixing woody plant	N
C			5.04	Geophyte	Y
C	6	Reproduction	6.01	Evidence of substantial reproductive failure in native habitat	N
C			6.02	Produces viable seed	Y
C			6.03	Hybridizes naturally	
C			6.04	Self-fertilization	
C			6.05	Requires specialist pollinators	
C			6.06	Reproduction by vegetative propagation	Y
C			6.07	Minimum generative time (years)	1
A	7	Dispersal	7.01	Propagules likely to be dispersed unintentionally	Y
C		mechanisms	7.02	Propagules dispersed intentionally by people	Y
A			7.03	Propagules likely to disperse as a produce contaminant	
C			7.04	Propagules adapted to wind dispersal	
E			7.05	Propagules buoyant	
E			7.06	Propagules bird dispersed	Y
C			7.07	Propagules dispersed by other animals (externally)	
C			7.08	Propagules dispersed by other animals (internally)	Y
C	8	Persistence	8.01	Prolific seed production	Y
A		attributes	8.02	Evidence that a persistent propagule bank is formed (>1 yr)	
A			8.03	Well controlled by herbicides	Y
C			8.04	Tolerates or benefits from mutilation, cultivation or fire	Y
E			8.05	Effective natural enemies present in Australia	Y

Weed type characteristic A= agricultural, E = environmental, C= combined.

- AQIS must determine quarantine status as a basis for assessing risk and taking necessary actions to prevent entry of new weedy plants. For weedy plants found to be present in Australia, States/Territories need to backup such decisions with effective response to incursions and regulatory measures.

Conclusion

Many potential new weeds of Australia can be identified on the basis of substantial problems elsewhere in the world. The major weeds of production are reasonably easy to identify from published information and AQIS's permitted list system ensures that they are recognized on a case by case basis. Recognizing other potential weeds of Australia, that may not have yet become weeds elsewhere or that are less well documented environmental weeds, requires a more detailed approach and AQIS's WRA system attempts to achieve this.

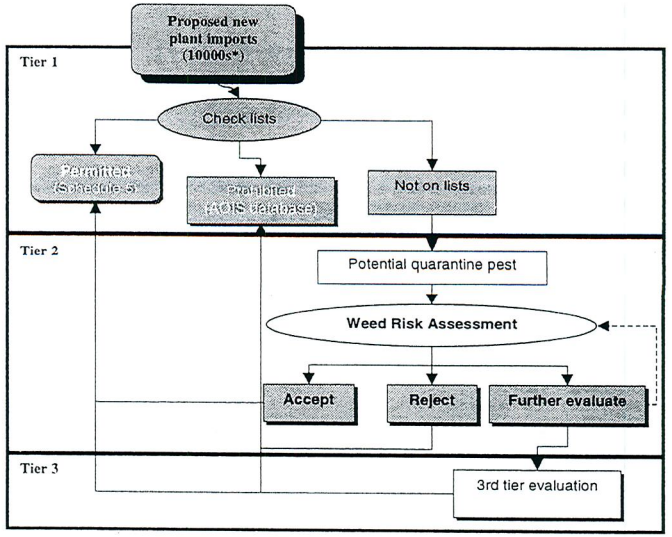

Figure 1. The three tiered process AQIS uses to screen proposed new plant introductions for weed potential.

Table 2. Weed Risk Assessment results, over an 18 month period, for proposed new plant introductions. In addition to the principle outcomes of *Accept*, *Reject* or *Further evaluate*, information on some taxa was too limited to make any kind of determination. For example, in some cases no published verification of the supplied botanical name could be found. Other taxa were found to be well established in Australia and thus could not be treated as a quarantine pest.

Result	Number assessed	Proportion of total assessed (%)
Accept	306	64
Reject	95	20
Further evaluate	54	11
More information required	23	5
Total	**478**	**100**

Acknowledgments

Data reported here is the result of work by staff of the Plant Quarantine Policy Branch of AQIS. AQIS's protocol for screening plant introductions for weediness was developed and implemented with the support of Agriculture Western Australia and Natural Heritage Trust funding of the National Weed Strategy.

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Contingency planning for new and emerging weeds in Victoria

John Weiss, Keith Turnbull Research Institute, Department of Natural Resources and Environment, PO Box 48, Frankston, Victoria 3199, Australia.
Email: John.Weiss@nre.vic.gov.au

Recent (since 1970) plant introductions into Victoria

A total of 135 new plant species have been recorded as introduced into Victoria since 1970. The number naturalizing per year is shown in Figure 1 and a regression indicates that the rate of new introductions is increasing with the present average of 7.3 new plants establishing per year with an annual increase of 0.25 plants each year. Predominantly these new plants have originated from South Africa and Europe, and have been deliberately introduced as ornamental plants. The most common new invaders into Victoria are from the; Iridaceae and Poaceae families from the Monocots; Salicaceae, Fabaceae, Asteraceae and Malaceae families from the Dicots; and the Pinaceae from the Conifer group (Groves and Hosking 1997).

The procedures presently being implemented by AQIS hopefully will prevent the introduction and release of many new weeds in Australia and Victoria. However, new weed problems would still arise in the future from several sources, including:

- invasive plants that continue to penetrate current or improved protocols for the introduction and release of potential weeds (e.g. plants may be considered benign but become weedy nevertheless);
- invasive plants that are introduced accidentally (e.g. as contaminants of imported seed);
- invasive plants already in Australia that assume major significance as weeds due to changes in environmental conditions (e.g. flood or fire) or other factors;
- and translocated native species.

Early intervention

A powerful weapon against weed invasions arising from these sources is early intervention. Early intervention can significantly reduce the social cost of weed invasions (Figure 2).

Currently, however, there are no established procedures to deal with new weeds quickly at either the Commonwealth or State level, although the National, Victorian and South Australian Weed Strategies suggest that procedures/protocols maybe in place in the near future.

Obtaining funding is an even greater problem. All too often priority is given to projects where a clear weed problem already exists. Areas where early intervention is urgently required generally go unfunded until weed infestations become critical, by which time action is often too late.

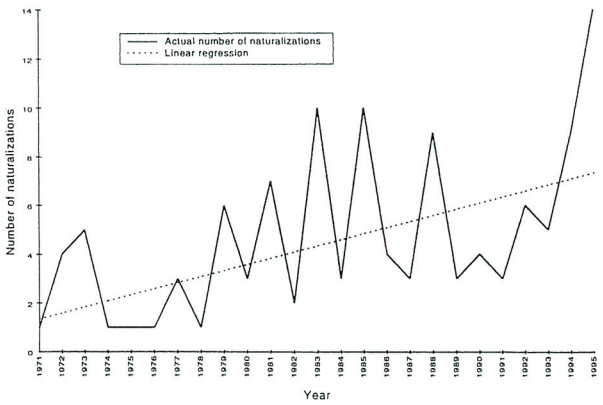


Figure 1. Number of new plant species naturalized in Victoria, 1970–1995, and linear regression indicating the rate of naturalizations.

