FloraBank

GUIDELINES 9

USING NATIVE GRASS SEED IN REVEGETATION

Australian National Botanic Gardens

Natural Heritage Trust
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Collecting and growing native grass seeds can be a very satisfying activity. With some basic knowledge and a little equipment, native grasses can be successfully incorporated with tree and shrub species into revegetation work. This guideline is an introduction to using native grasses in such projects. It is intended primarily for people who carry out revegetation, regeneration or the rehabilitation of degraded sites in their local area. It should help you understand what is possible to achieve with native grass seed and how to go about it – whether you do the work yourself or use contractors.

Although you can revegetate with native grasses, there is a catch – some grasses are difficult to use and will require a lot more care and effort than is necessary for trees and shrubs. Availability and viability of species may limit your choices about what seed to use and how it can be used.

There are reasonably effective hand and mechanical methods for collecting native grass seed yourself, especially in small amounts, but only a few species of grass seed are available commercially. Most seed is sourced from local wild stands so seasonal factors, and the extent and productivity of grass stands, limit the amount of seed available for harvest. Native grass seed from wild stands often has low viability – even if you sow viable (healthy) seed, it may be difficult to get it to germinate rapidly and at the same time. Because the seedlings of many grasses grow slowly and compete poorly with weeds, reliable and cost-effective large-scale establishment methods are not available for most native grasses.

Using native grasses in revegetation is very much a learning experience at this time. Be patient in waiting for results, particularly when using seed in the field.

Above all, plan ahead and consider the ecology of the species you are using. Native grasses are for the most part still wild grasses, although some are more wild than others, which gives them their distinctive ecological value. Their broad genetic diversity means they are well adapted to (sometimes harsh) Australian weather conditions and soils.

This guideline offers the best advice known to the authors but, because we cannot cover all situations here, you should seek further information about using grasses in your region. Look for some expert contacts through Bushcare offices, your state herbarium or botanic garden, state government departments such as those in conservation, land management and agriculture, the FloraBank partners or the Australian Network for Plant Conservation. References cited throughout this guideline provide further reading. Other FloraBank guidelines and the *Model Code of Practice for Community-Based Collectors and Suppliers of Native Plant Seed* provide important information about collecting, storing and testing seed, and keeping records. A comprehensive *Australian Native Grass User's Guide* (Waters, Walley & Huxtable, 2000) will soon be published by NSW Agriculture.

Identifying grasses

Native grasses still exist in many places and are often present (and overlooked) at sites selected for revegetation. If they are present, good management rather than re-establishment is the key to their greater proliferation. Your ability to recognise the presence of native grasses can save you time and money.

Identifying native grasses can be difficult at first – there are 1,100 types of grass growing in Australia. However, with a little effort you should be able to recognise the main native grasses in your area. Look for botanical guides and publications that apply to your local area, such as those listed at the

end of this guide. Publications which focus on leaf, stem and root parts, or the plant's appearance (height and habit), can be quite effective. However, be aware that many weeds look similar to native species. You may need to inspect flowers and seeds (using a hand lens) for accurate identification and these are only present for a short time each season.

A field herbarium is a useful and portable aid. This is a collection of correctly identified, pressed and dried specimens, line drawings and photographs (sometimes laminated for protection) that have been bound together. A simpler and more popular approach is to photocopy plants (either in colour or black and white) by arranging them on the copier glass with a well-labelled backing sheet.

Avoid using common names, as they can be confusing. For example, the term 'wallaby grass' is applied to more than a dozen species in New South Wales. Plant scientists have recently revised the classification of grasses, resulting in a large number of changes to scientific names. The forthcoming *Flora of Australia Volume 43* (due for publication in late 2000), and an associated CD-ROM with an interactive key to grass species, should better identify and name grass plants. Meanwhile, the Australian Plant Name Index lists all current plant names and synonyms, as well as 'illegal' names (for more information see http://www.anbg.gov.au/anbg/plant.names.html).

Where's the seed?

Seed is produced in the flowers of native grasses. These flowers occur in groups called spikelets. A number of spikelets are collectively called a spike. The arrangement of the spikes and spikelets is sometimes also called the head. The head is one of the distinguishing characteristics of grass species (see Wheeler *et al.*, 1994 for a good description of these structures).

The seed isn't always easy to find in native grasses. Most native grass seeds are adapted for natural dispersal by wind, water and animals and have hairy structures, a callus or long awns attached. Often what people call 'seed' is actually the bit that falls from the plant (the dispersal unit) that may include these structures. Indeed, that is what we refer to as 'seed' in this guideline. The real seed may be well buried and difficult to separate from the other flower parts. When you clean away these bits and locate the tiny seed, what you are actually holding is correctly known as a caryopsis or grain – a seed fused with the fruit surrounding it.

The structures attached to the seed are often left intact for use in revegetation, even though this makes handling, cleaning and sowing the seed difficult when using conventional equipment. Seed used like this is called 'fluffy' or 'chaffy'. Cleaning native grass seed requires specialised techniques and equipment to remove these structures without damaging the caryopsis (sometimes impossible). Even some commercially available seed is not cleaned down to the caryopsis. Another reason for leaving these structures attached is that they may play a role in helping to locate the seed for germination in more suitable microenvironments. For example, the awns of *Stipa* species and *Themeda triandra* help the seed to bed into the soil, while the surface hairs on *Danthonia* species seed are thought to retain moisture around the seed and assist in germination.

