Australian Tree Seed Centre Operations Manual

Brian Gunn

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CSIRO Forestry and Forest Products
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Background

The Australian Tree Seed Centre (ATSC), part of the Forestry and Timber Bureau and CSIRO Forestry and Forest Products, has functioned for over 35 years as a national and international tree seed bank. It supplies seed of Australia's unique woody flora, which is of major social and commercial importance in the development of many countries, to researchers in Australia and more than 100 other countries.

The ATSC is a national focus for the collection of seed from Australian trees and shrubs and sets standards in methods of collection and documentation. It is also a recognised source of information on the practical use of the Australian tree flora. ATSC provides technical advice on species selection, tree improvement, silviculture, utilisation, and conducts research on seed germination and handling, taxonomy, tree improvement and genetic variation in Australian trees. It also offers training courses in tree seed technology and tree improvement, sponsors workshops and has provided consultant services to over 30 countries.

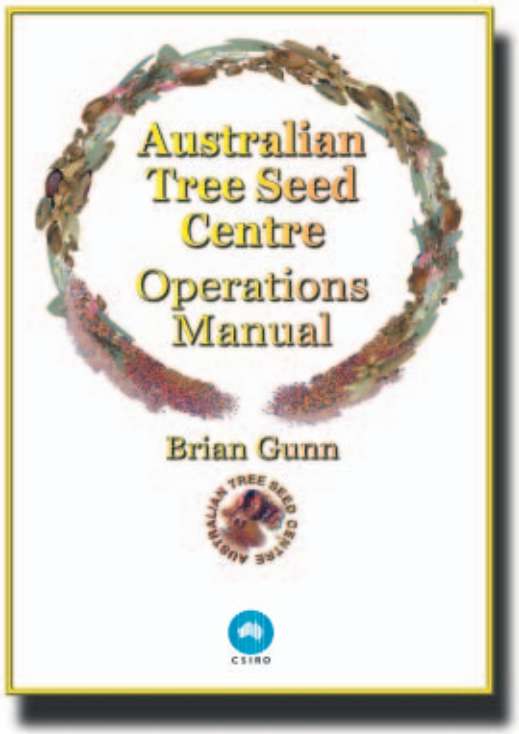
This manual has been developed from the need to document the procedures undertaken by the ATSC in seed handling from planning seed collections through to seed dispatch. It is specifically targetted at standardising procedures for staff working at the Centre as well as providing information to others involved in handling tree seed with a focus on research collections of Australian species. The procedures reflect the importance of genetic and physiological quality of seed which have a major bearing on the success or failure of establishment of any crop whether it be at the research stage or commercial application.

Seed collectors must apply sound practical genetic principles in their choice of seed trees if the full potential of the crop is to be realised. Following seed harvest, procedures must be in place to optimise the physical quality of the seed through retention of viability. Development of seed testing procedures which optimise germination, are accurate, reproducible and standardised is also an extremely important role at the Centre.

Most collections are made from natural populations covering the full geographical range for each species. This entails extensive travel throughout Australia and extends to undertaking collaborative collections with forestry organisations in neighbouring countries (Indonesia, Papua New Guinea, Philippines). Since collecting parties are required to access state and privately owned land, it is essential that seed collectors adhere to practices that are genetically sound, practical, achieve the required goals and are acceptable to those authorising access to the collection site.

Acknowledgments

The manual, a brain child of one of the ATSC summit meetings, has been developed over many years. During its early development Peter Burgess compiled information from members of the ATSC including Tim Vercoe, Jock Morse, Debbie Solomon, Craig Gardiner and Kron Aken. Gary Orr from CSIRO Plant Industry provided the information contained in Section 5 dealing with Quarantine Procedures. Maurice McDonald compiled the flowering and seeding information contained in the following Appendices: 1.3.4 and 1.3.5. John Doran and Maurice McDonald provided substantial support through their efforts in reviewing the manuscript. Warren Thornton prepared the seed storage table contained in Appendix 4.1 from the ATSC seed database. Chris Harwood provided comment on an early draft while John Turnbull provided valuable comment to the final draft.



Section 1

Seed Collection

This section summarises seed collection methods carried out by the ATSC with emphasis on provenance and individual tree collections for research. Whilst the main emphasis is on the collection of seed, field work also involves the collection of herbarium specimens for botanical studies, leaf samples for analysis of essential oil components, wood samples, scions and pollen for breeding programs and root symbionts. The collection program is reviewed on an annual basis and is strongly influenced by seed demand, project objectives and a commitment to maintain an extensive range of species represented by a broad genetic base. Sampling aims at either the specific tree level, populations or covering the full range of variability within a species. In order to meet objectives, collections are made from throughout Australia as well as into neighbouring countries (Papua New Guinea, Indonesia, Philippines) requiring extensive travel and access to government and private land. The ATSC is conscious of sensitivities related to entering stakeholders' lands. For this reason, strict adherence to permit conditions must be followed and field collectors are required to follow the ATSC Code of Practice for seed collecting (Appendix 1.3.1).

1.1 Planning

1.1.1 Forward planning

Once the broad objectives of the collection program have been defined, it is essential that ample time be allowed to plan an efficient and practical collection strategy. For scientific collections, the extent of funding for a particular program and the availability of experienced personnel will be the primary considerations and will dictate what can be achieved in the time allowed. The following steps should be considered during forward planning.

- Obtain a clear objective of the collection i.e provenance trials, family trials, seed orchards, plantation establishment.
- Select target species in order of priority. It is important to include a suite of species to offset crop failure of the main species.
- Identify populations to be collected. This will depend on the purpose of the collection and seed currently in stock or available from other authorised and reliable suppliers.
- Funding—prepare a budget for the collection and ensure appropriate funds are available.
- Define the requirements for individual tree collections and bulks. Decide on the number of trees to be sampled from each site and quantity of seed required to meet objectives.
- Obtain information on the location, identification and ecology of the species using previous ATSC collection records, herbarium data, literature and databases. Internet site for herbarium information can be obtained from the Erin website at: http://www.erin.gov.au/search/mapper.html
- Collate species monographs, keys and other information that will aid identification of the required species in the field.
- Time the seed collections to coincide with seed maturity.
- Apply for and obtain the necessary authorities to access land and undertake collections including relevant permits, licences, use of firearm, appropriate permission where rare and endangered species are involved.

1.1.2 Planning collections overseas

The ATSC focuses on sampling woody species of Australian origin. A number of these species for example, *Acacia mangium, A. crassicarpa, A. auriculiformis, Eucalyptus pellita, E. brassiana, Melaleuca leucadendra* have a natural distribution both in Australia and into neighbouring countries. There are also genera with important specific species not represented in Australia for example *E. deglupta* and *E. urophylla*. In order to meet the requirement to sample priority species across their natural distribution irrespective of political boundaries, it may be desirable to conduct collaborative collections in other countries, notably, Indonesia, Timor, Papua New Guinea and the Philippines.

Collections in other countries require careful and often lengthy planning over many years and an understanding of issues that may impact on obtaining permission. There may be specific issues not encountered when collecting in Australia. These include; sensitivities associated with the export of plant material, necessity for foreigners to conduct the collection as opposed to in country staff. Security restrictions on access to different parts of the country, diplomatic responsibilities associated with safety of foreigners, decision on who is the appropriate organisation to co-operate with, funding and how the germplasm will be shared are also important considerations.

As a first step, it is important to develop a positive working partnership with a potential collaborator in which there are clear benefits in undertaking the collections for all parties. The collaborator(s) may be required to act on your behalf in negotiating with senior government officials in order to obtain formal permission. It may be necessary to meet with the officers concerned to discuss the proposed collections and demonstrate the benefits of the collection to the host country. In certain instances third parties as for example companies and diplomatic support may be required. Collections may be facilitated where they are part of an official government to government project. Under no circumstances should collections be carried out without formal approval.

Once official approval has been given, it is then important to liaise with the counterpart(s) to plan the collection. When planning, it may be necessary to allow for down time for processing permits during the course of the collection. Central and provincial government approval may be required. Frequently the cost of the collection must be met by the ATSC given the often limited resources of the collaborator. Specific documents such as passports, visas and health requirements must be organised. The importation of specific equipment for example rifles may be prohibited unless prior approval is granted. Where the collection team is required to travel by air, there are restrictions on the weight, size and materials (e.g. inflammable liquids) that can be taken. Careful consideration must be given to selecting appropriate equipment taking into account what might be available locally.

Once in the field it is frequently necessary to negotiate with local land owners in order to access seed trees. The approach taken will be dictated by local conditions. It may be necessary to pay compensation and or employ members from the community during the collection. Employment of local committee members is often desirable from a strategic point of view as well as logistically. It may for example be necessary for locals to direct the collection team to where the species is growing, assist in accessing the seed through engagement of climbers and porters to transport the equipment and seed from the field. In some instances, it may be prudent to allow communities to undertake the collections and for the team to purchase seed as has been undertaken for *Acacia* collections in Papua New Guinea. Whilst this method is suitable for bulk provenance collections, it is not advised for individual tree collections where there is a high risk of contamination.

When travelling overseas special care must be taken with regard to personal safety. Before travelling it is important to ensure all relevant medical precautions have been taken with respect to the countries to be visited including medical advice from either your own doctor, the government medical officer or the Travelers Medical & Vaccination Centre (TMVC) (Ph. 62577156).

The following web sites provide important information when travelling overseas including procedures to follow and documentation to be completed by CSIRO staff.

http://www.tmvc.com.au/
http://www.csiro.au/doco/infocirc/ic9926.html
http://www.csiro.au/services/insuranc/traform.html
http://www.csiro.au/services/insuranc/instravall.html

1.1.3 Timing of collection

A key factor in planning is to time seed collecting to coincide with peak maturation of abundant fruit crops. Accordingly, the flowering and fruit pattern for the target species must be established.

Information is needed on the main flowering season and the time taken for fruits to mature. The interval between flowering and seeding varies considerably among species. In Boland *et al.* (1980) examples were provided for the interval between flowering and seeding for a number of eucalypts: e.g. about 6 months for *E. fastigata* (Fielding 1956), 8–10 months for *E. regnans* (Ashton 1975), 10–12 months for *E. delegatensis* (Grose 1957), 12 months for *E. pilularis* (Florence 1964), 10–16 months for *E. diversicolor* (White 1971). Red gums (section *Exsertaria*) take 5–6 months and up to 12 months in bloodwoods (*Corymbia* spp.) (McDonald pers. comm. 2000). For *E. brachyandra*, however, the time between flowering and seed maturation may be as short as one month, while viable seed of *E. gilbertensis* have been collected from an inflorescence still bearing buds and flowers. Maturation time following anthesis for *E. coolabah* (*E. microtheca* group within section *Adnataria*) may be as short as six weeks. For temperate zone bi-pinnate acacias the maturation period varies from four to five months (*Acacia decurrens*) to 12–14 months (*A. mearnsii*) (Thomson 1995). *Casuarina cunninghamiana* takes about 12 months from female anthesis to the production of viable seed (Boland *et al*. 1996). Harwood (1989) reports that under natural conditions, flowering of *Grevillea robusta* peaks in late spring (October–November) with seed shed occurring about two months after fertilisation. For *Melaleuca alternifolia* the time between flowering which occurs in October/ November in natural stands in NSW and seed maturity is 15 months (Doran pers. comm. 1999). Populations occurring along different altitudinal and longitudinal gradients may also vary in maturation times on a regional basis within species. For additional information on flowering times in eucalypts see: Boland *et al*. (1980), Brooker and Kleinig (1990), (1994), (1999), Chippendale and Wolf (1981).

The timing between fruit maturation and seed shed varies considerably from species to species. Variation within a species can also be considerable over the natural geographical range associated with factors including latitude, altitude and distance from the coast. Environmental factors, in particular temperature during the period leading up to maturity, also have a major influence. Pederick (1960) found that a mature seed crop will remain on *E. obliqua* trees for up to two years, and there are many eucalypts with the same characteristic for which timing of the collection is not critical. However, in the case of the paper-fruited bloodwoods, as for example, *Corymbia papuana* the thinned-walled fruits dry and begin to shed seed within a few days of maturation (Boland *et al.* 1980). *M. alternifolia* holds on to its seed for up to several seasons particularly those crops associated with heavy flowering. Species of *Banksia* and *Hakea* have serotinous woody fruit that may retain their seed for a number of years or shed following a fire (Ralph 1994). Arid zone acacias retain their seed for relatively short periods of time and seed crops may shed within a few days to a week under very hot windy conditions. By contrast, acacias from wetter environments may retain their seed for several weeks or even longer. In the case of *Acacia melanoxylon,* some of the seed crop may remain attached to the pod by the funicle for almost a year unless removed physically as in the case of birds. *G. robusta* fruit, which comprises a thin walled follicle containing two winged seed, has been observed to shed its seed over a two week period on an individual tree (Harwood 1989). Many species within *Allocasuarina* e.g. *Allocasuarina verticillata*, have serotinous fruits which retain the seed for several years (Turnbull and Martensz 1983). Other species such as *C. cunninghamiana*, shed their seeds annually and collection of mature fruits can be made in March–April immediately prior to seed dispersal.

In determining when to undertake a collection, strong emphasis is placed on historical records of collection times held by the ATSC and experience of the staff. Most species do not flower and fruit gregariously every year and may typically flower at intervals of two to three years and more. Boland *et al*. (1980) report that species such as *E. camaldulensis, E. grandis* and *E. saligna* usually bear heavy seed crops every two to three years. In *E. regnans* this period is every two to four years. *E. gomphocephala* and *Corymbia maculata* (syn. *E. maculata*) only seed heavily at longer intervals (Turnbull 1975b). Loneragon (1979) reported that *E. diversicolor* produces a good crop every four to seven years. Prolific flowering and heavy seed set in many dry-zone species are dependent on particular rainfall conditions. In *A. aneura* flowering is induced by summer rain followed by good winter rain (Davies 1976).

Collecting of new species or species from new locations may require monitoring over more than one season in order to determine the optimum time. For example, *Toona ciliata* (red cedar) is known to set seed between mid December and mid January in the Atherton region of northern Queensland (Latitude 17°S). It was therefore predicted that crops would mature a few weeks earlier in natural populations' further north in Cape York. However, through repeated visits to these populations, it was found that crops matured during October in the Claudie, Pascoe River region (Latitude 12°45′S) and were even earlier (September) further south in the area of Helenvale to Mossman (Latitude 16°S) (J. Larmour pers. comm. 1998). Clearly a range of seeding habits exists between species and generalisations are difficult to make with any certainty. Detailed observations on the phenology of flowering and fruiting are a desirable prerequisite in planning seed collections. Information on flowering and seeding times of Australian species have been published by a number of authors including; Boland *et al.* (1980), Doran *et al.* (1983), Willan (1985), Langkamp (1987), Searle (1989) Bonney (1994) Ralph (1994) and Doran and Turnbull (1997). Appendix 1.3.4 provides flowering and seed collection times for eucalypts whilst Appendix 1.3.5 provides information on seed collection times for acacias, casuarinas, grevilleas and melaleucas.

1.1.4 Location and determination of seed crop maturity

On arrival in the field, the seed collector needs to locate suitable populations of the target species and determine individual trees carrying mature seed. The ability to distinguish fruit bearing trees, especially from a distance, is dependent on the species and the skills of the collector. Fruit crops are most easily identified on a sunny day, when the sun is at a low angle (i.e. early to mid morning and late afternoon) and the light behind the observer. This is when differences in colour and shape can be best observed. Thomson (1995) makes the point that red wavelengths are more apparent in the late afternoon, making this the best time of day to locate fruiting trees of species with reddish brown or purplish fruits (e.g. *A. mangium*). For crowns close to the ground, the job of checking the identity, maturity and extent of the fruit crop is relatively straightforward. However, for tall forest trees containing small fruit (e.g. *Eucalyptus*) a pocket size pair of light weight binoculars with a moderate magnification of × 8 or × 10 with a 25 or 30 mm aperture, is essential for both locating and assessing crops on potential seed trees (Thomson 1995).

Once a potential seed tree has been identified the next step is to determine whether the seed crop is at the right stage of maturity and of sufficient quality and quantity to collect. The quantity of the crop can be assessed by looking at the crown and through experience deciding whether it is worthwhile collecting. When assessing the maturity of the seed, it is important to note that fully ripened seed retains viability longer than seed collected when immature (Stein *et al*. 1974). To determine the identity of the species and condition of the crop, it is best to closely examine a sample of fruit from the tree. Several different methods have been described to determine seed maturity involving both field and laboratory assessments (Barner 1975, Boland *et al*. 1980, Willan 1985 and Bonney 1994). Characteristics to observe include size and colour of seed or fruit, whether the embryo is firm and swollen or whether the seed coat collapses when cut. A number of methods commonly used by ATSC seed collectors when in the field are given below:

- Dry the fruit in a sunny location for a couple of days, for example on a vehicle dashboard, and observe the progress of fruit opening and seed shed.

- Mature seeds have a firm white endosperm (where present) and a fully developed firm embryo (Turnbull 1975a).

- For *Eucalyptus, Melaleuca* and other genera within Myrtaceae which produce capsules. The lines of dehiscence on the capsule become pronounced as the fruit matures, and once fully mature, the valves of the capsule usually open partially although the seed are not released. Non-viable immature seed are frequently pale in colour and the embryo is milky and rather soft when squashed. The seed can be inspected by cutting open the capsule with a pair of secateurs (see Plate 1A) revealing the seed which should have white firm embryos with dark seed coats, and brown chaff towards the top of the capsule (Boland *et al*. 1980).

- Acacia pods and seed are usually dark in colour while the seed has a hard seed coat. Seed that is still green or dark and soft when pressed may mature depending on the species, drying

conditions and the stage of development. Where it is uncertain whether the crop is sufficiently mature to collect, take a sample of pods and leave them to dry in a shady location for a few days. If the seed remains swollen and seed coat turns hard, then there is a strong likelihood that the seed is sufficiently mature to collect. Drying can also take place in the sun but this method is more severe.

- For grevilleas, timing is crucial and mishandling can easily damage the seed. Collecting can commence when there are signs of the follicles turning from green to brown with the occasional follicle opening. Timing may differ from tree to tree within and between population. If collected too early, the follicle will not open preventing seed shed.

- Scratching the surface of the seed follicles of *Banksia* cones provides a good indication of maturity. If they are brown and hard the cones are ready for collection whereas if they are soft and green the seeds are immature (Bonney 1994).

- *Toona ciliata* collection and handling strategies are similar to those for *G. robusta* with both shedding their seed shortly after maturity. It has normally been recommended that the fruit are ready for collection when they turn from green to a golden colour as seed sheds within a few days. However, experience has shown that green fruit can be collected with no serious detriment to the germination recorded after eight months of storage provided the fruit are dried under cool well-ventilated conditions (J. Larmour pers. comm. 1998). By being able to collect while the fruit is still green, there is a longer time period for collecting and this allows more flexibility to collect over a wider natural distribution. There are also indications that the cedar tip month (*Hypsipyla robusta*) which can cause serious damage to seed crops, is less active in the green fruit stage than at full maturity.

- For rain forest fruit, familiarisation with fruit colouring during development is an important factor in determining maturity. Softness, moisture content and seed shed are also important indicators.

- It can't be assumed that seed is present in fruit attached to the tree. Fruit may be retained on the tree after seed shed even to the extent of appearing unopened. A sample of fruit needs to be removed from the tree and cut open to check the presence of seed.

- Insect damage can reduce the number of viable seeds and may even give fruit a false appearance of maturity by causing a colour change. It is important to continuously monitor the level of insect attack in a seed crop, as this can vary considerably between trees and populations.

1.1.5 Collection permits

Collection parties are required to undertake seed collections throughout Australia. Access to collection sites on private land, Aboriginal Land, State Forest, National Park or under other Federal, State or Local government control requires the consent of the land holder or manager.

The procedure required to obtain permission varies between States and Territories and on the basis of land ownership. Permission and formal contact are often required from more than one source (e.g. regional and local). Collectors must also be aware of conditions that apply to rare and endangered species. For guidelines on requirements to collect Australian plants under the control of the Australian Nature Conservation Agency refer to Anon (1993). The following information is provided in order to assist in determining who to contact in relation to gaining collection permits.

- **Australian Capital Territory**

National Parks ACT—Permission to collect and use firearms may be obtained from:

The Manager
Resource Protection Unit
ACT Parks and Conservation Service
PO Box 104
Jamieson Centre, ACT, 2614.
Ph. 02 6246 2849,
Fax. 02 6247 0852.

For collections controlled by ACT Forests contact:

Forester
ACT Forests
Department of Urban Services
PO Box 3252
Weston, ACT, 2611.
Ph. 02 6207 2542,
Fax. 02 6207 2544.

• **New South Wales**

State Forests of New South Wales. When undertaking collections in State Forests, an Authority to Collect Seed must be obtained from the relevant district forest office under a section 301 permit.

District Forester
State Forests of NSW
Batemans Bay Forestry Office
Batemans Bay, NSW, 2546.
Ph. 02 4472 6211,
Fax. 02 4472 6557.

Alternatively:

Director of Research
Wood Technology and Forest Research Division
Forestry Commission of NSW
PO Box 100
Beecroft, NSW, 2119.
Ph. 02 9872 0111,
Fax. 02 9871 6941.

NSW National Parks and Wildlife Service. A Scientific Investigation Licence must be obtained before any collecting activities. Applications are for specific projects, nominated species and areas. Permits usually take about four weeks to obtain. Permission to use firearms requires further approval. A report detailing all activities is required on completion of the collection. Forms may be obtained from most National Parks Offices and are sent to:

The Director
National Parks and Wildlife Service
Licensing Section
PO Box 1967,
Hurstville, NSW, 2220.
Ph. 02 9585 6536,
Fax. 02 9585 6495.

• **Northern Territory**

The Conservation Commission of the Northern Territory (CCNT) has overall responsibility for the collecting of plants and animals. Initial inquiries should be addressed to the CCNT for an application for a Licence for Scientific Research and Investigation.

Note that research to be undertaken in Uluru National Park and Kakadu National Park will require licences from both the CCNT and Australian National Conservation Agency.

For research to be carried out mainly in the southern half of the Northern Territory (i.e. south of Elliott), contact:

Principal Wildlife Research Officer
Conservation Commission of the Northern Territory
PO Box 1046
Alice Springs, NT, 0871.
Ph. 08 8922 1759,
Fax. 08 8922 1739.

For research to be conducted mainly in the northern half of the Northern Territory contact:

Principal Wildlife Research Officer
Parks and Wildlife Commission of the Northern Territory
Permits and Licences
PO Box 496
Palmerston, NT, 0831.
Ph. 08 8999 4820,
Fax. 08 8999 4524.

• **Queensland**

Permits/ licences are required for collections on state forest, crown land, lease hold and national parks.

Where collections are to be made from state forests, timber reserves and forest entitlement areas, a permit from the Queensland Department of Environment (Queensland Forest Service) is required. Note that the conditions usually include the requirement to obtain a permit from the local forestry office to traverse state forest areas.

Applications should be made to:

Manager
Land Use and Information Branch
Queensland Forest Service
GPO Box 944
Brisbane Qld., 4001.
Ph. 07 3234 0145,
Fax. 07 3234 0326.

Department of Primary Industry (DPI). For commercial collections, a Sales Permit is issued at the regional level and linked to royalty payments.

National Parks Queensland- A Scientific Permit is required from each Regional Office. Special negotiations are needed for the use of firearms.

Inquires should be addressed to:

The Director
National Parks and Wildlife Services
PO Box 155
North Quay, Qld., 4002.
Ph. 07 3227 7805,
Fax. 07 3227 7676.

• **South Australia**

In the case of the National Parks and Wildlife Service (SA NPWS), applications should be directed to:

Department of Environment and Natural Resources,
Wildlife Management Section,
284 Portrush Road,
Kensington, SA, 5068.
PO Box 1047,
Adelaide, SA, 5001.
Ph. 08 8204 8888,
Fax. 08 8204 8889.

Collections in forest reserves will require a permit from the Woods and Forests Department, at the following address:

The Executive Director
Forestry South Australia
Department for Administrative and Information Services
GPO Box 1604
Adelaide, SA, 5001.
Ph. 08 8226 9900,
Fax. 08 8226 9933.

Forestry South Australia
Coordinator Northern Forests
Wirrabara Forest
PO Box 91,
Wirrabara SA, 5481.
Ph. 08 86668 4163,
Fax. 08 8668 4115.

• **Tasmania**

Forestry Tasmania is responsible for issuing permits for collecting seed from State forests. Inquiries should be directed to:

The Chief Commissioner
Forestry Tasmania
GPO Box 207B

Hobart, Tas., 7001.
Ph. 03 6233 8180,
Fax. 03 6233 8280.

For collections under Parks and Wildlife Service management contact:

The Secretary
Parks and Wildlife Service
GPO Box 44A
Hobart, Tas., 7001.
Ph. 03 6233 6191.
Email: interps@dpiwe.tas.gov.au
Internet site: www.parks.tas.gov.au/permit/index.html

- **Victoria**

Permission must be obtained from the Department of Conservation and Natural Resources to access public land. A separate permit is required to collect from National Parks Service.

Collections of protected plants and animals may be made only with a permit under the Wildlife Act 1975 (Anon 1993) issued by:

The Director
Flora and Fauna Division
Department of Conservation and Natural Resources
PO Box 137
Heidelberg, Vic., 3084.
Ph. 03 9450 8600,
Fax. 03 9450 8712.

Within areas administered by the National Parks and Public Land Division, a supplementary permit to collect plants or animals, must be obtained from:

The Director
National Parks and Public Land Division
Department of Conservation and Natural Resources
PO Box 41
East Melbourne, Vic., 3002.
Ph. 03 9412 4111,
Fax. 03 9412 4166.

- **Western Australia**

In Western Australia the controlling authority for the collecting of plants and animals in the areas is the Department of Conservation and Land Management. Applications should be directed to:

The Executive Director
Department of Conservation and Land Management
Flora Permits Officer
Locked Bag 104
Como, WA, 6152.
Ph. 08 9334 0500, or
08 9386 8811,
Fax. 08 9334 0278 or
08 9386 1578.

1.1.6 Field reconnaissance

If the species is little known, or known to present problems to the collector, a field reconnaissance of species variability, natural distribution, phenology and seeding time may be desirable as part of planning the collection program.

In the interests of time and economy, the biosystematic exploration of the species has frequently had to be combined with the collection of seed for provenance trials. A single combined exploration and seed collection expedition cannot be expected to furnish all the answers on variation.

While a reconnaissance may provide valuable information on species distribution and variation, information relating to seed collection (timing, quantities) can be misleading since there may be heavy crop losses leading up to seed maturity caused by environmental conditions or predation by birds or animals for example. If the reconnaissance is undertaken some time prior to seed set, then information on seed maturity may not be reliable particularly for species that set seed rapidly then shed immediately thereafter.

Phenological information can be gleaned from local observers who are reliable and know what to look for. In the case of tall eucalypts where it is not easy to observe the seed crop from the ground, it is important to use binoculars or preferably remove a seed bearing branch from the crown in order to be able to look closely at the crop. There have been instances where a casual observation has mis-identified fruit for buds. In other cases a local observer having on the basis of a quick observation of a few trees determined the presence or absence of seed. However, as is frequently the case, only a limited number of trees bear seed requiring extensive searching. It must also be borne in mind what constitutes sufficient seed to make a collection. This will differ considerably according to the objective. Commercial seed collectors require large quantities of seed in order to make the collection economically viable, whilst researchers will be satisfied with smaller crops (50–200 g per tree).

1.1.7 Training of staff

At the ATSC a minimum of two people make up a collection party. All staff must receive training in collection methods, aspects of safety, be in

possession of a first aid certificate and it is highly desirable that an appropriate course in handling off-road vehicles be undertaken. Anyone involved in the use of firearms must undertake a firearm safety course recognised by the Australian Federal Police or its equivalent and obtain a 'Business Firearm Licence' issued by the police. Before using climbing spurs, staff must undertake a recognised training course in tree climbing (e.g. Canberra Institute of Technology course in advanced tree climbing). When climbing trees, the climber should be assisted by another trained person based on the ground for safety reasons and to provide support.

1.2 Collection

1.2.1 The concept of provenance

Provenance relating to seed material, otherwise known as 'place of origin', is the geographical area and environment in which parent trees grow and within which their genetic constitution has been developed through natural selection. The idea of provenance implies that genetic patterns of variation are associated closely with the ecological conditions in which the species evolved (Turnbull and Griffin 1986) and that some morphological or other traits can be recognised to characterise them. No taxonomic structure is applied to provenance naming as for example "Lake Albacutya" *Eucalyptus camaldulensis* refers to the naturally occurring trees of *Eucalyptus camaldulensis* subsp. *camaldulensis* from the edge of Lake Albacutya in Victoria. For further information refer to Burley and Wood (1976), Boland *et al.* (1980), Doran *et al.* (1983), Willan (1985) and Eldridge *et al.* (1993).

The 'ideal' provenance based on Barner (1975) is:

- composed of a community of potentially interbreeding trees of similar genetic constitution (and of significantly different genetic constitution from other provenances)
- sufficiently large for the seed collection to provide sufficient seed to meet objectives
- defined by means of boundaries wherever possible

The ATSC defines the term provenance to refer to where the original trees were growing in natural forest. The general term 'seed source' and 'land race' refers to seed collected from planted trees (Eldridge *et al*. 1993).

The ease of delineating the boundaries of provenances depends on the natural distribution pattern of the species. If a species is restricted to a single site or the distribution is limited and discontinuous, the term 'provenance' may be synonymous with 'site' and can be readily defined. The problem of delineating provenances is much more difficult with species that occur over an extensive area—during initial sampling, provenance boundaries may have to be set in an arbitrary way in the absence of hard information on geographic variation.

1.2.2 Selection of provenances

The term provenance is used to serve as a marker to identify the local population and the population boundary is therefore the provenance boundary. Turnbull and Griffin (1986) make the point that it is rarely possible to delineate natural provenance boundaries on the basis of gene exchange. Some species are found over a wide range of environments and cover extensive areas (e.g. *E. camaldulensis, E. tereticornis, E. coolabah*). Variation within these widely distributed species may sometimes be as great as the variation from between closely related species. Other species have a more limited distribution which, however, may sometimes consist of isolated provenances adapted to specific environmental conditions. Others again, like *E. dunnii*, may occur naturally on very limited areas but still be genetically variable, and adaptable to a variety of conditions when planted (Jacobs 1981).