A much higher priority should be given to early intervention at both Commonwealth and State levels. Formal protocols for early intervention should be developed and implemented as a matter of urgency. Such protocols must:

- facilitate early detection of a potential problem,
- provide for the identification and reporting of a potential problem, and
- ensure action against a potential problem, including the availability of resources.

Contingency plan

An early warning and contingency plan needs to have many separate systems with well defined protocols, procedures as well as defined roles and responsibilities of the key players. The strategy should include:

- a system to highlight new or potential weeds which may need action;
- a system to identify;
- a system to assess risk;
- a notification system;
- a process to ensure a plan of action is developed;
- a process to implement and review the plan.

Waterhouse and Corlett (1996) indicated a similar procedure.

Whenever a new (escaping or naturalized) alien species is recorded by any of the State herbaria:

i. Convey the details promptly to the appropriate 'designated authority' (e.g. Department of Natural Resources or Department of Agriculture).
ii. Conduct a literature review to determine whether the species has been documented as a weed elsewhere.
iii. Investigate the known native and exotic distributions and predict the potential Australian distribution.
iv. Perform a weed risk analysis to determine whether it is likely to be a weed of any significance.
v. Recommend and implement actions as necessary. This may range from maintaining a 'watching brief' on the weed's distribution and invasiveness; through localized control efforts; to a full-scale eradication program.
vi. Notify interstate 'designated authorities' of all new weeds, and keep informed throughout the assessment process.

The process should not be halted at Step 2 if the literature review fails to reveal previous documentation as a weed, otherwise invasive species like *Praxelis clematidea* will continue to be overlooked.

Early detection

Procedures are necessary to ensure that any new weeds are detected as early as possible. Early detection requires community awareness coupled with strategic monitoring and encouragement of collections as relatively few people collect weedy species and submit them.

An effective awareness program would lead land managers and users to recognize how important it is to call attention to any new plants appearing in their locality. The need for an awareness program is recognized in the Australian National Weeds Strategy (1997).

As distinguishing between indigenous and introduced flora is difficult, monitoring is required in native vegetation. Such surveys should determine hazard site selection or target areas that are prone to invasion (e.g. disturbed sites, roadsides and waterways) and possibly remote reserves, where weed invasions could otherwise go undetected for a long time.

As predicting problematic plants is difficult, all introduced plants in native vegetation should be subject to field surveys, particularly with the anticipated change in weed distribution and impact associated with global warming forecasts. The Department of Natural Resources and Environment is not sufficiently funded to routinely survey introduced species, although the need is recognized.

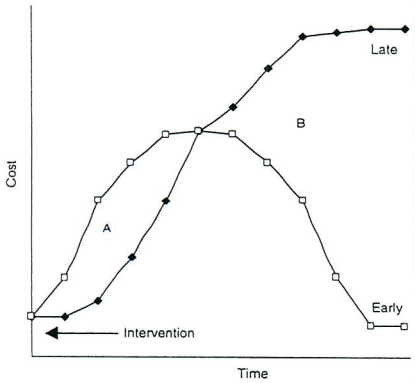


Figure 2. Total social cost of plant invasion in relation to timing of intervention: early versus late. Costs of early expenditure (area A) and the resulting benefit (area B) (adapted from Chipendale 1991 and Hobbs and Humphries 1995).

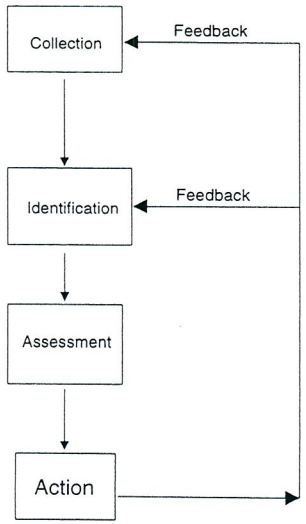


Figure 3. Basic flow chart of early warning or contingency plan.

Identification and reporting

Detection of potential problems must be supported by a readily accessible identification and reporting mechanism. The Australian National Weeds Strategy proposes that formal procedures should be developed through which:

i. All interested individuals will know where plants new to a particular area can be sent for identification.
ii. Potential weeds submitted by individuals will be determined to be either:
  - plants previously recorded in the particular state or Territory or region/catchment from where they were submitted;
  - plants not previously recorded in the particular State or Territory or region/catchment but recorded elsewhere in Australia; or
  - plants not previously recorded in Australia.
iii. Agencies to which such plants are sent (National and State herbaria and government agencies with botanical expertise) will report plants new to an area to relevant weed control authorities.
iv. Weed control authorities can rapidly assess the weed potential and significance of the new plant and make an appropriate response.

Plant identification and reporting mechanisms should be well co-ordinated across Australia. A compatible protocol should be implemented in Victoria, however the National Herbarium of Victoria is not currently funded to routinely collect or describe introduced species.

Assessment

With the limited amount of funding available to pest plant management, an assessment procedure has to be able to compare the relative importance of both existing and of new and emerging weed problems. To accurately assess any plant requires using a combination of scientific data and expert knowledge. The problem is how to integrate human judgements with quantitative assessment techniques. The Analytical Hierarchy Process (AHP) is a Multiple Criteria Analysis technique which addresses this problem. Complex issues can be broken down into a set of related criteria. This systematic process is a 'divide and conquer' approach to problem solving. It is used across many problem domains. By mapping out issues as a set of nested criteria, a decision hierarchy can be developed. The process also allows for relative importance or weight applied to each criteria and group. The DSS is a multi-layered system which rests on a database layer which contains spatial data and tabular data from the departmental corporate database.

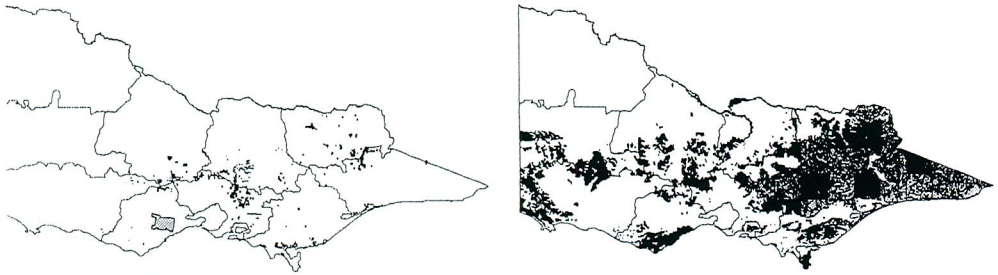
Victoria's Pest Plant Assessment project at KTRI has established a procedure to assess and prioritize any plant on its intrinsic abilities to invade suitable ecosystems and its present and potential impacts on social, environmental or agriculture land use. This procedure utilizes the AHP of a Decision Support System.

The assessment procedure is split into three main parts. A scoring system which analyses a plants intrinsic invasiveness characteristics, the present distribution and potential distribution (utilizing climate modelling programs) which is linked to geospatial information databases enabling impacts to be estimated on social, environmental or agricultural resource base. A separate economic model will be incorporated into the system which estimates the potential benefit in controlling agricultural weeds.

