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Natural Regeneration: principles and practice

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What is Natural Regeneration?

'Natural regeneration' refers to the natural process by which plants replace or re-establish themselves. Cremer (1990) defines 'natural regeneration' as "reproduction from self-sown seeds or by vegetative recovery (sprouting from stumps, lignotubers, rhizomes or roots) after the tops of the plants have been killed (by fire, cutting, browsing, etc.)". Temple and Bungey (1980) define it as "regrowth which occurs naturally after stress or disturbance. It may be growth from seed of both pioneer or permanent species, or growth from lignotuber (e.g. *Eucalyptus spp.*), rootstock (e.g. *Melaleuca spp.*), etc; remaining in the ground". Planting seedlings and direct seeding are alternative methods of re-establishing vegetation.

Why use natural regeneration?

Natural regeneration is a powerful tool for anyone wishing to re-establish vegetation on a property at minimum cost and is an essential part of managing a bushland area. Areas that are managed in a way that enables natural regeneration to occur can be self-sustaining and may not require further expensive establishment costs. Natural regeneration ensures that the plants established on a site are from parents that currently occupy the site. Hence it helps to preserve genetic identity and variation throughout Victoria's plant species. This natural 'conditioning' to a site means that these plants are capable of withstanding long-term natural fluctuations and should do well, once established. Natural regeneration is particularly useful for establishing plants on a broad scale but can also be used in localised areas. Natural regeneration has also been used as a means of producing seedlings for planting in other areas.

Throughout much of rural Victoria this natural process is no longer occurring. Mature plants are reaching the end of their lifespan and the benefits associated with them are being lost (e.g. shade and shelter, wildlife habitat).

Under what circumstances is natural regeneration a useful option?

So long as there are mature and healthy native plants on the site, natural regeneration is an option. It is limited in many areas by the depleted, and therefore limited range, of species existing at a site compared to its natural diversity. Supplementary planting or the introduction of seed from other areas is often required to attain full natural diversity. Natural diversity is essential to re-establish a 'healthy' ecosystem. Natural regeneration can be a sporadic event. It is therefore not as reliable to produce results in a given season as planting might be, however, when it is successful, the results are often dramatic. For many species, natural regeneration is effective only near the parent plant.

In a healthy ecosystem natural regeneration is an inbuilt part of the process that maintains the ecosystem, its communities of plants and animals. Under natural conditions, human interference is not desirable.

How can I encourage natural regeneration?

A number of factors, both natural and man-made, are believed to be involved in the control of natural regeneration in rural Victoria. Some of these are discussed below and some management options are proposed. There are likely to be other factors not covered here.

The controlling factors

1. SEED SUPPLY

Problem: No seed, or seed of poor viability. This may be due to the absence of fertile plants with viable seed; seed harvesting by ants & predation by other insects, birds and mammals; lack of fire; lack of pollinators or seasonal variations.

Absence of fertile plants with viable seed - background:
The lack of suitable plants from which seed/spores (etc.) can be generated may preclude natural regeneration. This may occur because the plants that are present are too old or stressed, because some species are no longer present at the site, due to bad seasons, or because both sexes are no longer present in plants with separate males and females (e.g. She-oaks *Casuarina*).

Management options:
In some instances seed may not be available at the site immediately but may be carried in from nearby sources by water, wind or wildlife. In this case, simply waiting can produce results. Direct seeding or planting may be the only option in areas cleared of native vegetation. It should be noted that native plants do not produce seed in equal quantities each year. Heavy seed fall in some eucalypts is infrequent. Monitoring of seed fall may be necessary using a suitable seed trap. DCE can provide advice on a suitable design and germination testing. It may be necessary to wait for a better season, plant individuals of the other sex (in plants with separate males and females), or pollinate existing females from elsewhere.

Seed harvesting by ants and predation by other insects, birds and mammals - background:
Ants can be very effective harvesters of seed and may take 100% of the year's crop of seed for food and nest-building. This may prevent germination. Other arthropods also feed on seeds. In contrast, many insects, including ants, (& birds and mammals) also play a beneficial role in seed dispersal and germination. For example Berg (1975) found that 1500 species of Australian plants are regularly dispersed by ants because of ant-attracting structures (elaiosomes) on their seeds or fruits.