The area constituting a local population, provenance, or region of provenance, is determined arbitrarily on the basis of local ecological conditions and meeting the criteria of minimum number of sampled trees. In natural forests, especially where they cover extensive areas in underdeveloped regions, it is often difficult to find an appropriate name to indicate provenance. It is common practice to name the provenance after the river, nearest road, town, geographic feature, which may be some distance from the actual collection site. A single name is frequently insufficient to convey the exact location of a population of trees. There is no standard way of assigning provenance names and they frequently indicate a general area only. Lack of precision in applying locality names must be compensated for by the provision of latitude and longitude co-ordinates, an accurate altitude or a map showing the collection site in relation to local features. It is essential that the

location of the collection be sufficiently precise to enable others to return to the location.

The choice of provenances to represent species should involve a careful, detailed study of the climatic, edaphic, and other factors within the natural distribution. Green (1971) described a coarse grid system of sampling localities in a study designed to provide basic information on genetic variation in *E. obliqua*. A one degree (approx. 110 km) square grid was superimposed on a map of the known distribution of the species from which 22 locations were identified. Once in the field minor adjustments were made to the locations according to seed crop abundance, lack of human disturbance to the stand, and convenience of access.

For species with a very restricted and disjunct distribution, for example *E. scoparia* (Hall and Brooker 1974), it may be necessary to sample all sites even for use in a species trial. For *E. camaldulensis* which occurs mainly in narrow, almost continuous bands along river banks, provenance may refer to a section of a river, a whole river or whole catchment system (Turnbull and Griffin 1986).

For species in which comprehensive provenance trials have already been conducted, the published results are an important source of information when determining which provenances to focus on.

Because of the frequent limitations placed on resources, there is a trade-off between numbers of provenances collected and numbers of trees sampled per provenance. It is frequently a question of whether to collect from a few provenances with a large number of trees per provenance as against a large number of provenances with limited trees per provenance.

Sampling provenances within species can be split according to two distinct requirements:

(1) Sampling methods for species introduction trials.

(2) Wide-ranging sampling of many provenances to represent part or whole of the distribution for use in provenance trials.

For the first requirement, where there is little known about the species variation, several provenance collections should be made to include:

- Sampling from that part of the natural range where the species appears to be growing best.
- Part of the range that most closely matches the climate for which the seed is required.
- Marginal sites within the natural range.

For the second requirement (wide-ranging sampling for provenance trials) the number of sources sampled will depend on the extent of the natural distribution, the diversity of the species, ease of access, seed availability, time available, money, staff resources, and other resources available to mount a collecting expedition. A knowledge of the breeding system of the target species and its pollen and seed dispersal mechanisms will assist in determining the collection strategy.

1.2.3 Sampling trees within a provenance

The ATSC has developed a set of guidelines for sampling trees within a population which closely matches those prescribed by FAO (FAO 1969).

- For each provenance, collect from a minimum of about 10 trees. In the case of proven provenances showing high levels of genetic diversity, it may be desirable to collect from up to 100 or more trees as part of a base population for intensive breeding programs. Larger numbers of trees per locality, 50–100 or more, are sampled after provenance trials have shown which provenances are best and where there is a requirement to obtain large quantities of seed. These large samples become base populations for further selections (plus trees).
- Selections should aim to sample unrelated trees that cover the genetic variability of the population. To reduce the probability of sampling trees that are siblings, seed should be collected from trees which are at least seed-fall distance apart from each other; this means about twice the average height of the trees (Eldridge *et al*. 1993). One hundred metres is a useful rule of thumb for tall forest trees.
- Collect from trees of above average form. Avoid trees that show signs of disease and where timber characteristics are important, avoid trees exhibiting spiral grain. Normally no particular attention is given to selecting and collecting

plus-trees in natural stands as environmental and competition effects are unknown.

- Selected trees must be carrying a mature seed crop. It is desirable to collect approximately equal quantities of seed from each tree. However, in practice the aim is to collect sufficient seed not only to meet the immediate aims of the collection but also to maintain seed stocks to meet future requests (e.g. minimum of 100–300g/tree for eucalypts).

The number of trees required to be sampled in order to capture the genetic variation within a population is open to debate. It is therefore more important to meet certain minimum requirements as stated in the above guidelines. These guidelines are supported by the findings of McDonald *et al*. (1996) on genetic diversity of *E. camaldulensis* from Lake Albacutya. The study concluded that the number of rare alleles recovered is higher if seed is collected from a relatively large number of trees. However, seed from five widely-separated trees would be adequate to capture 90% of the alleles while seed from a single tree would capture 80% of the alleles detected. Glaubitz *et al*. (1999) when working on *E. sieberi*, found that the levels of genetic diversity that were representative of the local population were retained when only 12 or fewer trees were used as seed sources. In this study, 30 DNA markers (RFLPs and microsatellites) were used to compare the genetic diversity of sapling regeneration after logging *vs*. adjacent unharvested stands. Saplings in coupes regenerated by the seed tree method, where only 3–5 *E. sieberi* seed trees were left behind, had diversity levels that were only slightly lower than the unharvested controls. Although there should be caution over extrapolating these findings to other species, they do suggest that most of the local alleles will be retained in a seedlot collected from ten or more trees of a highly outcrossing species that is abundant in the sampled population.

1.2.4 Collection methods

Collection methods vary according to the size of the tree, species and conditions prevailing at the site of the collection. For example, using a rifle in remote areas of the forest may be acceptable but would not be permitted in or near urban settlements and in some National Parks. The following descriptions summarise the main collection methods adopted by the ATSC.

Rifle: A most effective method for removing branches from tall forest trees has been to use a .308 calibre, bolt action rifle, with a 6–8× scope to fire 150 grain soft point (SP) ammunition as described by Kleinig and Boland (1977) (see Plate 1B). Green and Williams (1969) referred to the use of a .222 calibre rifle for collecting seed from tall eucalypt trees. However, the ATSC has found a .308 calibre rifle to be more effective for use in removing seed bearing branches in the range of 10–20 cm compared with both the .222 and .243 calibre rifles.

An average four-week trip requires about 3000 rounds, allowing for 5–10 rounds per branch and up to 20 rounds per tree on average. The number of rounds used will depend on the species, time of the year, number and size of the branches to be removed, calibre of the firearm and accuracy of the firearm and user.

CSIRO firearm safety policy does not permit the use of reloaded ammunition. Military ammunition is also considered unsuitable because the projectiles come with hard points which tend to go through the branch with minimum impact rather than fragmenting which maximises the shearing of the wood. The practice of cutting off the projectile tip to increase effectiveness on impact is strongly discouraged for safety reasons. Military ammunition also has a much higher charge which has the potential to cause greater discomfort to the person shooting and at the same time increases the distance which the projectile can travel as opposed to a lower grain charge.

Rifles are most effective for use on branches up to 20 cm in diameter. Careful selection should be made to ensure there is an acceptable crop and that there is a good likelihood of the branch falling to the ground without being caught up in other branches within the crown or in the understorey. The position of the shooter should be chosen so that the rifle is pointed away from human habitation and at an angle of at least 45° to the horizontal. For greatest effect, shooting should be done at right angles to the branch placing shots in a straight line at right angles to the branch at the bottom and top of the branch followed by the centre. It may be necessary for the shooter to change positions a number of times to remove branches that are difficult to sever.

Ear, eye and head protection while shooting is essential. It is important when selecting earmuffs

that they are designed to protect the user when firing the rifle (meet OH&S requirements for decibel noise limits. e.g. heavy-duty earmuffs conforming to the following code EH12 32DB). Staff must be familiar with the CSIRO OH&S Policy Circular (94/16) on Firearm Use.

Bow and arrow: In situations where a rifle is not permitted and it is necessary to gain access to tall forest trees, a bow and arrow combination can be used to shoot a fishing line or fine cord over a branch up to 40 metres above ground. A suitable rope is then attached to the line and is in turn pulled over the branch. The rope can be used to assist in breaking off branches, attach a flexible saw, haul up a climbing ladder or, where the collector wants to gain access to the crown, use rope climbing techniques (single rope technique) (Stubsgaard 1997).

The ATSC uses a recurve break down long bow with a draw weight of 13.5–18 kg (30–40 lb.) and a wooden or aluminum riser. Modified fibre glass fishing arrows are attached to a 22.5 kg (50 lb.) breaking strain fishing line which is spooled on to an archery fishing reel mounted on the front of the bow. The arrow tips are weighted and covered with a rubber bung. Great care must be taken when shooting the arrow to ensure the line is not tangled or likely to catch on the bow, user or surrounding vegetation. A short length (2–4 m) of weaker breaking strain line (6.8 kg (15 lb.) breaking strain) should be connected between the arrow and main line. The weaker line is designed to break should the line be impeded immediately after firing, thereby allowing the arrow to continue rather than jerking back and endangering the operator. A face visor should also be used.

Catapult: A catapult is also effective in shooting a line over a branch. Conventional catapults are arguably less accurate than a bow but are more convenient to carry and simple to use. The ATSC uses a free standing catapult Big Shot which is considerably larger than the normal hand held version and is mounted on a 3 m pole (Plate 1D). The pole is held upright with one hand. The other hand stretches the rubber sling holding a weight (throwing bag, 450 g) attached to a cord downwards as with a hand held catapult. The operator lines up the target before letting go the sling. It is estimated that the weight can be propelled to a vertical height in excess of 25 m and is arguably more effective than a bow.

Throwing rope: A rope (4–6 mm diameter and 25 m long) with a weighted end can be thrown over branches up to 12 m above the ground. For small branches (<50 mm diameter) one or two people are often able to break off the branch by pulling on the rope. For larger branches a flexible saw may be used (Boland *et al.* 1980). This method is suited to branches positioned horizontally, as is often the case in open-grown populations of *E. camaldulensis,* but becomes difficult where branches are acutely ascending as for example *E. tereticornis*.

Climbing spurs: Various designs of spur have been developed which enable a climber to gain access to the tree crown by climbing up the bole. Care should be taken in selecting appropriate tree climbing spurs since many were originally designed for pole climbing and have not been properly adapted. The standard climbing spur comprises a shank, with upper and lower straps and pads for attaching to the leg and support the foot through a stirrup to which is fixed a gaff or spike. Nylon straps are therefore recommended since leather straps can decay losing strength without visible defects. The climber must wear a safety belt or harness (tree surgeon's harness) to which are attached two strops. The strop is passed round the bole or branch and secured to either side of the harness to provide safety in the event of the climber falling. As the climber ascends or descends, the strop is adjusted to ensure free movement but at the same time ensuring the strop is tight enough to minimise any injuries through slipping. A minimum of two belts are used to maintain a safety line round the tree whilst negotiating branches. Appendix 13.3 gives an example of equipment that might be required for climbing a tree bole using spurs. Spurs are best suited for trees with bark that is sufficiently deep and soft, but firm enough to enable the gaff to penetrate and grip securely. Keep the gaffs properly sharpened and tightened during use. Always have protectors over the gaffs when walking on the ground or during transport.

The main disadvantage of spurs is that they may damage the tree when the gaff penetrates the bark. For more detailed information on climbing spurs refer to Robbins (1983), Willan (1985), Stubsgaard (1997).

Other climbing aids: Rigid ladders, caving ladders or rope techniques can be used. In the case of caving ladders and rope techniques, an advance line has to first be secured over a desirable branch

in the tree crown as described under the description relating to the use of the bow and arrow. The advance line is used to pull up a caving ladder, or for a single rope technique a caving rope (11 mm diameter and over 80 m long) which must then be secured on the ground before ascending. When descending, the rope is placed over a secure branch and the climber descends using appropriate descender gear used by cavers. Robbins (1983) describes the technique.

Ladder sections can also be used for gaining access to tree crowns. The following description on their use is taken from Willan (1985). For heights from about 8 to 40 metres, vertical scaling ladders in several sections provide a safe and convenient means of climbing the bole of the live crown. They can be made of a variety of materials including wood, aluminum etc., but each section must be light enough to be easily pulled up by the climber. The length of each section varies between 1.8 and 3 m and its weight should not exceed 3–4 kg. The climber ascends with a safety strap around both the trunk and the ladder until the persons shoulders are level with the top of the ladder. The ladder is then secured to the trunk by a rope or chain. Subsequent sections are pulled up by rope and fitted into the section below.

Collections from the ground

Fruit accessible from the ground are stripped by hand into a bucket (see Plate 1E) or on to a sheet spread out on the ground. Mature fruit of arid zone acacias which readily release their pods are well suited to this technique as for example *A. ancistrocarpa, A. colei, A. cowleana, A. stipuligera*. Leather gloves are recommended for this activity. Where it is difficult to remove fruit as for example eucalypt fruit, secateurs can be used to remove branchlets or hand saws for larger diameter branches.

Pole implements with saws, shears or hooks may reach heights of up to 8 m. A heavy-duty roof rack mounted on a vehicle provides a raised working platform where vehicle access is available.

Collecting from felled trees

Collections of large quantities of seed can be achieved by synchronising it with normal commercial logging operations. Where phenotypic quality of parent trees is more important than quantity of seed, it is preferable to select, mark, fell and collect the fruit in advance of the main felling (Willan 1985). Alternatively, select logging operations, where only the better-formed and highest quality trees are felled (Boland *et al.* 1980). Research collections from clearfelling operations are discouraged unless the seed collector can control which trees are felled. In uncontrolled felling conditions there is the risk of inadvertently collecting seed from more than one tree crown when the objective is to ensure seed is collected by single parents.

Collecting off the ground

Collecting of fruit and seed from off the ground following natural shedding is not normally recommended for the following reasons (Thomson 1995).

- uncertainties regarding their source
- risks of contamination from morphologically similar seeds of nearby related species
- their possible low physiological quality, compared with those obtained direct from the crown due to collecting a higher proportion of immature, empty and unsound seed, insect damaged, and early onset of deterioration or germination
- greater risk of contamination of the fruit or seed surface with soil-borne pathogenic fungi
- impractical for the collection of fine seed

The method is best suited to bulk collections of large fruit or seed as in the case of a number of rainforest species. Fruit containing sound seed should be collected as soon as possible after shedding to minimise fungal, insect and animal attack and to reduce the incidence of mortality and germination.

In the case where seed or fruit is in the process of shedding at the time of collection, large tarpaulins can be strategically spread out on the ground to catch the fruit or seed from under the harvested tree. This method has been used for *G. robusta*. Alternatively, tarpaulins can be spread out under small trees and shrubs to catch the fruit or seed that are dislodged by shaking or beating the crown. Doran *et al*. (1983), Willan (1985) and Thomson (1995) provide descriptions on the subject.

Harvesting

Once the crop has been removed from the tree, the fruit needs to be harvested ready for transport,

temporary storage, drying, extraction and cleaning. Tree seed harvesting is essentially a manual task in which as much of the unnecessary material like branchlets and leaves are removed in order to reduce the bulk, ensure seed cleaning is not hampered by impurities and minimise the risk of large sticks puncturing the container. The degree to which the crop should be free of impurities needs to be a balance between ease of harvesting versus ease of cleaning as discussed under Section 3. In the case of eucalypts that have small capsules, it is very time consuming to remove capsules when they are located within the mass of leaves. In this case it is better to harvest the branchlets containing the fruit and leaves since it is fairly straightforward to separate seed from leaf at the time of cleaning. This is provided the leaves are not allowed to become brittle in which case they can break up into small segments making separation more difficult. By contrast, casuarina cones and melaleuca capsules should be separated from the leaves at the time of harvest since they break up during drying into segments of a similar size to the fruit making cleaning very difficult.

For dehiscent fruit (e.g. *Eucalyptus*) which release their seed upon drying, the fruit will dry quicker if attached to the twig. Ralph (1994) stated that with some species, such as *Dillwynia* and *Eutaxia*, the pods would not readily open unless they are attached to the stem or branches. Leaving the fruit attached has the added advantage of reducing the workload by not having to pluck off individual fruit. For most collections involving both individual tree or bulk collections, either collection sheets measuring approximately 1.8 × 1.8 m (made from calico or a cotton synthetic fibre mix) or calico bags (100 × 50 cm) are used. The fabric must allow free air movement to avoid the crop from turning mouldy particularly where the environment is moist. For this reason, plastic containers are not advised unless the seed crop is to be stored only for a short period or in the case of fleshy fruit where it is important that the seed does not lose moisture.

1.2.5 Bagging and transportation

After the harvest is complete, the fruit must be bagged and clearly labelled both inside and out. For labelling in the field, each collector has their own sequential numbering system starting with 1 and prefixed by their initials (e.g. Peter Smith—PS1, PS2, PS3, etc.). A separate number is issued to each tree collection. In the case of a bulk collection representing a provenance, then a single field number is used to identify the bulk collection and the name of the provenance should also be added on the label to reduce the risk of confusing with individual tree collections. The individual tree number then becomes a permanent identifier throughout the system with the number linked to the seed and documentation at all times (see Seed collection data sheet, Appendix 1.3.2).

Once bagged care must be taken to ensure that the fruit are not damaged or lost during transportation. At the time of bagging check there are no holes through which seed can escape. Sheets containing fruit must be kept upright and tied effectively in order to minimise the risk of seed loss. Where transporting entails more than a few days particularly under hot and poorly ventilated conditions (e.g. back of a closed in vehicle or trailer), the fruit must be checked regularly for fungal or insect activity and whenever possible spread out to air dry. The decision of whether to dry the fruit in full sun or in shade depends on the condition of the fruit. For dry fruit with low moisture content (e.g. arid zone acacia pods, mature capsules of eucalypts and melaleucas) drying in full sun is desirable. However, for immature or green fruit, moist fruit or sensitive seed (e.g. *Toona, G. robusta*), the material should be aerated in the shade to avoid excessive rapid drying which may have an adverse effect on the viability of the seed.

Fruit can either be extracted during the course of the field trip or brought back to the ATSC seed processing facilities. The decision depends on a number of factors including the species, whether dehiscent or indehiscent fruit, condition of the fruit, quantity of fruit, carrying capacity of the vehicle, climatic conditions for drying and time available to clean the seed in the field. Eucalypt, melaleuca and casuarina fruits open readily when dried, and provided the climatic conditions are conducive to drying, the seed can be extracted within a few days. Acacias vary in their requirements. For acacias where the seed readily sheds once the pods are dry (e.g. *A. ampliceps, A. victoriae, A. dictyophleba*), cleaning can be undertaken in the field. However, for the majority of acacias collected and particularly those from tropical humid conditions (e.g. *A. mangium*, *A. crassicarpa*, *A. auriculiformis*, *A. cincinnata*) the seed does not readily separate from the pod and requires extraction including the use of machinery before cleaning which is normally undertaken at the ATSC.

1.2.6 Recording field data

It is essential that all relevant information related to the seed collection site and trees sampled are recorded at the time of collection. Seed collection data sheets are used by the ATSC to record field information for each provenance collection. A blank and completed data sheet is shown in Appendices 1.3.2A and 1,3,2B. The information can either be entered electronically (Prodata) and/or on paper format with final versions completed electronically. When using electronic format it is essential that a backup copy be made. Relevant information must also be recorded in the 'field botanical book'. Information should be provided on the following making use of the descriptions provided in the seed collection data sheet key (Appendix 1.3.2C).

- **Species:** To be written out in full giving genus, species and subspecies.

- **Latitude and longitude:** Space on the data sheet only allows for a single set of figures for each co-ordinate making it necessary to record the mid point for the collection. Other co-ordinates such as the boundary limits of the collection can be recorded under 'comments'. Geographical Positioning Systems (GPS) have been used by the ATSC since 1992 enabling accurate and instant readings to be taken in preference to using maps.

- **Location:** When recording the provenance location it is essential to provide the precise location in sufficient detail for future collectors to return to the same site. The most appropriate information varies from site to site. Geographical features such as mountains, rivers and/or distances along roads or rivers or specific locations within forest areas are useful locators. When using distances along roads it is important to record the starting point in relation to a permanent feature such as post office, bridge crossing, road junction (e.g. 3.5–7.2 km from Murrurundi Post Office along the New England Highway towards Willoo, New South Wales). However, bear in mind that road locations can change. As a matter of course, collectors should take the speedo reading if there is any possibility of this information being used to determine the distance from a fixed point. Information on the location should be written providing information progressing from detailed to general. Recording the location of each tree is not normal practice. However, it may be done for specific projects where selected trees need to be sampled over several years (e.g. *E. polybractea* selected for oil traits). For provenance collections involving a large number of individual trees for which a number of pages are required, the page number should be recorded following the location description and placed in brackets (e.g. Page 1/4, 2/4 etc.).

- **State:** States of Australia or country where collection was made.

- **Altitude:** Single figure for altitude in metres representing the mean for the collection site. The range can be entered under 'comments'. Best taken from a topographic map, calibrated altimeter or recently manufactured GPS units with accurate elevation readings.

- **Seedlot number:** Entered from the ATSC seed register on returning to the laboratory. This is a unique number issued to each provenance collection.

- **Provenance names in ATSC seed database:** The allocation of the provenance name on the seed database is at the discretion of the seed collector based on a maximum of 24 characters. The description is normally a sub-set of the Location details written on the Seed Collection Data Sheet together with the state or country of collection. This method of provenance naming does have the potential for repeated collections from a particular location to be given different provenance names. For example, collections of *E. camaldulensis* subsp. *obtusa* made in the vicinity of the Emu Creek crossing near Petford by different collectors may end up being called either 'Emu Creek' or 'Petford' provenance on the seed database.

  In an attempt to standardise provenance names on the seed database there are plans to use the Australian gazetteer place names. A program linked to the seed database would allocate the nearest gazetted place name to a seedlot based on the latitude and longitude of the collection site. However, specific well known provenance names such as Lake Albacutya and Petford would remain in the system.

- **Map:** Map name and scale corresponding to the collection area.

- **Climate:** Used for classification of climate, based on Koppen (1923).

- **Individual:** Number of individual tree collections for which the seed is family identified.

- **Bulk:** Number of trees represented in the bulk seed mix for the provenance collection. The bulk is normally mixed in the laboratory once the seed weights and viabilities are known for each tree seedlot.

Following information used in conjunction with field collection data sheet key (Appendix 1.3.2C)

- **Habitat:** Description of the environment in which the collection is made, e.g. river, ridge top, estuary.

- **Vegetation structure:** Comparison between 'projective foliage cover of tallest stratum' and 'life form and height of tallest stratum'. This ranges from 'tall closed forest' to 'low open shrubland', based on Specht (1970).

- **Species frequency:** Descriptions range from abundant to rare.

- **Aspect:** Compass direction in which the slope of the collection site is facing.

- **Slope:** Four options depending on the level of the slope.

- **Soil texture:** Based on soil bolus prepared in the field, ranging from sand to clay. Refer to Northcote (1979) and McDonald *et al*. (1998). Briefly, field texture is a measure of the behaviour of a small handful of soil when moistened, kneaded into a ball and then pressed out between thumb and forefinger. The resulting behaviour of the bolus is compared with the texture grades listed in the seed collection data sheet key (Appendix 1.3.2C).

- **pH:** Tested in the field using representative soil sample from a depth of 10–15 cm. It is more reliable if two or more tests are undertaken to cover the range of sites. Avoid testing near roads or other areas where soil is disturbed as these areas may have a non-representative pH.

- **Soil colour:** Visual estimation. Colour can indicate much about a soil's history and likely behaviour. Where detailed soil descriptions are required, it is important that colours are determined on the moist soil with a MUNSELL soil colour chart or its equivalent (Charman and Murphy 1991).

- **Geology:** Selection based on collectors' knowledge or reference to geological maps for the area. Often difficult to determine accurately. Draw on local knowledge (rangers, ecologists etc.).

- **Seed crop:** Size of crop ranging from heavy to light, relative to typical crops for that species.

- **Crop timing:** Whether the majority of the seed crop is at early, peak or late stages of maturation through to dehiscence.

- **Predation:** Level of predation of the seed crop being light, moderate or heavy and predator-avian, insect or other.

- **Flower buds:** Relates to presence of buds ranging from heavy to light or absent and stages of anthesis.

- **Flowers:** Relates to presence or absence and an indication of abundance if present.

- **Flower timing:** Whether the flower crop is early, peak or late.

- **Root sucker:** Present or absent. A root sucker is described as a shoot arising from below the ground level either from the root or a rhizome (NAS 1980).

- **Coppice:** Present or absent. Defined as the ability to regenerate by shoots, root suckers or lignotuber (eucalypts), typically following loss of, or damage to, the foliage of the plant (NAS 1980).

- **Associations:** Facility for listing the most dominant/ co-dominant associated species together with related information on their frequency and mean height.

Tree description

- **Field Collection No:** Each field worker records their collections whether they be botanical or seed collections according to a sequential field number prefaced with the collector's initials as

described earlier under Section 1.2.5 Bagging and transportation (page 13). It is important that the collector's initials are unique to avoid any duplication with other collectors using the same system. A separate number is allocated to each tree for identification purposes. Apart from being recorded on the data sheet, the same number is used on the seed label, botanical label, or any other collection item which are linked to the tree. It is good practice to enter field numbers into a field botanical book.

- **Bot. Sp.:** Indicate whether a botanical specimen was taken.
- **Photo:** Whether a photo was taken and, if so, some method of recording the particular frame(s) e.g. roll and frame number.
- **Ht. M:** Height of tree in metres.
- **Age:** Recorded according to age classes.
- **Bole dbh cm:** Diameter of bole taken at breast height (1.3 m) on the upper side of the slope.
- **Crown density, branching and width:** This is a comparison between trees of the same species within a stand. Three options are given for each character.
- **Crown height %:** Crown height as a proportion of the tree height given as a percentage.
- **Seed wt. and germination/10g:** Recorded after the seed has been cleaned, weighed and tested for germination in the laboratory.

1.2.7 Collections from plantations

Seed collections from plantations should only be considered where appropriate information on the origin of the seed used to establish the plantation is available. The stand must contain an adequate genetic base in terms of the species, provenance and the number of unrelated parent trees. Collections would not normally be made from plantations that have been established from seedlots comprising fewer than 10 unrelated seed trees.

Where plantations have the desired attributes, seed collections can be made from selected trees with the desired characteristics. Phenotypic selection is more likely to result in genetic gain in plantations compared with natural stands, because the trees in a plantation are of uniform age and exposed to a more uniform environment (Eldridge *et al*. 1993).

The field collection data sheet is still used to record the collection details except that a clear reference under 'Location' requires to be made that the collection is from a planted stand and name the original source (provenance).

1.2.8 Collections from seed orchards

Well-designed and managed seed orchards are a means of obtaining large quantities of genetically improved seed. It is important to know the history of the seed orchard, including the following:

- origin of the material used to establish the orchard (provenance and family origin, numbers of families, and whether it is a first-generation orchard using material collected from natural stands, or whether it is an advanced generation orchard based on material collected from plantations or a breeding program)
- field layout (if family identity has been retained)
- history of the orchard—extent of thinning, material after thinning relative to that initially used to establish the orchard. Do not collect seed from orchards until at least 30% of individual trees (or clones, in the case of a clonal orchard), flower and set seed to produce the crop that is being collected. Avoid collecting from trees that have flowered out of phase with the others in the orchard (early or late flowering), as this seed may be highly inbred.
- It will generally be appropriate to maintain separate individual seedlots of the best trees in the orchard with individual tree identity retained.
- When recording the seed orchard details, provide information on reference documents describing the seed orchard, its physical location, whether it is a seedling seed orchard (SSO) or clonal seed orchard (CSO), and the original genetic material (natural provenance source). Where possible provide a reference document describing the history of the seed orchard.

Seed orchard seed is generally more valuable than seed from natural provenances, so greater care is needed during harvesting, to avoid disrupting later crops.

1.2.9 Botanical voucher specimens

Botanical specimens are taken to vouch for the botanical identity of the seed collections or as herbarium specimens. The decision to collect specimens is left to the collector's discretion. Apart from herbarium specimens for use in taxonomic studies, a voucher specimen is also collected when there is any doubt as to the identity of the trees from which the seed was collected.

In addition, collections are made as part of botanical studies (e.g. *A. holosericea* complex. Maslin and Thomson 1992). Specimens must be labelled with the collector's field number. The following is a guide to the minimum number of specimens that should be collected and where they should be lodged. A single representative specimen of the species from each location (provenance) is normally sufficient for each herbarium unless there is considerable variation between trees.

- Well documented species—one specimen placed in the ATSC herbarium as a voucher.
- Species of botanical interest to the ATSC—one retained in the ATSC herbarium, with a second offered to the CSIRO, Australian National Herbarium.
- Species of wide botanical interest or new recordings- voucher specimens are retained in the ATSC herbarium, one for the State or Territory herbarium in which it was collected and one provided to the herbarium currently studying the plant group.

It is the responsibility of collectors to document, distribute and look after specimens. Each collector has a limited allocation of space to store specimens in the ATSC herbarium. To avoid specimens being mishandled, each collector must restrict their specimens to the space allocated.

1.2.10 Collection of root symbionts

Symbioses between higher plants and bacteria or fungi are known to be important, and perhaps essential in some cases, for good plant growth (Date 1995). Species within Casuarinaceae, Mimosaceae and Caesalpiniaceae form associations with nitrogen-fixing soil micro-symbionts, often forming root nodules. In the case of *Acacia* for example, there are symbiotic associations with *Rhizobium* bacteria (Doran and Turnbull 1997). In Casuarinaceae they are associated with a nitrogen fixing actinomycete, *Frankia* (Reddell *et al*. 1996). Most genera of trees and shrubs also form symbiotic relationships with soil fungi, which assist in the uptake of soil water and nutrients. These are termed mycorrhizas; for more detailed information refer to Schmidt (2000).

Symbiont collections by the ATSC are usually made during seed collection as part of a collaborative research study (e.g. P. Reddell on Casuarinaceae *Frankia*, P. Dart and Reddell on *Rhizobium* associated with specific species of *Acacia,* N. Malajczuk on mycorrhizas associated with *Eucalyptus*). However, seed collections are often made during the drier summer months, before the rainy season, whereas nodule development is at its best when there is adequate soil moisture.

Steps to be taken when collecting nodules:

(1) Nodule samples from different plants should normally be kept separate.

(2) Try to collect at least 10 nodules per plant.

(3) Sample only fresh, firm nodules, avoiding those that are damaged or decayed.

(4) With *Rhizobium* nodules from acacias, it is often easier to sample young plants with new root growth (pink colour).

(5) Once collected, the soil should be removed from the nodules before they are placed in a vial containing desiccant under a layer of cotton wool. The desiccant (silica gel) should occupy one-quarter to one-third of the volume of the container and must not touch the nodules.

(6) *Rhizobium* and mycorrhizal fungi are also contained in the soil. Soil samples can therefore be taken from the immediate vicinity of the plant roots and stored in calico bags in cool conditions.

(7) Label the sample with the collector's field number.

(8) Store in a cool place (refrigerate) and dispatch to collaborating laboratory as soon as possible ($<$14 days) to minimise loss of viability.

(9) Tools used for symbiont collection should be thoroughly sterilised with absolute alcohol between collection locations to avoid contamination.