Thus any plant can be assessed for its relative importance compared to other weed based on it's intrinsic ability to invade (or rate of spread), its present and potential distribution and it's social, economic and environmental impact.

Action

Rapid action increases the likelihood of achieving eradication. Early control efforts for karoo thorn (*Acacia karoo*) and ivy gourd (*Coccinia grandis*) in Western Australia, parthenium weed (*Parthenium hysterophorus*) in the Northern Territory and Taurian thistle (*Onopordum tauricum*) in Victoria, have or are likely to result in the eradication of these weeds. In contrast, the slow and unco-ordinated response by authorities to the invasion of nodding thistle (*Carduus nutans*) in New South Wales largely prevented the eradication of



Present distribution

Potential distribution

Figure 4. Present and potential distribution of English broom (*Cytisus scoparius*) as produced from KTRI's Pest Plant Assessment procedure.

this species. A similar scenario seems inevitable for pampas grass (*Cortaderia* spp.) in Victoria (Adair 1995), and, unless rapid action is taken, for many of the 135 recently established weeds in Victoria.

In order to facilitate a rapid response to new weeds, the roles and responsibilities of participating parties need to be well defined, eradication efforts well coordinated and management receptive to providing resources. To this end, both the Australian National and the Draft Victorian Weeds Strategy has indicated that a contingency plan should be developed for new outbreaks of weeds.

It is in Victoria's interests to develop a complementary contingency plan. Such a plan would support action taken at the national level and assist the rapid implementation of action within Victoria, including action that crosses state borders. The need for complementary state and territory plans is recognized in the Australian National Weeds Strategy.

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Future and expanding weeds

Kate Blood, CRC for Weed Management Systems, Keith Turnbull Research Institute, PO Box 48, Frankston, Victoria 3199, Australia.

There are many new and emerging weeds in Victoria. These are just a few:

Trees

Arbutus unedo, strawberry tree – found around Creswick and elsewhere invading under pine plantations. Fruit spread by animals.

Psoralea pinnata, blue psoralea – found in south west Victoria in plantation and coastal areas and along Gippsland roadsides.

Shrubs

Calluna vulgaris, heather or ling – not recorded as naturalized in Victoria, but highly invasive in New Zealand's high country on the North Island.

Cytisus multiflorus, white Spanish broom – infestation at St. George's Lake near Creswick.

Erica baccans, apple-berry heath – Found at Arthur's Seat State Park and around Red Hill on the Mornington Peninsula, and at Mt. Cannibal in South Gippsland.

Leonotis leonurus, lion's tail – invading coastal New South Wales, growing at Somers foreshore in Victoria, banned in Western Australia.

Leycesteria formosa, Himalayan honeysuckle – has invaded large areas at the base of Mt. Buffalo, also in the Dandenongs, Otways, Strezlecki Ranges etc. Dispersed by birds and deer, possibly foxes. Each fruit contains over 60 seeds.

Grasses

Cortaderia spp., pampas grass – expanding in many areas.

Nassella neesiana, Chilean needle grass – west of Melbourne and elsewhere.

Nassella tenuissima, Mexican feather grass – sold earlier in 1999 at two nurseries at Mt. Macedon, Victoria. All plants removed by quarantine but eight plants sold and unaccounted for. Potential to be worse than serrated tussock (*Nassella trichotoma*).

Climbers and creepers

Anredera cordifolia, Madeira vine – big weed in New South Wales and Queensland. In Melbourne gardens. Invading along the Yarra River at Abbotsford and along Werribee River, Werribee. Has potato-like tubers dropped with garden waste.

Araujia sericifera, moth vine, moth plant, white bladder-flower, kapok etc. – suburban gardens around Melbourne.

Asparagus densiflorus, asparagus fern – found invading on the New South Wales coast.

Asparagus scandens, asparagus creeper – found at Somers foreshore in Victoria and coastal areas. Closely related to and grows in association with bridal creeper (*A. asparagoides*).

Clematis vitalba, old man's beard, travellers joy – big weed in New Zealand, recorded in suburban Melbourne, invading in Tasmania.

Galium aparine, cleavers, bedstraw – considered to be one of the worlds worst weeds. Widespread in Victoria. Smothers indigenous vegetation. Common in gardens as a weed. Seeds stick like velcro.

Senecio angulatus, climbing groundsel – often confused with another South African invasive cape ivy, *Delairea odorata*. Invading coastal areas.

Herbs

Alstroemeria aurea, alstroemeria or Peruvian lily – invading near Bogong Village below Falls Creek.

Chasmanthe floribunda, African corn flag – often confused with watsonia, but flowers earlier than watsonia. Increasingly common in coastal areas and along roadsides.

Crassula multicava, crassula – succulent increasingly common particularly in coastal areas.

Equisetum spp., horsetail – one of the world's worst weeds and a Weed of National Significance in Australia. Still sold legally in Victoria despite being banned in all other States. Infestation near Castlemaine.

Myosotis sylvatica, forget-me-not – widespread particularly in coastal areas. Seeds stick like velcro.

Watsonia spp., watsonia – bulbil watsonia widespread, others expanding. Bulbil watsonia has small bulbils spread along roadsides by slashers and other maintenance equipment.

Aquatics

Alternanthera philoxeroides, alligator weed – Weed of National Significance in Australia. Grown accidentally around Melbourne as a cooking plant. Many infestations found in Victoria, many now treated.

Eichhornia crassipes Water hyacinth – floating plant banned throughout Australia. Found recently at Melbourne nursery.

Early intervention: the process

Roger Spencer, Royal Botanic Gardens Melbourne and National Herbarium, Birdwood Avenue, South Yarra, Victoria 3141, Australia.

Summary

An account is given of the procedures recommended for the identification and recording of weeds for lodgement as voucher specimens in the National Herbarium of Victoria. Attention is drawn to the importance of voucher specimens as permanent historical records. A summary of resources at the National Herbarium of Victoria that may be of assistance to weed recognition and recording is given. Suggestions are made for the improvement of inter-departmental communication and weed collections in the Herbarium. The Greenlife Database™ is recommended as Australia's most extensive cross-referencing source of the full range of plant names and as a list of names linked to growers/suppliers that would be useful as an early warning system for potential problems.

Finding, identifying and recording a potential weed

The National Herbarium of Victoria is the major state repository of plant specimens and forms part of an important network of similar institutions, both nationally and internationally; it is also the State centre for taxonomic research.

In recording plants for surveys or official purposes of any kind the true identity of a particular plant may be called into question. How can it be proven that the plants listed in a survey undertaken four years ago are what they claim to be? In situations where the correct identity of a plant is particularly important plants may be officially identified at the National Herbarium of Victoria and a voucher specimen lodged in the Herbarium, to remain there as a permanent historical record.

