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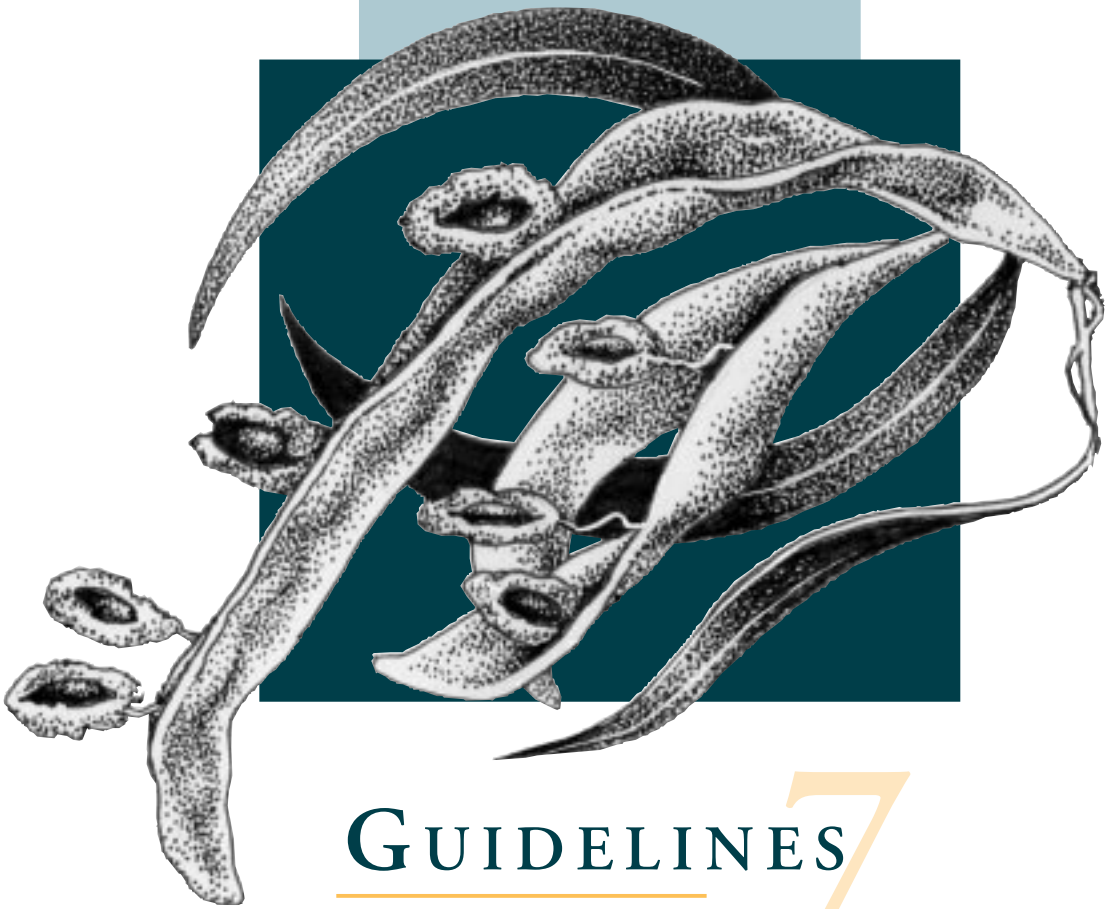

GUIDELINES 7

SEED PRODUCTION AREAS FOR WOODY NATIVE PLANTS

Australian National Botanic Gardens

Natural Heritage Trust
Helping Communities Helping Australia
A Federal Government Initiative

Bushcare

Greening Australia

CSIRO
FORESTRY AND FOREST PRODUCTS
Australian Tree Seed Centre

This guideline is an introduction to the establishment and use of native seed production areas. It focuses on the production of seed from woody native plants for revegetation purposes.[1] It includes guidance on practical approaches to planning, siting, designing, and establishing seed production areas, as well as harvesting and using the seed they produce.

Seed is the major raw material for native plant propagation and increased effort in revegetation can lead to increased pressure on seed resources in the wild. Such pressure can result in increased competition among collectors, damage to plant communities from collection practices, or the removal of so much seed that plant survival is threatened or community structure changed. Collecting viable seed on a regular basis is often hampered by natural conditions such as unseasonable rain, unpredictable seed maturation and sporadic seed set, high levels of seed predation by insects and fauna and naturally poor seed viability. Collectors often face logistical difficulties such as working in remote locations or difficult terrain, monitoring seed set, timing collection so the seed is mature and organising pickers during the short period when collecting seed is possible.