Plan for collection

You must plan ahead to have the right resources and equipment to take advantage of what may be a narrow 'window' for seed collection. You should plan to collect seed that is mature, the best quality possible, and of appropriate origin for its intended use.

However, collecting native grass seed also involves taking advantage of any opportunities when they arise and you can't always plan for these. For example, in drought years few native grasses set seed and the species you seek may be unavailable, so in good seasons it is wise to harvest in excess of immediate requirements. This provides a reserve supply for years with low seed set or poor seed quality.

FloraBank promotes ecologically sustainable collection practices so that seed is not over-collected from any population and so that damage to the natural environment is minimised. The FloraBank *Model Code of Practice* (Mortlock, 1998a) provides guidance to community-based seed collectors about good collection practice. Other FloraBank guidelines provide detailed relevant information about seed collection including Guideline 4: *Keeping Records on Native Seed* and Guideline 6: *Native Seed Collection Methods.*

Remember to work safely. Vary the precautions you take to suit local conditions, species and collection methods.

Collect mature seed

Only a small proportion of native grass seed collected at harvest may be ripe and it is commonly mixed with under-ripe seed. Try not to collect this immature seed because it often fails to produce a healthy seedling.

Collecting mature seed is largely a matter of timing. In most species the amount of seed on the plant (the seed set) varies with seasonal weather conditions, as does seed head size and height. This limits the amount of seed available at harvest.

However, seed also ripens gradually and unevenly on each flower head and is usually not retained once ripe. Many native grasses throw new shoots and head in a continuous cycle throughout the season, depending upon the availability of moisture. Cooler temperatures or rain after seed set slow down ripening and result in larger seeds. Hotter temperatures may reduce the ripening period to only a couple of weeks and result in smaller seeds.

Collecting too early yields immature seed with reduced viability. Waiting a few days too many can see most seed lost to the ground. Time your collection for the day when seed is mostly mature and still attached to the plant. Because seed heads mature sequentially, you might collect at the site again in a few days. Such timing requires close monitoring of the grass stands to be harvested and a close watch on the weather at the end of the growing season.

Seed ripeness can be estimated before you commit to collection. In the field, start by running a seed head firmly (but not too hard) through your fingers. Some spikelets will dislodge, including those containing ripe seed (some may also be empty of seed). Take a sample of spikelets and check for the presence of fully formed caryopses by:

- feeling the grains with your fingertips; or
- squeezing the dispersal unit between two fingernails (suitable, for example, for *Danthonia* species and *Bothriochloa* species); or
- using your teeth (suitable for larger seeds such as *Microlaena* species and *Themeda* species – be careful of the spiky callus and don't inhale!).

Collect the best quality seed possible

Good quality implies that seed has been collected in a sustainable way from a known, well-documented location and contains the same levels of genetic diversity and viability as the plants from which it was collected. Generally, less is known about how we should approach collection strategies for native grasses compared to woody plants, however the principles outlined in Brown and Briggs (1991) are a useful starting point.

Even mature seed may have lower viability than expected because of seasonal factors. Some grass species produce many sterile flowers containing no seed. In some seasons there are higher proportions of empty or aborted seeds. The field inspection techniques outlined above help to flag viability problems prior to collection. Most grass seed is too small for a cut test (see FloraBank Guideline 8). However, in seeds that have a pale-coloured seed coat, simply soak a small sample of the seed in water for about an hour or until the seed coat becomes transparent. At this point, fully formed seed can be seen through the seed coat using a hand lens.

Seed must be dry when it is collected. Do not collect just after rain or in the early morning if the sward is wet with dew. Rub the seed heads and seed in your hands to see how dry they are.

Make sure that collected seed is as weed-free as possible because the weed seeds could be very difficult to identify or remove later from the seedlot. Take extra care to observe and identify weeds present at the time of collection. Some weeds are more important than others. Make sure that you do not contaminate your seed with noxious weed seeds – destroy seed that is contaminated. Where weeds of lesser importance contaminate seed, you should inform all seed users and allow them to decide the usefulness of the seedlot. Weeds can make seed unpleasant to handle (for example, thistles) and increase seed cleaning costs for an uncertain result.

Other potentially useful native species may be present in seed collected from natural stands (rather than seed production areas). Once recognised, this should not be a concern and could even add biodiversity value to revegetation work. It is one way of establishing minor species that are not present in sufficient density or over large enough areas to warrant harvesting in their own right.

Purity is an important measure of seed quality. Purity refers to the sometimes large amounts of trash (plant material such as stem and leaf) present in a seedlot. Trash can be light in comparison to seed, so a seedlot that is 90–95 per cent pure seed by weight may actually contain a lot of trash by volume. Impurity gives the seed material a poor appearance but does not necessarily detract from its usefulness in revegetation as most of it is inert and will not pose a problem if sown. However you should, wherever possible, try to reduce the amount of trash included in the material you collect as it can affect storage life of the seed.

The awns and other structures surrounding the caryopsis are often referred to as chaff. Chaffy structures give native grass seed a different appearance and feel to conventional seed materials. The tangling of appendages and bulk of the seed make it a difficult material to handle. However, you have almost no control over this aspect of seed quality at collection.