For the plant identification to be completed adequately it is often necessary to have samples of all the major plant parts – material of typical leafy shoot, flowers, fruits and any other characters that may be of taxonomic importance. Some common sense is needed here. For instance, for eucalypts the habit and bark type is particularly important, in some grasses the growth habit is critical. If there is any doubt the Herbarium can be contacted.

The information provided with a specimen is extremely important as it will be recorded for posterity on the Herbarium database. The usual and most critical items of information are:

- collections date;
- locality (a description of exact spot with a Melways reference would do but the specimen will eventually be given a full geographic reference);
- collector and local ecology.

Further notes concerning features that are not immediately obvious from the specimen (such as the size of the plant) can also be added. In the case of environmental weeds it is important to know the abundance of the plant, its impact on the surrounding vegetation and a possible source of the invasion. This is the opportunity to place anything of relevance on the record.

Fresh or pressed and dried specimens may be sent to: Identification Service, National Herbarium of Victoria, Birdwood Avenue, South Yarra, Victoria 3141.

Specimens of naturalized plants are often poorly represented in the Herbarium. In the absence of specific projects directed at collecting weeds they are often, apparently, perceived as uninteresting (just weeds), ugly and common (growing everywhere), or difficult to process (cacti) and therefore not collected.

At the Herbarium specimens are checked against their known distribution. If the plant proves to be a new record or to have extended its distribution range according to Herbarium records then the information is retained for use in the Flora of Victoria and Viclist. If a weed alert is appropriate then Keith Turnbull Research Institute is contacted. The specimen is then mounted and recorded before incorporation with the main collections.

Resources available at the National Herbarium of Victoria

The National Herbarium of Victoria has the following resources to assist with weed names, identification and recording:

Books

Ross, J.H. (1996). 'A census of the vascular plants of Victoria', 5th edition. (Royal Botanic Gardens, Melbourne). $10.00. Royal Botanic Gardens Bookroom.
Generally referred to as 'Viclist' this census is a formal listing of the names of native and naturalized vascular plants occurring in Victoria with the author(s) and reference to the original publication. Naturalized plants have an asterisk in front of the name. New edition due 1999.

Albrecht, D. (1993). 'Collecting and preserving Herbarium specimens'. (National Herbarium and Royal Botanic Gardens, Melbourne). $10.50. Royal Botanic Gardens Bookroom.
This is a simple, no-nonsense account of the Gardens identification service and reference collections, describing in detail how specimens are mounted and preserved and running through the items needed to be recorded for each specimen. There is a special section detailing the special features needed to identify the plants in particular families.

Foreman, D.B. and Walsh, N.G. (eds) (1993). 'Flora of Victoria, Volume 1, Introduction'. (Inkata Press, Melbourne). $95.00.

Walsh, N.G. and Entwisle, T.J. (eds) (1994). 'Flora of Victoria, Volume 2, Ferns and Allied Plants, Conifers and Monocotyledons'. (Inkata Press, Melbourne). $195.00

Walsh, N.G. and Entwisle, T.J. (eds) (1996). 'Flora of Victoria, Volume 3, Dicotyledons: Winteraceae to Myrtaceae'. (Inkata Press, Melbourne). $295.00

Flora of Victoria, Volume 4 is to be published before 2000.
The Flora of Victoria volumes are the formal botanical account of the State flora including keys, descriptions, illustrations, common names and distribution maps. All volumes are available at the Royal Botanic Gardens Bookroom.

Spencer, R.D. (1995, 97, etc.). 'Horticultural flora of south-eastern Australia', Volumes 1 and 2. (Volume 3 to be published shortly, volume 4 will cover monocotyledons).
An identification guide to the garden plants of the region including keys, descriptions, illustrations, common names, natural distributions as well as spotting characters, literature, propagation, collections and brief reference to growers and history of cultivation in Australia.

Plant identification

Plant Identification Service, 10 am – 1 pm weekdays, $10 per specimen and $90 per hour pro rata. Identification facilities $60 day ($30 half day). Fees waived for good quality specimens.

Herbarium Facilities

Main collections (over 1.2 million specimens) are used for research – access by special appointment.

Public access to:

- Victorian Reference Collection: specimens of all of Victoria's native and naturalized plants.
- Horticultural Reference Collection: Specimens of cultivated plants available in gardens and the nursery industry – good for identifying naturalized exotics.

Databases

- Greenlife Database™
  This database lists all the plants available in the Australian nursery industry with the names linked to wholesale 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

Nigel Ainsworth, Keith Turnbull Research Institute and CRC for Weed Management Systems, PO Box 48, Frankston, Victoria 3199, Australia.

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.

STRATEGIES TO MANAGE NEW WEED INCURSIONS - NEW SOUTH WALES

Richard J Carter[1]; John R Hosking[2] and Barry J Conn[3]
[1]NSW Agriculture, Locked Bag 21, Orange, NSW 2800
[2]CRC for Weed Management Systems & NSW Agriculture, RMB 944, Tamworth, NSW 2340
[3]National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, NSW 2000

Abstract NSW introduced a new weed incursions strategy in June 1998. We investigated 46 potential weed incursions in the first year. The majority of the new reports originated from the WeedAlert system established with the National Herbarium of New South Wales, Royal Botanic Gardens, Sydney (RBGS).

INTRODUCTION

The rate of naturalisation of plants in Australia increased for the 1981–1995 period compared with the 1971–1980 period and between 1975 and 1995 an average of 12 new species naturalised each year in Australia (Groves *et al*. 1997). The Australian Quarantine Inspection Service (AQIS) assesses all imported plants prior to entry to Australia. The biggest potential weed problems for New South Wales (NSW) are believed to be plants already in Australia.

The NSW Weeds Strategy outlines procedures to identify and address significant new incursions. NSW Agriculture aims to identify new incursions to New South Wales while they are establishing. We assess potential impact and, if justified, rapidly initiate weed control.

The strategy summarised in Figure 1 includes a system to highlight new or potential weeds that may need action, a system to assess risk, a notification system, a process to develop a plan of action and a process to implement and review the plan.

NEW INCURSIONS STRATEGY

System to highlight new or potential weeds The strategies used include development of high risk target plant lists for NSW. This type of list has limitations as outlined by Waterhouse and Mitchell (1998) for the Northern Australian Quarantine Strategy weeds target list. However, a list helps direct surveys to look for specific species in high risk areas. The first plants to consider in a target list are weeds already in Australia but not known to be naturalised in NSW.

Encourage collections Relatively few people collect weedy species and submit them to herbaria for verification and storage of vouchers. The NSW strategy includes training weed officers, government field workers and individuals to collect and submit exotic plants to herbaria.

Notification of new incursions To allow rapid response to a new weed incursion the responsible agency must become aware of it. A key to this is setting up and maintaining a reporting system where herbaria notify NSW Agriculture of new incursions upon receipt of a specimen. In 1998 RBGS started an automatic notification system called WeedAlert, as part of PlantNET, the Herbarium's computerised plant information network (Conn *et al*. 1999).

WeedAlert automatically notifies users of new plant introductions to NSW, and changes in range within NSW, via changes to the RBGS main collections' database. It also allows searches at any time.