Local seed production has great potential to supply local seed in high demand and may also add to the genetic base of species used in revegetation or habitat reconstruction.

We recognise that people often plant native trees and shrubs to serve more than one purpose. If seed production is one of your motivations, you should find this guideline useful.

Seed production for revegetation and conservation is relatively new in Australia but is standard practice in commercial forestry and agriculture (see references). It is much like growing long-term horticultural or forest crops, with the exception that relatively little is known about the cultivation and seed production capability of many native plants. Successful production requires careful planning, management, and harvesting. A bit of luck wouldn't hurt either.

It is strongly recommended that you seek advice and undertake further discussion of your aims and requirements before committing resources to seed production. A lot of effort and careful planning is required to realise the full potential of seed production areas. Look for expert contacts through Bushcare offices, your state herbarium, state government departments such as National Parks, the FloraBank partners or the Australian Network for Plant Conservation.

[1] Although some general concepts are similar, it does not cover native forbes and grasses.

Genetic rejuvenation

Small patches of remnant vegetation may be a very poor source of seed, especially where plants are isolated from other trees of the same species. Self-pollination (inbreeding) will often lead to seed with poor viability and vigour. There may be low genetic diversity inherent in the seed because so few parent plants remain and they may be closely related. Seed may be infertile due to poor fertilisation by pollinators or an absence of pollinators.

It may be possible to use seed production areas to increase the genetic diversity of some species within local remnants that have been fragmented through land clearing. Such genetic rejuvenation should only be attempted with a good understanding of the genetics and some expert advice. If you think this may be an issue in your area, start looking for expert contacts through the sources listed in the introduction.

Genetic quality

The genetic quality of the seed you might produce is more important than the quantity. Local collection for local planting will do nothing to improve local genetic diversity if a very limited genetic base is used for collection (see Templeton, 1991). If used widely, seed from poor collections or a poorly constructed seed production area may actually reduce genetic diversity and, over time, make the plantings less resilient to changes in the environment.

This guideline will help you maintain a high standard of genetic quality in the seed you produce. Be aware that maintaining this standard may place limitations on what you can achieve with available resources in terms of the number of species or quantity of seed you produce. Most likely, you will have to concentrate on producing seed of a few key species for revegetation in your local area.

Indeed, wherever seed production is a major objective of replanting work, it will predominate over consideration of other revegetation objectives if genetic quality is to be maintained in the seed produced. This can significantly affect design and siting, species composition, seed sources, planting densities and record keeping. For example, narrow linear plantings, such as windbreaks and shelter belts, do not usually make good seed production areas because the plants have limited opportunity for cross-pollination. A block planting, by comparison, allows for better cross-pollination with a wider range of neighbouring trees (see 'Planting layout' below).

Seed production area or seed orchard?

The term 'seed production area' refers to plant populations established with the primary or secondary objective of seed production. They are established using known seed sources and planted in a design that maximises the potential for cross-breeding. They are generally planted fairly close together in the knowledge that some plants will be lost, allowing for vigorous and healthy plants in the final population. Genetic diversity is maintained by using seed from as many parent plants in the source provenance(s) as possible.[3]

A 'seed orchard' produces seed that is improved whereas seed production areas produce seed more closely related to the parent population. The source material for seed orchards is selected on the basis of desired traits or characteristics. Individual plants in the orchard are identified and those that do not exhibit the desired traits or characteristics may by thinned to ensure the production of 'better' seed than the original parents.

The important difference between the two is that seed orchards are established to alter the genetic base to favour a particular set of genes. In seed production areas the genetic mix can remain representative of the original population(s), although it is still possible to manipulate the mix through time by selective removal of plants. Seed orchards are not covered in this guideline. They can be established from seedlings (seedling seed orchard) or planting stock propagated through cloning, such as cuttings (clonal seed orchard).

It is possible to use natural populations as dedicated seed production areas, but this requires management practices that may not be appropriate for the natural environment, such as fertiliser application, removal of diseased or non-seed bearing plants and access with machinery for harvesting.

[3] See FloraBank Guideline 5, *Seed collection from woody plants for local revegetation*, regarding provenance.

Planning considerations

Coordination & management

Seed production requires a long-term management structure such as a local or state government, a community organisation or group or a commercial venture. A person is needed to coordinate the site selection and establishment phase and someone must be responsible for ongoing management and the allocation of seed collection and distribution rights.