Appropriate seed origin

FloraBank recommends that when you collect seed (including native grass seed) for use in revegetation and rehabilitation plantings, it is collected as locally as possible from natural populations. Start looking from where you are sitting now! If you have difficulty in harvesting sufficient amounts of native seed from these local plants, you should look for the next closest (geographically) viable population of the species and keep moving outward. As you move further away, observe the plant and planting site characteristics and how they may change. It is usually the case that at some point you no longer feel comfortable that the characteristics of plants from which you are harvesting, or the area in which they are located, sufficiently match those of the planting location or its local vegetation. At this point it is wise to set a 'local provenance' boundary for that species or group. Note that this boundary may be different for different species that occur together. Also note that it is easier to declare smaller provenance areas initially and gradually extend or group them over time, than it is to make large provenance regions and attempt to split them as more is learnt.

In the absence of detailed information on gene flow and genetic diversity, this is a precautionary approach. See Guideline 5: *Seed Collection from Woody Plants for Local Revegetation* for more information on this practical method, which is based on what we know about plant provenances in Australia. There is considerable uncertainty about genetic differences between seed of the same species collected from different locations (or provenances) because very little work on this important topic has been done.

However, there are areas where land use or degradation processes have greatly altered the original growing conditions with the result that locally adapted plants may not be the best suited to the current growing conditions. A good example is an area that has recently been affected by salinity.

It may be difficult to collect sufficient seed from local plants. Native grass seedlots harvested from wild areas are often relatively small because, for example, these areas may be of limited extent and seed yields may be low.

Consequently, the pragmatic approach of combining (or bulking) smaller seedlots from a wide area may be necessary to provide sufficient quantity for revegetation work. Bulking of smaller lines on a 'regional' basis may at least preserve a 'regional' genetic identity. Unfortunately there aren't clear and agreed botanical regions. Each state has its own system for defining botanical regions, usually based on topographic and climatic features to which the species is assumed to be locally adapted, rather than an understanding of the genetic characteristics of that species. Above all, use common sense and keep records of the collection location and any bulking carried out. Accurately label seedlots so that the seed user can make informed decisions. Don't contaminate good quality seedlots by mixing them with poor quality seedlots, especially those that contain weed seeds.

Collection methods

Hand collection methods

Collecting by hand will only yield small quantities per picker but, with enough pickers, can produce quite a lot of seed. You can also control the quality of seed collected by monitoring for contamination with weed seeds and by rejecting seed heads that have been attacked by fungus (they have a black sooty coating), or those which show signs of insect damage.

The usual method for seed collection is to run a cupped hand along the seed head with an upward motion and depositing the seed into a belly bag. Cutting the seed heads off with scissors, shears or a scythe is a practical alternative. Plastic supermarket bags threaded on to a belt are a convenient way of collecting several species separately. Transfer seed to the appropriately labelled paper or cloth bag immediately after collection, allowing it to dry without further handling. Be careful, as some grasses easily cut the hands or provoke an allergic response. You could wear gloves made of material that does not allow seed to penetrate and become lodged in the fabric. However, fabric that does 'catch' seed in this way can also be used to advantage – dragging a length of suitable material (such as curtain netting) over a *Stipa* or *Themeda* grass sward will pick up a lot of ripe seed.

Mechanical harvesting methods

A wide range of mechanical harvesting methods has proven successful. Different machines and harvest techniques suit some species better than others. You can buy (or perhaps hire) quite effective custom-built native grass harvesters ready to use from machinery makers for less than $10,000. Modified whipper-snippers and garden vacuums, costing less than $1,000, can also be used. Three mechanical approaches are useful in small-scale revegetation activities: cutting and baling, brush harvesting and vacuum harvesting. Machinery recommendations aren't given in this guide because each harvester has advantages and disadvantages that vary between regions and situations. However, some of the species that may be harvested using these three approaches are identified below.

You should think about the target species, weed concerns, terrain, location and weather conditions at harvest when choosing the most appropriate machine. The best method will not necessarily be that which harvests the most seed, but rather that which is most cost-effective for producing a seed product that can be readily used or sold. Be aware that the efficiency of harvesting depends on many factors, including machine settings, plant density and seed maturity.

Using machinery well is a specialised skill. Practice and patience are needed. If you plan to start mechanically harvesting your own seed, look for some in-field advice. Alternatively, get a contractor to harvest the seed for you.

Machinery is continually evolving. There is still room for innovation and fine-tuning. For example, one type of harvester not covered below is the 'trough' harvester that attaches to the front of a vehicle. Other types include the 'reel' or 'beater' harvesters. These have been used to harvest a wide range of species (including *Heteropogon contortus*, *Dichanthium sericeum, Themeda triandra* and *Danthonia* species). However, while these are useful for harvesting the more upright species with robust flowers, the brush harvester is a more efficient machine.

Cutting and baling

Simply cutting and baling the ripe seed heads using conventional equipment (such as that used for hay) produces a straw which contains seed and which can be spread directly onto the revegetation site. This is a crude method – the straw has a low seed content that varies with season,

timing of harvest, drying technique and storage conditions – but it is suited to almost any species. It is especially suited to species that retain seed in the head (such as *Astrebla, Bothriochloa* and *Dichanthium*) rather than those that drop the seed as soon as it is ripe, such as *Themeda triandra* or *Danthonia* species. Cutting just under seed head height allows some control over the seed content of the hay – and with precision settings a product similar to that from brush harvesting is produced. At least one native grass seed supplier is currently processing these cut heads to recover a high value pure seed product. Storage and transport of such bulky material can be difficult. A whipper-snipper or brush-cutter is useful for cutting native grasses (removing seed head from the stem), especially if fitted with some form of catcher to avoid the need for vacuuming or for raking and gathering cut material.