NSW Agriculture established a manual notification system with Australian National Herbarium in Canberra (CANB) in 1998. The system however relies on CANB staff keeping NSW Agriculture informed. To date we have no formal arrangements with other herbaria. Reports from herbaria to NSW Agriculture depend on accurate identification of species. This takes time when the native range of introduced species is not known, or leads to misidentification if relying on current Australian floras.

Plants in commercial trade Commercial trade, such as through nurseries, aquaria, herbalists and agriculture distribute plants, some of which are potential weeds. To address this we have increased inspection of nurseries and other premises by including it as an objective for grants to local weed control authorities. An area not yet developed is to study plants being distributed and conduct risk assessments of these.

System to assess weed risk Once we flag a new incursion, we make an assessment of the risk associated with it. There are a range of weed risk assessment (WRA) processes available. These systems, such as that used by AQIS (Walton and Ellis 1997), are useful as a quarantine tool but limited when a plant is already established. It does not take into account economic impact of the weed or the cost and feasibility of destroying an infestation.

NSW Agriculture has adopted a staged approach. The initial stage is a desktop scan with "weed risk assessment" type questions. If a plant is established, then we need to decide the feasibility and costs of control.

Field assessment Field inspections are a valuable tool to determine the risk of a naturalised plant becoming a widespread weed. To improve the quality of field inspections we developed a protocol for field inspection. The protocol for use by field staff ensures they collect maximum information on initial inspection as this aids subsequent monitoring and risk assessment.

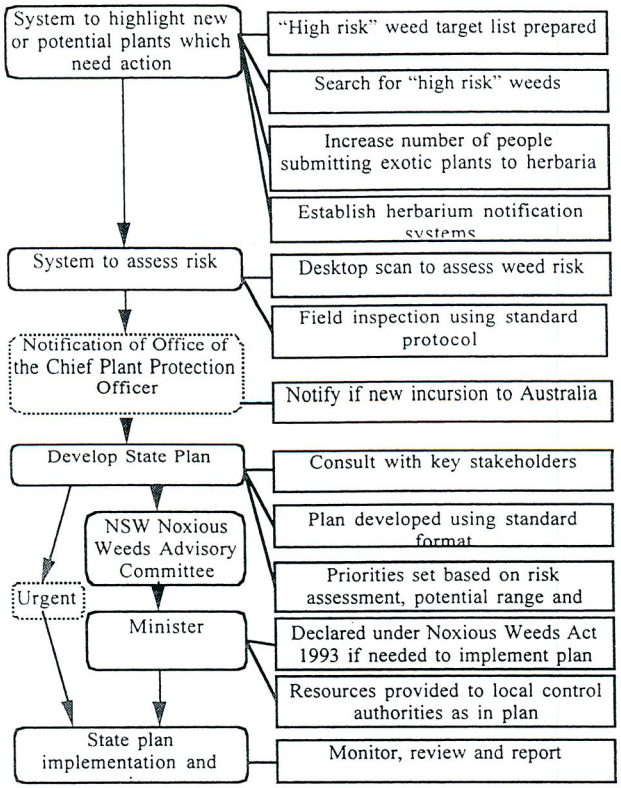

Figure 1. Key stages of the New South Wales new weed incursions

Establish notification system Once we detect a new weed incursion and assess it as a high risk a reporting system needs to be instituted. This system provides management, and for incursions new to Australia, the office of the Chief Plant Protection Officer and interstate authorities, with timely reports. Member States already provide new incursion reports to the Australian Weeds Committee.

State plan A draft plan is developed quickly after consulting with stakeholders. Priorities for control of a weed are established based on risk assessment, potevntial range and potential impact.

The plan may require declaration of the plant species before enforced control or entry to private land is allowed and it will also need resources. A review process is essential to make sure that control is being achieved and that resources are not being wasted.

The New South Wales new incursion strategy is progressively being implemented.

RESULTS & DISCUSSION

Between June 1998 and June 1999, 46 potential incursions were reported or investigated, 26 were identified from new accessions to herbaria (two were misidentifications), ten were identified from literature reports, six were identified by weed officers or NSW Agriculture staff following public enquiries (one was promoted as a potential crop), two resulted from incursions or declaration in other states, one from a media report and one from the Office of the Chief Plant Protection Officer.

Table 1. Possible new weed incursions investigated under the NSW New Weed Incursions Strategy

Genus and species	Family	Reason for investigation
Alstroemeria aurea Graham	Alstroemeriaceae	RBGS record[a]
Amaranthus dubius Mart. ex Thell.	Amaranthaceae	Office of the Chief Plant Protection Officer
Anagallis minima (L.) E. H. Krause	Primulaceae	RBGS record [n]
Arctium lappa L.	Asteraceae	NSW Agriculture officer- potential crop
Berberis lycium Royle	Berberidaceae	CANB record [bc]
Calluna vulgaris (L.) Hull.	Ericaceae	Csurhes & Edwards (1998)
Campanula rapunculoides L.	Campanulaceae	RBGS record[n]
Campsis x *tagliabuana* (Vis.) Rehder	Bignoniaceae	RBGS record
Celtis sinensis Pers.	Ulmaceae	RBGS record
Centaurea maculosa Lam.	Asteraceae	CANB record
Centaurea nigra L.	Asteraceae	NSW Agriculture Officer
Cotula turbinata L.	Asteraceae	RBGS record
Cucumis metuliferus Naudin	Cucurbitaceae	RBGS record
Cuphea carthagenensis (Jacq.) Macbride	Lythraceae	Public concern
Cyperus involucratus Rottb.	Cyperaceae	RBGS records [n]
Elephantopus mollis Kunth	Asteraceae	Harden (1992), Declared in Queensland.
Epidendrum ibaguense Kunth	Orchidaceae	RBGS record [n]
Equisetum hyemale L.	Equisetaceae	Local Control Authority report
Equisetum ramosissimum Desf.	Equisetaceae	Local Control Authority report
Fuchsia magellanica Lam.	Onagraceae	RBGS record [n]
Gamochaeta purpurea (L.) Cabrera	Asteraceae	RBGS record [c]
Hieracium aurantiacum L.	Asteraceae	Plants found in nursery report from WA
Hygrophila costata Nees (*H.brasiliensis* (Spreng.)Lindau)	Acanthaceae	Local control authority, weed in Qld.
Hypericum elodes L.	Clusiaceae	CANB record
Hypericum hypericoides (L.) Crantz	Clusiaceae	RBGS record
Hypoestes aristata (Vahl) Sol. ex Roem. & Schult.	Acanthaceae	RBGS record
Linaria nigricans Lange	Scrophulariaceae	RBGS record [n]
Ludwigia longifolia (DC.) Hara	Onagraceae	RBGS record
Miconia calvescens DC.	Melastomataceae	Csurhes & Edwards, (1998)
Mikania species	Asteraceae	Csurhes & Edwards, (1998)
Nassella charruana (Arechav.) Barkworth	Poaceae	Groves *et al.* (1997)
Nassella tenuissima (Trin.) Barkworth	Poaceae	Local Control Authority report
Onopordum nervosum Boiss.	Asteraceae	Media report. Sold by nursery
Passiflora coccinea Aublet	Passifloraceae	RBGS record [n]
Paulownia tomentosa (Thunb.) Steud.	Scropulariaceae	Csurhes & Roberts (1998)
Rotala rotundifolia (Buch.-Ham. ex Roxb.) Koehne	Lythraceae	Csurhes & Roberts (1998) [n]
Sedum album L.	Crassulaceae	RBGS record [n]
Sedum rupestre L.	Cracculaceae	RBGS record [n]
Senecio glastifolius L. f.	Asteraceae	RBGS record
Senecio pterophorus DC.	Asteraceae	Harden (1992)
Silene noctiflora L.	Caryophyllaceae	RBGS record [n]
Solanum hispidum Pers.	Solanaceae	RBGS record
Solanum sarrachoides Sendtner	Solanceae	RBGS record [n]
Spiraea x *billardii* Herincq	Malaceae	RBGS record [n]
Tamarix ramosissima Ledeb.	Tamaricaceae	Groves *et al.* (1997)
Thunbergia grandiflora (Roxb. ex Rottler) Roxb.	Acanthaceae	Csurhes & Roberts (1998) [n]