Secure land tenure is needed for at least 10 years in the case of most native species and longer for species where seed crops are not initiated for a decade or more. Even small costs associated with lease or tenure arrangements may be significant over such a period. A management agreement or management plan may provide more security for sites located on private land.

We recommend you start with a single site and set readily achievable goals: keep it simple!

Establishing a single seed production area can be a significant undertaking. The basic approach is to collect seed widely in the local area and plant it together in a single, local seed production area on a site that provides conditions for good growth and seed production in the target species.

The degree of difficulty increases as more species are introduced or the range of end uses for the seed is widened. Larger or greater numbers of seed production areas, with greater capacity for seed production, require more resources and management. Coordination at some regional level may be needed to avoid duplication of effort.

Purposes of seed production

For many community groups and organisations involved in revegetation, the main purposes for establishing a woody native seed production area are to:

- provide seed of certain species or origin that is in high demand (for example, seed specifically from your local area);
- provide seed of species that are difficult to collect from the bush, such as those that set seed irregularly or for very narrow time periods or that grow in remote, rugged or difficult terrain; and
- produce seed in a location that is easily accessible for seed collection.

Seed production areas might also be established to:

- bring together remnant scattered plants to allow for cross-pollination and rejuvenation of the genetic base for a particular species (provide highly outcrossed seed);
- reduce the pressure of collection on the natural bush; and
- educate local people about their local plants.

These purposes might also lead to production of material that can be used commercially and this interest should be declared at the planning stage to ensure there is no conflict with other objectives.

Production of genetically diverse native plant seed for revegetation can only result where seed is carefully collected from a sufficiently large number of parent plants and where a planting layout that encourages cross-pollination between plants is used.

The guidelines below place practical limits on both the amount of seed and the range of species and provenances you can produce from seed production areas. The significance of the production seed crop in terms of quantity produced should increase with time, but it is unlikely to replace the need for collections from the wild.

Site selection

The site you select must have growing conditions suitable to produce a seed crop of the target species – the primary purpose of a seed production area. If there are other objectives, then site selection should reflect their requirements.

Consider the following:

Growing conditions

Seed production may be regarded as similar to floriculture, horticulture or forestry in that native plants have basic requirements which must be met for reasonable growth to be achieved (for example, for season length, altitude, temperature, rainfall, soil type and aspect). However, unlike most horticultural and forest crops, these requirements are poorly understood or unknown. There may also be requirements for flowering, fruiting, seed set and the production of viable seed.

We recommend you start with a small number of species and learn as much as possible about their requirements for growth and seed set before you choose a location. If there are many species or there is poor information, you should, in practice, simply ensure that the site has the best growing conditions possible given the options available. Avoid degraded sites, such as saline or potentially saline areas, but be aware that some adverse conditions may be addressed by management options such as irrigation or the application of fertiliser.

The site should be on a land system representative of its area or of those on which revegetation is typically carried out locally. Land systems are a well accepted method of classifying broad variation in the landscape and are a composite of soil, vegetation, landform and climate (see Gunn *et al.*, 1998).

Natural hazards

Some hazards may be managed, but this usually increases costs, which can be significant over the lifespan of a seed production area. Evaluate the natural hazards present at a potential site and try to avoid sites that have a high hazard from bushfires, flooding, landslip or erosion or that exhibit excessive weed problems, dieback fungus, high winds, spray drift, waterlogging or excessive grazing by fauna, feral animals or stock.

Site size

Ensure the site is large enough for current and future requirements. Determine a minimum site area and width based on the area needed for the number of plants you wish to grow and additional space for firebreaks, access tracks, turning areas and so on. Establish minimum site size using a recognised mature plant density or revegetation spacing used in your region. For example, a spacing of four metres within rows and four metres between rows for seedlings produces about 625 stems per hectare. This could be reduced for small shrubs or increased for large trees. A site should preferably be a regular shape for ease of access and establishment. Avoid long, thin configurations which can restrict cross-pollination (see 'Planting layout' below).

Access

It may also be useful to site the seed production area close to collectors or seed processing or nursery facilities, reducing the transport and handling required. Easy all-weather access is required for maintenance and seed harvesting. In the tropics, this may include access during the wet season. However, it may be necessary to limit public access to conserve the seed resource for specific collectors and users, or to protect plants at the site. Also consider the distance from home base to the site and the time taken to travel there. If access is by four-wheel drive, then only those who have a four-wheel drive could maintain the site or collect seed from it. It may also be more difficult to get equipment to the site.