Management options:
Light raking of the soil during seed fall may hide sufficient seed from ants that consume seeds. Insect numbers vary seasonally and in most cases no action is required to prevent opportunistic predation of seeds by other species.

Lack of fire - background:
Many native plants shed seed following fire, usually from woody capsules that are designed to protect the seed from the intense heat of the fire, then open immediately following its passage. Other species, such as some *Acacias*, produce seeds with thick seed coats that must be cracked by the heat of a fire before germination can occur. Controlled burning of such vegetation, to stimulate seed release or germination, may be a pre-requisite to achieve natural regeneration.

Most Australian vegetation is adapted to withstand fires of

a certain frequency and intensity. Frequencies vary from 2-5 yrs for grassland habitats, to 60-90 yrs for wetter forest types, and may be as infrequent as every 200 years. Rainforest species are usually not tolerant of fire. Fire plays a major role in the ecosystem, affecting what plants will be present at a site, in what densities and at what time in the life of that vegetation community. Expert advice should be sought for your vegetation type, and safety, from the Department of Conservation and Environment (DCE) and Country Fire Authority (CFA).

Management options:
Use fire to promote seed release in woody-fruited species (e.g. *Banksia*, *Hakea*) and for seed germination (e.g. some *Acacia* spp.). Fire can also be used to reduce pest insect populations. Timing should be as close to natural occurrence as is permissible under fire restrictions.

Lack of pollinators - background
In severely disturbed or isolated areas, there may be a lack of natural pollinators (birds, bees, moths, butterflies, etc). Thus, no seed may be set or, due to a lack of outcrossing (pollen transfer between plants rather than between flowers of the same plant), any seed that is set may be of poor viability.

Management options:
Supplementary planting of local natives to improve natural diversity and support natural pollinators, by providing habitat for them, may assist. Connecting remnants to other remnants with corridor plantings may encourage re-establishment of pollinators. Use of honeybees (*Apis mellifera*) as pollinators is not recommended. Note that honeybees may adversely affect wildlife by occupying hollows used by wildlife, by denying large quantities of nectar to wildlife, by increasing in-crossing (pollination by a plant of its own flowers) of native plants and may also have adverse effects on native bees.

Seasonal variations
Seed supply, dispersal and viability will vary seasonally due to a range of climatic and biological factors. These factors should be considered as 'natural events' and should be planned for rather than reacted too.

2. SOIL CONDITION

Problem: Seed germination and establishment will be impaired by 'unhealthy' soil conditions. Such conditions might include: no suitable site for germination as a result of soil compaction, loss of topsoil, an unstable site, lack of mychorrhizal fungi (fungi which associate with plant roots and assist with nutrient uptake), lack of an 'ash bed' (nutrient pool created by fire), loss of the cryptogamic (lichen & moss) mat or changes to soil chemistry.

Soil structure

Soil compaction
The heavy hooves of stock, including cattle, sheep, horses and goats, can compact soil and destroy soil structure. This diminishes the air spaces in the soil and reduces its capacity to absorb and retain water, leading to greater runoff, and has detrimental effects on biological activity in the soil. These changes may prevent or restrict germination by excluding penetration by seedling roots, increasing the chance of desiccation (drying out), killing helpful soil micro-organisms which associate with plants and decay organic matter, and by causing other effects.

Loss of topsoil
Topsoil contains most of the organic material from which plants obtain their nutrients. Where it has been removed, such as by erosion, seedlings may be unable to establish due to a lack of nutrients.

Unstable site
Soil provides anchorage for plant roots. If there is movement of soil, plants may fail to remain stable and may fall over, have their roots damaged and opened to infection or suffer other ailments.

Cryptogamic mat
The 'cryptogamic mat' provides a sheltered, moist environment at the soil surface. Its presence in some vegetation types (e.g. grasslands) may play an important role in assisting seedling establishment.