[a] Australian National Herbarium, Canberra, [b]National Herbarium of New South Wales(RBGS) notified by WeedAlert.

[c]Mis-named. [n]Plant identified by WeedAlert but not investigated further for various reasons, mainly as they are unlikely to be problems or present in NSW for many years.

In Table 1 we include potential new weed incursions investigated under the NSW new weed incursions strategy. We did not further investigate plants such as *Thunbergia grandiflora* (Roxb. ex Rottler) Roxb., and *Cucumis metuliferus* Naudin as they are widely planted in NSW and, although weedy, were not new incursions. *Senecio pterophorus* DC. is already widespread and *Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne is widespread, widely grown and still being sold so no action was taken on these. Others such as *Onopordum nervosum* Boiss. and *Centaurea nigra* L., which we found in nurseries, were destroyed. *Hieracium aurantiacum* L. was detected under cultivation in a nursery. The plant was added to the Noxious Weed list and plants destroyed.

The system also identified *Centaurea maculosa* Lam., in the Australian Capital Territory (ACT). ACT weeds staff are now controlling this incursion, reducing the threat to NSW. Surveys revealed that *Cuphea carthagenesis* (Jacq.) Macbride is a pasture weed, so NSW Agriculture established herbicide screening trials in 1998. *Berberis lycium* Royle, was a misidentification of *B. aristata* DC., similarly *Gamochaeta purpurea* (L.) Cabrera is likely to be a misidentification of another *Gamochaeta* sp. A survey confirmed that the only known infestation of *Elephantopus mollis* Kunth, remained despite control efforts by land-owners. *Tamarix ramosissima* Ledeb. was listed as a new record for NSW by Harden (1993), but was not investigated prior to the implementation of this strategy. It does not appear to have naturalised in NSW, however it is naturalised in Victoria (Groves *et al.*, 1997) in riverine areas and is a potential threat to watercourses in NSW.

NSW National Parks and Wildlife Service is considering action on *Senecio glastifolius* L. f., a significant weed in New Zealand detected using WeedAlert. Local authorities located and destroyed two species of *Equisetum*. NSW Agriculture will monitor the infestation of *Hypericum elodes* L. to determine its impact.

The PlantNET system relies on rapid identification and data-basing of newly reported exotic species. Notification times are being reduced although this has not always been the case. One of the species appearing in WeedAlert was collected in 1991 and not identified until late 1998. However, the transparency of the PlantNET process provides valuable quality control information that will enable Herbarium staff to recognise delays sooner, minimising delays in the future.

The strategy outlined above is speeding up the process of identifying and addressing new weed incursion in NSW. The success is largely due to the WeedAlert system. The preferred system of notification of new exotic plant species is automatic. However, the new formal reporting systems are still more rapid and reliable than previous intermittent contacts with herbaria. Extension of the WeedAlert system, or similar systems, to major herbaria in all states would benefit early control of weeds throughout Australia. This could improve the speed and reliability of risk assessment by defining the range of weeds already in Australia, and ensure weeds submitted to all herbaria are known. It is also clear that there is value in developing a target list of potential weeds as this allows specific investigations rather than awaiting for the weed to be sent to a herbarium.

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ESTABLISHMENT OF A WEED SURVEILLANCE AND RESPONSE PROTOCOL FOR NEW PEST PLANT INCURSIONS IN TASMANIA

Mark Boersma, Andrew Bishop, Christian Goninon, Cindy Ong, Tim Rudman, Stephen Welsh.
Department of Primary Industries, Water and Environment
PO Box 44A, Hobart, TAS. 7001

Abstract The development of the Tasmanian State weed strategy 'Weedplan' and recent incursions by potential pest plants has highlighted opportunities to increase the rate of early detection and the need to develop a clearly defined response protocol. New pest plant species recently (< 5 years) detected in Tasmania have included *Alternanthera philoxeroides, Amaranthus spinosus, Amaranthus albus, Cyperus rotundus, Kochia scoparia, Myrsiphyllum asparagoides, Cuscuta suaveolens, Adonis microcarpa* and *Teucrium scorodonia.* The past approach to the detection of recently introduced species has been ad hoc and informal with only one of the above species *A. philoxeroides,* having been detected through a formalised surveillance program. The establishment of a surveillance network and the development of a response protocol is discussed.

INTRODUCTION

The challenge to prevent and detect the establishment of new plant species is complex. Despite having quarantine barriers in place the unwanted arrival of pest plants will likely remain an inherent eventuality, as evidenced by the findings of Rozefelds *et al*. (1999). Rozefelds study revealed 159 new plant taxa have naturalised in Tasmania since 1970. This is to some degree a reflection of the extensive range of candidate species, and the difficulty in predicting their potential impact, invasiveness and distribution. As only 58 plant species (*Noxious Weeds Act* 1964) and 99 seed species (*Seeds Act* 1985) are prohibited entry to Tasmania, a large proportion of new introductions will be 'legal'.

From the moment a new species becomes established, early detection and evaluation of its potential impact becomes paramount. The earlier an incursion is detected the greater the chance of eradication or containment.

The approach to the detection of new plant incursions in Tasmania has in the recent past been ad hoc and informal, relying to a large extent on chance detection by botanists or other people well versed in plant identification.

Since 1994 new infestations of *Amaranthus albus* L., *Amaranthus spinosus* L., *Bassia scoparia* (three introductions), *Stipa caudata* Trin., *Myrsiphyllum asparagoides* (L.) Willd., *Cyperus rotundus* L., *Teucrium scorodonia, Alternanthera philoxeriodes* (C. Martius) Griseb., *Cuscuta suaveolens* Ser, *Adonis microcarpa* DC. and *Paronychia brasiliana* have been detected in Tasmania. Of these, only alligator weed (*A. philoxeriodes*), and secondary introductions of *B. scoparia* have been detected through active surveillance.