Bare or vegetated

Choose a bare area, old cropping area or pasture where possible, as you would for other horticultural or forest crops. Limited existing tree cover may be retained, especially where other objectives such as habitat reconstruction are involved. Avoid areas of persistent or woody weeds or improved pastures unless good weed control can be achieved.

Slope

Ideally, look for a flat to gently sloping site. Steep slopes obviously restrict access and make management more difficult. However, even moderate slopes cause problems with runoff and erosion.

Proximity to natural bush

There may be benefits in locating a seed production area in close proximity to reserves or other natural bush, including:

- increased populations of pollinating insects, birds and other fauna;
- greater genetic diversity in seed produced than at more isolated sites; and
- the establishment of an ecological corridor.

However, the proviso is that seed production area propagation material is sourced from the local area. If species are from outside the local area, proximity to local bush may lead to contamination of local gene pools of other species (for example, through natural seed fall) resulting in local regeneration biased towards the seed production area species. In the worst case, a weed problem may arise, depending on the species and the environment.

Duplicate sites

Seed production areas may be duplicated where there is a high risk of damage or loss due to natural hazards. Duplication may provide greater long-term security against changes in tenure or land use. Be aware that this will add greatly to the management load.

Design considerations

Many design considerations are important in maintaining the genetic quality of seed produced from seed production areas. These include the number of plants, the source material, the area required for inclusion of any particular species and the layout.

Sampling

You may use seed or vegetative propagation (cuttings or grafts) to establish seed production areas. As a general guide, the more plants you collect seed or propagation material from the better. However this quickly becomes expensive where the natural populations are large.

In keeping with FloraBank Guideline 5, *Seed collection from woody plants for local revegetation*, we suggest you aim to collect from at least 10 broadly spaced, healthy plants per population.

The plants sampled should be widely spaced to avoid collecting from closely (genetically) related plants.

If the species or provenance is highly variable, you may wish to subdivide the populations and collect from about 10 plants per subpopulation.

Where conservation of the species or provenance is one of the main objectives (or the seed from the seed production area will be used for conservation plantings) we recommend at least 50 plants be sampled (Breese, 1989; Brown and Briggs, 1991).

Using seed collected from a limited range of scattered trees can have undesirable effects. In the long term, a loss of genetic variation through the use of small numbers of parent plants will leave species with few evolutionary options in the face of changing environmental pressures. In the short term,

increased inbreeding from close relative matings can dramatically affect the chance of the plants' survival. Inbreeding results in offspring that are not as fit as their parents, producing plants that do not grow as quickly or have reduced tolerance to extreme environmental factors like salt or drought. They do not set as many flowers or have as many seeds. Used widely, genetically inferior seed may actually reduce local genetic diversity.

Using seed

Seed is the most often used propagation material. It is feasible to establish seed production areas through direct seeding methods with the correct mix of seed (see comment below on bulking). You should make special collections of seed unless you are certain of the origins of seedlots in storage.

Once collected, seed from individual parent plants should be kept separate if possible. Where direct seeding is to be used or large areas are to be sown, it is possible to combine seed from the 10 or more plants to produce a bulk sample representative of the original population(s). However, bulking reduces the control you have over representation of parent plants in a seed production area. For the bulked seed to be representative it is advisable that parent plants be evenly represented not only in the bulked seed but in the progeny from it.

Ideally, you should establish the germinability of the seed from each parent. If there is wide variation, you should bias each parent to ensure roughly equal numbers of plants will be contributed by each. It is also possible to grow seedlings from each sampled parent separately and then plant them in a randomised design which ensures equal representation. This even-handed approach comes at the cost of greater complication through the seed handling and nursery phases and greater (more skilled) resources required for layout and planting.

Species may need to be kept separate to avoid the possibility of cross-pollination or to avoid pollen contamination from (or of) existing vegetation (different species).

Using cuttings

In some situations it may be more desirable to use cuttings or grafts. For example, in declining remnants or where plant communities are highly degraded, the parent plants may have greater genetic diversity combined than the seed they produce individually. In other species, vegetative propagation may be necessary because of naturally low seed viability, seed dormancy mechanisms or problems with germination. With vegetative propagation you can directly control the number of plants contributed to the seed production area by each parent plant.

Cuttings can be taken from young plants or coppice regrowth, but grafting may be required if you need to get material from older plants.

How many plants?