It is possible to use a conventional header harvester (direct heading), to produce a fairly clean seed product. This method is most suited to species that retain seed in the head (for example, *Astrebla lappacea*, *Astrebla pecinata* and, to a lesser extent, *Themeda* species), especially if it is possible to windrow or desiccate (to even up seed ripening) prior to harvesting.

More efficient for most native grasses, however, are the brush harvesters now available. Brush harvesters are versatile and will harvest seed of most species in most seasons (suitable for *Astrebla, Bothriochloa*, *Chloris*, *Cymbopogon*, *Danthonia*, *Digitaria*, *Enneopogon*, *Enteropogon*, *Heteropogon, Monachather, Microlaena*, *Paspalidium*, *Poa, Stipa*, *Themeda, Thyridolepis, Aristida contorta, Dichanthium sericeum, Diplachne fusca, Erogrostis eriopoda, Eulalia aurea, Iseilema vaginiflorum, Oxychloris pectinata, Panicum decompositum*). They come in all different shapes and sizes and range from hand-held versions made from modified whipper-snippers, to large converted headers with harvesting fronts of 10 metres or more. This is a non-destructive harvesting technique that tends to brush ripe seed from seed heads, allowing for multiple harvests in a season. Seed harvested at peak maturity may be reasonably pure but, as the season progresses, more and more stem material is picked up with the seed. Experimenting with brush height, vehicle speed, cowling height and harvesting from opposite directions in successive runs or against the wind can increase seed yield.

The vacuum harvester has also proved more effective for some species (for example, *Danthonia*, *Paspalidium* and *Microlaena stipoides*). Vacuum harvesters may have some advantages over brush machines when harvesting with species that set seed close to the ground (*Microlaena stipoides* and some *Paspalidium* species). The petrol-driven garden blower or vacuum is the simplest version and it is especially useful for collection from small low plants or those with profuse and fine seed. The seed may be easily vacuumed either from the plant or from the ground immediately below. Be careful not to contaminate the seed collection through inadvertent collection of non-target (weed) species, soil and litter. Some blower models duct incoming material through a fan or shredder blade before depositing into the collection bag. For large-seeded species it is generally better to use machines that do not duct the seed through a fan and to remove any shredding blades to aviod damaging the seed. *Microlaena* is particularly susceptible to this type of damage. However, for some species, breaking up the chaffy inflorescences may produce a more desirable product. The Centralian Land Management Association has successfully used versatile four-wheel motor bikes with a vacuum mounted at the front and seed storage at the rear. The Scorpion harvester uses a combination of vacuum and mechanical beating or brushing to help dislodge seed from the head and has a species range similar to the conventional brush harvester.

Drying, cleaning and storage

Drying, cleaning and storing native grass seed is basically carried out in the same way as for woody native plants. For more information, see the FloraBank guidelines:

1: Native Seed Storage for Revegetation;

2: Basic Methods for Drying, Extraction and Cleaning of Native Plant Seed;

3: Improving on Basic Native Seed Storage; and

4: *Keeping Records About Native Seed.*

Some important additional considerations are covered below.

Drying

Ensure seed is thoroughly air dry before storing it for any length of time. Brushing or vacuuming seed from still-green plants at harvest results in seed moisture levels that are unacceptably high, often over 30 per cent.

Cleaning

Because the cleaning techniques that are currently available are primitive and limited, we recommend that you collect the cleanest possible weed-free seed at harvest rather than rely on cleaning at a later stage. Some species are clean enough for most uses when collected by hand (for example, some *Danthonia* and *Stipa* species) and may be sown as harvested. Drying and cleaning can be done in one process for some grasses, such as *Poa* species. As the seed heads dry, the ripe seeds fall out and can be separated with a sieve. Small-seeded grasses, such as *Poa*, can also be left to dry for a few days in a well-ventilated container where the ripe seed falls to the bottom of the container on shaking.

Trash such as seed heads, stalks, leaves and stems can be simply removed by hand or with a coarse sieve. An electric fan helps to winnow lighter material from the stream falling through the sieve.

Fortunately, chaff need not be removed because specialised planting machinery is available that will handle most chaffy seeds used in revegetation. Indeed, it is sometimes considered preferable to sow the seed with the chaff as mulch, increasing the sowing rate accordingly. Some seed structures assist establishment and help lodge seeds in the ground, which is useful in surface sowing. Further cleaning to trim or remove seed structures and recover the caryopsis is a specialised task requiring specialised equipment. Such processing improves the flow characteristics of seed through sowing machinery, improves purity, reduces bulk for storage and reduces the possibility of fungal contamination from the chaff present.