In an endeavour to effectively address surveillance for, and respond to new plant incursions, the Department of Primary Industries, Water and Environment (DPIWE) and Tasmanian Weed Management Committee have initiated the development of the Tasmanian Weed Alert Network.

This network is comprised of surveillance and response protocol components. The primary goal of this system is to minimise the time between establishment and detection, and ensure timely, efficient, consistent and comprehensive management of new infestations.

The development of a Weed Alert Network is supported by and meets objectives specified in 'WeedPlan', the Tasmanian State weed strategy (DPIF, 1996), and the National Weeds Strategy (CoA, 1999).

SURVEILLANCE NETWORK

The success of any effort to detect a new incursion is linked to: 1) The number of people aware of and actively looking for an alien plant species. 2) The level of training and information they have received in the identification of new incursions.

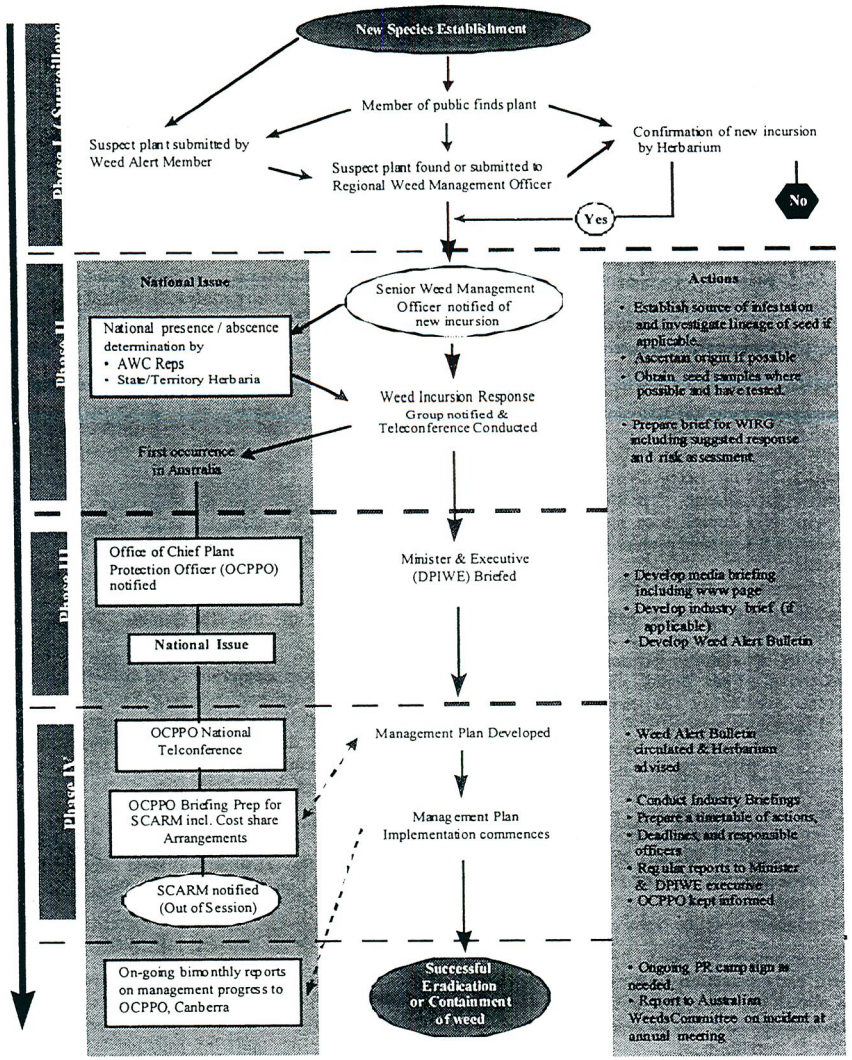

Figure 1. Weed Alert Network surveillance and response protocol.

The weed alert network recognises and takes advantage of the botanical skills and resources already present in the community, within which there are already many people skilled in plant identification. The objective of the network is to provide 100 people within Tasmania with clear and simple information necessary for the tentative identification of new pest plant incursions. The network is also intended create a culture within itself that engenders a sense of responsibility to continually watch for and report the presence of any plants that appear 'suspicious'.

Target Plants Plants targeted for inclusion into the Weed Alert Network must satisfy one of three categories. Categories are listed in order of priority to aid the allocation of limited resources.

- Species recently detected (<5 years) and formally assessed as a perceived threat to the economy, environment or public health. Must have a limited distribution and be considered eradicable.

- Species present longer than 5 years and formally assessed as a perceived threat to the economy, environment or public health. Must have a limited distribution and be considered eradicable.

- Species formally assessed as a perceived threat to the economy, environment or public health. Not present in Tasmania but considered as high potential for entry.

Participants Nominees are selected on the basis of demonstrated experience in plant identification and their likelihood of exposure to new pest plant incursions in the field. This includes skilled members of the public often belonging to community groups, government officers involved in land and water management, industry personnel such as field officers, Parks and Wildlife Rangers and others. The network currently consists of 40 members with a target participation of 100 persons.

Information resources Network participants are provided with an A5 sized folder for storing Weed Alert Bulletins. Each bulletin contains simple, concise information on a target weed's identification. Descriptions are accompanied by two full colour pictures and line drawings if available. Weed Alerts are double sided and printed on A5 water proofed paper.

As new incursions occur network members are provided with a Weed Alert bulletin and an opportunity to attend briefings on the significance and identification of the new species. Preliminary colour bulletins are released via e-mail where possible and published on the Weed Alert Web page to minimise print production delays.

NEW INCURSION RESPONSE PROTOCOL

Prior to 1998 no clear protocol had been available to manage the response to new pest plant incursions in Tasmania. Consequently a response protocol has been developed (Figure 1) in conjunction with the surveillance network. This protocol is described as four phases beginning with the discovery of a new plant species and culminating with the implementation of a management program. Each of the response phases (II-IV) is allocated an optimal time for completion of forty eight hours.

Phase I (Discovery): Suspect plants found by a Weed Alert Network member or handed to them by a member of the public are forwarded to either a Regional Weed Management Officer (DPIWE) or direct to the Tasmanian Herbarium for identification. In all cases formal confirmation of a specimens identity must be made by the Tasmanian Herbarium before further progression of the response protocol.

Phase II (0-48 hours): Upon confirmation as a new incursion, the Senior Weed Management Officer (DPIWE) and the Weed Incursion Response Group (WIRG) are notified and meet within the first 48 hour period. A preliminary weed risk assessment and investigation into the distribution and source of the incursion is initiated at this time. The national significance of a new incursion is determined through contact with Australian Weeds Committee representatives and herbaria from each State. These contacts may in future be substituted for linkages into similar surveillance and response networks from other States and Territories.