There is a minimum number of plants of a species or provenance required to ensure a reasonable genetic base in seed produced from a seed production area. The absolute number or any given species or provenance is unknown because genetic variation in natural populations is largely unknown. However, we can make estimates based on some well respected guidelines for sampling natural populations (see FloraBank Guideline 5, *Seed collection from woody plants for local revegetation*, which provides important information on seed collection from natural and planted populations that are used to establish seed production areas).

We recommend at least 10 plants be established in the seed production area to represent each parent (the individual plant from which seed was collected). We also recommend there should be at least 10 original parent plants. Several authors recommend collection from at least 50 parent plants for conservation objectives.

It means a minimum of 100 plants should be established for each species to maintain genetic quality in seed produced. This number will allow for some deaths or damage. If you begin with fewer plants, the risk of losing diversity over time compared with the original population is increased.

This in turn affects the area required for seed production. With a small plant, this could mean an area of 10 metres by 10 metres if the plants will grow and produce seed at a 1 metre by 1 metre spacing. For larger forest trees you probably need at least a 10 metres by 10 metres spacing between trees for the final population, requiring, therefore, a minimum area of 1 hectare.

Another way to estimate the number of plants required is to work out how much seed you would like to collect and the amount sustainably produced by one plant, and then divide one into the other. For example, if the target is to have 10 kilograms of red gum seed for revegetation work each year and you estimate a six-year-old red gum tree will produce 100 grams of seed each year then you will require 100 trees in the seed production area at the time of harvest. We might add to this to allow for attrition and errors in the estimates. As the number goes up, it is important to maintain the relative proportion of the contribution of original parent trees in the seed production area. Of course, the more plants the greater the seed crop for collection.

Planting densities

Final plant density should allow for plant growth, easy collection, and not promote excessive competition between plants. Different species will require different planting and final densities. Large trees will require much greater spacing than smaller shrubs, but trees may be pollarded to reduce overall size.

If little is known about a species it may be necessary to plant at relatively close spacing and then carry out one or more thinnings to reduce the number of plants and increase the spacing. This strategy allows for greater selection of healthy final plants although it does require more resources for the thinning. As a guide, you should allow at least two-thirds to three-quarters of final plant height between planting rows, but densities within rows may be higher to allow for later selection.

Vehicle access may also dictate the spacing between rows or groups of rows, particularly if collection will be done from the roof of a vehicle or by using a hoist.

You should plan to end up with roughly even spacing between plants in all directions.

Seed production areas can be added to over time as new material becomes available or mortality reduces the original planting.

Planting layout

A good base map and layout plan is essential. An aerial photo is a good start and can provide a base plan to scale for designing a layout. You should have already collected information about the environmental conditions at the chosen site. Now, you should include any variations in drainage, vegetation or soil type, major site features, roads, fences and other features onto your base plan.

There are many possibilities for site layout but the critical elements are to:

- maximise the opportunities for cross-pollination between plants (see box);
- ensure the plants are thoroughly mixed to reduce the possibility of related plants being side by side (a random allocation of plants to planting spots will help, or talk to an expert about planting design);
- facilitate access for maintenance and harvesting; and
- use the land economically as it will generally be at a premium (that is, odd shapes or designs may 'waste' the land area and increase the amount of land that needs to be set aside).

In general, a unique area should be used for each species; however, it may be possible to mix (for example, understorey and overstorey) plants in the one area provided they will not exchange pollen and hybridise.

Problems may be caused by competition between the different plants and there are potential difficulties with maintenance and harvesting. You should seek further advice before establishing a mixed species seed production areas.

Good land management

Make sure you use good land management practices. Plant on the contour, include good drainage and runoff management and use silt traps to avoid sediment movement off-site. Wind breaks may be necessary and site boundaries may be delineated by another (non-interbreeding) species.

Fencing is highly recommended to protect the plants and seed resource, though it is not essential in all cases. Fencing should be used to remove grazing pressure from fauna, feral animals and stock, restrict public access, deter opportunistic seed collectors, remove recreational vehicle traffic and clearly define the seed production area boundaries.

In most cases, a perimeter firebreak should be used whether or not the seed production area is fenced. A perimeter firebreak can also assist in maintaining separation from adjacent bush.

Planting configuration and pollination

Your layout should aim to give every tree an equal chance of pollination by every other tree. Block plantings are much more effective than long lines for pollination in seed production areas because there are more opportunities for cross pollination from neighbouring plants in all directions. Plants in a line tend to be limited to pollination by their nearest neighbours on either side. Wind-pollinated species in a wind break will generally have their pollen blown away (assuming the windbreak is at right angles to the prevailing wind) and insect or bird pollinators will tend to work along the line rather than the wider range of options they have for movement in a block planting.