Laboratories that have collaborated include CSIRO, Divison of Soils, Townsville for *Frankia* and University of Queensland for *Rhizobium* bacteria. ATSC does not maintain a reference collection or supply of root symbionts. Liaise with collaborating laboratories in advance of any collecting.

1.2.11 Collection of pollen

For information on the collection and handling of eucalypt flower buds and pollen refer to Turner *et al.* (1994) and Moncur (1995). Similar techniques have been applied with success in other Myrtaceae such as melaleucas (M. Moncur pers. comm.). Boland *et al*. (1996) reviewed information on the floral biology of casuarina including the collection and handling of pollen.

1.2.12 Preparation of reports

Following the completion of any field trip, it is essential that a report be written covering the aims and results of the collection, itinerary and seed collections including provenance data sheets. The report should provide information such as the biology, ecology, and distribution useful for the reader to gain an understanding of the collection and for use in interpreting the results of provenance/ progeny trials. In an attempt to maintain consistency ATSC collection reports should follow the following format.

- **Title page:** Include the title, authors and whom they represent (e.g. CSIRO Forestry and Forest Products, Australian Tree Seed Centre), Internal Report, year compiled and, if lodged under the ATSC report series include the sequence number.

- **Table of contents:** If appropriate for the size of report.

- **Summary:** Briefly discuss what was achieved, when and where.

- **Introduction:** Background information covering historical information related to previous collections, objectives of trip, sponsors involved, permits required etc.

- **Aims of collection:** This should include the method of sampling, itinerary, personnel, collection techniques and map(s) to show areas covered and identify collection locations using seedlot numbers.

- **Results:** Highlight information on species, provenances, locations ecology and climate covered as a supplement to the provenance sheets rather than duplicating what is already provided. Provenance sheets can either be presented here or in an appendix. Recommendations can be made for future sampling. Information pertaining to specific ecological and climatic parameters of a species will be of interest to readers. Photographs of species habit and habitat are particularly useful to help elucidate information.

- **Acknowledgments**

- **References:** The presentation of a report depends on the duration of the collection trip and the purpose of the trip. Guidelines for presentation and lodgment of reports:

- For trips that do not have any specific sponsor, a copy of the report must be placed on the ATSC file for the relevant state with other copies distributed according to requirement.

- For collaborative collections, bound reports must be sent to the clients with copies for the CSIRO FFP library and ATSC report series.

PLATE 1

(A) At maturity, the valves of eucalypt capsules should be fully formed and containing dark coloured seed. By cutting representative capsules in half using secateurs, the seed can then be inspected.

(B) .308 calibre rifle fitted with a 6–8× telescopic scope is used to shoot down branches.

(C) For tall forest trees, a bow and arrow combination is used to shoot a fishing line over a selected branch. A suitable rope is then attached to the line and is in turn pulled over the branch. The rope is used to assist in removing branches or for gaining access to the tree crown.

PLATE 1 (CONTINUED)

(D) A free standing catapult (Big Shot) can be used in place of a bow and arrow combination to shoot a line over a branch. It is effective for vertical distances in excess of 25 metres.

(E) A long handle pruning saw is used to reach branches from the ground. Where vehicle access is available, the operator can gain additional height by standing on the roof rack.

(F) For low shrubs, fruit is stripped by hand into containers.

PLATE 2

(A) When harvesting eucalypt seed, retain the capsules on the stalk but where practical remove leaf material. Ensure that a label indicating the collector's number is included.

(B) When in the field, harvested fruit should be laid out to aerate and dry whilst collections are in progress. Once dry, the seed can be extracted. Ensure that environmental conditions like wind and termites do not cause seed loss.

PLATE 2 (CONTINUED)

(C) Information on the collection site including the pH of the soil should be recorded on the Field Data Sheet. The soil used for the pH must be representative of the collection site and be taken approximately 150 mm or deeper below the soil surface.

(D) A GPS is used to record co-ordinates for collections.

Section 1

Appendices

1.3 Appendices to Section 1

Appendix 1.3.1 ATSC Code of Practice for seed collecting

Also refer to Anonymous (1993). Guide to requirements for collecting Australian plants and animals. Australian Nature Conservation Agency, Canberra.

(1) All collections are to be made in a manner sympathetic to maintaining conservation of the species and integrity of the population.

(2) When severing branches, no more than one quarter of the crown should be removed. This typically amounts to about four branches. Under no circumstance will the tops be removed from trees.

(3) Trees for collection should be a minimum distance apart of at least two tree heights.

(4) All branches will be removed from the road and must not obstruct traffic or road maintenance. Large branches should be cut into sections. Avoid shooting trees overhanging roads where there is the possibility of the branch hanging in the crown. State and Federal Government regulations relating to the use of firearms near roads must be observed.

(5) Necessary authorisations and permits for collecting will be obtained before collections.

(6) Field personnel of relevant authorities are to be contacted before the start of the trip to complete arrangements and discuss specific details such as contact name, collection localities, and condition of seed crop and access to collection sites.

(7) Private land holders are to be contacted before commencement of any collections on freehold land.

(8) Every effort is to be made to call in at the office of the appropriate authority before the collection and to make a courtesy call on completion of the collection.

(9) Prior authority is to be obtained where rifles are required for the collection. Adjacent landholders in the vicinity of the shooting and users of the forest are to be contacted where possible. Police to be contacted where appropriate. All spent cartridges must be retrieved.

(10) Due care and attention are to be taken when using vehicles to minimise road damage especially under wet conditions. Gates will be left as found. Any damage to property to be reported immediately to the landowner or manager.

(11) Staff will conduct themselves in such a manner that they will be welcomed back.

(12) Follow up the trip with a letter of thanks and where appropriate indicate outcome of collections.

All relevant CSIRO Policy Circulars must be adhered to. The following are of particular relevance: 80/09 Safety Guidelines for Motor Vehicle Driving, 93/13 Fieldwork in Remote Locations, 93/15 Working Alone, 2001/01 Firearm Use.

Appendix 1.3.2A Seed Collection Data Sheet (blank)

CSIRO Forestry and Forest Products
PO Box E4008, Kingston,
Canberra, ACT 2604

AUSTRALIAN TREE SEED CENTRE
SEED COLLECTION DATA SHEET

CSIRO

Species:	Lat: ° '	Long: ° '	Seedlot:
Location:			
		State:	Alt (m):

Habitat:	Provenance name for Database:	Koeppen Climate Class
Veg'n structure:	Soil texture:	Association includes: / Freq: / Ht (m) / Comments:
Sp freq:	pH:	
Aspect:	Soil colour:	
Slope:	Geology:	
Seed crop:	Predation status:	
Bud:	Root sucker:	
Flowers:	Coppice:	Map name:

Colln No	Bot sp	Film No	Ht (m)	Age	Bole dbh (cm)	Bole Form	Crown Den	Crown Brn	Crown Wdt	Crown Ht (%)	Description/notes:	Seed weight (g)	Viab/ 10g

Team:	Date:	Collected as Bulk: / Individuals: / Total:		

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Appendix 1.3.2B Seed Collection Data Sheet (completed)

CSIRO Forestry and Forest Products
PO Box E4008, Kingston,
Canberra, ACT 2604

AUSTRALIAN TREE SEED CENTRE
SEED COLLECTION DATA SHEET

CSIRO

Species:	Lat:	Long:	Seedlot:
Eucalyptus cladocalyx	32° 18'	137° 58'	20269

Location: **Ridge Tops along walking trail to summit of Dutchmans Stern, Dutchmans Stern National Park 10km N/W Quorn**

State: **SA** Alt (m): **800**

Habitat:	Provenance name for Database:	Koeppen Climate Class
Ridges	Dutchmans Stern	Cool, rainfall evenly distributed, semi arid

Veg'n structure:	Soil texture:	Association includes:	Freq:	Ht (m)	Comments:
Open woodland	gritty sandy loam	*E. leucoxylon*	c	22	Almost a pure stand on ridges and upper slopes
Sp freq:	pH:	*A. quornensis*	c	2	Fruit size much smaller than populations to the south
Common	6	*Callitris sp.*	c	7	
Aspect:	Soil colour:	*Allocas. verticillata*	c	4	
all	grey				
Slope:	Geology:				
mod-steep	Quartzite				
Seed crop:	Predation status:				
scattered light					
Bud:	Root sucker:				
mod					
Flowers:	Coppice:	Map name:			
Mod(immature fruit)	Y	Augusta 1:100,000			

Colln No JSL	Bot sp	Film No	Ht (m)	Age	Bole dbh (cm)	Bole Form	Crown Den	Crown Brn	Crown Wdt	Crown Ht (%)	Description/notes:	Seed weight (g)	Viab/ 10g
3096	Y	27	15	M	47	P	H	H	S	40		26	275
3097	Y	28	15	M	40	P	H	H	BS	50		46	475
3098	Y	29	12	M	37	P	H	H	BS	50		58	500
3099	Y	30	16	M	30	G	M	M	NS	60		40	700
3100	Y	31	12	M	28	P	M	H	BS	30		41	300
3101	Y	32	14	M	65	P	H	H	S	45		33	2400
3102	Y	33	14	M	60	P	M	H	BS	50		29	350
3103	Y		12	M	38	P	M	H	BS	45		52	525
3104	Y		14	M	35	P	M	M	BS	50		8	175

Team: Larmour, Whitfeld

Date: 20.5.99

Collected as Bulk:
Individuals: 9 Total: 332

Appendix 1.3.2C Seed collection data sheet key

VEGETATION STRUCTURE: Life form and height of tallest stratum	Foliage projective cover of tallest stratum 100%–70%	70%–30%	30%–10%	<10%
Trees >30m	Tall closed forest TCF	Tall open forest TOF	Tall woodland TW	Tall open–woodland TOW
Trees 10–30m	Closed forest CF	Open forest OF	Woodland W	Open woodland OW
Trees <10m	Low closed forest LCF	Low open forest LOF	Low woodland LW	Low open woodland LOW
Shrubs>2m	Closed scrub CS	Open scrub OS	Tall shrubland TS	Tall open shrubland TOS
Shrubs 25cm–2m	Closed heath CH	Open heath OH	Low shrubland LS	Low open shrubland LOS
Cultivated plants CP				

SPECIES FREQUENCY:
A = Abundant C = Common O = Occasional
UC = Uncommon R = Rare

INDIVIDUAL TREE CHARACTERISTICS:

Age class		Bole form		Crown density (Den)	
Young	= Y	Poor (3 or more defects)	= P	Sparse	= S
Maturing	= Mg	Fair (2 defects)	= F	Medium	= M
Mature	= M	Good (1 defect)	= G	Heavy	= H
Overmature	= O	Excellent (no defects)	= E		
Coppice	= C	Multi–stemmed	= M		
		Not applicable	= NA		
Branching (Brn)		Crown width (Wdt)		Crown height (Ht) as a proportion of the tree height given as a percentage	
Light	= L	Narrow	= N		
Medium	= M	Spreading	= S		
Heavy	= H	Broad spreading	= BS		

SOIL TEXTURE:		Behaviour of soil bolus
Sand	(S)	little or no coherence, cannot be moulded
Loamy sand	(LS)	slight coherence, minimal ribbon of 5mm
Sandy loam	(SL	bolus just coherent but very sandy to touch, will form short ribbons (2cm)
Loam	(L)	bolus coherent and rather spongy, no obvious sandiness but may be somewhat greasy to touch, if much organic material present will ribbon to 2.5 cm
Sandy clay loam	(SCL)	sandy to touch, sand visible, ribbons 2.5–4cm
Clay loam	(CL)	bolus coherent, plastic and smooth to manipulate, ribbons to 4.5cm
Clay	(C)	smooth plastic bolus, can be moulded into rods without fracture, ribbons > 7.5cm

SLOPE:

L Level (0°)
U Undulating
G Gently inclined (1–3°)
M Mod. inclined (4–10°)
S Steep (11–23°)
VS Very steep (24–37°)
P Precipitous (38–60°)
C Cliffs (61–80°)

PHENOLOGY:

Seed, bud, flower crop
Light (L) / Early (E)
Medium (M) / Peak (P)
Heavy (H) / Late (L)

HABITAT:

e.g. river, creek, drainage line, floodplain, plain, rocky outcrop, undulating hills, rocky slopes, plateau, swamp disturbed area, salt lake, sand dune, estuary, escarpment, etc.

PREDATION STATUS OF SEED CROP

Avian (A) / Heavy (H)
Insect (I) / Medium (M)
Other (O) / Light (L)

COPPICE ABILITY/
ROOT SUCKERING ABILITY

Yes = Y
No = N
Undetermined = U

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Appendix 1.3.3 ATSC equipment checklist for the field

Authorities

collection permits

firearm permits

movement approval
- — travel request
- — trip plan

Office equipment

booking board/file

computer loaded with software for entry of collection data/botanical keys etc.

credit card

field note books

fuelcard for specific vehicle

list of official and private phone numbers

maps

mobile phone

reference material on flora etc.

rulers, pens, pencils

seed collection data sheets

Collection equipment

altimeter

bags collecting
- —large
- —medium

bags seed
- —calico
- —envelopes

Big Shot catapult

binoculars

botanical press
- —paper
- —plastic bags
- —jewelers tags
- —straps
- —boxes for dried specimens
- —specimen book with record of next field collection number
- —screw jars containing alcohol

bow
- —string
- —arrows
- —reel with line
- —face shield

bow saw with blades

cameras with film

chainsaw
- —spares to include bars, chain, sprocket, plug, diaphragm, starter rope, sharpening equipment
- —fuel-(2 stroke)
- —oil for bar
- —sharpening equipment
- —protective clothing

compass

diameter tape

flexible saw

geologist's pick

global positioning system

height measuring instrument

helmets for all party members

needles

ph kit

pruning saw-long handle and attachment

rifle
- —bolt
- —ammunition
- —cleaning equipment
- —rifle case
- —ear muff, hard hat and safety glasses
- —screwdrivers and hex. key wrench set to fit rifles

secateurs

seed identification labels

sheets collecting

sieves
- —large
- —fine (brass)

string

tape for marking and repair of sheets

tarpaulins

throwing rope—25m (4–6mm diameter)

wool bales

Tree climbing equipment

Big Shot head and 2.4 m pole

Big Shot fine line (45 m)

Big Shot sling replacement

Big Shot throw bag (450 g)

Appendix 1.3.3 continued

climbing rope (50 m static × 12 mm diam)
gaff guard
harness carry bag
helmet
karabiners—2 steel and 2 aluminium
kit bag
pole pruner with extendable handle
pole straps
prusick rope (2 m × 8 mm diam)
pulleys
rope bag
sheathed saw (24 cm)
climbing spikes
throwing rope—25 m × 5mm diam. plus weight
tree climbing harness

Vehicle items

brake fluid
extra fuel
electrical wire
hydraulic jacks with levers
insulating tape, clips
oil
levers for tyre repairs
puncture repair fit
spare inner tyre tubes
spare parts to include:
—air pump
—bolts
—fan belt
—filters
—fuses
—jump leads
—radiator hoses
spare tyres
tool kit to include spanners, screwdrivers, pliers, shifter, wheelbrace, hammer, grease
tow rope
winch operating switch
wire

Safety Items

emergency position indicating radio beacon (epirb)
first aid kit
—standard kit
—remote area kit
hard hat, earmuffs (heavy duty EH12 32DB), safety glasses for use with firearms
mobile phones
sunscreen 15+

Miscellaneous

axes
cargo nets, straps etc. for securing loads
rope
tape measuring—30 m
tape—masking
torch for each member of the party
wet weather gear

Appendix 1.3.4 A rough guide to seed collection times of the eucalypts

Corymbia and *Eucalyptus* taxa collected by ATSC over the past 30 years. As many eucalypts carry more than one seed crop, seed collections for most species can be conducted at any time of the year. Many of these species are denoted as all year (a.y.) in the table. Maturation of the most recent seed crop can be assessed using flowering time as a guide. However, capsule maturity following anthesis can vary considerably among species. For example, capsule maturation times following anthesis can range from as short as six weeks in the *E. coolabah-E. microtheca* group (section *Adnataria*), 5–6 months in many of the red gums (section *Exsertaria*), 8–10 months in many species in section *Monocalyptus* and up to 12 months in bloodwoods (*Corymbia* spp.). Populations occurring along different altitudinal and latitudinal gradients may also vary in maturation times on a regional basis within species. Heavy seed crops are also often produced after a number of sparse years. Seed collections are best conducted during a year of peak seed production. Flowering times for many of the species shown have been derived mainly from records in the program EUCLIST (cited in Chippendale and Wolf, 1981). Flowering times marked with an asterisk (*) are from Brooker and Kleinig (1990, 1994 and 1999). For further details regarding eucalypt phenology see Boland *et al*. (1980).

Corymbia	**Flowers**	**Seed collected (# = all year)**
abbreviata	May	Jul–Aug
abergiana	Aug–Oct	Jul–Sep
aparrerinja	Nov–Dec	Oct–Feb
aspera	Dec–Jan	Jan–Feb
bleeseri	Apr–Jun	Aug–Oct
bloxsomei	Jun–Aug*	Feb
cadophora	Apr–Sep*	Oct–Dec
calophylla	Jan–Mar	Dec–Mar
chippendalei	Jan–Mar*	Oct–Dec
citriodora	Nov–Jan	Sep–Feb
clavigera	Aug–Nov	Oct
collina	Apr–Jun	May–Nov
confertiflora	Jul–Oct	Nov–Feb
dampieri	Mar–May	Aug
dichromophloia sens. lat.	Mar–July	Oct–Nov
drysdalensis	Jul–Aug	~
eremaea	Oct–Jan*	Jul–Oct
eximia	Sep–Nov	Mar–Jul
ferriticola	Nov–Dec*	~
ferruginea	Dec–Mar	Jul–Nov
ficifolia	Dec–Mar	Oct–Feb
foelscheana	Oct–May	Sep–Oct
gilbertensis	Oct–Nov*	Jun–Aug
grandifolia	Oct–Nov	Nov–Jan
gummifera	Jan–Apr	Jul
haematoxylon	Dec–Feb	Jun
hendersonii	Jan–Feb	Apr
henryi	Nov–Jan*	May
hylandi	~	Aug
intermedia	Jan–Mar	Mar–Nov
jacobsiana	Nov–Dec*	Jun–Oct
latifolia	Nov–Mar*	Aug–Nov
leichhardtii	Jan–Mar*	Sep–Oct
lirata	Nov–Jan*	May–Oct
maculata	Jan–Sep	Aug–May
nesophila	Jun–Aug	Sep–Dec
opaca	May*	Oct
peltata subsp. *dimorpha*	~	Jun
peltata subsp. *peltata*	Jan–Feb*	Aug–Nov
polycarpa	Mar–Jul	Sep–Dec
porrecta	Jan	Jun–Aug
ptychocarpa	Dec–Mar	Jul–Nov
setosa	Oct–Apr	May–Jun
similis	Dec*	Aug–Nov

concluded on next page

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Corymbia **(continued)**	**Flowers**	**Seed collected (# = all year)**
terminalis	Mar–Oct	Dec
tessellaris	Nov–Feb*	Jan–Mar
torelliana	Aug–Oct	Dec–Mar
trachyphloia	Jan–May	Sep–Feb

Corymbia **(concluded)**	**Flowers**	**Seed collected (# = all year)**
variegata	Jan–Mar	May–Jun
watsoniana	Jun–Sep*	Oct–Nov
zygophylla	Feb	Dec–Feb

Eucalyptus	**Flowers**	**Seed collected (# = all year)**
acaciiformis	Dec–Jan	Apr/a.y.
accedens	Dec–Feb	Aug–Feb
acies	Sep–Nov*	Dec
acmenoides	Oct–Jan	Aug–Nov/a.y.
aeqioperta	~	Aug
agglomerata	Oct–Nov	Dec–Feb/#
aggregata	Dec–Feb*	Jan–Jul/#
alba	Jun–Oct	Jun–Jan
albens	May–Oct	Jan–Jun
amplifolia subsp. *amplifolia*	Nov–Jan	Aug–Apr
amplifolia subsp. *sessiliflora*	~	Jan
amygdalina	Nov–Jan	Sep–Apr/#
anceps	Jan–Feb*	#
ancophila	~	Sep
andrewsii subsp. *andrewsii*	Nov–Jan	Jan–Apr/#

Eucalyptus **(continued)**	**Flowers**	**Seed collected (# = all year)**
andrewsii subsp. *campanulata*	Oct–Nov	Sep–May/#
angophoroides	Oct–Dec*	Jan
angulosa	Oct–Dec	Apr
angustissima	Nov–Jan	Feb–May
annulata	Sep–Dec*	Dec–Mar/#
apiculata	Jan–Apr	Jun /#
apodophylla	Jul–Aug	Nov
approximans subsp. *approximans*	Mar–May*	Apr–Aug/#
approximans subsp. *codonocarpa*	Apr–May*	#
aquilina	Apr–Jun*	Apr
arachnaea	~	Sep
archeri	Jan–Feb*	Feb–Mar
argillacea	Oct–Dec*	May–Dec
argophloia	May–Jun	Oct–Apr
aromaphloia	Mar–Apr	Nov

***Eucalyptus* (continued)**	**Flowers**	**Seed collected (# = all year)**
astringens	Sep–Dec	Nov–Feb/#
badjensis	Dec–Mar*	Mar–Feb/#
baeuerlenii	Feb–Mar*	Feb–May
baileyana	Nov–Jan	Aug–Oct
bakeri	Aug–Oct*	Aug–Nov
bancroftii	Nov–Jan	May
banksii	Jan–Apr*	Oct
barberi	Mar–May	Jun
bauerana	Sep–Jan	Dec–May
baxteri	Dec–Mar	Oct–Dec/#
behriana	Oct–Jan	May–Jun
benthamii	Apr–May	Sep–Jun
beyeri	Oct–Jan	Jan
bigalerita	Jul–Sep	Sep–Oct
biturbinata	Dec–Feb*	Feb
blakelyi	Nov–Dec	Feb–Jun
blaxlandii	Oct–Nov*	Mar/#
bosistoana	Jan–Feb	Apr–Sep
botryoides	Jan–Mar	Oct–Jun/#
brachyandra	Aug–Oct	Nov
brachycalyx	Oct–Dec	Mar
brassiana	Nov–Jan	May–Dec
brevifolia	Jul–Sep	Sep–Nov
brevistylus	Apr–Nov*	Feb
bridgesiana	Jan–Mar	Jan–May
brockwayi	Feb–Apr	Oct–Apr
brookerana	Mar–May*	Jan–Apr
brownii	May–Oct	Mar–Jul
buprestium	Nov–Apr*	#

Eucalyptus	**Flowers**	**Seed collected (# = all year)**
burdettiana	irregular	#
burgessiana	Dec–Feb*	~
burracoppinensis	Aug–Oct	Mar
caesia subsp. *caesia*	May–Sep	#
caesia subsp. *magna*	May–Aug*	Jan/#
calcicola	May–Jun	Oct
caleyi	Apr–Oct	Sep–Oct/#
caliginosa	May–Jul	#
calycogona	Aug–Dec	Feb–Mar
camaldulensis	Nov–Dec	Apr
var. *camaldulensis* (NSW)		
var. *camaldulensis* (SA)	Nov–Jan	Apr
var. *camaldulensis* (SW QLD)	Oct–Nov	Mar
var. *camaldulensis* (VIC.)	Dec–Jan	May–Sep
var. *obtusa* (Kimberley)	Oct–Nov	Feb
var. *obtusa* (N QLD)	Jun–July	Dec
camaldulensis (continued)		
var. *obtusa* (NT)	Oct–Nov	Feb
var. *obtusa* (Pilbara)	Oct–Nov	Feb
subsp. *simulata*	~	Oct–Apr
cambageana	Aug–Jan	Sep–Dec
cameronii	Feb–May	Jan/#
camfieldii	Nov–Dec*	~
campaspe	Nov–Jan	Apr/#
camphora subsp. *camphora*	Feb–Mar	Jan–Nov/#
camphora subsp. *relicta*	~	May
canaliculata	Nov–Dec*	~
capitellata	Jan–Feb	Apr/#
carnei	Nov–Jan	Nov
celastroides	Aug–Nov	Nov–Feb
cephalocarpa	Mar–Apr	Jan

***Eucalyptus* (continued)**	**Flowers**	**Seed collected (# = all year)**
cerasiformis	Oct–Mar	Jan
chapmaniana	Jan–Mar	Jan–Feb
chloroclada	Sep–Oct	Feb–Mar
cinerea	Sep–Nov	Jun–Jan
cladocalyx	Jan–Mar	Oct–May
clelandii	Aug–Nov	#
clivicola	~	Oct
cloeziana	Dec–Jan	Sep–Aug/#
cneorifolia	Mar–May*	Nov–May/#
coccifera	Dec–Feb	Jan–Apr
comitaevallis	Mar–Apr*	Apr
concinna	Sep–Dec	Nov–Feb
confluens	Feb–Mar	Jul–Aug
conglobata	Nov–Mar	Feb–Mar
conglomerata	Mar–Jun*	Oct/#
conica	Sep–Nov	Feb–May
consideniana	Oct–Nov	#
coolabah	Nov–Feb	Jan–Apr
cooperana	Sep–Nov	May/#
cordata	Aug–Sep*	Dec–Feb
cornuta	Nov–Mar	Feb–Mar
coronata	Jul–Aug*	~
corrugata	Oct–Mar*	Mar
cosmophylla	Mar–Nov	Dec–May/#
crebra sens. lat.	July–Jan	Jan–Dec
crenulata	Sep–Oct*	Jun–Aug
croajingalensis	Dec–Jan*	Jan
crucis	Dec–Mar*	Nov–Dec
cullenii	Jan–Feb	Jun–Aug

Eucalyptus	**Flowers**	**Seed collected (# = all year)**
cupularis	Oct–Nov*	Jun
curtisii	Oct–Nov	Apr–Nov
cyanophylla	Aug–Nov*	~
cyclostoma	Feb–Apr*	Jun
cylindriflora	Jan–Feb	Dec–Feb
cylindrocarpa	Nov–Feb	#
cypellocarpa	Dec–Feb*	Jan–Jun
dalrympleana subsp. *dalrympleana*	Mar–May	Jan–Dec
dalrympleana subsp. *heptantha*	Dec–Feb*	Mar
dawsonii	Oct–Nov	Mar–Jul
dealbata	Oct–Dec	Feb–Mar
deanei	Mar–May*	Jan –Nov
decipiens	Sep–Dec*	Apr
decorticans	Dec–Jan*	Aug–Sep
decurva	Jun–Jul	#
deglupta	irregular	Jan, May,Sep
delegatensis	Jan–Mar	#
dendromorpha	Jul–Sep*	Dec–Feb/#
densa subsp. *densa*	Jun–Aug*	Nov/#
densa subsp. *improcera*	~	Jan/#
denticulata	~	Jan–Mar
desmondensis	irregular	Dec
dielsii	Jan–Feb	Oct/#
diminuta	Oct–Dec*	Apr
diptera	Feb–May	Oct/#
discreta	Jan–Apr*	Apr
dissimulata	Dec–Jan*	~
distans	Feb–Apr*	Sep
diversicolor	Sep–Feb*	Jan–Mar

***Eucalyptus* (continued)**	**Flowers**	**Seed collected (# = all year)**
diversifolia	Jan–Dec	Dec/#
dives	Oct–Dec	Feb–Sep/#
doratoxylon	Aug–Nov*	#
dorrigoensis	Jan–Mar*	Jan–May
drepanophylla	Jan–Dec	Mar–Dec
drummondii	Oct–Nov	Jan
dumosa	Feb–Jun	Jan/#
dundasii	Feb–May	Mar–Apr/#
dunnii	Mar–May*	Sep–Jan (–Apr)
dura	Apr–Aug*	~
dwyeri	Sep–Nov	Dec–Feb
ebbanoensis	Sep–Dec	Apr/#
effusa	Mar	#
elata	Sep–Oct	Dec–Apr/#
erectifolia	Mar–Apr*	~
eremophila	Aug–Jan	Mar/#
erythrocorys	Mar–Apr	Feb–Aug/#
erythronema var. *erythronema*	Aug–Jan	Jan–Mar/#
erythronema var. *marginata*	Jan	#
eudesmioides	Feb–Mar	Dec/#
eugenioides	Sep–Nov	Oct/#
ewartiana	Oct–Feb*	Oct/#
exilis	Aug–Oct*	Jan
exserta	Nov–Jan	Dec–Jul/#
falcata	Oct–Mar	Jan
fasciculosa	Feb–Dec	May–Jul
fastigata	Jan–Feb	Oct–Mar/#
fibrosa subsp. *fibrosa*	Nov–Feb	Jan–Mar
fibrosa subsp. *nubila*	Jun	Jan–Mar

Eucalyptus	**Flowers**	**Seed collected (# = all year)**
flavida	Nov–Dec*	~
flindersii	Aug–Nov	~
flocktoniae	Sep–Mar	Mar–Apr
foecunda	Aug–Mar	Mar–Nov
formanii	Dec–Apr*	~
forrestiana subsp. *dolichorhyncha*	Apr–Jun*	Apr
forrestiana subsp. *forrestiana*	Jan–Mar*	Oct–Feb
fraseri	Jan–Mar*	Jan–Apr
fraxinoides	Dec–Jan*	Aug–Mar
froggattii	Jan–Apr*	Mar–Sep/#
fusiformis	Jun–Aug*	Jan–Jun
gamophylla	Oct–Mar	Mar–Jul/#
gardneri	Mar–Nov*	~
georgei	Jan–Mar*	Jan
gillenii	Nov–Dec	Jun–Dec
gillii	May–Nov	May–Jun/#
gittinsii	Dec–Feb*	~
glaucescens	Feb–Apr	#
glaucina	Sep–Nov*	Dec–Feb
globoidea	Apr–Nov	Jan–Mar/#
globulus subsp. *bicostata*	Aug–Feb	Jul–Mar/#
globulus subsp. *globulus* (Tas.)	Nov–Dec	Aug–May
globulus subsp. *globulus* (Vic.)	Aug–Nov	Nov–May
globulus subsp. *maidenii*	Mar–Sep*	Jan–Apr
globulus subsp. *pseudoglobulus*	Jan–Feb*	Jan–Feb/#
gomphocephala	Jan–Apr	Sep–May
gongylocarpa	Jan–Feb*	Oct–Nov/#
goniantha subsp. *goniantha*	Aug–Oct	Dec–Feb
goniantha subsp. *semiglobosa*	Apr–Jun*	Nov
goniocalyx	Feb–May	Nov–Jan