Storage

Seed of most native grass should be stored in a cool (20–25^{0}C), dry area in porous sacks (wool packs, fertiliser bags, canvas, calico or paper bags). In such conditions it should remain viable for up to five years. Seed kept at room temperature and room humidity in far northern Australia is likely to lose viability quickly – even over the dry season. Here, it is important to maintain low seed moisture and get the temperature down to 25^{0}C by air-conditioning the storage area (don't use an evaporative cooler). In the tropics, use refrigerated storage for periods longer than two years, making sure that you dry the seed and seal it in an air-tight container to keep moisture out. Be aware that to overcome dormancy and achieve high levels of germination in some grass species, storage for several months will be necessary. Lane (2000) has recommended that seed of northern Australian native grasses should, when sown, be older than 12 months in the case of perennials and three months in the case of annuals.

Dormancy and germination

Dormancy is a common survival strategy in grasses. It delays seed germination until conditions are favourable for growth, or spreads out germination to increase the chance of at least some plants establishing. Within any particular species there may be many different dormancy responses (see, for example, Groves, Hagon & Ramakrishman, 1982), especially if the species has a very extensive geographical range. Some species of grasses have dormancy responses which can vary depending upon the type of season, harvest method and harvest site within a region.

Seed of native grasses may sometimes have low germination levels, or germination that is spread over a long period. For example, the northern Australian native grasses *Ectrosia leporina*, *Eriachne schultziana* and *Dichanthium sericeum* (perennials) and *Pseudopogantherum contortum* (annual) maintain higher germination over longer periods than the commonly used introduced species Rhodes grass (*Chloris gayana*) (Lane 2000). Germination spread over a long period may improve survival chances in an unpredictable climate. Where rapid establishment and groundcover is required in the field, sowing rate should be adjusted so that a known number of germinable native grass seeds are sown per unit area. Any dormant seed germinating at a later date may be regarded as a bonus.

Usually, the most practical means of overcoming dormancy is by manipulating dry storage conditions. Experiment with temperature (for example, high temperatures, low temperatures, combinations of high and low temperatures) or the duration of storage, or both. Injuring the seed exterior or applying gibberellic acid can also be effective. Read and Bellairs (1999) found that smoke significantly increased germination for nine native grasses of New South Wales. Lane (2000) however, found that pre-treating seed of tropical native grasses with smoke offered no advantages.

Germination testing

Basic inexpensive visual inspection and germination tests can be conducted outside laboratories provided that you standardise the method and test conditions as described in FloraBank Guideline 8: *Basic Germination and Viability Tests for Native Plant Seed*. Doing these tests will help you to develop a better understanding of seed viability, dormancy and germination. However, there is a limit to what you can achieve without special equipment and expertise, particularly where seed fails to germinate.

Native grass seed should start germinating within a few days and rarely is it necessary to wait more than about a month for results. Test seed as close to the intended planting date as possible because seed of some species can fall in and out of dormancy. You may find fungi and bacteria contaminate the test seed. Contamination is usually associated with the seed coat and is usually in species that germinate slowly. Sterilising the seed with a weak chlorine solution (domestic bleach) or a fungicide prior to testing can help, but should be avoided if possible – adding chemicals may interfere with the germination response. Another approach is to have five replicates (perhaps more) of each species tested. It is also good practice to remove contaminated seed from the test container (petri dish) as soon as contamination is observed.

If you are unable to germinate certain native grass seed it does not necessarily mean that the seed is dead or useless. You should use quick methods such as visual inspection, a cut test or squeeze test (see Guideline 8) to confirm seed viability. Count the number of seeds that are firm and creamy-white in colour (these are considered viable). A seedlot with low viability and very poor or no germination may be discarded. If the viability appears reasonable but germination cannot be achieved, we recommend you send a sample to a laboratory for testing. Some species are tricky to germinate and you may not be aware of the best physical or chemical treatment to break dormancy.

Keeping records for minimum seed labelling

Seed quality considerations help a user determine whether a certain seedlot is useful for a particular purpose. Suppliers of native grass seed need to be able to communicate to a user the main quality parameters of a particular seedlot. In addition, sellers of seed have responsibilities under various State and Commonwealth legislation, in particular regarding false or misleading claims about products.

Internationally recognised seed quality parameters, tests and standards are not easily applied to uncleaned native grass seed. This is because of:

- the likely presence of other seed (potentially useful species);
- complex dormancy response and low germination levels of many grass species; and
- the high levels of trash and chaff it contains.

There have been calls for an industry standard to describe seed quality of native grasses (Waters & Monsen, 1999; Cole *et al.,* 1999) and provide a basis for determining the commercial value of seedlots as well as a clear and accurate description of the seedlot to protect both supplier and user (vendor and purchaser).

The approach is to require labelling that describes the important characteristics of a seedlot. Based on this approach, we recommend that suppliers of native grass seed routinely provide the following information to seed users:

- genus, species and seedlot number;
- collection location;
- collection date;
- name and contact details of the collector;
- seeds of other plants, including useful native species;
- important weed seeds;
- number of normal germinating seeds.

The first four criteria are easily established through simple record keeping at the time of collection – see FloraBank Guideline 4: *Keeping Records on Native Seed.* Forms to support this record keeping are included in Guideline 4 and available at the FloraBank web site. The collector should certify in writing that seed comes from the claimed location, allowing suppliers to pass on this information to seed users.