Soil structure - management options:
Exclude stock by fencing or reduce stocking rate. If necessary, lightly scarify compact soils at time of seed fall. Follow up weed control with a knockdown (not residual) herbicide (e.g. glyphosate) may be required. In severely degraded soils, where no topsoil remains, addition of weed-free, pathogen-free topsoil may be necessary. Alternatively, use native pioneer species such as *Cassinia* which can, over time, re-condition the soil. Sterile hybrid grasses (e.g. ryecorn) have been used as 'cover-crops' to arrest erosion. Addition of a small soil sample from healthy vegetation of the same type can reintroduce lost soil microorganisms. Care must be taken that the soil sample is from healthy vegetation and is free of weed seeds and potential pathogens. Mulching will aid water retention, slowly add to the organic content of the soil and reduce weed competition but if applied too heavily will prevent germination. Where erosion is severe, other erosion control practices should be employed. Advice should be sought from DCE.

Soil chemistry

Application of chemicals
Many of Victoria's soils contain naturally low levels of elements that are important to plant growth, such as phosphorous and nitrogen. Much of our native vegetation is adapted to these low levels of soil nutrients and has developed efficient strategies for recycling nutrients. Application of superphosphate ('super'), weedicides and pesticides has changed the chemistry and biology of the soil (worms and 'super' don't mix). 'Super' favours the rapid growth strategy of introduced pasture annuals over native species. The resulting competition from weeds may effectively exclude native plants.

Lack of an 'ash bed'
Some native plants have specific soil-bed requirements for germination. For example, some species need a fire to release nutrients for use during establishment.

Soil chemistry - management options:
Do not apply fertiliser to areas that are to be regenerated or managed to retain native vegetation. Other chemicals should be used with care and in minimal quantities to achieve a management aim.

Fire may be used to promote conditions for germination (e.g. ash bed for germination) in appropriate vegetation communities. Expert advice should be sought.

3. COMPETITION

Problem: Competition from the same or other plant species may prevent successful seedling recruitment. This may be due to weeds, parent plant allelopathy (chemical inhibition) or fungal attack.

Competition from weeds
Weeds can be very efficient at occupying space, using available nutrients and consuming water. In this way they may outcompete native species in the 'race' to grow. Weeds can be expected to be a major problem in areas that have been previously fertilized and that have been subject to seedfall from weedy species (either native 'environmental weeds' or introduced).

Management options:
There are several options available. The technique employed will depend on your situation (natural bush versus pasture), time constraints and area being managed.

Briefly, the options are: hand weeding using an appropriate technique such as the Bradley Method; mulching, although this can prevent regeneration if applied too heavily; chemical methods (application of weedicides can be very effective although note concerns above re: soil chemistry); use of fire as a means of selecting out fire-sensitive species (e.g. Sweet Pittosporum *Pittosporum undulatum*) or to remove above-ground vegetation for a short period. Fire may be particularly useful where it is necessary to retain the binding capability of plant roots in areas subject to erosion. Removal of the top few centimetres of soil (scalping) can be used to remove unwanted seeds and can be a useful technique if done at the time of seedfall of the species to be regenerated. Positive weed control strategies in areas abutting 'improved' pasture are usually required. For example, a buffer (e.g. screen of tall plants, weeded area) may be needed to prevent *Phalaris* spreading from paddocks into fenced natural areas. Specific advice should be sought from DCE.

Parent plant allelopathy - background
Many species of plants (e.g. *Eucalyptus*, *Allocasuarina*) produce chemicals that inhibit germination of their own seedlings beneath them. This prevents competition from the seedling with the parent plant. Typically, the zone of inhibition extends to the width of the crown of the plant.

Management options:
Landholders need to be aware of this effect. The area managed for regeneration should not be restricted to the base of the parent plant. If only a small area can be fenced, it should be offset downwind.

Fungal attack - background
Soil fungi, whilst vitally important to plant growth (c.f. mychorrizae), can also be pathogens of young seedlings. Attack by fungi can be a problem for seedlings.

Management options:
Sterilization of the soil is neither practical nor desirable. Fungal problems are likely to be seasonal, so repeated attempts may be necessary. Revegetation of areas with contaminated soil containing *Phytophthora* or other soil pathogens must be avoided.