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Eucalyptus **(continued)**	**Flowers**	**Seed collected (# = all year)**
gracilis	Aug–Oct	Dec–Feb/#
grandis	May–Jun	Feb–May/#
gregsoniana	Nov–Dec	May
griffithsii	Sep–Nov	#
grossa	Aug–Oct	#
guilfoylei	Dec–Jan	Jan
gunnii	Nov–Mar	Oct–May/#
haemastoma	Jul–Aug	Jan–May
hallii	Jan–Feb*	Apr–Sep
halophila	Jan–Apr*	Jan–Apr
herbertiana	May–Nov*	Sep
histophylla	Nov–Mar*	~
horistes	Nov–Jan	Sep–Feb
houseana	Aug–Sep	Oct–Nov
howittiana	Jan–Jul	Aug–Sep
incerata	~	Jan
incrassata	Sep–May	Jan/#
indurata	Jun–Sep*	May
infera	~	Apr
insularis	~	Apr
intertexta	Jan–Sep	Oct–Apr
jacksonii	Jan–Mar*	Dec–Feb
jensenii	Mar–May	Feb–Nov
johnsoniana	~	Aug–Sep
johnstonii	Jan–Mar*	Mar–Jun
jucunda	Jan–Mar	Apr/#
jutsonii	Nov–Feb*	#
kartzoffiana	Mar–May*	Dec–Feb

Eucalyptus	**Flowers**	**Seed collected (# = all year)**
kingsmillii	Jul–Sep	#
kitsoniana	Jan–Feb*	Oct
kochii subsp. *kochii*	Sep–Feb	Jun–Feb
kochii subsp. *plenissima*	Jan	Oct–Mar
kondininensis	Oct–Dec*	Feb–Mar
kruseana	May–Sep	Aug/#
kumarlensis	Feb	Dec–May
kybeanensis	Oct–Dec	Jan–Feb/#
laeliae	Dec–Feb*	Apr
laevopinea	Mar–Jun	Jul–Oct/#
lanepoolei	Jan–Apr*	Jul
lansdowneana subsp. *albopurpurea*	Mar–Oct	Mar–Jul/#
lansdowneana subsp. *landowneana*	Dec–Feb	Dec/#
largeana	May–Jul*	Nov
largiflorens	Aug–Jan*	Jul–Apr
lehmannii	Oct–Apr	#
leptocalyx	Oct–Mar	Apr
leptophleba	Jan–Jun	May–Aug
leptopoda	Jan–Feb	Dec–Feb
lesouefii	Jan–Feb	Apr/#
leucophloia	Jun–Aug	Nov–Dec
leucoxylon subsp. *leucoxylon*	Aug–Oct	May–Jul
leucoxylon subsp. *megalocarpa*	Jun–Aug	May–Jul
leucoxylon subsp. *petiolaris*	Aug	Dec–Jan
leucoxylon subsp. *pruinosa*	Aug–Nov	Apr–Jul
ligulata	Mar–Apr	Apr
ligustrina	May–Jun*	Mar /#
longicornis	Nov–Jan	Oct–Mar/#
longifolia	Mar–Jul	Feb–Apr
longirostrata	Dec–Apr*	Nov–May

Eucalyptus **(continued)**	**Flowers**	**Seed collected (# = all year)**
loxophleba subsp. *gratiae*	Oct–Nov	Mar
loxophleba subsp. *lissophloia*	Aug–Oct	~
loxophleba subsp. *loxophleba*	Aug–Dec	Feb–Mar
lucasii	Aug–Sep	Nov
lucens	Feb–Mar*	Mar–May
luehmanniana	Aug–Nov*	Feb/#
macarthurii	Feb	Aug–Feb
macrandra	Jan–Feb	Jan/#
macrocarpa	Aug–Nov	#
macrorhyncha	Jan.–Apr	Jan–May/#
major	Dec–Feb*	Nov–May
malacoxylon	Feb	Mar
mannensis	Apr–Oct*	Mar–May/#
mannifera subsp. *maculosa*	Feb–Mar	Mar/#
mannifera subsp. *mannifera*	Nov–Feb	Feb–May/#
mannifera subsp. *praecox*	Jun–Jul*	May
marginata	Sep–Dec	Aug–Feb
mckieana	Mar–May	Oct–Feb
megacarpa	Mar–May	~
megacornuta	Jul–Dec*	Nov–Jan/#
melanoleuca	Jul	Jun–Aug
melanophitra	~	Jan
melanophloia	Sep–Feb	Oct–May
melanoxylon	Jan–Feb	Oct–Nov
melliodora	Oct–Jan	Jul–May
merrickiae	Sep–Nov	Jan
michaeliana	Sep–Nov*	Jan–Mar
micranthera	Mar–May	Mar–May
microcarpa	Jan–Aug	Feb–May/#
microcorys	Aug–Jan	Oct–Jun

Eucalyptus	**Flowers**	**Seed collected (# = all year)**
microneura	Feb	Jul–Aug
miniata	May–Jul	Aug–Jan
miscella	~	May
mitchelliana	Dec–Jan	Dec–Feb
moluccana	Feb–Mar	Oct–May
moorei	Mar–May	Jan–Mar
morrisbyi	Jan–Apr*	Apr–Jun
morrisii	Nov–Dec*	Jun–Aug
muellerana	Mar–May	Jan–May
multicaulis	Sep–Oct	Aug/#
myriadena	Nov–Apr*	Mar–Apr/#
neglecta	Dec–Jan*	Dec–Feb
newbeyi	~	Jan
nicholii	Mar–Apr*	Jan–Mar
nitens	Jan–Mar*	Oct–May
nitida	Nov–Feb	Mar–Jul/#
nobilis	Jan–May	Oct–May
normantonensis	May–Aug	Jul–Aug
nortonii	Feb–Mar	Mar–May
notabilis	Nov–Jan	Mar–May
nova–anglica	Feb–Apr	Oct–Mar
nutans	Sep–Jan	#
obliqua	Dec–Mar	Sep–May/#
oblonga	Feb–Apr	Nov/#
obtusiflora	Dec–Jan	Jan/#
occidentalis	Apr–May	Sep–Apr
ochrophloia	May–Nov	Aug–Jan
odontocarpa	Jul–Aug	Aug–Jan
odorata	Mar–Nov	May

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Eucalyptus **(continued)**	**Flowers**	**Seed collected (# = all year)**
oldfieldii	Jun–Oct	Apr/#
oleosa	Jun–Apr	Nov–Dec/#
olida	~	Feb–May
oligantha	Sep–Nov	Sep–Nov
olsenii	Apr–Nov	Oct /#
oraria	May–Oct	Apr
orbifolia	Apr–Sep	Jul/#
ordiana	Apr–May*	~
oreades	Jan–Feb	Mar–Jun/#
orgadophila	Apr–Aug	May–Dec
ornata	Dec–Jan	Jan
ovata	Mar–Jan	Sep–Dec
ovularis	Sep–Apr*	Dec–Feb
oxymitra	Jan	Jul–Oct/#
pachycalyx	Feb	Jun–Aug
pachyloma	Jan–Apr	#
pachyphylla	Jul–Aug	Apr–Nov/#
paliformis	Apr–May	May–Jun
panda	Sep–Nov	~
paniculata	May–Feb	Aug–Mar
parramattensis	Nov–Jan	Oct/#
parvula	Jan–Mar*	Apr–Jul
patellaris	Dec–Jan	Jun–Sep
patens	Jan–Feb	Aug–Dec
pauciflora subsp. *debeuzevillei*	Jan	Mar/#
pauciflora subsp. *niphophila*	Dec–Feb	Jan–May/#
pauciflora subsp. *pauciflora*	Oct–Mar	Dec–Apr/#
pellita	Dec–Feb*	Aug–May
pendens	Oct	Apr

Eucalyptus	**Flowers**	**Seed collected (# = all year)**
perriniana	Jan–Mar	Jan–Feb
persistens	Apr–Jun*	~
petraea	Jan–Jul*	Jan
phaenophylla	Aug–Nov*	Feb
phoenicea	May–Jul	Sep–Nov
pilbarensis	Jul*	~
pileata	Jan–Jun	May/#
pilligaensis	Mar–May	Mar–Oct
pilularis	Sep–Mar*	Feb–May/#
pimpiniana	Aug–Oct	Apr–Nov
piperita	Jan–Apr	#
planchoniana	Jan–Mar	Jun–Sep
platycorys	Aug–Oct	#
platypus var. *heterophylla*	Jan–Mar	Jan
platypus var. *platypus*	Dec–Feb	Oct–Mar
pluricaulis	~	Apr–Sep
polyanthemos	Sep–Dec	Feb–Jul
polybractea	Mar–Jun	May–Jun/#
populnea	Jul–Dec	Sep–Apr
porosa	Jul–Dec	May
praetermissa	~	Jan
preissiana	Aug–Nov	Mar/#
prominens	Sep	Apr
propinqua	Jan–Feb	Nov–May/#
pruinosa	May–Aug	Aug–Jan
pryoriana	Jan–Mar	Nov–Mar
pterocarpa	Sep–Nov*	Mar
pulchella	Nov–Feb	Oct/#
pulverulenta	Jul–Oct	Feb–Jun/#

***Eucalyptus* (continued)**	**Flowers**	**Seed collected (# = all year)**
pumila	Apr–May*	Jun–Jul
punctata	Feb–Mar	Sep–Jul/#
pyriformis	Jul–Nov	/#
pyrocarpa	Jan–Mar*	Jan–Apr
quadrangulata	Feb	Oct–Apr
quadrans	Sep	Mar
racemosa	Feb–Mar	Jan–Aug/#
radiata subsp. *radiata*	Oct–Jan	Feb–May/#
radiata subsp. *robertsonii*	Jan–Feb	Jul–Sep/#
rameliana	Jun	Oct–Nov/#
raveretiana	Dec–Jan	Mar–Apr
redacta	~	Jan
redunca	Jan–Dec	Apr
regnans	Feb–May	Jan–Nov/#
remota	Nov	Dec
resinifera	Nov–Jan	Jul–Sep
rigens	~	May/#
risdonii	Nov	Sep–Jan
robusta	May–Aug	Jan–Apr
rodwayi	Feb	Dec–Feb
rossii	Oct–Feb	Feb–Mar
roycei	Mar	Apr
rubida	Nov–May	Jan–Aug
rubignosa	Sep–Nov*	Apr
rudderi	Nov	Nov
rudis	Jul–Nov	Jan–Apr
rugosa	Sep–Nov	Nov–Dec/#
rummeryi	Dec–Jan*	Mar–Apr
rupestris	May*	~

Eucalyptus	**Flowers**	**Seed collected (# = all year)**
rupicola	Apr	Jan–Mar/#
salicola	~	Feb
saligna	Jan–Feb	Oct–Mar
salmonophloia	Nov–Mar	Oct–Mar/#
salubris	Sep–Dec	Jul–Jan/#
sargentii	Oct–Nov	Mar–Apr
scias	~	Jan
scoparia	Nov–Feb*	Jul–Nov
seeana	Nov–Dec*	Oct–Feb
sepulcralis	Oct–Nov	~
sessilis	~	Jan
sheathiana	Jan–Mar	Feb–Apr
shirleyi	Jan	Dec–Feb
siderophloia	May–Jan	Sep–Oct
sideroxylon	Apr–Jan	Jul–May
sieberi	Sep–Nov	Oct–Mar/#
signata	Aug–Oct	Jan–Mar
silicifolia	~	Jul
smithii	Jan–Mar	Sep–May
socialis	Aug–Jan	Nov–Jan/#
sparsicoma	~	Feb
sparsifolia	~	Jan–Mar
spathulata	Dec–Mar*	Jan–Mar
spectatrix	~	Jan
sphaerocarpa	Sep	Jun–Oct
squamosa	Jun	Mar
staeri	Apr	#
staigerana	Feb–Apr	Aug–Sep
steedmanii	Dec–Jan*	Jan

***Eucalyptus* (continued)**	**Flowers**	**Seed collected (# = all year)**
stellulata	Mar–Jun	Dec–Feb/#
stenostoma	Sep	Dec–Jul
stoatei	Dec–Feb	Feb–Apr
striaticalyx	Jan	Nov–Mar
stricklandii	Nov–Feb	Sep–Feb
stricta	Sep–Jan	Aug–Sep/#
sturgissiana	Aug–Nov*	Apr
subangusta	Jan–Mar*	~
subcrenulata	Mar	Jun
suberea	Dec–Jan*	~
suffulgens	Apr–Sep*	May
suggrandis	Dec–Feb	Oct–Apr
tectifica	Oct–Dec	Jan–Feb
tenuipes	Mar–Jun*	Jun–Aug
tenuiramis	Nov–Feb	Dec–Mar
tenuis	~	Jan–Mar
terebra	~	Feb
tereticornis	Jul–Oct	Jul–Mar
tetragona	Oct–Apr	Feb/#
tetraptera	irregular	Jan
tetrodonta	Jun–Sep	Sep–Dec
thozetiana	Apr–Oct	Dec–Jan
tindaliae	May–Jul*	Feb/#
todtiana	Nov–Feb	Sep–Jan
torquata	Aug–Nov	Feb/#
transcontinentalis	Jul–Nov	Sep–Mar
tricarpa	Jul–Nov	Nov–May
triflora	Dec	Dec–May/#

***Eucalyptus* (concluded)**	**Flowers**	**Seed collected (# = all year)**
trivalvis	Jan–Aug*	Oct–Feb/#
tumida	~	May
umbra subsp. *carnea*	Oct–Dec	Feb/#
umbra subsp. *umbra*	Sep–Nov	Jun–Oct/#
umbrawarrensis	Oct–Jan*	Jun
uncinata	Feb–Apr	Apr/#
urnigera	Apr–Jul	Feb–Mar
urophylla	Jan–Mar	Jun–Nov
vernicosa	Dec–Feb	Feb
viminalis subsp. *cygnetensis*	Feb–Apr	Dec
viminalis subsp. *viminalis*	Dec–May	Jan–Dec
virens	~	Apr
viridis	irregular	Jun–Aug/#
volcanica	~	Jan
wandoo	Mar–Apr	Dec–Mar
websterana	Sep	Aug
whitei	Feb–Jun	May
wilcoxii	Mar*	Dec
willisii	Oct–Dec	~
woodwardii	Aug–Oct	Sep–Feb
yalatensis	Dec–Feb*	Apr–May
yarraensis	~	Dec
yilgarnensis	Mar–Sep*	Mar
youmanii	Jun–Aug*	Oct–Mar/#
youngiana	May–Aug	Jan–Apr
yumbarrana	Jul–Sep	Mar

Appendix 1.3.5 Seed collection times of acacias, casuarinas, grevilleas and melaleucas

The following seed collection month(s) have been derived from records of the ATSC. The 258 *Acacia* species shown are mainly woody shrubs and tree species in the genus. Bracketed months indicate seed collections can sometimes be conducted during these months but are not representative of the main seed collection period.

Acacia	Seed collected
acradenia	Sep–Nov
acuminata	Nov–Dec
adoxa	Oct
adsurgens	Sep–Nov
alleniana	Sep
alpina	Feb
ammobia	Nov
ampliceps	(Sep–) Oct (–Nov)
anaticeps	(Oct–) Dec
ancistrocarpa	Sep–Nov
aneura	Oct–Nov (–Dec)
aphanoclada	Oct
arepta	Oct
argyraea	Oct
aulacocarpa	Sep–Nov
auricoma	Oct
auriculiformis	Sep–Oct (–Nov)
auriculiformis × *leptocarpa*	Oct
ayersiana	Oct
baileyana	Nov–Dec
bakeri	Feb
bancroftii	Oct–Dec
bidwillii	Sep–Apr
binervata	Dec
binervia	Dec
bivenosa	Oct–Nov (–Dec)
bivenosa × *ampliceps*	Nov
blakei	Oct–Dec
blakelyi	Nov
blayana	Dec–Jan
brachystachya	Oct–Jan
brassii	Sep–Oct
brownii	Dec
burrowii	Nov
buxifolia	Mar
calamifolia	Nov
calcicola	Oct
calcigera	Aug, Oct
cambagei	Sep–Nov
cardiophylla	Mar
catenulata	Oct
celsa	Oct–Jan
cheelii	Dec
chinchillaensis	Oct
chisholmii	Sep
chrysotricha	Oct
cincinnata	(Nov–) Dec
citrinoviridis	Oct–Nov
colei	Sep–Nov
complanata	Oct
concurrens	Nov–Dec
conferta	Nov–Dec
coriacea	Oct–Nov (–Dec)
cowleana	Sep–Nov
crassa	Oct–Dec
crassicarpa	Sep–Nov
cretata	Oct
cultriformis	Nov–Dec
cupularis	Jan
cuspidifolia	Mar
cuthbertsonii	Sep–Oct
cyclops	Jan–Feb (–Apr)
cyperophylla	Sep–Oct
dealbata subsp. *dealbata*	(Dec–) Jan (–Mar)
dealbata subsp. *subalpina*	Jan
deanei subsp. *deanei*	Oct–Jan
deanei subsp. *paucijuga*	Dec
decora	Oct
decurrens	Nov–Feb
dictyophleba	(Sep–) Nov
dietricheana	Oct
difficilis	Sep–Oct
dimidiata	Sep–Oct
diphylla	Dec
disparrima subsp. *disparrima*	Sep–Nov
disparrima subsp. *calidestris*	Sep–Nov

***Acacia* (continued)**	**Seed collected**
distans	Oct
doratoxylon	Nov
drepanocarpa	Sep
drepanophylla	Nov
drummondii	Jan
dunnii	Jun–Jul, Nov
effusa	Nov
elachantha	Sep–Nov
elata	Dec (–Feb)
elongata	Nov
eriopoda	Oct–Nov
estrophiolata	Nov–Dec
everestii	Oct
excelsa	Dec
exilis	Nov
falcata	Sep–Dec
falciformis	Dec–Feb
farnesiana	Sep–Dec
fasciculifera	Dec, (Jul)
filicifolia	Dec
fimbriata	Oct–Dec
flavescens	(Sep–) Oct (–Dec)
flexifolia	Nov
floribunda	Dec
frigescens	Feb
fulva	Dec
galeata	Nov
georginae	Nov–Dec
gittinsii	Oct
gladiformis	Nov
glaucocaesia	Oct
glaucocarpa	Nov–Dec
gonoclada	Sep
gracilima	Nov
grandifolia	Nov
grasbyi	Nov
gregorii	Nov
hakeoides	Nov–Dec
hamersleyensis	Oct–Nov
hammondii	Sep–Nov
harpophylla	Oct–Nov
havilandii	Oct
hemignosta	Oct–Nov
hemsleyi	Sep
hilliana	Sep
holosericea	Sep–Nov
hylonoma	Dec
implexa	Dec–Jan (–Feb)
inaequilatera	Oct–Dec
irrorata	(Nov–) Dec
islana	Oct
jennerae	Oct–Dec (–Jan)
julifera subsp. *gilbertensis*	Sep
julifera subsp. *julifera*	Oct (–Dec)
juncifolia	Oct–Dec
kempeana	Oct
laccata	Sep
lamprocarpa	Sep–Nov
lasiocalyx	Jan
latescens	Sep–Oct
latzii	Oct–Nov
leichardtii	Oct
leiocalyx	Nov–Dec
leptocarpa	Sep–Nov
leptoloba	Apr
leucoclada	Nov–Dec
ligulata	Oct–Dec (–Jan)
limbata	Oct
linifolia	Jan
longispicata	Oct–Nov
lysiphloia	Sep–Nov
mabellae	Dec–Feb
maconochieana	Oct
macradenia	Oct–Dec
maidenii	Oct–Nov
maitlandii	Oct (–Dec)
mangium	(Sep–) Oct–Nov (–Dec)
mearnsii	Dec–Jan (–Mar)
melanoxylon	(Oct–) Jan (–Mar)
midgleyi	Oct–Nov
mimula	Aug
mollifolia	Dec
monticola	Sep–Nov(–Dec)
mountfordae	Sep–Oct

***Acacia* (continued)**	**Seed collected**
mucronata	Jan
muellerana	Nov
murrayana	Nov–Dec
myrtifolia	Jan
nanodealbata	Feb
neriifolia	Nov–Dec
nuperrima subsp. *cassitera*	Feb
obliquinervia	Jan
obtusata	Dec
olgana	Oct
olsenii	Jan–Mar
oncinocarpa	Sep
oraria	Sep–Oct
orites	Dec
orthocarpa	Oct
oswaldii	Dec
pachyacra	Oct–Nov
pachycarpa	Oct
pachyphloia	May
pallidifolia	Sep
parramattensis	Jan
parvipinnula	Dec (–Jan)
pendula	Oct–Dec
penninervis	Oct–Dec
peregrina	Sep–Nov
peuce	May, Sep–Oct, Apr
platycarpa	Sep–Nov (May, Jun)
plectocarpa	Sep–Oct (–Nov)
podalyrifolia	Dec
polybotrya	Dec–Jan
polystachya	Oct–Dec
pravissima	Jan–Mar
pruinocarpa	Jan–Mar
ptychophylla	Oct
pubercosta	Oct
pustula	Nov
pycnantha	(Dec–) Jan (–Feb)
pyrifolia	Oct–Nov
ramulosa	Oct–Nov
retinodes	Jan
retivenia	Sep–Nov
rhodophloia	Oct–Nov
rhodoxylon	Oct

Acacia	**Seed collected**
rothii	Sep–Oct (–Dec)
rubida	Dec–Jan
sabulosa	Oct–Dec
salicina	Sep–Nov
saliformis	Dec
saligna	Dec–Jan
schinoides	Dec
sclerosperma	Oct–Nov (Mar)
sclerosperma × *ligulata*	Oct
sericoflora	Oct
shirleyi	Sep–Dec (Aug)
silvestris	Jan (–Dec)
simsii	Sep–Oct; Apr–Jul
sophorae	Dec–Jan
sparsiflora	Nov
spathulata	Nov
spectabilis	Oct–Nov
spondylophylla	Nov
stenophylla	Sep–Dec (May)
stigmatophylla	May
stipuligera	Sep–Oct (–Dec)
storyi	Oct–Dec
stowardii	Oct
strongylophylla	Nov
striatifolia	Nov
suberosa	Nov
subporosa	Mar
subtessarogona	Oct–Nov
sutherlandii	Oct
sylvestris	Jan
synchronicia	Nov
tenuinervis	Nov
tenuissima	Sep–Nov
tephrina	Nov
terminalis	Dec
tetragonophylla	Oct–Dec
torulosa	Sep–Nov (–Dec)
trachycarpa	Oct (–Nov)
trachyphloia	Dec–Jan
translucens	Oct
triptera	Dec
tropica	Sep–Oct
tumida	Oct–Nov (Sep–)
umbellata	Oct

***Acacia* (continued)**	**Seed collected**	***Acacia***	**Seed collected**
uncinata	Nov–Dec	*wanyu*	Oct
validinervia	Oct–Nov	*xanthina*	Dec
verniciflua	Dec	*xiphophylla*	Oct–Nov (Mar)
vestita	Dec–Jan	*yirrkallensis*	Apr
victoriae	Nov–Dec (Mar, May)		

Allocasuarina	**Seed collected**	***Allocasuarina***	**Seed collected**
acutivalvis	Aug	*huegeliana*	Jul–Aug
campestris	Aug	*lehmanniana*	Dec
corniculata	Aug–Oct	*littoralis*	May–Aug
decaisneana	Sept–Nov	*luehmannii*	Dec
decussata	Aug	*paludosa*	Feb
dielsiana	Oct	*tessellata*	Oct
fraseriana	Feb	*torulosa*	Jun–Sept
helmsii	Aug	*verticillata*	Jan–Apr

Casuarina	**Seed collected**	***Casuarina***	**Seed collected**
cristata subsp. *cristata*	Jul–Sept	*glauca*	Jul
cunninghamiana subsp. *cunninghamiana*	Feb–Jul	*grandis*	Apr
cunninghamiana subsp. *miodon*	Mar–May	*junghuhniana*	Aug–Oct
equisetifolia subsp. *equisetifolia*	Nov–Feb	*obesa*	Oct–Nov
equisetifolia subsp. *incana*	Mar–Apr		

Grevillea	**Seed collected**
dryandri	Jan
glauca	Oct–Jan
heliosperma	Sept, Jan
juncifolia	Oct–Jan
nematophylla	Jan
parallela	Nov
pinnatifida	Jan
pteridifolia	Sept–Jan
pterosperma	Oct
pyramidalis	Nov–Dec
refracta	Nov–Jan
robusta	(Dec–) Jan (–Mar)
spinosa	Dec
stenobotrya	Oct–Jan
striata	Jan–Feb
wickhamii subsp. *wickhamii*	Oct–May
wickhamii subsp. *aprica*	Sept

Melaleuca	**Seed collected**
acacioides *subsp.* acacioides	Oct–Nov
acacioides subsp. *alsophila*	Dec
acuminata	Feb
adnata	Mar
alternifolia	Jan–July
arcana	Dec–Jan
argentea	Dec–Jan
bracteata	Jan–Feb
cajuputi subsp. *cajuputi*	Nov–Jan
cajuputi subsp. *cumingiana*	Jul
cajuputi subsp. *platyphylla*	Oct–Dec
citrolens	Sept–Oct
clarksonii	Jan
dealbata	Dec–Jan
decora	Jan
decussata	Jan–Feb
dissitiflora	Jan
eleuterostachya	Mar
ericifolia	Sept
fluviatillis	Dec–Jan
foliolosa	Jan
glomerata	Oct–Nov
halmaturorum	all year
lanceolata	Feb–Mar
lasiandra	all year
leucadendra	Oct–Apr
linariifolia	Jan
minutifolia	Apr
nervosa	Nov–Jan
nesophila	Jan
nodosa	Dec
pauperiflora	all year
preissiana	Jan
quinquenervia	Oct–Nov
saligna	Jan
sericea	Dec
stenostachya	Nov
thyoides	Mar
trichostachya	Jan–Feb
uncinata	all year
viridiflora	Oct–Dec

Section 2 Seed Processing

Seed is rarely clean enough for immediate storage following collection. Most collections require harvesting of fruit that must then be processed by drying or depulping, extraction of the seed from the fruit, further cleaning and fumigation. These processes are to:

- remove impurities such as leaves, twigs, dirt to facilitate cleaning;
- dry dehiscent fruit to allow for seed extraction;
- remove pulp from fleshy fruit in order to reduce bulk, minimise fungal problems and reduce the risk of viability loss;
- clean the seed to achieve maximum purity and viability;
- reduce moisture content of the seed;
- mix seed from individual tree collections to form a provenance bulk;
- fumigate the seed to kill insects contained in the seed.

These processes should be carried out as soon as possible following collection and care must be taken to avoid damage to the seed and maintain the identity of each seedlot. Methods for processing are many and varied and depend very much on the type of fruit, seed and equipment available. This section covers seed processing following collection with the focus on species represented by eucalypts, *Melaleuca, Casuarina, Allocasuarina, Grevillea* and *Acacia*. Methods for handling fleshy fruit are also discussed.

2.1 Seed extraction

2.1.1 Pre-processing

Following harvesting, seed can either be processed in the field or at the ATSC facilities. Following collection, freshly collected fruit normally have a relatively high moisture content and are susceptible to mould if stored inappropriately. It is therefore important to arrange for the rapid transportation of the crop if it is to be processed at the ATSC. At every opportunity the crop should be spread out and well-ventilated to minimise deterioration prior to seed extraction with regular inspections to allow early detection of deterioration due to fungi and insects.

Impurities such as twigs and leaves are removed in order to reduce unnecessary bulk and to facilitate drying and cleaning. This is initially undertaken at the time of harvesting but may also be required prior to seed drying and again at the time of extraction. This is particularly important where impurities left in the crop can not be conveniently removed during the cleaning process (e.g. casuarina branchlets should be removed prior to drying leaving only the cones). Pre-cleaning may be necessary following drying but before extraction and cleaning (e.g. removal of acacia pods from twigs once they have been dried but prior to threshing to prevent damage to the rubber flails).

2.1.2 Drying

Some drying is a necessary part of processing most fruit unless they have already dried on the plant (e.g. pods of arid zone acacias—*A. aneura, A. victoriae*) or in the case of fleshy fruit which require depulping. The drying process causes a continuous release of moisture the rate of which is determined by temperature, humidity, air flow, moisture content of the fruit and fruit structure. The most effective drying conditions are low humidity, continuous air circulation and a temperature that ensures the seed does not lose viability. For this reason drying should be done using a safe minimum temperature which will allow for the extraction of the seed within a practical time limit.

Natural drying
The most straightforward method of drying is to spread the harvested crop out on calico sheets (2 × 2 m) on the ground either in full sun or in the shade and tying them up again into bundles at the end of the day or for transportation. The method is suited to dry conditions above about 20°C and is commonly adopted during extended field trips where it is essential to dry and extract the seed as frequently as possible to reduce the bulk of collected material and avoid the development of mould. Most species collected by the ATSC benefit from this method of drying. The time required for natural drying depends on a number of factors including species, the degree of fruit maturity and weather conditions. Under warm (>30°C) dry (relative humidity <40%) conditions, dehiscent fruit (e.g. eucalypts, melaleucas, casuarinas) may be ready for extraction within a few days or even a few hours under very hot conditions, especially those species with thin walled fruit. Similarly, acacia pods collected in the near-dry, mature state require a minimum amount of drying. However, green pods should be dried out at a moderate temperature (about 25°C). For moist fruit or seed which is not fully mature, care must be taken not to let the fruit overheat otherwise this can result in excessive moisture being removed from the seed thereby reducing the seed viability. In this situation it is better to place the seed in semi or full shade particularly if the temperature is above about 25°C.

Whilst this method is very convenient during field trips, it is important to minimise the risks involved when leaving the crop un-attended in the field. Where there is the risk of wind lifting the sheets, the sides of the sheets should be weighted down. Seed should not be dried near ants nests as they are known to remove viable eucalypt seed leaving the chaff. Other risks to be mindful of include rain, fire, people and animals. It is also important to avoid contamination from foreign seed. Do not spread sheets out under trees that are shedding seed and avoid areas with tall grass with mature seed.

Where conditions (e.g. climate, time) are not conducive to field drying, then the fruit will need to be artificially dried. In this situation it is either a case of returning with the material at the end of the trip (short trips) or, where there is a risk of mould or the accumulation of excessive material for the vehicle, sending the harvest back to base using commercial carriers. Some commercial seed collectors have developed mobile drying facilities to counter this problem.

Artificial drying
Fruit not completely dried in the field requires further drying in the ATSC drying room. The fruit and associated impurities are spread evenly over the sheets to maximise air circulation and turned regularly to encourage even drying throughout the crop. The room is normally set at a temperature of 35–38°C with air movement assisted by fans. With immature and moist material, it is wise to initially dry the material for one to two days at a lower temperate (25°C)—to partially dry the fruit then increase the temperature each day by approximately 5°C to 35°C.