Seed users want to know that no important weed seeds are present in a seedlot, so good collection practice is important. Records made at the time of collection will assist greatly in determining the component of other seed (including weeds) that may be present. However, visual inspection to determine the presence of weed and other seeds may be a demanding task. Seeds of other plants, including useful native species, should be expressed by percentage weight where the component is equal to or greater than five per cent by weight. Important weed seeds should be expressed by percentage weight regardless of the amount present.

The last criterion requires that you establish the number of normal germinating seeds and, where germination rates are low, provide an estimate of seed viability in terms of the number of viable seeds of the main species per unit weight. Viability can be estimated as the number of fresh ungerminated seeds in the germination test, or by using one of the viability tests discussed above.

If you are uncertain about the presence of weed and other seed or about the germination and viability of a seedlot, we recommend that you use the services of a recognised seed laboratory for a reliable assessment. Seed laboratories require that samples of seed submitted for testing are obtained by random sampling of the seedlot and are of a sufficient quantity for the tests required.

Plan for planting

You need to plan ahead to establish native grasses, paying attention to the requirements for pre-planting, planting and post-planting stages. Be clear about what you want to achieve through revegetation and what your starting point is. Ask yourself what resources you have. Carefully inspect the planting site to see what is there already. The objectives of revegetation often include:

- biodiversity;
- habitat restoration;
- grazing production;
- seed production; or
- amenity.

Your planning needs to respond to your objectives and starting point. For example, if you want to reintroduce grasses at a site for their appearance or amenity value, then a lower establishment density may be tolerated (provided weeds don't take over) than if seed production or grazing were your objectives. If, as your starting point, grasses are already present, then perhaps adding to the range of species present would be suitable. In such a situation, site management rather than revegetation may be more appropriate.

The methods for revegetation of native grasses are similar to those for revegetation of trees and shrubs. For example, direct seeding, planting seedlings, hydromulching and brushing are all used, and similar factors are critical for establishment (such as soil type, soil seed banks, weed competition, weather conditions, predators and so on).

However, the difficulties of establishment should not be underestimated. Australian grasses have generally evolved under a low disturbance–high-stress environment. They are generally described as stress tolerators. They may tolerate moisture stress, adverse soil conditions and low fertility, but do not necessarily establish easily or compete strongly with other species. Difficulties also arise from the dormancy response, low

germination rates and extended germination spread, and low viability of grass seed. So, choose planting sites carefully and, given the high cost of seed (at least initially), it may be wise to direct seed grasses separately and concentrate grass seed over small areas to better ensure success. As your confidence grows, you can begin to tackle larger sites. Simply adding native grass seed to the seed mix and using your 'trees and shrubs' methods may have limited success. You must resolve any conflict in management requirements for trees, shrubs and grasses – especially those concerning weed control.

Make sure you know the germinability (established through testing) of the seed you are using. It is pointless wasting resources on dead or dormant seed.

Other considerations are that:

- several sowings of different species may be necessary over time to achieve your objective; and
- post-planting management (such as grazing, weed control, burning or slashing) is almost certainly required.

You should plant in phase with the seasons. Make sure that sufficient quantities of the right species of seed are available at the time of year you need them and that machinery and equipment are available and in good order.

Planting methods

The following is an introduction to establishment using both direct seeding and seedlings raised by 'cell' or 'plug' methods. We do not specifically address hydromulching or spreading seed as chaff, which are less popular methods. Note that successful operators within a few hours' drive of each other can and do have very different views of essential requirements for planting success. In a short guideline we cannot cover all situations and the information presented is general.

Planting seedlings involves greater effort but has some advantages over direct seeding on small, difficult sites that are steep, rocky, seasonally inundated or weed-infested, such as hills, rocky outcrops, wetlands, dam walls, and road embankments.

Raising seedlings in the nursery

Many native grasses grow well in the nursery using cell propagation trays such as Speedling® and Viro-cell®. These are a low-cost way of growing large numbers of seedlings in a small space. Less growing medium and water are required than for tubestock systems. There are advantages in being able to hold plants for long periods without damage to root systems and easy removal of plants from trays for planting, either at the nursery or in the field.

You will need a propagation igloo, hothouse or warm, sunny, protected growing area. Water the seedlings with an automatic micro-irrigation system – set up the misting sprinklers about one metre apart.

Growing media is a critical part of propagation with cell systems – commercial 'plug' mixes are available. If you need to prepare your own potting mix, it should be sterile. Do not include real soil or compost, as these harbour plant diseases. Try a mix of four parts peat moss, two parts vermiculite and one part washed river sand. Add one litre of slow-release fertiliser and one litre of dolomite (or lime) for each 100 litres of mix. Do not compress the media into the trays as this reduces air space needed for plant growth. Keep good air space under the trays, which should be on benches off the floor. Plant three to five seeds per cell and lightly cover the seeds with vermiculite. Don't over-seed or plants will suffer from competition. Don't bury the seeds, especially if they are small. Keep seeds warm and constantly moist using good quality water. Summer grasses (C4 plants) need higher temperatures of 25–35^{0}C to strike in the nursery. Winter grasses (C3 plants) often prefer 15–25^{0}C. Add slow-release fertiliser, such as Osmocote® or Nutricote®, and liquid-fertilise every five to six weeks. When even the smaller seedlings can be pulled from the trays easily they are ready to plant.