Other seedlings - background
Where there is a range of plants all germinating together (same or different species) there will be competition between individuals for the available resources. Some plants (of a species), or other species, may do better than others. This should not necessarily be seen as a problem unless the successful competitors are weeds (see above). Some seedlings may die whilst stronger and more successful ones survive.

Management options:
If the aim of management is to increase diversity, you may wish to selectively remove competition against 'rare' species by selectively weeding around them using a suitable technique (e.g. hand-weeding).

4. PREDATION OF YOUNG PLANTS

Problem: Seedlings may be destroyed by predators such as insects and other invertebrates; stock; rabbits and hares; or wildlife. Seedlings and young stems may lack natural deterrents (toxic or unpalatable chemicals, hard leaves or leaf structures such as thorns and hairs) and so be relatively defenceless compared to mature plants. Grazers may select particularly palatable species. Thus, some species may be particularly vulnerable.

Insects or other invertebrates
Caterpillars, crickets, beetles, mites, nematodes, and other invertebrates eat seeds and seedlings.

Stock
Stock, including cattle, sheep, horses and goats eat seeds and seedlings and may selectively choose a particularly palatable species.

Introduced species
Deer, rabbits and hares eat native plants. Rabbits & other species may strip bark from young plants and ringbark them.

Native wildlife
Native animals including kangaroos, bandicoots, Swamp Rats and others may feed on seedlings.

Management options:
The most effective control for larger predators is good fencing. Specific advice for the wildlife species you need to exclude is available from the Department of Conservation and Environment and, for stock, from the Department of Agriculture. Reducing the stocking rate has also been effective in some instances, particularly if commensurate with a rabbit control program. An effective rabbit control program is essential in areas subject to large numbers of rabbits. DCE has information on the best methods to suit your property. Invertebrates are difficult to exclude and are likely to be bad in one season and less of a problem in another. Snail and slug baits could be used over small areas or natural predators encouraged by providing cover, feeding and breeding requirements. 'Benign' chemicals, such as white oil, may be useful in specific instances.

5. NATURAL HAZARDS & CONTROLS

Problem: There may be natural climatic, biological and physical constraints upon natural regeneration. These include fire, flood, wind, drought, temperature extremes (e.g. frosts), time of year and light conditions.

Background:
Natural events can affect the survival of seedlings. Drought, fire or flood may kill seedlings. Some species require natural events to occur prior to germination. For example, acacia seeds germinate following fire, whilst River Red Gums respond to flooding. Severe wind may be hazardous to young plants, particularly in exposed situations. There is some evidence that large-scale regeneration events are more likely to be successful in particularly 'good' years (years with above average rainfall when the soil is warm). Lack of light or water can prevent germination (e.g. in a rainforest the collapse of a mature tree may allow light to the forest floor and initiate germination). Germination may fail to occur in a vegetation community during drought. The first heavy rains may initiate germination on a massive scale.

Management options:
There is little that can be done to prevent nature taking its course. It is advisable not to put all your effort into one season. Where it is obvious that a lack of natural events due to man-induced changes is to blame for a deficiency of regeneration you can seek assistance and advice from DCE.

Some basic rules

A number of management options have been outlined above to deal with many factors that may be preventing natural regeneration. The practical application of natural regeneration techniques is considered next. What is done, where it is done and when it is done are all important.

It is suggested that you take note of the following general principles:

1. Do not apply a technique to the whole area under management until you have tested it on several small representative areas.
2. Do not put all your effort into one season.
3. Don't be surprised if at first you fail. Your chances of success, as with all techniques, will improve with

experience. The rewards are great for those who are prepared to show some dedication, are open to investigation or experimentation and can learn from experience. There are no guarantees with natural regeneration. Talk to those people who have experience in your area.