Drying time depends on a number of factors including the volume of material, initial moisture content and the structure and density (woodiness) of the fruit. On average, seed should be ready for cleaning after 2–3 days but drying may take up to a week or more where there is a large volume of leaf and woody fruit material.

Ralph (1994) reported that *Banksia* and *Hakea* fruit are placed in an oven at 80–100°C for 30 minutes in order to release the seed. Alternatively, the cones are placed in a fire for a minute or two then plunged in cold water and allowed to dry. This method is repeated until all the valves open. For banksia cones which do not adequately respond to this treatment, an alternative method is to soak the cones for 24 hours in cool water then placed in an oven at 250°C for one hour or placed on the fire for a minute.

2.1.3 Seed extraction

Extraction and subsequent cleaning is either carried out manually, mechanically or in combination. The wide variation between individual tree lots and species and the need to ensure there is no contamination between seedlots requires considerable manual handling. Care must also be taken to ensure as much of the seed contained in the fruit is removed yet avoid damaging the seed. Machinery used must be designed for ease of cleaning and adjustment but not damage the seed.

Extraction by hand: Manual shaking of the fruit or as part of a sieving process is sufficient for many species (e.g. eucalypts, melaleucas, casuarinas, grevilleas). Ensure that as much of the seed as possible has been removed from the fruit before discarding the waste. Some seed may need to be removed individually from the fruit by hand using tweezers where other methods are not effective.

Species that may require this treatment include banksias and native grasses (Ralph 1994).

Manual threshing: The seed of dry brittle pods including many acacias can be extracted by beating with a flail or slender pole, crushing the pods between canvas sheets by trampling underfoot or, with small samples, simply by breaking up the pods by hand (Doran *et al*. 1983). Thomson (1995) reported that large, hard-coated seeds of some phyllodinous *Acacia* species (e.g. *A. anaticeps, A. pachycarpa, A. platycarpa* and *A. wanyu*) can be separated from the pod by placing the pods between a heavy-duty tarpaulin and running the wheels of a vehicle over them. The seedheads of some native grasses, such as *Danthonia* and *Poa*, can be rubbed between two rubber car-mats to dislodge the seed (Ralph 1994).

Mechanical threshing: The ATSC 15 cm flailing thresher has been most effective in breaking down both humid tropical and arid zone acacia pods. Searle (1989) reported that the same thresher adapted to run in the field with a 2 horsepower motor was effective in breaking down fruit of *Acacia*, *Adenanthera, Albizia, Alphitonia, Brachychiton, Cathormium, Dendrolobium, Geijera* and *Rhodosphaera*.

A description of the machine is given by Doran *et al*. (1983). The machine's motor rotates a metal shaft (belt driven) bearing four replaceable flailing rubber strips inside a chamber. The pods are drawn downwards from the overhead hopper into the chamber where the material is broken down by the rubber flails before falling through the sieve into a container. Interchangeable sieves of varying aperture and shape determine the extent to which the material is broken down before falling through the holes. The thresher causes minimal damage to the seed and is very easy to clean thus avoiding the risk of contamination. The thresher can also be used effectively for the removal of funicles from acacia seed. A number of other examples of other threshing machines are described in Doran *et al*. (1983).

Dust associated with the threshing and cleaning of acacia pods in particular can cause skin irritation and respiratory problems. For this reason the ATSC extraction and cleaning facility is fitted out with ducting for removal of dust. However, it may still be necessary to wear protective breathing apparatus to further reduce inhalation of irritating dust during threshing and should be worn when threshing under field conditions. Suitable ear muffs should also be used when the thresher is in operation.

Extraction methods for eucalypts, melaleucas, casuarinas, (capsulated fruit) and grevilleas: For small lots typically handled by the ATSC, the method discussed above under Extraction by hand is the most appropriate method. A careful inspection should be made to ensure that the fruit have fully opened before vigorously shaking by hand or when sieving. With eucalypts, the fertile seed is usually located near the bottom of the fruit loculi, and may not be as readily shed as the chaff located near the top of the capsule. Seed are more easily extracted from fruit of species with half-superior ovaries in which the valves spread more easily e.g. *E. camaldulensis*, than from fruit of species with fully inferior ovaries, e.g. *E. delegatensis* (Boland *et al*. 1980). Make certain there are no holes in the container as sharp sticks may have punctured the sheet or bag. For larger operations mechanical methods which combine drying and extraction are used as discussed by Boland *et al*. (1980).

Acacias: The method for extracting acacia seed depends on whether the seed can be freely removed from the pod or not. If the pod opens following drying and the seed is not attached to the funicle the fruit can be vigorously shaken or manually threshed as in the case of many bi-pinnate acacias (e.g. *A. mearnsii, A. dealbata*). However, where the seed is firmly secured to the pod by the funicle (*A. mangium*), the pod has to be broken up using the CSIRO 15 cm flailing thresher before the seed can be cleaned. For best results and to minimise cleaning problems and damage to the rubber flails, remove as much of the stick material as possible before threshing.

Fleshy fruited species: Fleshy fruit contain a relatively high percentage of moisture either in the fruit or in both the fruit and the seed. The method of seed extraction and storage depends on the structure of the fruit and seed.

- Indehiscent fruit which does not split open when dry is stored as fruit.
- Species with seed covered by a thin fleshy covering may be stored after drying.
- Other species require to have the fleshy outer coat removed (depulped) prior to storage in order to minimise micro-organism development and to allow the seed to be cleaned. In some instances the pulp is known to inhibit germination (Stubsgaard and Moestrup 1991).

Depulping of fleshy fruit should be done soon after collection to avoid fermentation and heating. However, in certain cases (e.g. *Aleurites* spp., *Azadirachta indica*) fermentation is known to assist in the depulping process where the outer fleshy fruit is hard. Ralph (1994) makes the point that some species (e.g. *Dianella*, *Coprosma* and *Hymenanthera*) require fermentation in the fleshy fruit before germination can occur. With these species, do not remove the fruit immediately but allow the fruit to ferment in a plastic bag for 2–4 weeks. However, Stubsgaard and Moestrup (1991) report that seed from fruit that have fermented until acetic acid has been formed may be badly damaged. Searle (1989) reported successful depulping of a wide range of fleshy-fruited tropical trees using a concrete mixer and varying combinations of sand, rocks and water.

The first step is to soften the flesh by soaking the fruit in a container of clean water until the pulp becomes soft enough to remove by hand or with equipment. This will normally take one or more days depending on the thickness and softness of the flesh. Thin soft flesh may not require any soaking whilst hard fleshy berries may take up to a week. Change the water daily and keep the fruit in a cool place. The skin of overripe fruits begin to shrivel and become sticky, making it more difficult to remove.

As an alternative to soaking, the fruit can be stored in heavy duty plastic bags. This method is used in the field where facilities are limited. Make sure the fruit does not heat up or start fermenting.

Small lots of seed are usually macerated by hand. Alternatively fruit may be macerated by rubbing them against or through a screen (Stein *et al*. 1974). The pulp and skins can usually be separated from the seed by washing through appropriate sieves or by differential flotation in a deep bowl through which a slow stream of water is flowing. The seed sinks while the pulp rises to the surface. Alternatively, the pulp can be spread out to dry before being pulverised and cleaned using sieves or winnowing.

2.2 Cleaning

Once the seed is separated from the fruit it is ready for cleaning. There are a number of methods that include sieving, blowing, winnowing, flotation or imbibing the seed followed by gravity separation. Complete cleaning of a seedlot may not always be possible or is impractical such as eucalypt species within sub-genus *Monocalyptus* in which the 'seed' and chaff are similar in size and weight and therefore can not be separated readily. Where seed can be cleaned to a pure state, there is a requirement that the seedlot have a minimum viability of 70% and purity of 95% (refer to Section 3.2.1). This requirement may be waived for small valuable lots (<20 g) where re-cleaning would result in the loss of viable seed.

2.2.1 Sieving

This method is most effective for the majority of species including eucalypts, melaleucas, acacias and casuarinas. It is normally the only method available for cleaning in the field. Sieves come in a range of sizes, apertures with sieve material made from either perforated plate or woven wire. For small seedlots, 20 cm diameter laboratory sieves with a wide range of aperture sizes are normally used whilst large sieves (50–80 cm in diameter) are preferred for large seedlots especially during the initial stages of cleaning. Mesh sizes in common use vary from 500 micron to 4 mm for eucalypts (see Table 2.1) and 3 to 12 mm for acacias. In the case of acacias, sieves are only effective once the funicle has been removed otherwise it tends to catch on the sieve preventing effective separation of the seed from impurities. A combination of a large and small aperture sieve can be effective in removing both large and fine particles. An example of this is cleaning *Angophora costata* where the chaff can be easily separated from the seed by use of a fine sieve while a larger aperture sieve removes the larger impurities. Even fly wire can be used for fine seed including *E. grandis, E. camaldulensis*, *E. pellita* and *E. urophylla* under field conditions.

2.2.2 Winnowing and vacuum cleaning

This procedure makes use of air currents to separate seed from impurities through differences in weight, resistance to flow of air (volume or shape), and the velocity at which the air moves. It is effective in cleaning acacias and to a lesser extent casuarinas and grevilleas. The ATSC has found that air separators based on the Kurt Pelz Saatmeister Mark 2 design (see Doran *et al*. 1983) are most effective in cleaning acacia seed. The machine is also useful for separating eucalypt seed from chaff as an alternative to sieving. The South Dakota blower described in Doran *et al*. (1983) is useful for small seedlots.

A vacuum cleaner is effective in separating light fluffy seed. Screens can be used to control what is sucked into the vacuum.

Table 2.1. Sieve mesh sizes suitable for listed species

Species	Mesh aperture (mm)
Angophora costata	4.75 [1]
Corymbia citriodora	2.8–3.35 [2]
C. maculata	2.8–3.35 [2]
C. torelliana	2.0–2.36
Casuarina cunninghamiana	1.4
Cas. equisetifolia	2.8
Eucalyptus camaldulensis	1.2
E. camaldulensis subsp. *simulata*	1.0–1.2
E. delegatensis	1.8–2.0
E. diversicolor	1.7–2.0
E. dives	1.4–1.7
E. fastigata	1.7
E. globulus	2.36–2.8
E. grandis	1.2
E. leucoxylon	1.7
E. microtheca	1.7
E. nitens	1.7
E. obliqua	1.7
E. occidentalis	1.4–1.7
E. pellita	1.4–1.7
E. pilularis	1.7–2.0
E. regnans	1.4–1.7
E. saligna	1.2
E. sideroxylon	1.2
E. tereticornis	1.0–1.2
E. viminalis	1.4–1.7
Melaleuca alternifolia	500–850 microns

[1] 1.7 (mm) to remove chaff

[2] alternatively air blower or gravity separator

2.2.3 Flotation

Density method. Flotation in water is effective for cleaning seed with hard seed-coats not subject to imbibing. The method relies on differences in density with the sound seed sinking to the bottom while the light material, including empty seed floating to the surface. The light material can then be skimmed off the top of the water and checked for viable seed before being discarded. The fraction that sinks comprising the seed is dried by spreading out in a thin layer to dry.

Absorption method. The method is very effective in separating insect attacked seed in a number of arid zone acacias (e.g. *A tumida, A. coriacea, A. torulosa*). The seedlot is left to soak for a day by which time the insect attacked seed, which normally have a small hole in the seed coat absorb water, thereby swelling. Following an initial surface drying, the insect attacked seed being larger and heavier, can be removed by sieving or air blowing.

2.2.4 Imbibing seed combined with density separation

Nurseries who raise large quantities of eucalypt seedlings frequently use automated vacuum type sowers to sow seeds into individual containers. To be effective, it is important that the seed be as pure as possible with chaff and other impurities removed to ensure a high strike rate with a single seedling in each container. In the case of eucalypt seed, the method can only be effective if the viable seed can be separated from the chaff. Where there is a large size difference between seed and chaff as in the case of *E. globulus*, conventional methods such as sieving and aspiration techniques can be readily employed. However, for species where it is difficult to separate seed from chaff using the above mentioned methods as in the case of species within sub-genus *Monocalyptus*, a combination of techniques including gravity tables, aspiration, winnowing and sieves have been used with mixed success depending on the species and seedlot.

Cliffe (1997) describes a technique for the improved separation of seed from chaff in eucalypts that has been in common practice in a number of countries round the world. The method is a two stage process involving imbibing of seed followed by density separation. Seed is first spread out in a thin layer on fine gauze trays before being placed in an incubator in which the temperature is

adjusted according to the optimum germination temperature for a given species (20–25°C). The seed is kept constantly moist often through an intermittent misting system rather than immersing the seed in water. In the case of *E. pilularis*, this takes about 40 hours. At this stage the testa starts to become translucent indicating that the seed is imbibing and must be removed to avoid radicle emergence. The seed is then placed in a sugar solution that will vary according to species and seed structure. In the case of *E. pilularis*, one kg of sugar is added to 1 litre of water (Cliffe 1997). Through gentle agitation and correct sugar solution, the imbibed seed should separate out from the chaff and other impurities.

The seed that is removed from the top fraction, is thoroughly washed prior to storage or surface drying. Cliffe (1997) in reference to *E. pilularis* reported that the imbibed seed can be stored for four to five days in containers of fresh water which must be sealed and kept in a refrigerator at a temperature of 3–5°C.

2.3 Registration and categorising seed

Once cleaned the seed is brought to the laboratory, weighed and registered by allocation of a unique seedlot number from the registration book. Allocation of the number is sequential by date of entry irrespective of species or origin. The seedlot number is then recorded on the seedlot container and linked documentation. The seed is then tested for viability, fumigated and stored. Seed is entered into the store as individual tree lots, bulk or both.

2.3.1 Individual tree and bulk weights

It is normal practice to bulk a portion of the seed from individual trees to meet client requirements. The amount of seed to be kept separate by individuals varies according to collection objectives and demand. The following weights are given as a guideline but it is the decision of the collector in consultation with the leader of the collection party and other staff involved with the collection to determine the seed split. In practice, it may be necessary to make up repeated bulks based on a portion of the remaining individual treelots and the demand for bulk.

Genus	Wt of seed kept as individuals (g)
Eucalyptus	25
Acacias	50
Casuarinas	25
Grevilleas	50

The balance of the seed should then be bulked by thoroughly mixing to produce a homogenous seedlot. There has been a tendency in the past to simply bulk all the remaining seed irrespective of the weight or viability of each individual used. This method is discouraged since it can result in bulks comprising disproportionate amounts of seed from one or a few individuals. For the purpose of preparing a bulk lot from individual trees, the following guidelines are recommended.

Research grade bulk, based on individual tree representation

- Bulk mixes made up from less than 5 trees are not classed as research grade.
- For bulks mixes made up from more than 5 trees, each individual tree seed weight represented in the bulk should not exceed 3 times or 1/3 the average seed weight of the individuals for inclusion in the bulk (e.g. Proposed bulk weight = 630g from 10 trees, average = 63g. Acceptable weight range 21–189g).
- Under special circumstances, where it is considered highly desirable to have equal representation of mother trees in the bulk such as in seed production areas, the bulk is prepared with seed weights per tree adjusted according to seed viability to give a theoretical even representation in the progeny produced.

Secondary grade bulk

The balance of seed left over following the bulking of the research grade forms a separate seedlot. It should not be used for provenance trials or the establishment of seed production areas, but may be used for plantation establishment provided the client is aware of its genetic makeup.

PLATE 3

(A) Harvested crops that are brought back to the ATSC are placed on racks in the drying room set at a temperature 25–35°C. Drying may take from less than a day to over a week depending on the condition and nature of the fruit.

(B) Sieving is frequently used to clean seed following extraction. Once cleaned the seed is placed in bags or other suitable containers.

(C) Once cleaned and bagged, the seed is allocated with a seedlot number from the register book. Allocation of the number is sequential by date of entry into the register irrespective of species or origin. The seedlot number is then recorded on the seedlot container and linked documentation.

Section 2

Appendix

2.4 Appendix to Section 2

Appendix 2.4.1 Example of a completed seed record card

SEED RECORD CARD

CSIRO Forestry and Forest Products Australian Tree Seed Centre

Seedlot No.	Species code	BOTANICAL NAME	Store code	Cost code
20269	CLD	EUCALYPTUS CLADOCALYX		

EXACT LOCALITY OF COLLECTION

Dbase DUTCHMANS
STERN NP SA
RIDGE TOPS ALONG WALKING TRAIL TO DUTCHMAN'S STERN

Forest Type OPEN WOODLAND TO OPEN FOREST

Associate Trees E. LEUCOXYLON
A. QUORNENSIS, CALLITRIS
ALLO. VERTICILLATA

Latitude (°S') 32 18 Longitude (°E') 137 58'

Altitude (m) 800 Aspect ALL Slope MOD

Geology and Soil QUARTZITE SANDY GRITTY LOAM

pH: 6.0

PARENT TREEE(S)

No. of parents — In bulk 8 / I tree 9

D.B.H. TO 80 (cm)

Total Height TO 15 (m)

Form

Remarks DOMINANT TREE ALONG RIDGE LINES

Fumigation method: YES CO2

Date: 6.99

SEED

Collector LARMOUR / WHITEFIELD

Collectors No. JSL 3096 - 3104

Collection date 20.5 99

Project

Identified by

Condition GOOD

Storage 18 to 22°C ☑ 3 to 5°C ☐ - 15 to - 18°C ☐

Quantity (g) 333

GERMINATION

Method	Date From	Date To	Viability/10 g (%)
20C TY	9.6.30	6.6.99	SEE OVER

Seedlot No. 20269 Seedlot No.

Tree No. JSL	Initial wt. of seed	Seed Split (g) Bulk	Seed Split (g) I tree	Viability/10 g (%)		Tree No.	Initial wt. of seed	Seed Split (g) Bulk	Seed Split (g) I tree	Viability/10 g (%)	
3096		12	26	275							
3097		20	46	475							
3098		20	58	500							
3099		20	40	700							
31 00		20	41	300							
31 01		15	33	2 400							
31 02		12	29	350							
31 03		20	52	525							
31 04			8	175							

Section 3

Seed Testing

The purpose of seed testing is to assess and monitor the physical quality of the seed from the time of collection through to sowing. The methods for seed testing used by the ATSC are based on the principles of accuracy and reproducibility described by the International Seed Testing Association (ISTA) rules. However, the procedures used by the ATSC and described in this section have been developed to meet specific seed testing objectives. Factors taken into account in developing the ATSC testing procedures include the specific characteristics of Australian tree species that are collected from wild populations that demonstrate considerable variation in seed characteristics both between species and seedlots of the same species, and the comparatively small size of the seedlots tested. In reflecting the considerable range in seed types it should be noted that there are over 1000 species contained in the ATSC standards made up of 80 genera. By contrast, ISTA's main emphasis has historically been on the development of procedures for commercially important agricultural and horticultural crops and trees from temperate regions.

The focus of seed testing is to determine the initial germination of each bulked seedlot and individual tree lot that is entered into the ATSC system and to monitor the seed during storage. The tests provide information on methods for breaking dormancy, germination conditions, viability tests, vigour, purity and moisture content. The initial four dish germination test results are entered into the germination standards (Appendix 3.10.1) and form the guidelines on which tests are conducted.

3.1 Sampling

When sampling, which is the first step in any seed testing, it is essential to obtain a sample of the right size to meet testing requirements and which is representative of the whole seedlot. The validity of the test result for a large seedlot in particular is determined by the success of obtaining a representative sample. The following procedures are to be followed prior to testing. For more information see Bonner *et al*. (1994), ISTA (1996), Peterson (1987), Scholer and Stubsgaard (1989), Schmidt (2000), Willan (1985).

Procedure

- Prior to sampling, seedlots comprising bulks and/or individual tree lots must first be thoroughly mixed as discussed under Section 2.3.1.

- In the case of seedlots stored in a single container, thoroughly mix the whole seedlot before taking three random samples to form a 'composite' sample. Each random sample should contain roughly 100 seeds.

- For seedlots stored in different containers (particularly relevant to larger containers 20–60 kg), mixing of the whole seedlot as part of the sampling strategy is impractical. Instead, samples are taken from three levels within the container and mixed with samples taken from each container to form a 'composite' mix for use in the test. In the case of seed stored in drums, a seed trier (see Plate 4A) is used for sampling. The following table is provided as a guideline when sampling seedlots stored in large quantities in different containers.

No. of containers	No. of containers to sample
Up to 5 containers	sample each container
6–30 containers	sample 1 in 3 containers (minimum of 5)
Over 30	sample 10 containers or at least one in every five

- The composite sample is then further reduced until a working sample, approximately twice the amount of seed required for the test, is obtained. There are a number of methods used for mixing and sub-sampling. The simplest method is to spread the composite sample on a clean flat surface (lab bench), divide into four to eight equal portions and alternate portions rejected leaving sufficient seed for the tests (Plate 4B). Other methods range from Boerner gravity fed divider (Plate 4C) for large seedlots (>10 kg), electrically driven Gamet divider (Plate 4D) for smaller weights (<10 kg) and gravity fed soil dividers.

3.2 Purity analysis

3.2.1 Physical purity

Tree seed may contain impurities such as twigs, leaf matter, fruit particles, soil, foreign seed and other material. When a purity analysis is done, it is often the first test to be carried out since subsequent tests (except moisture content) are made only on the pure seed component. As defined by ISTA (1996), the object of the purity analysis is to determine the composition by weight of the pure seed as a percentage of seed of other species and inert matter. The seed of other species and the types of other matter present in the batch should be identified as far as is possible. The distinction between true seeds of the species under investigation and trash can be ambiguous for some tree seeds, especially those that are de-winged (Bonner *et al*. 1994). Pure seed refers to the undamaged, undersized, shriveled, immature or germinated seed and pieces of seed resulting from breakage that are more than half their original size identified as the species under consideration (ISTA 1996). The smaller the seeds, the more difficult the purity test will be. In the case of eucalypts, no distinction is made between the pure seed and chaff components unless there is a requirement for a seedlot to contain only pure seed without chaff.

Procedure
ATSC does not routinely undertake purity tests unless the information is required for particular clients or the seedlot is considered to contain too many impurities. As mentioned in Section 2.2, seed entering the store must have a minimum purity of 95%. The seed tester must make a visual observation to determine whether the seed is sufficiently clean for storage and phytosanitary purposes and is free of damage by insects or other injuries. Where it is relatively easy to clean the seed using rapid cleaning methods, as for example, separating eucalypts with fine seed from leaf using sieves, then it is expected that the seed will be almost free of impurities. However, where mechanical methods are not effective for the separation of seed from particles then it may be necessary to accept some level of impurities in the seedlot. This situation is best avoided by ensuring the fruit are sufficiently free of impurities at the time of harvesting as discussed in previous sections. If it is determined that the seed contains excessive impurities, then it must be returned to the seed collector for re-cleaning before a germination test is carried out.

Determination of physical purity follows the principal rules under ISTA (1996) but with sample size reduced to take into account the comparatively small size of the seedlots handled by the ATSC. Purity tests are recorded on the Germination Test Sheet (Appendix 3.10.5).

- Sample weight to contain at least 700 seed units. For fine seed use the mean germination/10g figure contained in the Germination Standards for the species in question. (e.g. *C. maculata* has a mean germination of 1137/10g which when converted to 700 seeds = 7.1g).

- The total weight of the sample is weighed following which the pure seed is removed and weighed separately.

- The percentage of pure seed is calculated as follows:

$$\text{Purity } \% = \frac{\text{weight of pure seed fraction}}{\text{total weight of sample}} \times 100$$

3.2.2 Genetic purity

As distinct from agricultural crops where certified seed is produced under strict controls, such systems do not exist for the collection of seed from indigenous trees and shrubs growing in the wild. The genetic variations within individual Australian plants and geographic areas of occurrence are not well documented. Laboratory procedures using electrophoretic protein separation techniques (isoenzyme analyses) for determination of genetic purity have been used by the CSIRO Forestry and Forest Products (e.g. *E. cloeziana, E. camaldulensis, A. mangium, A. auriculiformis, A. crassicarpa, M. alternifolia, G. robusta*). The development of electrophoretic DNA separation

techniques has added a new tool for genetic purity testing. These techniques include Restriction Fragment Length Polymorphisms (RFLPs) and Simple Sequence Repeats (SSRs or microsatellites). The microsatellite technology is the same as is used for human "DNA fingerprinting" for forensic analysis and paternity testing and is the most suited to routine analysis. While DNA analysis is more powerful than isoenzyme analysis, because of the larger number of available marker loci and the larger number of detectable alleles at each marker locus, it is also considerably more expensive than isoenzyme analysis. It is therefore necessary to determine which technique is best suited to a specific case (C. Bell pers. comm. 1999). The following key references provide information on isozyme and DNA studies on specific Australian tree species: Butcher *et al*. (1998), Byrne *et al*. (1996), and Moran (1992).

3.3 Seed dormancy

The term 'seed dormancy' refers to a condition where a viable seed is prevented from germinating despite being provided with optimum germination conditions i.e. temperature, moisture, light and oxygen. To a large degree, dormancy is under genetic control (Bonner *et al*. 1994) which has enabled agriculturalists to breed out dormancy in crops. However, in woody species and particularly those from wild populations, no such artificial selections have been made, making seed dormancy an important consideration for many species. Environmental conditions during seed maturation and time of collection can influence the degree of dormancy.

The least severe treatment to overcome dormancy should be tested first to avoid damage to the seeds, then increasingly severe treatments can be tested as required. The germination standards provide information on pre-treatment requirements by species (Appendix 3.10.1).

Types of dormancy
There are basically two types of dormancy:

(1) Seed coat dormancy—mainly relates to a physical, chemical or mechanical condition that does not allow uptake of moisture by the embryo (e.g. *Acacia).* Alternatively the physical structure of the seed coat or fruit is too strong, preventing the swelling of the embryo (e.g. *Owenia vernicosa*).

(2) Embryo dormancy—inhibiting substances usually within the embryo or surrounding tissue prevent germination as in the case of a number of eucalypts.

3.3.1 Procedures to break seed-coat dormancy

Many species with hard coated seed (*Acacia*) are impervious to water and gaseous exchange. In order to promote germination and ensure it is both rapid and uniform it is necessary to apply some form of pre-sowing treatment. Fresh or immature *Acacia* seed (green and slightly shrunken in appearance) may not require as severe a treatment as that prescribed in the standards and for some *Acacia* species with soft or semi-permeable seedcoats a pre-treatment is not required and, in fact, may be harmful as listed in Appendix 3.10.2.

Boiling (100°C) and hot water treatments

- **Boiling water, pour and soak:** Seed is placed in glass beakers (100 ml) and approximately 10 times the volume of boiling water added. Seed is then left to soak for approximately 24 h at room temperature before sowing. The soaking process provides the opportunity for the seed to imbibe water and hasten germination.

- **Boiling water, immersion for 1, 2 or 5 minutes:** Water is first brought to the boil. Seed (placed in a perforated container, [Plate 5A]) is immersed in the boiling water for the nominated time then removed from the heat source and either placed directly into a germination dish e.g. (*A. aulacocarpa* complex*)* or in water at room temperature and allowed to soak for approximately 24 h before sowing.

- **Hot water treatments:** Although seed of most Australian acacias requires some form of boiling water pre-treatment in order to promote germination, there are a number of species or specific seedlots which respond better to a hot water treatment (90°C for 1 minute) including *A. mearnsii* (Poggenpoel 1978) *A. stenophylla, A. synchronicia, A. pachycarpa, A. pendula, A. tephrina*.

Acid scarification
Acid scarification is seldom used on seed of Australian acacia species (Doran 1997) with preference being given to alternate methods that are safer and easier to apply. However, the method

is recommended as an alternative treatment for seed of species with very thick seed coats, e.g. *Acacia bidwillii, A. farnesiana, A. fulva, A. fasciculifera* and *A. stenophylla,* and is commonly used in Africa for the treatment of indigenous acacias.

Seed is soaked in concentrated sulphuric acid (95%, 36N) at room temperature for a nominated time (30–120 min) (Bonner 1974) depending on the species. The seed is then removed from the acid and rinsed under running water for at least 10 minutes. This can be done by placing the seed, which is contained in a perforated steel tea infuser, in a 1 litre glass beaker and allow the water to run through the beaker.

CAUTION: Extreme care is required when handling concentrated acid. Only trained staff should administer this procedure which must be conducted in a fume cupboard. Never pour water into undiluted acid; rather pour a small quantity of acid into running water. Beware of the gases given off by this procedure. Laboratory coats, glasses and gloves (chemical resistant R103-104) must be worn. A concentrated solution of potassium or sodium bicarbonate may be used as an antidote against accidental splashes (Laurie 1974). Alternatively or in addition to, wash the affected area in running water or use an eye wash bottle. Seek medical attention if required.

Scarification or cracking of the seedcoat
Scarification abrades the seed coat permitting water absorption. Scarification may be by hand, especially for laboratory purposes, or by mechanically operated scarifiers which rotate the seed contained in a drum against a rough surface like sand paper (Plate 5B). The coarseness of the surface, duration of scarification, amount of seed and thickness of seed need to be taken into consideration when using this method. Seed is seldom mechanically scarified because of the ease and success of boiling water treatments. Poulsen and Stubsgaard (1995) provide information on three methods for mechanical scarification of hardcoated seed developed by the Danida Forest Seed Centre. These include (i) The 'seedgun' which slings seed against a hard wall causing cracking of the seed coat through impaction; (ii) a hot wire 'glow burner' similar to a soldering iron for use in manually treating individual seeds, and (iii) a 'mechanical burner' which uses a hot glowing thread and continuous seed flow for treatment of larger seedlots.

Manual nicking
Manual nicking is often used to determine optimum germination of a seedlot especially where boiling water treatments have not been successful. Secateurs, nail clippers or a scalpel blade can be used to remove a small section of the seed coat at the distal (cotyledon) end of the seed. Manual nicking is not suitable for a large number of seeds due to the time this operation takes. It is useful as a research tool for small numbers of seeds or to check the results of other pre-treatment techniques. Manual nicking is usually the most reliable results since it overcomes the problem of seed-coat variation. However, Marunda (1990) reported that nicked seeds are less vigorous and more susceptible to fungal attack. A vice can be used to split thick seed coated species, e.g. *Macadamia.*

3.3.2 Procedures to overcome embryo dormancy

Cold moist stratification
Stratification is used to overcoming embryo dormancy in a number of cool temperate eucalypts, *Bursaria occidentalis*, *Nothofagus* spp. and has been shown to be beneficial in tests on a number of cool temperate acacia species (e.g. *A. mearnsii, A. kybeanensis*). Seedlots of the same species also vary in their dormancy. In a study on six provenances of *E. glaucescens* covering the species natural distribution, Doran and Gunn (1979) found that the optimum germination occurred following 6 weeks of cold moist stratification for four provenances, 2 weeks stratification for one provenance and in the case of the Mt Tingiringi NSW provenance, stratification did not improve germination.