Pre-planting

As with any revegetation, whether you direct seed or plant seedlings, attention to site preparation and post-planting follow-up management is essential for successful establishment. Look for local guides on revegetation or rely on the advice of experienced local operators. Carry out an assessment of the planting site to determine which species are suitable, what planting density to choose (plants per square metre) and which planting techniques to use. Site preparation may include weed control, soil preparation and fertilisation before planting. Spraying weeds immediately prior to sowing may not be enough to control them. If you intend to direct seed an area, a weed control program in the pre-planting year, and again immediately prior to planting, may be necessary.

Planting with seedlings

If you are hand planting, create a 10 to 15 centimetre hole for the seedlings using a petrol-driven drill planter (such as Echo ED2000® or Tanaka®) with a long auger attached. The auger should be as wide as the seedlings and long enough to be comfortable for the operator. A pointed pole, pick or other hand implement can also be used. Plant seedlings deeply in the base of the planting hole with some slow-release fertiliser (add water crystals as well in drier conditions) so that the root ball is in contact with the soil and some of the seedling leaf is visible. On smaller sites it is easier to mulch, keep seedlings moist and protect them from predators.

Plant after rain, ideally in well saturated soil. Less site preparation may be needed for hand planting and this minimal ground disturbance often means minimal weed growth. Planting holes can be placed in bare areas, perhaps further decreasing the need for weed control.

If you are machine planting, use a tractor-mounted seedling planter, commonly used to plant vegetables and saltbush seedlings, preferably with a water injection system that can deliver 125 to 250 millilitres of water automatically around each plant. Machines such as the Potiputki planter may be purchased and are sometimes available for hire. Up to 1,000 plants per hour can be planted with a crew of four people. Remember that you are creating a landscape, so try to plant in flowing 'natural' lines rather than regimented square patterns.

Seedlings may be over-sown with native species by direct seeding after about two weeks.

Direct seeding

The best times for sowing will depend upon the species sown and the likelihood of germination and follow-up rainfall. In general, across Australia, sowing should be timed to allow the seedlings opportunity for significant growth and flowering before they enter their dormant phase. In south-east Australia, warm season plants (mainly C4 types) are generally sown in late spring or early summer when soil temperatures are high. Cool season plants (mainly C3 types) are generally sown in mid to late autumn or spring in the higher elevation tableland regions of south-eastern Australia. Avoiding the normal 'break of season' allows the possibility of achieving some control of annual weeds prior to sowing. In northern Australia, tropical native grasses are sown so that germination occurs with the first significant rains of the wet season – this can be only a narrow window of opportunity. In more arid areas, sowing occurs in those months with the highest probability of rainfall (Reu, 1995).

In temperate areas at least two days of moist seedbed conditions are necessary for significant germination to occur – more in marginal areas. A single good fall of rain is enough, provided that the following days are overcast or that moisture is retained by surface mulch. Native grasses tend not to develop a strong taproot. Their fibrous root systems cannot support the plants without follow-up rainfall. The plants need further rain to promote root system growth before you can consider them to be established. Such conditions generally prevail in higher rainfall areas. In more arid areas that lack post-sowing rainfall, the incidence of false germination can be reduced by using seed that is still in its dispersal unit rather than the bare caryopsis. The structures and appendages attached to many native seeds delay and stagger germination, protecting some seed from false 'breaks' in the season. Awns aid optimal seed placement, especially where their action is triggered by water.

Sowing rates must be developed on a case-by-case basis because of the large variation in the number of viable seeds per kilogram of seed or of seed/trash/chaff mixture. As a rule of thumb, calculate a sowing rate that delivers a minimum of 100 to 200 germinable seeds per square metre. The greater the level of expected weed competition and the less reliable the rainfall, the greater should be the sowing rate.

Broadcasting seed by hand is a good 'low-tech' approach suitable for small or inaccessible areas where seed is cheap or extremely chaffy. Broadcasting will be more successful with large seed or those with awns that bury seed into the soil, and in situations where surface mulch provides a favourable seedbed. *Themeda triandra* is particularly easy to establish in this way as long as subsequent weed control is effective. Broadcast seed can be lightly buried by raking or harrowing to improve contact between soil and seed.

Another low-cost but effective approach is to use a light mesh hopper bolted to the top of a small scarifier to broadcast seed of a range of species. The bouncing of the implement causes chaffy seed to fall through the mesh to be lightly covered by the tynes.

With current technology, most native grasses in their chaffy form cannot be metered out at a known rate and placed accurately at the required sowing depth. Two exceptions are *Astrebla* and *Paspalidium* species, which can be sown effectively using conventional seedbox metering systems. The 'Crocodile planter' is a robust drum seeder that can be towed behind a four-wheel drive vehicle or tractor and is suitable for flat areas where rainfall is limiting. The machine disturbs about half the soil surface as it passes. Seed is placed in a water-collecting pit created by the seeder.

More sophisticated direct drill air-seed planters have been used with limited success and machines such as the 'Germinator' are available commercially for about $14,000. Direct drill machines may have the advantage of reducing weed competition by minimising soil disturbance.

Sowing depth is the subject of many recommendations. It depends greatly on species and site conditions, and whether seed is sown as a naked caryopsis or with other structures attached. Seeds of most species may be sown shallowly (five to 10 millimetres), but larger-seeded species tolerate greater sowing depths (10 to 25 millimetres).