Phase III (49-96 hours): WIRG notifies the Minister and Executive of the Department of Primary Industries, Water and Environment. Where a new incursion has been determined to have national significance, the Office of the Chief Plant Protection Officer (OCPPO) is notified. Media and industry (if applicable) briefings and an interim weed alert publication are also developed during this period.

Phase IV (97-144 hours): During this phase a draft management plan is developed in consultation with affected parties and implementation initiated. Weed Alert bulletins are distributed and briefings conducted. Each

management plan includes a timetable of actions and identifies responsible personnel for each action.

Where new incursions are of National significance, management planning and implementation, media and industry briefings are conducted under the auspices of and in cooperation with the OCPPO and the Standing Committee for Agricultural Resource Management (SCARM).

Independent to Phase IV time constraints the OCPPO conducts a national telephone conference and prepares a briefing for (SCARM). SCARM is subsequently notified out of session.

CONCLUSION

Weed surveillance and response protocols for new pest plant incursions in Tasmania are a formal recognition of the importance of preventing new weed problems from occurring. The Weed Alert Network, a direct result of a strategic, State wide approach to weed management, is intended to enhance Tasmania's pre-emptive approach to weed incursions and minimise the emergence of future pest plant infestations.

Early detection and intervention will maximise the effectiveness of managing new pest plant infestations while minimising the resources required for their future management. Anticipated savings will allow for allocation of a greater proportion of available resources towards other weed management activities.

Early detection and intervention will also limit the potential damage to the environment, economy, public health and other human interests that would otherwise be inflicted by future pest plant invasions.

One weed, is one weed too many.

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SOME RECENT INCURSIONS OF WEEDS TO NEW SOUTH WALES

Jim Dellow[1] and Richard Groves[2]
[1]NSW Agriculture & CRC Weed Management Systems,
Orange Agricultural Research Institute, Orange, NSW 2800
[2]CSIRO Plant Industry & CRC Weed Management Systems,
GPO Box 1600, Canberra, ACT 2601

Introduced species enter Australia and become naturalised at the rate of about 6 plant species per year with the relationship between time and the number of new naturalised species being linear over the last 100+ years. Of the recent incursions that have naturalised over the last 25 years (1971-1995), about 60 per cent of species aredeliberate horticultural introductions. Many of these 'new' species have been promoted and distributed by ornamental plant nurseries in southern Australia. Some are of major environmental and agricultural concern.

Species recently detected and identified for New South Wales include: *Centaurea* spp.; *Hieracium aurantiacum, Hypericum elodes, Nassella tenuissima* and the thistle *Onopordum nervosum.* All these are known to be weedy outside Australia. Considered as a group, their entry to New South Wales and the promotion of their horticultural attributes are of considerable concern for present and future land management. We draw attention to case histories for these five examples in the hope of minimising the number of new, potentially weedy species in the future.

The knapweed genus *Centaurea* is very complex taxonomically in its native Europe and identification of individual taxa is very difficult. A nursery near Orange, NSW, in 1997 had for sale as cottage garden plants three *Centaurea* taxa, subsequently determined as *C. nigra* (incorrectly labelled by the nursery as *Scabiosa columbaria*!), *C. salonitana* and *C. macrocephala.* This was the first record of the latter two for Australia and only the second recording of *C. nigra* in NSW. As far as we know, these taxa are still for sale.

Our second case history concerns the herb *Hiercium aurantiacum*. The species is of European origin but now naturalised in New Zealand and North America as a weed of upland pastures. Though currently naturalised as restricted populations in Tasmania and Victoria, no *Hieracium* species is yet known to be weedy in southern Australian grasslands. In 1999, this small rosette herb was advertised in a mail-order catalogue as 'Orange Hawkweed' by a nursery at Berrima, NSW. The material had been propagated vegetatively from stock taken over from the previous owner 10 years ago and was not necessarily a new introduction. In co-operation with the Weeds Officer for the shire, the owner was persuaded to remove the species from sale and destroy the source material.

The introduced *Hypericum elodes* was found to be naturalised near Robertson, NSW, in 1998. Native to western Europe and the Azores, *H. elodes* is a new record for Australia, and possibly a garden escape. The species is weedy in Portugal. Its occurrence in the Nepean River immediately upstream from the Nepean Dam and its ability to produce abundant seed and to root from nodes, poses a potential problem to the Sydney water supply catchment.

Nassella tenuissima was being sold recently by a Sydney nursery under the common name 'elegant spear grass', a name that could be confused with that of the Australian native grass *Stipa elegantissima* (syn. *Austrostipa elegantissima*). The botanical situation is further confused by the fact that vegetative plants of *N. tenuissima* and those of its closely-related weedy congener *N. trichotoma* (serrated tussock) cannot be distinguished; only flowering material enables positive identification. This recent incursion, of American origin, has the potential to have an even greater eventual distribution in southern Australia than serrated tussock. The same species has also been detected for sale recently by several Victorian nurseries in the Mount Macedon area. Only prompt action by both States in co-operation with the nurseries concerned seems to have prevented further sale of *N. tenuissima*.

High-profile television 'garden shows' have recently promoted the thistle *Onopordum nervosum* as a desirable 'cottage garden' plant. *O. nervosum* is indigenous to Spain and Portugal. Seed of this weedy taxon was advertised as being available from a nursery at Sutton Forest, NSW, the original seed having been obtained by mail order from Cumbria, UK. Sale from this source of *O. nervosum* seed has now ceased and the television show concerned regrets its ill-advised promotion of this potentially weedy species.

One way to reduce the number of new and recent incursions of undesirable weedy species or taxa entering or naturalising in Australia is to publicise recent case histories and to work co-operatively with individual nursery proprietors and with all levels of the nursery industry generally when such species as those above are discovered. This would operate in line with the **G**arden **P**lants **U**nder **T**he **S**potlight national strategy. Another way to reduce the number of recent incursions having a known potential to be weedy in natural and agricultural ecosystems is to follow the "Protocol for Field Inspections to Follow up Suspect New Weed Incursions" compiled by NSW Agriculture. A serious complication concerning the overall limitation of new incursions to Australia is the availability of exotic plant species through the internet, as many undesirable plant species with weed potential are advertised readily in this way and subsequently introduced to Australia by mail order, albeit illegally.

GARDEN PLANTS BECOMING WEEDS – INITIATIVES WITH THE NURSERY INDUSTRY

Kate Blood
Cooperative Research Centre for Weed Management Systems, Keith Turnbull Research Institute,
PO Box 48, Frankston, Vic. 3199

Garden plants around Australia are jumping the back fence and becoming weeds of agriculture and the natural environment. There are over 700 invasive garden plants or 'Garden Thugs' in Australia. Government, the nursery industry and horticultural media are working together to find solutions. An awareness and education campaign called 'Garden plants under the spotlight' is one of the main features of a national strategy proposed by the Weeds CRC and the Nursery Industry Association of Australia. The aim is to educate gardeners, industry and the horticultural media and ultimately to replace highly invasive plants in the trade with safer alternatives.