Cold moist stratification of seed follows the same procedure used for establishing germination tests as discussed under Section 3.4. Petri dishes or other containers are set up as for a normal germination test. Once the test has been set up the seed is first stratified under moist conditions at 3–5°C for between 3–9 weeks depending on the species (see Appendix 3.10.3). Once the stratification period is complete the containers are removed and placed in germination cabinets at the appropriate temperature.

Whilst not a prescribed treatment to overcome physiological dormancy, some problem species may respond to chemical treatments as follows:

- hydrogen peroxide—seedcoats are cut to expose the radicle and incubated in a 1% hydrogen peroxide (H_2O_2) solution for 48 hours in the dark with alternating temperatures of 20 and 30°C. Radicle growth is measured after 3 to 4 days (Bonner *et al*. 1994). The method is not practical for very small seeds and may take 7 to 8 days to get a result. Schmidt (2000) provides a slightly different method using H_2O_2.

- citric acid—soak seed for 48 hours in a 1% citric acid solution, or combined with stratification (Bonner *et al*. 1994).

- potassium nitrate (KNO_3)—0.2% KNO_3 solution, prepared by dissolving 2g KNO_3 in 1 litre of water, is used to saturate the germination substrate at the beginning of the test (ISTA 1996). This method is used for a number of agricultural and vegetable seeds as indicated in the ISTA rules. However, the method has not been used by the ATSC.

- gibberellic acid—Bachelard (1967) found that the germination of dormant seeds of *E. delegatensis, E. fastigata* and *E. regnans* could be improved by 24 hours immersion in GA_3 at concentrations of 50 and 100 mg/L and germinated at 21°C. Gordon (1979) reported that *Nothofagus obliqua* seed treated in GA 4/7 gave rapid germination within 14 days compared with the normal procedure of 28–42 days stratification. ISTA (1996) also refers to the GA_3 method for breaking physiological dormancy in seed.

For additional information on the types and methods for breaking dormancy see: Adkins and Bellairs (1997), Boland *et al*. (1980), Bonner *et al*. (1994), Doran *et al*. (1983), Langkamp (1987), Schmidt (2000), Willan (1985).

3.3.3 Procedures for removing inhibitory substances

Seed of many Australian species contain inhibitors in the seed coat that prevent or delay germination. In such instances the inhibitor is leached out by placing the seed under running water for several hours or even days or soaking the seed in a large volume of water that is changed at frequent intervals (every 6–12 hours). It has been reported by McKintyre and Veitch (1972) that seed of *Eriostemon australasius* successfully germinated after chipping of the radicle end of the seed coat followed by leaching in running water for two weeks. Seed of *Correa* species are also reported to improve their germination substantially following soaking in running water for one to two weeks (Elliott and Jones 1980). Bonney (1994) reported that ripened seed of *Boronia* and *Eriostemon* need to be placed in moving water for many hours to help leach out inhibitors. This can be achieved by suspending the bag of seed in the cistern of a flushing toilet. Other leaching methods that have been used include alkaline solutions. For *Themeda triandra* (syn. *T. australis*) Groves *et al*. (1982) suggested various methods to overcome dormancy; gibberellic acid, removal of the glumes and/ or palea and lemma and that dormancy is normally overcome naturally after six to ten months in storage. Tests on *T. triandra* by the ATSC experienced similar results with nil germination on fresh seed and successful germination after 4 months.

Recent research into the treatment of certain species, particularly from Western Australia, using varying degrees of smoke normally in the form of ‘smoke water’ has shown promising results (Dixon *et al*. 1995). High levels of sulphur and ammonium, available in the smoke, may be the combined triggers to break seed dormancy (Bonney 1994). The method entails the pretreatment of seed by soaking for approximately 6 to 24 hours in a 10:1 water. Smoke water is available from Kings Park, Perth, Western Australia under the name of Kings Park Seed Starter. The ATSC assessed the effects of pre-treating seed with smoke water on a range of species to include: *Acacia calamifolia, A. pycnantha, A. spongolitica, Allocasuarina acutivalvis, Banksia integrifolia* var. *compar*, *Dillwynia retorta, Eucalyptus delegatensis, E. polybractea, Grevillea pteridifolia, Isopogon anemonifolius, Lomandra longifolia* and *Themeda triandra*. For each species, seed samples were initially subjected to a pretreatment of diluted smoke water (10:1 by volume of water to smoke solution) for 24 hours. After treatment the seed was tested for germination following the ATSC germination standards. A comparative germination test was also set up at the same time except that in this case the seed did not undergo a smoke water pretreatement. The results showed no significant difference between treatments for all species.

Fermentation of seed such as *Eremophila*, *Santalum*, *Nitraria*, can also be helpful (Bonney

1994). The author also noted that *Grevillea* and *Dianella* species responded to peeling or slitting of the seed.

3.4 Germination testing

All seed entered into the store requires an initial germination test followed by five year re-tests on seed remaining in storage. A set of germination standards (Appendix 3.10.1) has been prepared based on controlled laboratory test results carried out by the ATSC. Emphasis has been placed on *Eucalyptus, Acacia, Casuarina, Allocasuarina, Melaleuca, Callitris* and *Grevillea* but also includes a number of other Australian genera.

3.4.1 Test conditions

Where possible, germination tests should be carried out using a known number of seeds per replicate. Standard procedure is to select 25 randomly selected seeds for each replication which are then weighed in order to calculate germination/10g prior to being placed on the substrate (Plate 5C, 5D). However, for fine seed such as in the case of eucalypts and melaleucas, it is not practical and in many cases not possible to count the number of seeds, thus tests are on a known weight basis. Test weights are given in the standards and are based on obtaining approximately 50 germinants per replicate. The following table is used in determining the number of replicates required for a given seedlot weight.

Bulk seedlots	Seed weights [1]	No. of replicates
Replicates based on known **number** of seeds e.g. *Acacia, Grevillea*	<8kg	3
	8–12 kg	12
	>12 kg	16
Replicates based on known **weight** of seed e.g. *Eucalyptus, Melaleuca*	<8kg	4
	8–12 kg	12
	>12 kg	16

Qualifications to the above.

[1] For seedlot weights which are less than those prescribed only a single replicate is required:
For seeds which can be readily counted e.g. acacias, senna. Seedlots containing <10 g no germination test is required.
For **fine** seeded species e.g. casuarinas, eucalypts, melaleucas. Seedlots containing <5 g no germination test is required.

Germination containers: Tests are normally conducted using 9 cm diameter glass petri dishes in which the seed is placed on a moist substrate of No.1 grade vermiculite (30 ml). Filter paper (Whatmans No.1) is placed on top of the vermiculite when conducting germination tests on fine seed for ease of identification. In some species leachates from the seed or chaff become concentrated on the paper and cause the radicles to become deformed. With these species it is necessary to germinate the seed directly on vermiculite (see Appendix 3.10.4). For larger seed use is made of clear plastic containers including 'Petawawa' trays.

Controlling fungi: Fungal problems are generally associated with poor quality seed as in the examples of immature, damaged seed or old seed which has lost considerable germination and vigour. Fungal development is also associated with acacia seed subject to insect attack or where the pre-treatment has been too severe. Sound hygienic practices as discussed under Section 3.8 will provide effective preventative measures in the control of fungi. Other laboratory practices include preventing seeds from touching each other, adequate aeration, removal of decayed seed, avoidance of pre-treatments that cause injury to the seed and keep the substrate moist (there should be no signs of free water). Where chemical controls are required the ATSC has soaked seed for 10 minutes in a 1% solution of sodium hypochlorite followed by a rinse and surface drying before sowing to treat for possible external infections. Bonner *et al*. (1994) recommends a 10% sodium hypochlorite (NaOCl) solution or a 30% solution of hydrogen peroxide (H_2O_2) for 20 minutes. In a study by Yuan *et al*. (1990), observations were made on the presence of fungi on germinating seedlings of *Eucalyptus*, *Acacia* and *Casuarina* species with and without sterilisation. The results found only a weak correlation between the frequency of seed germination and the level of fungal infection. Contamination above a level of 60% did not result in further depression in germination frequency.

Moisture: Distilled water should be added to the substrate (28 ml for 30 ml of vermiculite). The substrate should be wet but not saturated. Avoid excessive moisture that can lead to fungal and bacterial problems. Ensure that the container lid fits firmly and check the moisture level regularly, particularly in the cabinets set at 30 to 35°C.

Temperature: Temperatures for germination of most species are in the range of 15° to 35°C. Temperature requirements for species cited in the Germination Standards are based on tests conducted in growth cabinets and on a thermogradient bar set at a temperature range of 10–40°C. Seed is tested under constant temperatures with the exception of *G. robusta* for which there is empirical evidence that an alternating temperature of 30°C daytime and 20°C at night may be advantageous. Bonney (1994) reported that alternating day/night temperatures for seeds of semi and arid areas of South Australia play a large role in promoting germination. Grose (1962) found little difference in germination between constant and alternating temperatures for a number of eucalypts tested, however, the rate of germination was slower under alternating temperatures. Seed of tropical species tend to have optimum temperatures of 25–35°C, whilst those from alpine environments and southwest Western Australia often prefer 15–20°C.

Light: As discussed in Boland *et al*. (1980), light is required for the successful germination of eucalypts particularly where the temperature is sub-optimal. The germination cabinets are fitted with 2 × 30 watt cool fluorescent tubes which provide 12 hours of light per day.

Germination counts: All tests are recorded on a 'Germination Test Sheet' (Appendix 3.10.5). The sheets record details of the seedlot, method of test, replication weight, date of germination count and number of germinants. Counts should be carried out at regular intervals (Plate 5E). The number of counts per week depends on the rate of germination and ranges from one to two times per week. The test period given in the standards is only an indicator based on previous tests and varies from 10 days to over one month. However, tests should not be concluded if it is obvious that germination is likely to continue. Old seed, particularly where stored in the cool room or deep freeze, often take longer to germinate.

3.4.2 Evaluation

The time at which a germinant is counted as normal varies. In the case of eucalypts, counts are made once the seed coat has been shed. For acacias the radicle must be at least three times the length of the seed. Once counted, the germinants are discarded. Abnormal germinants to include albinos, abnormal cotyledon, radicle, hypocotyl or mouldy germinants should also be recorded as indicated on the Germination Test Sheet.

On completion of the germination test, a count of non-germinated seed (squash test figure) is made. With eucalypts and other small seed, a pair of tweezers is used to squash non-germinated seed. Any seed found to have a firm white embryo is considered to be potentially viable. For acacias, forceps can be used for soft seed otherwise the seed is subject to a cut test. A record should also be made of insect attacked seed. The count of viable acacia seed should be recorded according to hard or soft seed. This indicates whether the pre-treatment was insufficient (i.e. high % of hard seed) or whether the seed coat was soft indicating that the pretreatment had been effective but that the germination conditions were not right. Mouldy seed should also be recorded as this reflects injured or dead seed.

Steps taken when assessing results

- The number of normal seedlings produced is calculated and converted to a germination figure per 10g. This is a more conservative and realistic figure than referring to seed viability where it includes sound non-germinated seed in the final figure. Where the number of seeds is known, a figure for average germination percentage is also calculated.

- The germination results are compared with the standards and tolerance tables (Appendix 3.10.7A & B) to assess whether the variation between replicates is within acceptable tolerances. If an inexperienced seed tester has run the tests, the results should be shown to an experienced staff member to determine whether the test should be accepted. If the germination figures between replicates are beyond the accepted tolerances, then the seedlot must be retested.

- High squash test figures (>25% of total germination), are not acceptable making it necessary for the tester to seek an explanation. It might be that the seedlot contained too many dead or damaged seed, pre-treatment or germination conditions were sub-optimal or whether there was operator error. Based on the findings, the tester must decide whether the seeds needs to be recleaned, retested, both of which may require a cut test, or whether to accept the test and enter the results into the system.

- In the case of germination tests on bulk seed, the results are used for updating the ATSC germination standards. Results of the test are transferred from the test sheet to the provenance sheet, seed record card and seed database. The pre-treatment code is also included on the seed database.

3.4.3 Re-test

Re-tests are carried out on seed where the initial test gave unsatisfactory results (see above), where there have been changes in the composition of the seedlot (e.g. re-cleaning) or after each 5 year period in storage.

- For initial retests and where the composition of the seedlot has been changed, the retest is comprised of four replications.

- 5 year re-tests: 1 dish test for weights under 8 kg, thereafter one quarter of the number of replicates indicated for bulk seedlots under Section 3.4.1.

- Re-test figures are recorded on the card and seed database.

It has been found that following a period in storage, that acacia seeds often require a more severe pre-treatment compared with the initial test (C. Doran pers. comm. 2000). It may therefore be more effective when testing acacia seeds after 5 years in storage to use the standard pretreatment method plus a more severe method. The following guidelines should be used in determining what action to take following a drop in germination over the previous test results:

- For seedlots of orthodox species stored in air-conditioned rooms (18–20°C) with MC $<8\%$. Should the average annual germination capacity for a species drop more than 6% (compare germination retest figures with original figures across the range of seedlots for a given species), then serious consideration should be given to recommending that the species be routinely stored in the cool room.

- Once a seedlot has dropped its viability by 35% over the original test figure, then an assessment must be made on whether to replace it if an alternative seedlot is not already in the seed store.

- Once germination for a seedlot drops below 50% of the original figure, a decision must be made on whether to discard the seedlot from the system (Schmidt 2000). In determining whether to discard the seed, consideration must be given to the value of the seed i.e. whether it is the only seedlot represented in the system, amount of seed and can it be replaced.

3.4.4 Vigour test

Vigour is used to determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions. Seed vigour declines more rapidly than the ability to germinate (Bonner *et al*. 1994). Specific vigour tests are not routinely carried out by ATSC. However, it is important that a vigour assessment (based on germination data) is made when conducting 5 year retests particularly where the seed is more than 10 years old. For most tree seed, the rate of germination is the most practical expression of vigour. This can be assessed by determining the time taken in days for 50% germination to be achieved. Alternatively compare the time taken for germination to be completed with the standards or if available the previous test for the specific seedlot. If the time taken for germination to be completed (when 90% of the seed has germinated) is greater than one third of the final count day recommended for a given species (refer germination standards), then it should be considered that there is an unacceptable lack of vigour. An assessment can also be made on the development of individual germinants as to whether it is stunted, has growth abnormalities and whether it has sufficient vigour to shed the seed coat. When using germination data to determine vigour, more frequent counts are required i.e. every one or two days. For additional information, see Bonner (1984); Schmidt (2000); Willan (1985).

3.5 Indirect viability tests

X-ray: This method offers a quick estimate of seed viability and is non destructive but can only be applied to seed with a diameter over about 5 mm. The ATSC has used the method for small and rare seedlots or seed of species that do not germinate readily (e.g. *Terminalia*). The ATSC has a Faxitron X-ray machine with power range of 5–30 KVP. Medical negative x-ray film (Dupont Cronex 13 $\times$ 18 cm) is used in conjunction with an automatic developer. Instant Polaroid 4 in $\times$ 5 in positive images can be used but are more expensive and lack clarity compared with negative film. Contrast agents are used to increase the density of

certain tissue by treating the seed prior to exposure. These agents include barium chloride ($BaCl_2$) and silver nitrate ($AgNO_3$). Seed are soaked for one hour after full imbibition and salts impregnate dead or damaged tissue thus greatly increasing the density of the tissue image on the radiograph (Bonner *et al*. 1994). Vaporous agents as for example chloroform ($CHCL_3$) can also be used. Interpretation of the seed images requires experience and as a rule over estimates the germination capacity of a seedlot. Film should be stored at 4°C. Staff must be instructed in the procedure, including safety aspects. The ACT Health Authority Radiation Safety Section makes inspections of the unit once a year. For further information see Schmidt (2000); Simak (1991); Willan (1985).

Excised embryo test: Seeds are soaked for 1–4 days before the embryos are excised and placed on moist filter paper in a petri dish (Willan 1985). The embryos are germinated under constant light for 10 to 14 days at the temperature nominated in the germination standards. The method is slow and suited to larger seeds. The technique could have application for determining whether seed dormancy can be attributed to the seed coat or the embryo by germination of seed with the seed coat attached compared to germination of the excised embryo.

Cutting test: This is a simple viability test in which the seed is cut open lengthwise and the endosperm inspected to determine whether the seed is viable or not. The method is not suited to fine seed. Good seeds are firm, white to ivory, sometimes green in colour with the endosperm taking up the complete space inside the seed coat. Non viable seeds are discoloured (grey), shrunken, damaged to include insect attack. The ATSC uses this method as a tool to estimate the quality of seed at the time of collection in the field and determine whether it is mature enough to collect. It is also used for acacias to assess whether the cleaning process is sufficiently rigorous. At the completion of a germination test the method is used to determine the condition of those seeds which have not germinated. The method is fairly reliable for healthy, fully mature fresh seed, but less reliable for seed that was collected slightly immature and for older seed.

Squash test: The basic approach is similar to a cut test except that the seed is squashed often using a pair of tweezers since it is more applicable to fine seed with a soft seed coat (eucalypts, melaleucas) where cutting in half is not a practical option.

The main application for this method at the ATSC is to determine which remaining seeds are viable following a germination test. The method can also be used to determine viability of a seedlot as follows. Seeds are first soaked in water for 1 to 4 days. The water is then drained off and individual seeds are squeezed gently using a pair of tweezers and visually inspected to assess the number of viable seeds. For fine soft oily or moist seed (eucalypts), spread the seed samples between two pieces of absorbent paper (brown). Roll a glass bottle or rolling pin over the seeds with enough pressure to crush them against the paper. Viable seeds will leave a stain on the paper whereas dead seed and chaff will not stain. Count the stains to determine the number of viable seeds per unit weight (Quayle and Gunn 1998).

Tetrazolium chloride: (TZ) (2,3,5-triphenyl tetrazolium chloride) is used to differentiate living from dead tissue through staining live tissue red. The concentration normally used should be 1.0%. For specific instruction on the procedure to follow refer to the ISTA Rules.

Hydrogen peroxide: Bonner *et al*. (1994) provides the following technique. Seedcoats are cut to expose the radicle and incubated in 1% hydrogen peroxide (H_2O_2) in the dark with alternating temperatures of 20 and 30°C. Radicle growth is measured after 3 to 4 days, then the seeds are placed in fresh hydrogen peroxide. Radicle growth is measured again at 7 and 8 days. Developed on barley, the test is used on many North American conifers. Evaluation is based on radicle growth. 5 mm growth or more is good; less than 5 mm growth is classed as uncertain; no growth is non viable. The method is not practical for very small seed, and has only been tested on conifers amongst tree seeds.

Distinguishing seed from chaff: The difficulty of separating seed from chaff with eucalypts depends on the species. Most problems occur where the seed and chaff are of similar size, weight and colour as in the case of *E. cloeziana* and most species within the sub-genus *Monocalyptus*. A method for distinguishing seed from chaff in *E. obliqua* (*Monocalyptus*) was devised by Mount (1972). Seed was soaked in distilled water to which was added a drop of detergent which acted as a wetting agent. After a few hours a pale patch formed on the flat sides of the viable seed and the

edges became dark, whereas the chaff developed pale edges.

3.6 Moisture content

Moisture contents (MC) of the seed along with storage temperature are the most important factors affecting seed longevity in storage. It is therefore important to be able to determine seed MC accurately for processed seed, when drying seed as part of reducing the moisture content prior to storage or assessing the effects of storage conditions on seed moisture. The ATSC does not routinely determine moisture content of seedlots entering the system. However, as discussed under the section dealing with seed storage, a standard procedure has been developed for the routine reduction of seed moisture in orthodox seed down to 8% or below which will require more attention towards MC testing.

There are a number of methods for determining moisture content of seed. The oven drying methods prescribed by ISTA is routinely used by the ATSC. Other methods designed for more rapid results include electric meters and infrared driers.

3.6.1 Oven method

The oven method follows the procedures prescribed in the ISTA Rules (1996).

Equipment and other factors to consider

Fan forced oven

Aluminium containers with numbered base and lid

Desiccator and silica gel

Balance, accurate to 0.01g

Moisture content test sheet

Tongs, gloves

Ensure oven has reached desired temperature before use

Two representative seed samples with a weight in excess of 4 g

Any seed >10 mm in diameter should be ground up to facilitate drying or sliced into 5 mm thick sections

Refer to ISTA Rules for allowable tolerance between replicates

Low constant temperature oven method
Seed is weighed in a lidded aluminium container prior to drying. The oven is heated to 103°C before drying the seed for 17 hr ±1 hr. Time starts when the oven returns to the nominated temperature following the placement of the seed in the oven and closure of the door. The container tops are removed when placed in the oven and replaced again after completion in the oven prior to being cooled in a desiccator with silica gel for 30 to 45 minutes. After cooling, the seed and container are re-weighed. Check the balance is tared between weighing. This method is used for most species especially those with high moisture contents or oily seed. Under ISTA (1996) rules, Table 9B specifies that all tree seed should be tested using the low constant temperature oven method.

High constant temperature oven method
The procedures are the same as above except that the seed is subject to a temperature of 130 to 133°C for 1 hour. This method has been compared with the low constant temperature oven method for a range of eucalypt species and found to give similar results.

3.7 Authenticity test

Species with similar adult botanical characteristics or where there is possible hybrid seed may be able to be more confidently identified on the basis of seedling characteristics. This requires raising seedlings in order to authenticate the species or to assist in decisions where seedlots are suspected of being mixed or of hybrid origin.

3.8 Laboratory hygiene

The laboratory seed testing area should be cleaned after completing any test or counting procedure. Used petri dishes should be soaked overnight in disinfectant (1% Ammonia) and washed thoroughly in hot water. Disinfectant should be used to wipe down laboratory benches. Tweezers, used for seed counting, are soaked in 70% ethanol solution with distilled water between germination counts on each dish to avoid fungal contamination between replicates. All equipment should be cleaned between seedlots to avoid contamination.

3.9 Laboratory safety

CSIRO staff and others affected by work carried out by CSIRO, Chiefs of Divisions and Officers-

In-Charge as 'local site proprietors', must exercise on behalf of the Organisation, the 'duty of care'. While responsibility for health and safety in CSIRO is a prime function of all levels of line management, staff are responsible for complying with all occupational health and safety instructions and taking action to avoid, eliminate or minimise risks to themselves and others. Staff must promptly report every new identified hazard, incident or accident in the workplace.

Whilst ATSC activities associated with the lab should be considered as 'low risk' there are however, a number of specific activities or materials for which there is a potential risk. These include:

- Pre-treatment of seed using acid. Refer to the text under Section 3.3.

- Fungicides on seed. The ATSC discourages treating seed with fungicides. When ordering seed particularly from overseas countries, it should be requested that the seed not be dusted with any fungicide. Where a fungicide is applied, information on the fungicide should be provided with the seed shipment. Seed which has been treated with a fungicide should on arrival at ATSC be handled with care. Staff should use gloves, and a face mask. Where considered appropriate, the seed should be washed using the lamina flow facilities available in the upstairs labs.

  For seed required to be treated with a fungicide prior to dispatch or for other purposes, the officer should take the same precautions as described above.

- Fumigated seed. The ATSC routinely fumigates seed with carbon dioxide, which does not put the user at risk. However, there are occasions where the seed is fumigated with methol bromide by quarantine on arrival in the country or by the dispatching organisation. Under these circumstances, it is important to allow for adequate aeration of the seed by spreading the seed out in a well ventilated area away from people for sufficient time to allow the fumes to be dispersed.

  Use of vermiculite. Under the Material Safety Data Sheet (MSDS Ref. AP91R3), vermiculite is regarded as an irritant if inhaled. For personal protection against respiratory problems, wear a filter respirator suitable for dust and minimise dust generation during handling.

PLATE 4

Mixing and sub-sampling can be carried out using a number of different methods:

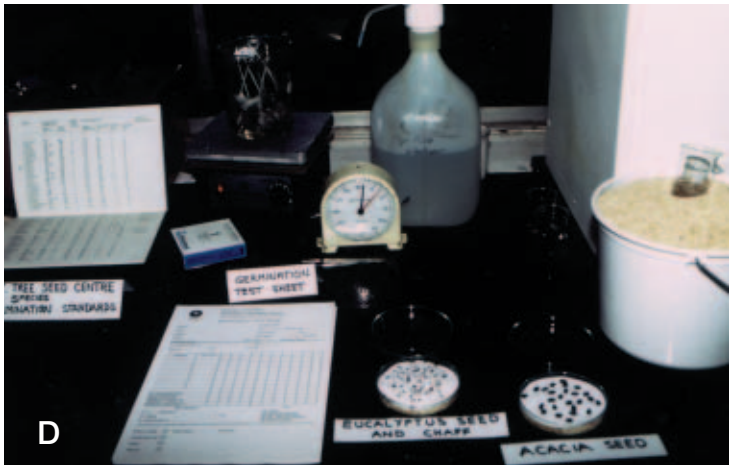
(A) Seed trier

(C) Boerner divider

(B) Manual sub-sampling

(D) Gamet divider

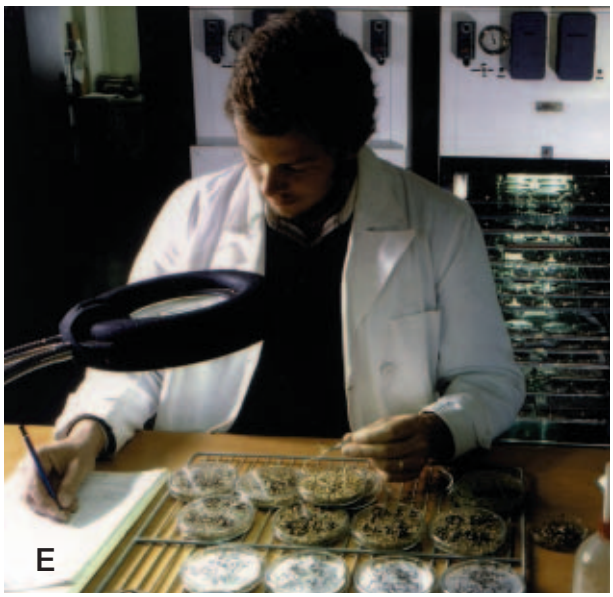
PLATE 5



(D) Example of equipment and materials required for setting up germination tests

(A) Pre-treating *Acacia* seed using boiling water for a nominated period of time

(B) Motor driven scarifier used to pretreat acacia seed



(E) Following germination in growth cabinets in which light and temperature are controlled, germinated seed is removed and recorded on a germination test sheet

(C) Sub-sampling and counting out the required number of *Acacia* seed in preparation for pretreating and establishing a germination test using a sub-strate of moist vermiculite in 9 cm petri dishes

Section 3 Appendices

3.10 Appendices to Section 3

3.10.1 Germination standards list of genera

Appendix 3.10.1 ATSC germination standards

Species	Germination per 10g [I]		No of seed-lots tested	Highest recorded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
ACACIA											
acinacea	500	0	1	500		(25)	17	37	E	TV	Acid soak
acradenia	1017	0	8	1333		25	4	21	E	TV	
acuminata	345	0	2	500		(25)	4	21	E	TV	
adsurgens	1128	285	19	1628		25	9	30	E	TV	
adunca	380	0	1	380		(25)	6	27	E	TV	
alleniana	511	0	4	857		(25)	6	20	E	TV	
ammobia	981	0	2	1430		25	5	21	E	TV	
ampliceps	377	107	32	621		25	9	30	E	TV	
anaticeps	10	0	5	12		30	5	20	EF	TV	
ancistrocarpa	228	59	17	393		30	4	21	E	TV	
aneura	652	0	7	1139		25	4	21	E	TV	
anthochaera	209	0	1	209		(25)	4	21	E	TV	
aphanoclada	230	0	1	230		(25)	4	21	E	TV	
aphylla	618	0	1	618		(20)	4	21	ED	TV	
arepta	1041	0	1	1041		(25)	4	21	E	TV	
argyrophylla	190	0	2	271		(25)	8	60	E	TV	
atkinsiana	986	0	2	1180		(30)	4	15	E	TV	
aulacocarpa	540	0	1	540		25;30	5	21	ED	TV	
auricoma	310	0	1	310		(30)	4	21	CE	TV	
auriculiformis	417	115	139	676		25;30	4	26	ED	TV	
auriculiformis × *leptocarpa*	441	0	1	441		25;30	4	21	E	TV	
baileyana	460	0	1	460		(25)	4	30	E	TV	
bakeri	175	0	1	175		(25)	4	21	C	TV	
bancroftii	103	0	2	185		25	4	21	E	TV	
beauverdiana	1	0	1	1		(20)	5	21	G	TV	
betchei	572	0	1	572		(25)	3	20	E	TV	
bidwillii	30	0	2	30		25	7	21	H	TV	1 hour acid soak
binervata	430	0	4	458		(25)	4	21	ED	TV	
binervia	1075	0	2	1500		(25)	4	10	E	TV	
bivenosa	322	0	10	480		(25)	4	21	E	TV	
bivenosa × *ampliceps*	287	0	1	287		(25)	4	21	E	TV	
blakei	1048	0	3	1375		25	4	21	E	TV	
blakelyi	431	0	3	500		(25)	7	24	DE	TV	
blayana	156	0	6	243		(25)	4	21	ED	TV	
brachybotrya	320	0	1	320		(25)	10	28	E	TV	

Appendix 3.10.1 Acacia continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
brachystachya	508	0	3	836		(25)	6	12	DE	TV	
brassii	816	0	5	1150		25	5	21	E	TV	
burkittii	230	0	1	230		(25)	5	20	E	TV	
burrowii	1627	0	8	2222		25	0	0	E	TV	
buxifolia	445	0	1	445		(25)	4	17	E & P	TV	
calamifolia	404	0	4	665		(25)	5	30	E	TV	
calcicola	235	0	1	235		25;30	4	17	E	TV	
cambagei	227	0	2	250		25	5	21	A	TV	
cangaiensis	339	0	1	339		(25)	4	21	E	TV	
cardiophylla	475	0	1	475		(25)	4	21	E	TV	
celsa	643	0	2	700		(25)	4	21	E	TV	
chinchillaensis	162	0	1	162		(30)	8	32	D	TV	
chrysotricha	273	0	2	520		(25)	4	21	E	TV	
cincinnata	823	97	11	1052		25;30	4	21	E	TV	
citrinoviridis	202	0	8	240		30	5	21	E	TV	
colei var. *colei*	740	163	46	1461		25	5	21	E	TV	
var. *ileocarpa*	768	0	7	888		25	5	21	E	TV	
complanata	86	0	2	154		30	4	21	E	TV	
concurrens	892	0	3	1097		25	3	21	E	TV	
conferta	297	0	2	545		(25)	5	26	E	TV	
confluens	203	0	1	203		(25)	7	20	E	TV	
conspersa	885	0	1	885		(30)	7	20	E	TV	
coolgardiensis	4475	0	2	6250		(20)	6	21	D	TV	
coriacea											
ssp. *coriacea*	68	0	4	114		25	5	25	ED	TV	
ssp. *pendens*	70	0	5	93		25	7	21	ED	TV	
ssp. *sericophylla*	70	30	13	108		25	6	26	D	TV	
covenyi	720	0	1	720		25	7	21	E	TV	
cowleana	758	0	7	1186		25	5	21	E	TV	
crassa ssp. *crassa*	867	0	3	999		(25)	3	20	E	TV	
crassicarpa	309	76	79	575		25;30	5	25	E	TV	
cretata	1053	0	1	1053		25;30	4	25	E	TV	
cultriformis	590	0	1	590		(25)	6	21	D	TV	
cupularis	806	0	1	806		20	4	21	E	TV	
cuspidifolia	113	0	2	116		(25)	3	21	CE	TV	
cuthbertsonii	46	0	6	63		(25)	5	24	CF	TV	
cyclops	238	0	3	270		(25)	7	24	E	TV	
cyperophylla	208	0	2	235		(30)	5	26	D	TV	
dangarensis	463	0	1	463		(25)	6	17	E	TV	