Establishment

Site preparation

As with any revegetation, whether you direct seed or plant seedlings, attention to site preparation and post planting follow-up management is essential. It is worth carrying out thorough and intensive site preparation for what will be a very valuable resource. Your actions might considerably improve seed production on the site.

Look for local guidelines for revegetation or rely on experienced local operators to ensure success. Site preparation may include:

- weed control (follow-up weed control is essential in many areas);
- deep ripping, mounding, and other soil preparation;
- fertilising before planting; and
- installing firebreaks while machinery is on site.

The design and layout of the planting should be clearly marked for the planters, particularly where this includes plots of individual families or provenances.

It may be necessary to include supplementary watering at establishment, but it would not normally be necessary to install an irrigation system.

Keeping a record

Prepare a layout plan showing the actual planted location of each species and provenances. Label each block or row using stakes, aluminium tags or other permanent

markers. These will last for varying amounts of time depending on the material used and local conditions. Field labels make it much easier to find particular blocks or to record information about the plants but they are often lost or damaged. Your detailed plan may be used to guide label replacement as part of the maintenance program or relabelling from scratch in an emergency.

Notate the plan according to the origins of the seed used and how that seed was collected. This is of particular importance in choosing replacement plants.

You should keep performance records by date covering:

- growth and health of plants;
- replacement of lost plants;
- flowering, seed set and seed maturation data; and
- seed yields.

It is also a good idea to set up photo points and keep a photographic record of the seed production area over time.

Maintenance

There may be no significant ongoing management practices in place. However, at a minimum, you will usually have fire control, weed and pest management obligations. We suggest you develop a fire, weed and pest management plan.

It will be necessary to periodically inspect the seed production area (if only at harvest times) to ensure:

- plants are healthy (dieback and other disease control);
- weeds are well managed (weed control);
- fire fuel loads are low and firebreaks around the site are maintained; and
- labels and signage are in good condition or replaced.

More intensive maintenance may include removal of additional plants to increase space for final crop plants or regular replacement of losses (see also harvesting by destructive sampling below). Plants may also be pruned to limit plant height and encourage large, open crowns to facilitate fruiting and seed production. It is possible to make collection a bit easier by management of plant size and shape. For large trees, it is always beneficial to get the seed produced as close to the ground as possible. This can be facilitated by pruning to encourage lateral rather than vertical growth and to encourage larger spreading crowns.

If the objective is to maximise seed production from as small an area as possible, management options could also include horticultural treatments to improve seed yield (for example, flower-inducing chemical and hormone application, fertiliser and supplementary watering). You should be very careful of the effect these treatments may have outside the seed production area and only consider them if the seed resource is extremely valuable or scarce.

Seed harvest

In general, seed should be harvested in the normal way for that species. You should decide whether you need to harvest regular (annual) seed crops or larger periodic seed crops. In the case of annual collection it is necessary to take great care that the harvesting does not damage the plants' ability to produce seed in the following year. In the case of many trees, the new seed crop will have been initiated before the current seed crop has ripened. This means that over-vigorous collection can eliminate the next crop or render it much smaller.

Another option to consider is the destructive sampling of sections of the seed production area to harvest the seed. If you have a five-year cycle to set seed, divide the seed production area into one-fifth size blocks and harvest every seed from one block in a year – if necessary by severe pruning, pollarding, killing or removing the parent plant. These areas are immediately replanted to keep the five-year cycle producing seed every year.

In all cases, the safety of the collectors needs to be addressed, especially where the use of machinery or working at a height is involved.

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Your Comment

The FloraBank guidelines are a consolidation of existing information and draw on the practices observed at seedbanks across Australia as well as the expertise and technical understanding of the Australian Tree Seed Centre at CSIRO Forestry and Forest Products, Greening Australia's Seedbanks and the Australian National Botanic Gardens Seedbank. The guidelines present, as far as is known by the authors, best practices. However, they are drafts because we recognise that other people may have better approaches, and that best practices change with time. Also, our climate and vegetation is diverse and not all practices are equally applicable across Australia. If you would like to comment on any of the guidelines please contact the FloraBank Coordinator. If you have practices or knowledge you would like to share with others you can do this through the forum pages of the FloraBank website.

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