4. Be patient, if it doesn't happen this year it may next year.

The tools

The following practices form the basic inventory of 'tools' available to encourage natural regeneration. Others may be devised from the suggestions given here.

fencing to control stock and pest animals; select a fencing technique that is the most appropriate for your stock and which may avoid any pest animal problems that you would expect to occur on your property.

destocking to control soil damage and browsing caused by stock; may not protect ground flora.

scarifying (loosening the top few centimetres of soil with a suitable hoe or tiller) to loosen compacted soils, and crack seed coats of soil-stored seed (e.g. wattles).

burning to promote seed release and conditions for germination of many native plants, as a means of weed control and to promote germination (crack seed coats, etc.).

hand-weeding to control weeds; labour intensive but avoids using harmful chemicals.

herbicide application to control weeds; an alternative to hand weeding which is much less labour intensive but employs potentially harmful chemicals, DCE can advise on specific non-residual 'knockdown' chemicals.

soil scalping to remove seeds present in the topsoil as a method of weed control; usually not suitable if ground flora is to be conserved and it can be destructive.

mulching to improve water/soil retention and suppress weeds; can prevent natural regeneration by eliminating light.

supplementary sowing (direct seeding) to add species where the full natural complement of species is not present and you do not wish to wait for wind/water or animal dispersed seed to establish.

planting to add species to those that regenerate naturally with the aim of introducing local native species which can become natural regenerators.

pesticide application to control insect predation on seed/seedlings; use of pesticides, which may have other less beneficial effects, should be avoided wherever possible.

1080 application, warren fumigation, warren ripping, etc. alternative methods of pest animal control, particularly for rabbits. DCE can give specific advice.

raking/repellent emulsions to hide seed from predators and ants; bitumen emulsions have been used to deter ants in direct-seeding trials.

erosion control to stabilise soil; specific advice is available from DCE.

soil supplementation to reintroduce soil micro-organisms to degraded soils where there is a lack of seedling vigour; healthy soil from vegetation of the same type must be used and it is advisable to try other techniques first.

The use of fertilisers and supplementary watering regimes are not recommended. Fertilisers may alter soil chemistry whilst supplementary watering should be unnecessary if the plant stock is local. Both treatments add costs.

The methods

The method of achieving natural regeneration will vary according to the situation. For example, bushland areas would be managed differently to paddocks.

Bushland areas

'Natural' techniques are usually the most appropriate in native bushland. Natural processes should be allowed to continue as often as possible. A controlled fire will probably be necessary to retain diversity, but advice should be sought first. Hand-weeding or burning are the preferred methods for removing weeds, though chemicals may be the only practical means in some circumstances. Soil disturbance by humans should be avoided in remnant native vegetation, as this can promote weeds. Human access is best confined to areas with no remaining natural ground flora.

Farms and disturbed sites

There is no definitive formula that will provide the desired results every time. If natural regeneration does not occur, further investigation will be needed as to the cause. Some strategies are suggested below (see also Note 16):

Strategy one: Fence and do nothing else.

This will almost always be the first step on land under production or other use. (i.e. not necessarily in bushland). Fencing can be carried out at any time but early autumn is the most likely time for regeneration to occur (spring-summer in cold wet climates). Follow-up plantings of additional understorey and ground species may be required. Problems with weeds should be anticipated. Patience is usually essential.

Strategy two: Fence and scarify.

To regenerate species in an area with compacted soil, such as a stock paddock, attempt to fence and 'tickle-up' the soil adjacent to remnant native vegetation. Problems with weeds may necessitate secondary measures.

Strategy three: Fence, apply weed control and/or fire with light soil scarification.

1. Fence in early spring. 2. Apply weed control just prior to seed fall (from February for most species), with follow up occurring throughout the period of germination, and/or apply fire in early autumn taking advantage of dry fuel produced by fencing before spring growth (take note of fire restrictions and precautions). 3. Lightly scarify the soil at the time of seed fall. Rapid regrowth of weeds can be expected. Fast growing acacias and other species may overshadow and eventually exclude some weeds.

Strategy four: Reduce stocking rate and control pest animals

If fencing is not an option, reducing the stocking rate, particularly if combined with an effective pest animal control program, can achieve successful regeneration especially in 'good' seasons for plant growth. There are many other strategies that could be devised using the tools suggested previously.

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