Appendix 3.10.1 Acacia continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
dealbata ssp. *dealbata*	532	165	49	960		(25)	6	23	E	TV	
deanei											
ssp. *deanei*	447	0	5	546		25	3	25	E	TV	
ssp. *paucijuga*	186	0	1	186		25	5	20	E	TV	
decora	660	0	1	660		25	6	25	E	TV	
decurrens	568	0	7	666		(25)	5	25	E	TV	
delibrata	228	0	2	266		30	5	25	N	TV	
denticulosa	662	0	1	662		20	5	20	E	TV	
dictyophleba	833	199	13	1280		(25);(30)	5	20	EN	TV	
dietricheana	305	0	1	305		(25)	5	21	D	TV	
difficilis	374	103	16	561		25;30	4	21	E	TV	
difformis	100	0	1	100		(25)	5	25	E	TV	
dimidiata	192	0	4	226		(25);(30)	7	25	E	TV	
diphylla	1916	0	1	1916		(25)	5	15	E	TV	
disparrima											
ssp *calidestris*	421	0	2	450		(25)	5	21	ED	TV	
ssp *disparrima*	416	0	6	546		(25)	5	21	ED	TV	
distans	525	0	1	525		25	3	24	D	TV	
doratoxylon	956	0	1	956		(25)	5	21	E	TV	
drepanophylla	246	0	1	246		25	4	15	A	TV	
drummondii	800	0	1	800		15	15	40	E	TV	
dunnii	19	0	4	28		25	10	30	N	TV	
effusa	260	0	1	260		(25)	7	14	E	TV	
elachantha	944	1149	36	7580		25	5	15	E	TV	
elata	200	36	12	248		(25)	3	21	DE	TV	
elongata	1095	0	1	1095		(25)	5	20	E	TV	
eriopoda	595	118	11	776		(25)	5	21	E	TV	
eriopoda × *tumida*	205	0	1	205		(25)	5	21	E	TV	
estrophiolata	280	0	1	280		(25)	4	20	D	TV	
everestii	255	0	1	255		(30)	2	20	D	TV	
excelsa	163	0	2	225		(25)	5	20	E	TV	
exilis	710	0	1	710		(30)	7	14	E	TV	
falcata	501	0	7	643		(25)	6	20	E	TV	
falciformis	193	0	8	247		25	4	29	E	TV	
farnesiana	65	0	1	65		25	4	20	E	TV	
fasciculifera	139	0	3	149		25	4	30	EH	TV	
fauntleroyi	730	0	1	730		(25)	7	21	E	TV	
filicifolia	643	0	4	863		(25)	4	26	E	TV	

Appendix 3.10.1 Acacia continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
fimbriata	821	0	4	1028		(25)	4	26	E	TV	
flavescens	224	0	5	335		25	5	23	E	TV	
fleckeri	140	0	2	250		(25)	7	21	E	TV	
flexifolia	865	0	1	865		(25)	5	30	C	TV	
floribunda	862	0	2	955		(25)	7	25	E	TV	
frigescens	462	0	1	462		(20)	10	30	E	TV	
fulva	576	0	5	630		(25)	4	22	EH	TV	
galeata	81	0	1	81		25	7	21	P	TV	
genistifolia	875	0	1	875		(25)	4	25	F	TV	
georginae	73	0	4	91		(25)	5	20	D	TV	
gittinsii	600	0	1	600		(25)	4	20	E	TV	
gladiiformis	450	0	1	450		(25)	4	20	E	TV	
glaucocaesia	340	0	1	340		(25)	7	21	GD	TV	
glaucocarpa	380	0	6	483		25	3	21	E	TV	
glaucoptera	540	0	1	540		(25)	20	40	E	TV	
gnidium	1600	0	1	1600		(25)	4	20	E	TV	
gonoclada	1838	0	7	2257		(25)	4	15	N	TV	
gracillima	316	0	2	326		(25)	7	21	E	TV	
grandifolia	375	0	2	450		(25)	7	21	E	TV	
hakeoides	161	0	2	182		(25)	10	30	E	TV	
hamersleyensis	520	0	2	529		(25)	7	15	E	TV	
hammondii	1377	0	4	1533		(25)	5	21	E	TV	
harpophylla	189	0	2	189		25	5	14	A	TV	
havilandii	1150	0	1	1150		30;20	5	40	E	TV	Alternating temp.
hemignosta	147	0	3	172		(25)	5	25	E	TV	
hemsleyi	624	89	11	828		30	4	21	E	TV	
hilliana	952	0	1	952		(30)	3	20	E	TV	
holosericea	949	209	44	1412		25;30	3	21	E	TV	
hylonoma	408	0	1	408		25	5	14	E	TV	
implexa	395	111	15	645		(25)	5	21	E	TV	
inaequilatera	144	0	3	170		(30)	5	20	E	TV	
inophloia	317	0	2	500		20	5	21	E	TV	
irrorata											
ssp. *irrorata*	1011	230	11	1334		25	5	21	E	TV	
ssp. *velutinella*	1239	0	2	1253		25	7	22	E	TV	
islana	130	0	1	130		(25);(30)	5	15	DE	TV	
iteaphylla	240	0	1	240		(25)	4	28	E	TV	
jennerae	112	0	4	202		25;20	6	25	E	TV	

Appendix 3.10.1 Acacia continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recorded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
jibberdingensis	480	0	1	480		(20)	5	20	E	TV	
julifera ssp. *julifera*	722	0	3	815		25	3	24	E	TV	
juncifolia	714	0	2	833		(25)	3	16	E	TV	
kempeana	423	0	2	465		(30)	4	16	E	TV	
kettlewelliae	260	0	1	260		(25)	10	30	E	TV	
koa	80	0	1	80		(25)	5	20	E	TV	
laccata	558	0	1	558		(25)	6	20	E	TV	
lamprocarpa	289	0	6	399		(30)	4	22	E	TV	
lasiocalyx	369	0	3	500		(20)	6	20	E	TV	
latescens	189	0	6	780		30	4	21	E	TV	
latzii	465	0	1	465		25	3	15	A	TV	
leichhardtii	209	0	1	209		(30)	5	35	D	TV	
leiocalyx	817	0	6	1166		25	4	20	E	TV	
leiocalyx aff.	894	0	1	894		(25)	3	26	E	TV	
leprosa	1570	0	1	1570		(25)	18	99	E	TV	
leptocarpa	744	279	17	1167		25;30	3	21	E	TV	
leptopetala	560	0	1	560		(25)	3	10	E	TV	
leptostachya	200	0	1	200		20;30	7	21	E	TV	
leucoclada											
ssp. *argentifolia*	522	0	1	522		25	4	28	E	TV	
ssp. *leucoclada*	516	0	3	789		(25)	5	28	E	TV	
ligulata	226	0	8	447		20;25	3	20	DE	TV	
linarioides	80	0	1	80		(25)	5	22	E	TV	
linearifolia	140	0	1	140		(25)	6	21	E	TV	
lineata	450	0	1	450		(25)	10	30	F	TV	
lineolata	2241	0	2	2300		15	7	15	E	TV	
linifolia	305	0	2	309		(25)	3	25	E	TV	
longifolia											
var. *longifolia*	490	0	1	490		(25)	13	35	E	TV	
var. *sophorae*	480	0	2	575		25	5	25	E	TV	
longispicata	892	0	2	917		25;30	5	21	E	TV	
longissima	700	0	1	700		(25)	7	21	**	TV	
lysiphloia	480	0	5	574		(25)	4	21	NE	TV	
mabellae	358	0	2	380		(25)	7	21	E	TV	
maconochieana	339	0	2	386		25	4	21	A	TV	
macradenia	414	0	2	428		(25)	5	21	E	TV	
maidenii	510	0	5	657		20;25	3	21	E	TV	
maitlandii	512	0	2	550		25;30	2	16	E	TV	
mangium	644	152	187	1044		25;30	5	25	E	TV	

Appendix 3.10.1 Acacia continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
mearnsii	704	194	81	1103		25	5	21	E	TV	
meisneri	64	0	2	88		15	7	20	D	TV	
melanoxylon	616	224	43	1066		25;30	3	21	E	TV	
melleodora	480	0	3	650		25;30	3	20	E	TV	
microbotrya	94	0	3	136		15	3	21	D	TV	
midgleyi	537	0	3	594		(30)	7	21	ED	TV	
mimula	37	0	1	37		(30)	5	30	E	TV	
mollifolia	369	0	1	369		(25)	5	28	E	TV	
monticola	252	0	5	389		25	3	20	E	TV	
mountfordiae	329	0	3	370		25;30	4	20	C	TV	
mucronata	630	0	2	739		(25)	10	30	E	TV	
muellerana	634	0	1	634		(25)	7	21	E	TV	
multisiliqua	343	0	1	343		25	7	21	D	TV	
murrayana	150	0	7	268		25	7	21	E	TV	
myrtifolia	633	0	2	1075		20	20	37	EN	TV	
nano-dealbata	588	0	2	627		(25)	7	21	A	TV	
neriifolia	223	0	3	261		25	4	25	E	TV	
neurocarpa	958	130	11	1150		30;25	7	21	E	TV	
neurophylla	1885	0	1	1885		20	6	20	ED	TV	
notabilis	340	0	2	460		30;20	18	40	E	TV	Alternating temp.
nuperrima ssp. *cassitera*	256	0	2	431		(25)	7	21	**	TV	
obliquinervia	129	0	5	380		(25)	20	40	E	TV	
obtusata	360	0	1	360		(25)	7	20	E	TV	
obtusifolia	542	0	1	542		25	8	20	E	TV	
olgana	616	0	1	616		(30)	2	10	E	TV	
olsenii	239	0	2	290		25	5	20	E	TV	
omalophylla aff.	840	0	1	840		(25)	3	15	E	TV	
oncinocarpa	515	0	3	657		30	6	21	E	TV	
oraria	262	0	4	430		25;30	5	26	C	TV	
orites	853	0	1	853		(25)	7	21	CE	TV	
orthocarpa	730	0	1	730		(25)	3	20	E	TV	
oswaldii	76	0	2	90		(25)	5	10	CA	TV	
pachycarpa	22	0	5	42		25	3	21	E	TV	
pachyphloia	6	0	1	6		(25)	7	21	E	TV	
papyrocarpa	210	0	1	210		(25)	7	21	E	TV	
paradoxa	830	0	1	830		(25)	14	90	E	TV	

Appendix 3.10.1 Acacia continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recorded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
parramattensis	674	0	8	933		(25)	5	21	E	TV	
parvipinnula	475	0	4	833		(25)	8	21	E	TV	
pellita	921	0	3	982		(25)	6	20	E	TV	
pendula	248	0	3	314		25	5	21	E	TV	
penninervis	183	0	3	295		25	10	26	E	TV	
peregrina	301	110	40	522		25;30	5	21	ED	TV	
peuce	425	0	1	425		(25)	3	21	A	TV	
platycarpa	37	0	9	78		25	5	20	E	TV	
plectocarpa	565	216	16	1260		30	4	21	EN	TV	
podalyrifolia	256	0	1	256		25	6	27	E	TV	
polybotrya	370	0	1	370		(25)	5	25	E	TV	
polystachya	344	0	4	618		25;30	5	21	E	TV	
prainii	396	0	1	396		20	6	20	D	TV	
pravissima	575	0	2	750		(25)	10	26	E	TV	
prominens	190	0	1	190		(25)	10	30	E	TV	
pruinocarpa	279	0	2	329		25	3	25	E	TV	
pruinosa	189	0	1	189		(25)	4	21	E	TV	
ptychophylla	760	0	1	760		(25)	7	21	E	TV	
pubercosta	386	0	1	386		25	5	21	E	TV	
pustula	449	0	1	449		(25)	4	14	CE	TV	
pycnantha	345	0	8	480		(25)	10	50	E	TV	
pyrifolia	204	0	5	230		(25)	3	20	E	TV	
ramulosa	266	0	1	266		(25)	3	10	E	TV	
reclusa ms	460	0	1	460		(30)	4	21	E	TV	
redolens	1123	0	1	1123		(20)	11	30	E	TV	
repanda	1800	0	1	1800		(20)	7	36	E	TV	
resinimarginea	2142	0	2	3283		(20)	6	20	E	TV	
retinervis	169	0	2	172		(30)	10	25	N	TV	
retinodes	660	0	2	800		(25)	7	25	E	TV	
retivenia	286	0	3	320		(25);(30)	5	20	E	TV	
rhodophloia	1020	0	2	1200		(25)	3	14	E	TV	
rhodoxylon	818	0	1	818		(25);(30)	5	20	DC	TV	
riceana	460	0	1	460		(25)	10	20	E	TV	
rigens	780	0	1	780		(25)	5	20	E	TV	
rothii	30	0	4	40		30	4	21	HE	TV	
rubida	506	0	4	688		(25)	5	20	E	TV	
sabulosa	432	0	4	731		(25)	7	21	E	TV	
salicina	140	54	15	245		25	4	30	E	TV	

Appendix 3.10.1 Acacia continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
saliformis	241	0	1	241		(25)	7	21	D	TV	
saligna	430	144	17	789		15	5	30	E	TV	
schinoides	495	0	2	521		25	6	20	E	TV	
scirpifolia	398	0	1	398		20	7	15	E	TV	
sclerosperma	29	0	8	41		25	5	25	EN	TV	
sclerosperma × *ligulata*	68	0	1	68		(25)	5	15	FH	TV	
semirigida	220	0	1	220		(25)	7	28	E	TV	
sericata	40	0	1	40		(25)	7	21	C	TV	
sericoflora	1353	0	1	1353		30	2	27	E	TV	
sessilispica	1714	0	1	1714		20	5	20	D	TV	
shirleyi	682	0	4	999		25	2	20	ED	TV	
sibina	893	0	1	893		20	5	19	E	TV	
signata	218	0	1	218		(25)	7	21	E	TV	
silvestris	374	0	5	460		25	5	25	E	TV	
simsii	699	0	6	1170		30	3	21	E	TV	
sparsiflora	939	0	2	962		25	7	21	E	TV	
species	262	0	1	262		(25)	7	21	E	TV	
spectabilis	320	0	4	381		25	3	27	E	TV	
spirorbis subsp. *spirorbis*	554	0	3	612		25	7	20	D	TV	
spongolitica	830	0	1	830		20	7	21	E	TV	
stenophylla	85	37	11	129		30;25	3	25	EC	TV	
stereophylla	2270	0	1	2270		15	5	20	E	TV	
stigmatophylla	580	0	1	580		(25)	7	20	E	TV	
stipuligera	803	84	15	1000		(30;25)	5	21	E	TV	
storyi	341	0	2	432		25	7	21	E	TV	
stowardii	945	0	1	945		(25)	7	21	E	TV	
striatifolia	1052	0	1	1052		25	7	21	E	TV	
suaveolens	228	0	4	273		(25)	4	24	E	TV	
suberosa	24	0	1	24		(25)	7	30	E	TV	
subtessarogona	326	0	2	342		(25)	3	10	E	TV	
subulata	225	0	1	225		(25)	7	30	E	TV	
sylvestris	220	0	1	220		(25)	5	24	E	TV	
synchronicia	346	0	2	552		(25)	7	21	G	TV	
telmica	635	0	1	635		(20)	5	20	E	TV	
tenuinervis	736	0	1	736		25	7	21	E	TV	
tenuissima	1010	0	8	1666		(25)	4	22	E	TV	
terminalis	385	0	2	489		(25)	6	21	E	TV	

Appendix 3.10.1 Acacia concluded

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
tetragonophylla	460	0	1	460		(25)	5	15	CE	TV	
thomsonii	1026	209	11	1353		(25)	7	15	E	TV	
torulosa	231	117	30	505		(25;30)	5	21	E	TV	
trachycarpa	119	0	9	181		25	4	21	E	TV	
trachyphloia	678	0	5	865		(25)	5	25	E	TV	
trinervata (syn. *cunninghamiana*)	7630	0	1	7630		20;30	7	21	CD	TV	
trineura	1916	0	1	1916		(25)	8	28	E	TV	
triptera	1100	0	1	1100		(25)	8	20	E	TV	
tropica	560	0	2	808		25	5	15	E	TV	
tumida var. *tumida*	144	61	66	393		(25;30)	4	30	E	TV	
ulicifolia	637	0	2	675		25	7	21	E	TV	
umbellata	910	0	2	958		(30)	6	20	E	TV	
uncinata	305	0	2	430		(25)	6	26	E	TV	
valida (syn. *calcigera*)	21	0	1	21		(25)	4	21	E	TV	
validinervia	416	0	3	615		(25)	6	21	E	TV	
validinervia variant	310	0	2	417		(25)	7	21	N	TV	
verniciflua	411	0	2	682		30;20	5	99	E	TV	Alternating temp.
verticillata	460	0	1	460		(25)	4	27	F	TV	Alternating temp.
vestita	238	0	2	266		(25)	6	30	E	TV	
victoriae	238	90	23	421		25	3	21	EN	TV	
viscidula	1,090	0	1	1090		(30)	7	20	A	TV	
wanyu	93	0	3	136		(20)	6	23	E	TV	
wattsiana	442	0	1	442		(25)	8	60	E	TV	
xanthina	360	0	2	393		(25)	6	21	A	TV	
xiphophylla	135	0	4	165		25	4	10	A	TV	
yirrkallensis	2383	0	1	2383		(25)	7	21	**	TV	
ADANSONIA											
gregorii	1	0	1	1		(30)	6	35	C	TV	
ADENANTHERA											
abrosperma	56	0	1	56		(25)	4	18	CD	TV	
pavonina	22	0	1	22		(25)	5	18	CD	TV	
AGATHIS											
robusta	168	0	2	186		(25)			A	TV	
AGONIS											
flexuosa	8800	0	1	8800	0.1	25	14	21	A	TV	

Appendix 3.10.1 Germination standards continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
ALBIZIA											
amara	19	0	1	19		25			E	TV	
chinensis	348	0	1	348		25			G	TV	
lebbeck	270	0	1	270		(30)	5	12	E	TV	soak overnight
ALLOCASUARINA											
campestris ssp. *campestris*	2600	0	1	2600	0.1	15	7	30	A	TV	
decaisneana	352	0	5	560	1.0	(25);(30)	3	14	A	TV	
fraseriana	680	0	1	680	0.5	(25)	10	30	A	TV	
huegeliana	2230	0	1	2230	0.2	15;20	7	35	A	TV	
littoralis	3766	0	7	5637	0.2	25	5	28	A	TV	
paludosa	6442	0	1	6442	0.1	15	12	30	A	TV	
torulosa	2025	0	4	2638	0.2	20	5	21	A	TV	
verticillata	572	0	10	1113	0.2	15	14	30	A	TV	
ALNUS											
nepalensis	7900	0	1	7900		(25)	7	14	A	TPV	
ALPHITONIA											
excelsa	87	0	1	87		25;30	4	16	CE	TV	
petriei	524	0	2	684		25	4	16	C	TV	
ANGOPHORA											
costata	686	0	4	735	0.5	20;25	4	17	A	TV	
floribunda	450	0	1	450	0.7	20;25	7	14	A	TPV	
ARAUCARIA											
bidwillii	1	0	2	1		30	5	21	A	TV	
cunninghamii	34	0	9	170		20;30	7	21	A	TV	
heterophylla (excelsa)	1	0	1	1		20;25;30	7	28	A	TV	
hunstenii	19	0	2	20		(25)	5	28	A	TV	
ASTARTEA											
fascicularis	1300	0	1	1300	0.5	(15)	25	56	A	TVP	
ASTEROMYRTUS											
brassii	1710	0	5	2650	0.1	(25);(30)	5	14	A	TPV	
lysicephala	19050	0	4	40100	0.1	(25);(30)	5	20	A	TPV	
magnifica	1550	0	1	1550	0.1	25	3	28	A	TPV	
symphyocarpa	3037	1216	14	5800	0.1	(25);(30)	5	20	A	TPV	
ATALAYA											
hemiglauca	70	0	7	132		25	7	21	A	TV	

Appendix 3.10.1 Germination standards continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recorded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
ATRIPLEX											
nummularia	32	0	1	32	0.5	(25)	6	28	I	TV	
BANKSIA											
integrifolia var. *compar*	378	0	1	378		25	7	21	A	TV	
serrata	80	0	1	80		25	10	30	A	TV	
spinulosa	196	0	3	300		30			A	TV	
BEAUFORTIA											
sparsa	30870	0	1	30870	0.01	25	7	26	A	TVP	
BRACHYCHITON											
populneus	45	0	2	55		25	6	27	D	TV	
BURSARIA											
occidentalis	170	0	1	170	0.2	15	12	30	A	TV	
spinosa var. *spinosa*	800	0	1	800	0.2	(15)	15	35	A	TV	
CALLISTEMON											
citrinus	85000	0	1	85000	0.01	30	7	21	A	TV	
linearis	215000	0	1	215000	0.01	30	7	21	A	TV	
macropunctatus	53,000	0	1	53000	0.01	30	7	21	A	TV	
phoeniceus	64000	0	1	64000	0.01	30	7	21	A	TV	
polandii	22000	0	1	22000	0.02	30	7	21	A	TV	
CALLITRIS											
intratropica	150	0	1	150		(30)	15	28	A	TV	
CALOTHAMNUS											
homalophyllus	5200	0	1	5200	0.1	20	14	28	A	TVP	
quadrifidus	7,400	0	1	7400	0.1	20	10	20	A	TVP	
rupestris	8900	0	1	8900	0.1	20	14	28	A	TVP	
CAPPARIS											
spinosa	297	0	1	297		(25)	12	19	A	TV	
CASSIA											
alata	207	0	1	207		25	1	10	G	TV	
brewsteri	64	0	1	64		25	5	12	CD	TV	
javanica	10	0	1	10		30	4	10	C	TV	
queenslandica	126	0	1	126		(25)	5	20	CD	TV	
siamea	204	0	2	216		(25)	3	20	E	TV	
CASUARINA											
collina	13200	0	2	13900	0.2	20	5	14	A	TV	
cristata	1184	0	6	1590	0.5	25	7	21	A	TV	

Appendix 3.10.1 Germination standards continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
cunninghamiana ssp. *cunninghamiana*	6924	0	8	12800	0.1	25;35	5	21	A	TV	
equisetifolia											
ssp. *equisetifolia*	2635	1569	79	10500	0.2	30	4	22	A	TV	
ssp. *incana*	2465	0	6	3515	0.2	(25;30)	7	21	A	TV	
glauca	4437	2473	17	9200	0.1	25	5	24	A	TV	
grandis	3663	0	2	3700	0.2	(25)	6	25	A	TV	
junghuhniana ssp. *junghuhniana*	11695	13365	30	81135	0.05	25-35	3	25	A	TV	
obesa	3678	0	7	5975	0.2	25	5	21	A	TV	
oligodon	14587	0	3	26562	0.1	(25)	9	22	A	TV	
papuanum	8750	0	1	8750	0.2	25	5	20	A	TV	
CATHORMION											
umbellatum var. *moniliforme*	13	0	1	13		(25)	8	20	GD	TV	
CEDRELA serrata	1353	0	1	1353	0.2	(25)	2	21	A	TV	
CHORISIA speciosa	22	0	1	22		(25)	5	8	C	TV	
CHUKRASIA											
tabularis	367	0	7	540	0.2	25	0	0	J	TV	
velutina	476	0	2	886	0.2	25	5	25	J	TV	
COCHLOSPERMUM											
fraseri	126	0	1	126		(30)	8	23	CG	TV	
CORYMBIA											
abbreviata	260	0	1	260	0.5	(25)	5	14	A	TPV	
bleeseri	350	0	1	350	1.5	30	6	10	A	TPV	
bloxsomei	760	0	1	760	0.7	25;30	10	14	A	TPV	
cadophora	317	0	5	481	1.0	(25)	5	15	A	TPV	
calophylla "rosea"	130	0	3	160	3.0	25	7	21	A	TV	Inhibitors
chippendalei	403	0	3	522	1.0	(25;30)	5	20	A	TPV	
citriodora ssp citriodora	1338	649	16	2720	0.5	25;30	5	14	A	TV	Inhibitors
citriodora ssp varegata	1399	632	20	2620	0.5	25	5	14	A	TV	Inhibitors
clavigera	400	0	1	400	1.0	30	5	12	A	TPV	
collina	590	0	1	590	0.5	25	7	21	A	TPV	
confertiflora	858	0	4	1700	0.5	30	5	14	A	TPV	
dampieri	563	0	1	563	0.8	(20)	6	18	A	TPV	
dichromophloia	530	0	1	530	1.0	25	5	12	A	TPV	
dimorpha	1180	0	1	1180	0.5	(25)	5	10	A	TPV	

Appendix 3.10.1 Corymbia concluded

Species	Germination per 10g [I]		No of seed-lots tested	Highest recorded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
eremaea	775	0	2	940	1.0	25	5	21	A	TV	Inhibitors
eximia	457	0	2	510	1.0	(25)	5	14	A	TPV	
ferruginea	240	0	1	240	2.0	30	5	14	A	TPV	
ficifolia	390	0	4	538	1.2	20	5	14	A	TPV	
foelscheana	350	0	1	350	1.5	25	5	14	A	TPV	
grandifolia	350	0	1	350	1.5	30	5	14	A	TV	Inhibitors
gummifera	576	0	5	730	0.6	30	5	14	A	TPV	
henryi	1021	0	3	1262	0.5	25	5	14	A	TV	Inhibitors
hylandii	880	0	1	880	0.5	(25)	6	26	A	TPV	
intermedia	1350	0	6	1785	0.6	25	5	14	A	TPV	
jacobsiana	430	0	1	430	1.2	30	7	21	A	TPV	
latifolia	420	0	1	420	1.2	20	5	14	A	TPV	
leichhardtii	970	0	1	970	0.7	(25)	7	15	A	TPV	
maculata	1334	326	15	1872	0.5	25	5	14	A	TV	Inhibitors
nesophila	770	0	1	770	0.6	25	5	10	A	TPV	
novoguinensis	672	0	1	672	1.0	25	6	15	A	TV	
papuana	710	0	1	710	0.6	(25)	5	10	A	TPV	
polycarpa	867	0	3	1238	1.0	25	5	21	A	TPV	
porrecta	120	0	1	120	4.0	(25)	5	14	A	TPV	
ptychocarpa	205	0	3	276	2.0	25	7	21	A	TPV	
setosa	233	0	2	300	2.0	(25)	7	21	A	TPV	
terminalis	370	0	1	370	1.5	(25)	5	21	A	TPV	
tessellaris	1552	0	2	1584	0.3	35	3	10	A	TPV	
torelliana	3861	0	8	4125	0.2	(25)	5	14	A	TPV	
trachyphloia	1320	0	1	1320	0.4	(25)	5	14	A	TPV	
watsoniana	254	0	3	382	2.0	(25)	5	28	A	TPV	
xanthope	690	0	1	690	1.0	(25)	6	14	A	TPV	
zygophylla	213	0	3	264	3.0	(25)	7	21	A	TPV	
CUNNINGHAMIA											
lanceolata	631	0	2	914		(25)	3	18	A	TV	
DAVIESIA mimosoides var. *laxifolia*	615	0	1	615		(20)	13	57	C	TV	
DICHROSTACHYS											
spicata	250	0	2	352		(30)	3	20	CD	TV	
DILLWYNIA											
sericea	1420	0	1	1420		25	7	30	G	TV	

Appendix 3.10.1 Germination standards continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
DOLICHANDRONE											
heterophylla	174	0	1	174		(25)	11	20	A	TV	
EREMAEA											
beaufortioides	840	0	1	840	1.0	20	14	32	A	TVP	
EREMOPHILA											
maculata	1	0	1	1		(25)	5	30	A	TV	
ERYTHRINA											
vespertilio	13	0	1	13		25			CD	TV	
EUCALYPTUS											
acaciiformis	1890	0	1	1890	0.2	25	7	14	A	TPV	
accedens	810	0	2	1270	0.2	20;15	10	21	A	TPV	
acies	281	0	1	281	0.8	(25)	7	30	A	TV	
acmenoides	2064	0	7	2837	0.4	(30)	7	30	A	TPV	
aeqioperta	10100	0	1	10100	0.1	(20)	5	25	A	TPV	
agglomerata	2625	0	2	4350	0.5	15	18	28	A	TPV	
aggregata	7225	0	6	12600	0.1	25	7	14	A	TPV	
alba	2165	0	2	2690	0.2	(25;30)	7	14	A	TPV	
albens	1400	0	3	2450	0.2	(25)	5	14	A	TPV	
amplifolia											
var. *amplifolia*	7559	0	9	17000	0.1	25;30	4	15	A	TPV	
var. *sessiliflora*	2500	0	1	2500	0.1	(25;30)	4	15	A	TPV	
amygdalina	1200	0	1	1200	0.4	20	3	25	B	TPV	28 days CMS
ancophila	2461	0	1	2461	0.1	(25)			A	TPV	
andrewsii											
ssp. *andrewsii*	1410	0	1	1410	0.4	(20;25)	3	20	A	TPV	
ssp. *campanulata*	1350	0	2	1450	0.4	(20;25)	3	20	A	TPV	
angophoroides	5740	0	1	5740	0.1	25	3	18	A	TPV	
angulosa	650	0	1	650	0.5	20	5	30	A	TPV	
angustissima	4550	0	3	8400	0.1	15;20	10	28	A	TPV	
annulata	4540	0	1	4540	0.1	15	7	21	A	TPV	
apiculata	933	0	2	1190	0.4	15	14	28	A	TPV	
apodophylla	6000	0	1	6000	0.1	25;30	7	14	A	TPV	
approximans	1697	0	2	1883	0.3	15	10	28	A	TPV	
aquilina	400	0	1	400	0.8	25	10	15	A	TPV	
arachnaea											
ssp. *arachnaea*	2600	0	1	2600	0.1	(25)	6	14	A	TPV	
archeri	2380	0	1	2380	0.2	(15;20)	7	21	A	TPV	
areuacea	525	0	1	525	0.1	(25)	6	14	A	TPV	
argillacea	1938	0	2	2500	0.2	25;30	5	21	A	TPV	