Ants are important harvesters of seed from the surface of the soil and are likely to be a problem in some areas, especially in the warmer months when they are most active. Surface-sown or lightly buried seed is most likely to be at risk. Burying seed to at least five millimetres, and avoiding uneven sowing depth (which may place some seed nearer, or on top of, the soil surface), are simple and effective measures for reducing the ant harvest, but not possible with species that are surface-sown.

There is no evidence to suggest that fertiliser increases establishment rates in normal situations. In pot trials, germination of some species was found to be reduced by fertiliser or biosolid mixed with the soil (Huxtable *et al.,* 1997; Huxtable, 1999).

Post-planting management

Perhaps more than any other ecosystem, management practices, or the lack of them, have a profound effect on the health and composition of native grasslands. If you have gone to the trouble of establishing grasses, you really should learn all you can about their management. The objectives of planting should carry through to management. Even tightly focused biodiversity, habitat and amenity plantings will need some management to ensure useful long-term outcomes. You will need to strike a balance between conservation and production.

Allow plants to set seed in the first year to start the development of a soil seedbank and permit further seedling recruitment and stand thickening if seasonal conditions allow. In the second year it is important to give plants time to develop significant crown or rhizome structures essential to their long-term persistence.

Sowing and establishment density is important in excluding weed competition, but you should anticipate and control expected weed problems. Weed control options are currently limited, highlighting the need for careful site selection and preparation. The options are slashing, grazing and perhaps in the future the use of appropriate herbicides (there are no selective herbicides registered for use in seedling native grass pastures at present). Slashing is probably the least risky option in a wide range of situations. It reduces native grass seed set and rarely kills weeds. However it does reduce competition for light and moisture and may produce useful mulch that retards further weed seed germination.

You must manage grazing pressure from stock and native and feral animals (although the latter are more difficult to control). Animals rarely graze areas evenly. If the revegetated area is used as pasture, be aware that management of any new pasture in the first two years is critical for effective establishment and long-term performance. Good management can compensate for early deficiencies in a new perennial pasture but the reverse is also true. Management in the first year largely determines plant density, seed production and weed suppression. In the second year it controls basal cover, weeds and botanical composition (Silcock & Scholz, 1996).

Seed production areas

Most of the native grass seed harvested in Australia at present comes from natural stands which exist more by accident, oversight or seasonal abundance than by planning. Seed production in natural stands varies greatly with the seasons, grazing pressure and management practices.

More land managers are interested in setting aside areas for seed production as the need for seed increases and its potential as a source of income is realised. However, there are relatively few native grass seed production areas at present.

Seed production is not always compatible with other objectives for planting grasses, such as amenity and biodiversity. This is because site design and management required for seed production may dominate the requirements for other objectives. The quality and quantity of seed that may be harvested from stands established and maintained for amenity or biodiversity may be lower than from dedicated seed production areas. For example, annual grass and broadleaf weeds may be tolerated where amenity objectives are paramount, but not so where seed production is required because they reduce perennial plant numbers and vigour, making it difficult to harvest seed economically.

The principles and practices outlined in FloraBank Guideline 7: *Seed Production Areas for Woody Native Plants* also apply in general to native grass seed. Seed yield and quality can be improved through even low input management such as slashing, crash grazing, burning and applying fertiliser or herbicide. Native grasses persist in soils of poor fertility, however moderate application of nitrogen fertiliser boosts both herbage and seed production. Boosting legume growth by fertilising with superphospate may benefit the native grass by adding nitrogen to the soil (fixed from the air by symbiotic fungi in legume roots), but care is needed to ensure that undue competition with the grass does not occur. Weeds may also respond to these increased soil nitrogen levels.

Weed control by short-duration intensive or 'crash' grazing (where possible) is probably better than slashing. Crash grazing prevents animals from grazing selectively as they do under lower stocking rates for longer periods. Removal of stock after crash grazing allows the perennial grasses to quickly recover and it synchronises seed set to produce a more harvestable crop. With some species, slashing or crash grazing after the first flush of seed production has finished may stimulate another seeding if the season is favourable. This technique has been used to good effect with *Danthonia*, *Bothriochloa, Chloris, Dichanthium sericeum* and *Microlaena stipoides*, but is not successful on other species such as *Stipa*, *Elymus scaber* or *Themeda triandra*.

Burning during winter and early spring has also been found to increase the purity and density of *Themeda triandra* and may have application with other tussocky species.

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Published by FloraBank with the assistance of Bushcare – a program of the Commonwealth Government's Natural Heritage Trust. The FloraBank partners are Greening Australia, CSIRO Forestry and Forest Products through the Australian Tree Seed Centre, and the Australian National Botanic Gardens. FloraBank is funded by the Bushcare program of the Natural Heritage Trust and operates under the Agreement between the Commonwealth of Australia and Greening Australia Limited in relation to financial assistance for FloraBank.

Acknowledgments
The authors would like to acknowledge and thank the following people for their contributions to the development of this guideline:

Warren Ganter, Warren Ganter Horticultural Services, Canberra

Charles Huxtable, Environmental Rehabilitation Unit, Department of Land and Water Conservation, New South Wales

Millie Nichols, Native Grassland Extension Officer, World Wildlife Fund for Nature, South Australia

Cathy Waters, Trangie Agricultural Research Centre, NSW Agriculture.

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 web site.

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