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recorded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
argophloia	12441	0	4	14900	0.03	25	7	21	A	TPV	
aromaphloia	4800	0	1	4800	0.1	25	3	14	A	TPV	
aspratilis	1563	0	2	2100	0.2	(25)	5	20	A	TPV	
astringens	1578	0	5	2405	0.4	15;20	7	15	A	TPV	
badjensis	5703	1826	11	9530	0.1	25	6	15	A	TPV	
baeuerlenii	1626	0	2	2442	0.7	25	5	14	A	TPV	
baileyana	225	0	2	240	2.0	25	7	21	A	TPV	
bakeri	6518	0	3	8125	0.1	15	10	35	A	TPV	
bancroftii	3320	0	1	3320	0.2	25;30	7	14	A	TPV	
banksii	1670	0	1	1670	0.3	30	7	14	A	TPV	
barberi	3890	0	1	3890	0.1	25;30	6	14	A	TPV	
baueriana	3960	0	3	7050	0.2	(25)	5	21	A	TPV	
baxteri	511	0	3	570	0.8	20;25	10	28	A	TPV	
behriana	3064	0	2	3950	0.15	(25)	5	14	A	TPV	
benthamii	9228	0	5	11815	0.1	(25)	5	12	A	TPV	
beyeri	6480	0	1	6480	0.1	(25)	3	14	A	TPV	
bigalerita	1470	0	2	1600	0.3	30	7	12	A	TPV	
biturbinata	1434	0	3	2080	0.2	(25)	5	15	A	TPV	
blakelyi	6870	0	1	6870	0.1	25;30	7	21	A	TPV	
blaxlandii	870	0	1	870	0.6	20;25	9	18	A	TPV	
bosistoana	4056	0	4	5000	0.1	25	5	14	A	TPV	
botryoides	3914	1567	14	8500	0.1	25	10	21	A	TPV	
brachyandra	15600	0	1	15600	0.05	30	6	12	A	TPV	
brachycorys	3500	0	1	3500	0.2	20	10	20	A	TPV	
brassiana	3171	0	7	7460	0.2	25	7	14	A	TPV	
brevifolia	3284	0	2	3738	0.1	(25)	5	21	A	TPV	
brevistylis	785	0	1	785	0.2	20	5	20	A	TPV	
bridgesiana	2510	0	2	3620	0.15	25	8	14	A	TPV	
brockwayi	5183	0	4	7520	0.1	15;20	7	14	A	TPV	
brookeriana	3087	0	7	8600	0.1	25	5	15	A	TPV	
brownii	37550	0	1	37550	0.01	25	3	10	A	TPV	
buprestium	40	0	1	40	10.0	20	10	20	A	TPV	
burdettiana	1510	0	1	1510	0.3	15	10	25	A	TPV	
burracoppinensis	710	0	1	710	0.7	15;20	10	21	A	TPV	
caesia ssp. *caesia*	1380	0	1	1380	0.4	25	5	18	A	TPV	
caesia ssp. *magna*	837	0	1	837	0.4	20	3	15	A	TPV	
calcicola	320	0	1	320	0.5	(20)	10	28	A	TPV	
caleyi	1490	0	1	1490	0.3	20	7	14	A	TPV	

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
caliginosa	480	0	1	480	1.0	20	10	28	A	TPV	
calycogona											
ssp. *calycogona*	2477	0	3	3880	0.2	20	10	28	A	TV	Inhibitors
camaldulensis											
ssp. *simulata*	6837	2004	12	9800	0.1	30	5	10	A	TPV	
var. *camaldulensis*	5084	2086	19	8600	0.1	25;30	5	10	A	TPV	Tropical 30°C and Temperate 25°C
var. *obtusa*	7656	3390	105	21800	0.1	25;30	5	10	A	TPV	
cambageana	7150	0	1	7150	0.05	20;25	9	21	A	TPV	
cameronii	2340	0	1	2340	0.2	25	3	21	A	TPV	
camfieldii	950	0	1	950	0.5	25	7	14	A	TPV	
campaspe	2430	0	1	2430	0.2	15;20	10	21	A	TPV	
camphora											
ssp. *camphora*	8499	0	8	12000	0.05	25	7	28	A	TPV	
ssp. *relicta*	20400	0	1	20400	0.05	(25)	4	25	A	TPV	
canaliculata	380	0	1	380	1.5	(25)	5	10	A	TPV	
capillosa											
ssp. *capillosa*	3250	0	1	3250	0.1	(25)	10	20	A	TPV	
capitellata	400	0	1	400	1.0	25	7	21	A	TPV	
carnei	1400	0	1	1400	0.3	(25)	5	14	A	TPV	
celastroides											
ssp. *celastroides*	2030	0	1	2030	0.2	15;20	7	20	A	TPV	
cephalocarpa	2560	0	1	2560	0.2	25	5	14	A	TPV	
cerasiformis	3000	0	1	3000	0.5	20	5	24	A	TPV	
cernua											
(ms syn. *nutens*)	1475	0	2	1530	0.25	(25)	7	20	A	TPV	
chapmaniana	2320	0	1	2320	0.2	25	5	20	A	TPV	
chloroclada	5650	0	2	5900	0.1	(25)	7	20	A	TPV	
cinerea	2926	0	3	3480	0.15	25	3	14	A	TPV	
cladocalyx	1537	1952	11	7180	0.4	20	5	21	A	TPV	
clelandii	3410	0	1	3410	0.25	15	10	21	A	TPV	
clivicola	2000	0	1	2000	0.2	(25)	5	26	A	TPV	
cloeziana	2663	0	9	11300	0.4	25	7	28	A	TPV	Inhibitors
cneorifolia	2410	0	3	2730	0.2	15	10	28	A	TPV	
coccifera	1210	0	3	1550	0.3	15	10	28	B	TPV	21 days CMS
concinna	2000	0	1	2000	0.3	25	5	14	A	TPV	
confluens	3400	0	1	3400	0.2	25;30	7	14	A	TPV	
conglobata	1465	0	2	1550	0.4	15;20	10	21	A	TPV	
conica	6740	0	2	9500	0.1	(25)	3	14	A	TPV	

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
consideniana	840	0	1	840	0.6	20;25	5	21	A	TPV	
cooperiana	2870	0	2	4190	0.1	20	10	28	A	TPV	
cordata	930	0	1	930	0.5	20;25	5	14	A	TPV	
cornuta	1588	0	3	2150	0.3	25	3	14	A	TPV	
coronata	490	0	1	490	1.0	15	10	21	A	TPV	
corrugata	1500	0	1	1500	0.3	25	3	14	A	TPV	
cosmophylla	1704	0	3	3366	0.7	25	5	14	A	TPV	
crebra	7933	0	3	12500	0.1	30	5	14	A	TPV	
crenulata	13350	0	1	13350	0.05	(25)	5	14	A	TPV	
croajingalensis	897	0	3	1466	0.1	25	4	21	A	TPV	
crucis ssp. *crucis*	1045	0	2	1600	0.9	25	10	28	A	TPV	
cullenii	1455	0	2	1740	0.6	(25)	5	21	A	TPV	
cupularis	490	0	1	490	1.0	25	4	14	A	TV	Inhibitors
curtisii	11243	0	3	14725	0.1	25	5	28	A	TPV	
cyanophylla	1240	0	1	1240	0.5	(20)	5	28	A	TPV	
cylindriflora	4980	0	1	4980	0.1	15;20	7	28	A	TPV	
cylindrocarpa	3250	0	1	3250	0.2	15	10	21	A	TPV	
cypellocarpa	1668	532	11	2720	0.3	20;25	7	14	A	TPV	
dalrympleana											
ssp. *dalrympleana*	1907	0	6	2830	0.3	20;25	5	14	A	TPV	
ssp. *heptantha*	3000	0	1	3000	0.2	(25)	5	21	A	TPV	
dawsonii	11265	0	2	14300	0.05	(25)	5	21	A	TPV	
dealbata	6310	0	1	6310	0.1	(25)	3	21	A	TPV	
deanei	5976	0	5	7900	0.1	20	5	21	A	TV	Inhibitors
decipiens	1310	0	1	1310	0.4	(25)	5	21	A	TPV	
decorticans	1640	0	1	1640	0.3	(25)	5	21	A	TPV	
deglupta	48700	0	7	96000	0.01	35	5	14	A	TV	Inhibitors
delegatensis											
ssp. *delegatensis*	908	0	9	1770	0.5	20	5	14	B	TPV	42 days CMS
dendromorpha	1070	0	1	1070	0.5	(25)	10	22	A	TPV	
densa ssp. *densa*	2175	0	2	2649	0.1	(15)	5	14	A	TPV	
ssp. *improcera*	1317	0	1	1317	0.1	(15)	5	14	A	TPV	
denticulata	3038	0	4	3550	0.2	15;25	7	14	B	TPV	21days CMS *
desmondensis	1924	0	2	2587	0.2	20	7	14	A	TPV	
dielsii	3720	0	2	4820	0.1	15;20	7	21	A	TPV	
diminuta	2450	0	1	2450	0.5	(15)	5	25	A	TPV	
diptera	1580	0	2	1740	0.3	15;20	10	21	A	TPV	
discreta	3350	0	1	3350	0.2	(15)	14	28	A	TPV	
diversicolor	492	0	7	840	0.6	20;25	7	14	A	TV	Inhibitors
diversifolia	339	0	3	473	1.5	20;25	7	21	A	TPV	

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
dives	761	288	13	1364	0.7	15	14	35	B	TPV	56 days CMS
dongarraensis	1400	0	1	1400	0.3	25	10	28	A	TPV	
doratoxylon	1830	0	1	1830	0.3	(25)	7	21	A	TPV	
dorrigoensis	10081	0	4	20700	0.1	(25)	5	12	A	TPV	
drepanophylla	1984	0	9	3360	0.2	30	7	21	A	TPV	
drummondii	300	0	1	300	1.5	20	10	28	A	TPV	
dumosa	2340	0	2	3530	0.1	15;20	10	21	A	TPV	
dundasii	3240	0	1	3240	0.1	15;20	10	21	A	TPV	
dunnii	2768	1080	38	5170	0.2	25;30	3	10	A	TPV	
dwyeri	3680	0	1	3680	0.2	(25)	3	10	A	TPV	
ebbanoensis	930	0	1	930	0.5	(25)	5	14	A	TPV	
elata	2128	0	6	2600	0.2	20;25	5	21	A	TPV	
eremophila											
ssp. *eremophila*	3529	0	3	5587	0.2	(25)	5	21	A	TPV	
erythrocorys	250	0	3	469	3.0	25;30	5	14	A	TPV	
erythronema											
var. *erythronema*	2193	0	2	2310	0.2	15;20	10	21	A	TPV	
var. *marginata*	1510	0	1	1510	0.3	(25)	7	28	A	TPV	
eugenioides	1090	0	2	1160	0.5	20	5	28	A	TPV	
ewartiana	670	0	1	670	0.7	(25)	7	21	A	TPV	
exilis	373	0	2	420	1.2	20	15	28	A	TPV	
exserta	3363	0	3	3750	0.2	25	5	21	A	TPV	
falcata	1600	0	2	2600	0.2	15;20	7	14	A	TPV	
falciformis	800	0	1	800	0.5	(20)	3	25	A	TVP	
famelica	320	0	1	320	1.0	(20)	8	18	A	TVP	
fasciculosa	4263	0	2	5125	0.2	15;20	5	14	A	TPV	
fastigata	1116	0	9	1770	0.5	15;20	10	40	A	TPV	
fibrosa											
ssp. *fibrosa*	1553	0	2	1980	0.2	20	5	14	A	TPV	
ssp. *nubila*	3535	0	2	3850	0.5	(25)	5	14	A	TPV	
flindersii	8500	0	1	8500	0.1	(25)	3	14	A	TPV	
flocktoniae	1523	0	2	1825	0.4	15;20	10	28	B	TPV	28 days CMS
foecunda	2253	0	4	4650	0.1	15	10	28	A	TPV	
forrestiana											
ssp. *forrestiana*	405	0	2	430	0.5	15	10	33	A	TPV	
fraseri	1887	0	2	2520	0.3	(25)	10	40	A	TPV	
fraxinoides	1380	0	4	1850	0.4	25	7	28	A	TPV	
froggattii	3819	0	2	4437	0.15	20	5	14	A	TPV	
fusiformis	2825	0	2	5150	0.2	25	7	20	A	TPV	

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recorded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
gamophylla	1358	0	8	2775	0.4	25	5	10	A	TPV	
gardneri	1410	0	1	1410	0.4	20	7	21	A	TPV	
georgei	2366	0	1	2366	0.5	(20)	6	21	A	TPV	
gilbertensis	100	0	1	100	5.0	(25)	3	10	A	TPV	
gillenii	5296	0	3	7900	0.2	(25)	5	14	A	TPV	
gillii	830	0	1	830	0.6	20	5	21	A	TV	Inhibitors
gittinsii	320	0	1	320	1.0	(20)	10	21	A	TPV	
glaucescens	905	0	6	1218	0.4	20	5	10	B	TPV	28 to 42 days
globoidea	1191	0	4	1540	0.3	20;25	7	21	A	TPV	
globulus											
ssp. *bicostata*	1004	330	22	1980	0.5	(25)	5	14	A	TPV	
ssp. *globulus*	675	326	156	2521	0.7	25	5	14	A	TPV	
ssp. *maidenii*	1518	268	21	1875	0.3	(25)	5	21	A	TPV	
ssp. *pseudoglobulus*	1350	0	3	2015	0.5	25	5	14	A	TPV	
gomphocephala	873	0	6	1302	0.7	25	5	14	A	TPV	
gongylocarpa	969	0	4	2287	0.8	(25)	5	21	A	TPV	
goniantha											
ssp. *goniantha*	1060	0	1	1060	0.5	15;20	7	21	A	TPV	
goniocalyx	1398	0	4	1800	0.5	(25)	5	14	A	TPV	
gracilis	5260	0	1	5260	0.1	15;20	10	21	A	TPV	
grandis	6728	4896	100	35230	0.1	25	5	14	A	TPV	
gregsoniana	1310	0	1	1310	0.4	(15)	7	21	A	TPV	
griffithsii	1620	0	1	1620	0.3	20	7	21	A	TPV	
grossa	3190	0	1	3190	0.2	15;20	10	21	A	TPV	
guilfoylei	610	0	1	610	0.8	(25)	5	28	A	TPV	
gunnii	3080	0	3	3920	0.1	20	7	28	A	TPV	
haemastoma	1330	0	2	1490	0.4	25	5	14	A	TV	Inhibitors
haematoxylon	200	0	1	200	3.0	(25)	7	21	A	TPV	
hallii	9856	0	2	11262	0.05	25	3	18	A	TPV	
halophila	969	0	4	1217	0.4	(15)	7	21	A	TPV	
herbertiana	3845	0	2	3890	0.15	(25)	7	21	A	TPV	
houseana	8470	0	1	8470	0.05	(25)	5	21	A	TV	Inhibitors
howittiana	7700	0	1	7700	0.1	25	7	15	A	TPV	
hypochlamydea	4383	0	1	4383	0.25	(15)	7	22	A	TPV	
incerata	6325	0	1	6325	0.1	25	7	21	A	TPV	
incrassata	197	0	2	280	2.0	20	5	14	A	TPV	
indurata	389	0	1	389	0.3	(15)	19	31	A	TPV	
infera	16800	0	1	16800	0.1	(25)	8	31	A	TPV	
insularis	2200	0	1	2200	0.2	(20)	10	21	A	TPV	
intertexta	2076	0	8	3908	0.3	25	5	28	A	TV	Inhibitors

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
jacksonii	963	0	2	1336	0.5	20	5	28	A	TPV	
jensenii	2630	0	5	4800	0.4	(25)	5	14	A	TPV	
johnstonii	1026	0	3	1530	0.3	20;25	7	21	A	TPV	
jucunda	290	0	1	290	1.7	(15)	14	49	A	TPV	
jutsonii	1540	0	1	1540	0.3	15	7	21	A	TPV	
kartzoffiana	3277	0	3	5630	0.1	25	3	10	A	TPV	
kingsmillii	460	0	2	800	0.6	15	10	14	A	TPV	
kitsoniana	3170	0	1	3170	0.1	(25)	5	21	A	TPV	
kochii											
ssp. *kochii*	1453	0	5	2280	0.2	15	7	21	A	TPV	
ssp. *plenissima*	5417	0	2	7950	0.2	(15)	10	28	A	TPV	
kondininensis	3702	0	4	5013	0.2	15;20	10	14	A	TPV	
kruseana	2140	0	1	2140	0.3	20	5	21	A	TV	Inhibitors
kumarlensis	5627	0	3	7850	0.1	20	5	21	A	TPV	
kybeanensis	1495	0	3	2950	0.4	20	5	14	B	TPV	42 days CMS
laeliae	1800	0	1	1800	0.3	25	9	15	A	TPV	
laevopinea	465	0	3	565	1.0	25	7	21	A	TPV	
lanepoolei	470	0	1	470	1.0	(25)	7	21	A	TPV	
lansdowneana											
ssp. *albopurpurea*	1350	0	1	1350	0.3	(25)	10	21	A	TPV	
ssp. *lansdowneana*	2640	0	2	3180	0.1	15	9	23	A	TPV	
largeana	1030	0	1	1030	0.5	(25)	5	15	A	TPV	
largiflorens	4840	0	4	7010	0.1	30	5	14	A	TPV	
lehmannii	390	0	1	390	0.8	25	7	28	A	TPV	
leptocalyx	1750	0	2	1900	0.2	(20)	10	28	A	TPV	
leptophleba	1466	0	5	2220	0.5	25	5	21	A	TPV	
leptopoda											
spp. *leptopoda*	3090	0	1	3090	0.2	15	7	14	A	TPV	
lesouefii	1780	0	1	1780	0.3	15	10	21	A	TPV	
leucophloia	3750	0	1	3750	0.2	25	5	14	A	TPV	
leucoxylon											
ssp. *leucoxylon*	1652	0	8	2675	0.2	(25)	5	28	A	TPV	
ssp. *megalocarpa*	2955	0	2	3960	0.1	(25)	5	28	A	TPV	
ssp. *petiolaris*	1760	0	2	1800	0.3	(25)	5	28	A	TPV	
ssp. *pruinosa*	2624	0	5	3500	0.2	(25)	5	28	A	TPV	
ligustrina	1940	0	1	1940	0.3	(25)	5	14	A	TPV	
lirata	410	0	1	410	1.2	(25)	7	14	A	TPV	
litorea	5600	0	1	5600	0.1	(20)	8	25	A	TPV	
longicornis	2121	0	4	2760	0.2	15	10	21	A	TPV	
longifolia	1553	0	4	1962	0.4	(25)	7	28	A	TPV	

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
longirostrata	891	0	7	1530	0.6	25	5	21	A	TPV	
loxophleba											
ssp. *gratiae*	1097	0	1	1097	0.1	(25)	9	29	A	TPV	
ssp. *loxophleba*	6811	0	4	7825	0.1	(25)	5	21	A	TPV	
lucasii	3190	0	1	3190	0.2	(25)	7	28	A	TPV	
lucens	4750	0	1	4750	0.2	(25)	5	36	A	TPV	
luehmanniana	390	0	1	390	1.2	(25)	5	14	A	TPV	
macarthurii	6930	0	8	18300	0.1	(25)	5	14	A	TPV	
macrandra	1290	0	2	2300	0.2	20	5	14	A	TPV	
macrocarpa											
ssp. *macrocarpa*	191	0	4	250	2.0	20	7	21	A	TPV	
ssp. *cannonii*	500	0	1	500	0.7	(15)	10	28	A	TPV	
macrorhyncha											
ssp. *macrorhyncha*	517	0	6	728	0.7	15	10	28	A	TPV	
major	3750	0	2	5500	0.1	(25)	5	14	A	TPV	
malacoxylon	2520	0	1	2520	0.2	(25)	5	10	A	TPV	
mannensis											
ssp. *mannensis*	921	0	5	1341	0.6	(20)	5	14	A	TPV	
ssp. *elliptica*	2137	0	1	2137	0.1	(25)	7	13	A	TPV	
mannifera											
ssp. *maculosa*	6150	0	1	6150	0.1	(25)	5	21	A	TPV	
ssp. *mannifera*	4307	0	6	7380	0.1	(25)	7	21	A	TPV	
ssp. *praecox*	3569	0	2	5950	0.1	(25)	7	21	A	TPV	
marginata	221	0	10	560	3.0	15;20	10	21	A	TPV	
mckieana	2050	0	1	2050	0.2	(25)	5	21	A	TPV	
megacarpa	390	0	1	390	1.5	(25)	5	28	A	TPV	
megacornuta	1848	0	3	2070	0.2	15	10	21	A	TPV	
melanoleuca	1160	0	1	1160	0.4	25	7	14	A	TPV	
melanophitra	5800	0	1	5800	0.2	(15)	11	35	A	TPV	
melanophloia	1366	0	4	1600	0.3	25	5	14	A	TPV	
melanoxylon	2610	0	2	3320	0.2	15	10	21	A	TPV	
melliodora	3634	1220	14	5500	0.2	25	5	21	A	TV	Inhibitors
merrickiae	1048	0	2	1115	0.5	(25)	10	28	A	TPV	
michaeliana	3280	0	2	5660	0.1	20	3	21	A	TPV	
micranthera	693	0	3	1089	0.5	(25)	7	21	A	TPV	
microcarpa	8709	4181	17	17850	0.1	(25)	5	14	A	TPV	
microcorys	1457	643	17	2760	0.2	(25)	5	14	A	TPV	
microneura	1440	0	1	1440	0.3	25	7	21	A	TPV	
microschema	3150	0	1	3150	0.1	(15)	5	14	A	TPV	
microtheca	4169	2261	17	8325	0.2	35	3	14	A	TV	Inhibitors
miniata	206	0	4	248	3.0	25	3	21	A	TPV	
mitchelliana	1142	0	2	2030	0.2	20	5	14	B	TPV	42 days

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
											CMS
moluccana ssp. *moluccana*	8420	0	6	15010	0.2	25;30	5	21	A	TPV	
moorei	3435	0	2	5570	0.1	(25)	7	14	A	TPV	
morrisbyi	3841	0	1	3841	0.15	(20)	9	15	A	TPV	
morrisii	3360	0	1	3360	0.2	(25)	5	14	A	TPV	
muelleriana	401	0	8	560	0.8	15	10	21	A	TPV	
multicaulis	910	0	2	1000	0.6	(25)	5	21	A	TPV	
myriadena	8675	0	2	9375	0.2	(15)	11	28	A	TPV	
neglecta	1150	0	1	1150	0.4	(25)	7	21	A	TPV	
newbeyi	1900	0	1	1900	0.2	20	5	14	A	TVP	
nicholii	7528	0	4	9800	0.1	(25)	3	10	A	TPV	
nigra (syn. *eugenoides*)	320	0	1	320	1.5	20	10	21	A	TPV	
nitens	2531	1445	43	7150	0.2	15;25	7	14	B	TPV	21days CMS *
nitida	1510	0	1	1510	0.3	15	10	28	A	TPV	
nobilis	2807	0	6	4150	0.2	20	5	21	A	TPV	
normantonensis	2525	0	4	3300	0.2	20;25	7	14	A	TPV	
nortonii	1707	0	2	1880	0.3	(25)	5	14	A	TPV	
notabilis	1958	0	4	2550	0.2	(25)	5	14	A	TPV	
nova-anglica	7360	0	1	7360	0.1	(25)	3	14	A	TPV	
nudicaulis	6025	0	1	6025	0.2	(25)	5	10	A	TPV	
obesa	233	0	1	233	0.1	(15)	5	20	A	TPV	
obliqua	598	235	11	880	0.6	15	7	28	A	TPV	
oblonga	1040	0	1	1040	0.5	20;25	7	21	A	TPV	
obtusiflora	480	0	1	480	1.0	20	10	28	A	TPV	
occidentalis	1570	0	10	2471	0.2	(25)	5	14	A	TPV	
ochrophloia	830	0	1	830	0.6	(25)	5	10	A	TPV	
odontocarpa	424	0	3	680	0.7	(25)	5	14	A	TPV	
odorata var. *odorata*	4070	0	1	4070	0.1	15;20	10	28	A	TPV	
oldfieldii	450	0	1	450	1.0	(25)	7	21	A	TPV	
oleosa	1458	0	3	2200	0.3	15	5	21	A	TPV	
olida	681	0	2	782	0.4	(25)	5	21	A	TPV	
oligantha	1170	0	1	1170	0.4	(25)	5	14	A	TPV	
oraria	2200	0	1	2200	0.2	20;25	5	14	A	TPV	
orbifolia	2320	0	2	2840	0.2	(25)	5	21	A	TPV	
oreades	1011	0	2	1152	0.6	(25)	7	28	A	TPV	
orgadophila	740	0	1	740	0.8	(25)	5	28	A	TPV	

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I] Mean	S.D.	No of seed-lots tested	Highest recorded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV] First	Final	Pre-treat [V]	Sub-strate [VI]	Comm-ents
ornata	1450	0	1	1450	0.2	(25)	10	22	A	TPV	
ovata	5942	0	8	6900	0.1	25	3	10	A	TPV	
ovularis	4960	0	1	4960	0.1	15;20	10	28	A	TPV	
oxymitra	367	0	4	550	0.9	(25)	3	14	A	TPV	
pachycalyx	1600	0	2	1870	0.3	25	5	10	A	TPV	
pachyloma	60	0	1	60	10.0	(25)	7	21	A	TPV	
pachyphylla	1068	0	6	2110	0.9	(25)	5	21	A	TPV	
paliformis	2700	0	1	2700	0.2	20	10	28	A	TPV	
paniculata	3885	0	4	4800	0.1	25	5	21	A	TPV	
parramattensis ssp. *parramattensis*	3340	0	1	3340	0.2	(25)	5	10	A	TPV	
parvula	4117	0	3	4710	0.1	(25)	5	10	A	TPV	
patellaris	1070	0	1	1070	0.5	30	5	14	A	TV	Inhibitors
patens	538	0	2	615	1.0	25	10	21	A	TPV	
patentinervis (*hybrid*)	1200	0	1	1200	0.1	(25)	7	14	A	TPV	
pauciflora											
ssp. *debeuzevillei*	1110	0	2	1280	0.4	(20)	7	21	B	TPV	28 days CMS
ssp. *niphophila*	1378	0	3	1575	0.4	20	5	10	B	TPV	28 days CMS
ssp. *pauciflora*	916	0	5	1675	0.8	15	7	21	B	TPV	21 days CMS
pellita	3234	1334	40	6000	0.3	(25)	5	21	A	TPV	
pellita × *brassiana*	1294	0	1	1294	0.1	(25)	7	14	A	TPV	
perriniana	3419	0	4	4220	0.1	20	5	10	B	TPV	21 days CMS
petraea	4850	0	2	5400	0.1	30	7	14	A	TPV	
petrensis	1284	0	1	1284	0.5	(30)	7	15	A	TV	
phaenophylla	2118	0	2	2160	0.1	(15)	10	36	A	TPV	
*phaeotricha**	2118	0	5	2890	0.3	(25)	5	14	A	TPV	
phoenicea	958	0	4	1650	1.0	25	5	14	A	TPV	
pileata	3260	0	1	3260	0.2	(25)	7	28	A	TPV	
pilligaensis	7570	0	2	7600	0.1	20	7	14	A	TPV	
pilularis	517	213	14	850	0.8	25			A	TPV	
pimpiniana	560	0	1	560	1.2	20	7	14	A	TPV	
piperita ssp. *piperita*	718	0	6	2080	0.2	20	5	14	A	TPV	
planchoniana	290	0	1	290	2.0	(25)	5	21	A	TPV	
platydisca (ms)	1280	0	1	1280	0.5	20	10	28	A	TPV	
platypus											
var. *heterophylla*	2173	0	2	2175	0.3	15;20	7	21	A	TPV	
var. *platypus*	3900	0	1	3900	0.3	15;20	7	21	A	TPV	

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
pluricaulis	1900	0	2	2700	0.2	(15)	10	28	A	TPV	
polyanthemos	5751	1796	13	9700	0.1	(25)	5	14	A	TPV	
polybractea	6208	2566	15	13600	0.05	15;20	10	28	B	TPV	7 days CMS
populnea	17250	0	2	19250	0.03	25	5	14	A	TPV	
porosa	3190	0	1	3190	0.2	(25)	5	28	A	TPV	
preissiana	700	0	1	700	0.7	15;20	10	21	A	TPV	
prominens	3050	0	1	3050	0.2	25	7	15	A	TPV	
propinqua	3880	0	5	4800	0.1	(25)	5	21	A	TPV	
pruinosa	1275	0	2	1300	0.4	30	5	14	A	TPV	
pryoriana	2664	0	4	4337	0.2	(25)	7	14	A	TPV	
pterocarpa	2300	0	1	2300	2.0	20	5	45	A	TV	
pulchella	790	0	1	790	0.6	15	14	21	A	TPV	
pulverulenta	3934	0	4	6375	0.2	25	5	28	A	TPV	
pumila	1130	0	1	1130	0.5	(25)	5	14	A	TPV	
punctata	851	0	6	1450	0.6	25	5	21	A	TPV	
pyriformis	370	0	1	370	1.5	25	7	21	A	TPV	
pyrocarpa	298	0	2	340	2.0	(25)	7	21	A	TPV	
quadrangulata	4211	0	6	6866	0.1	(25)	5	21	A	TPV	
quadrans	7100	0	1	7100	0.1	25	5	21	A	TPV	
racemosa	933	0	2	1320	0.4	25	5	14	A	TPV	
radiata											
ssp. *radiata*	2008	896	30	4000	0.3	15;20	10	21	A	TPV	
ssp. *robertsonii*	970	0	1	970	0.5	15;20	10	21	A	TPV	
raveretiana	28696	0	4	39000	0.01	30	3	10	A	TPV	
redacta	3150	0	1	3150	0.2	(20)	7	22	A	TPV	
redunca	1260	0	1	1260	0.4	(20)	5	21	A	TPV	
regnans	1218	0	5	1810	0.3	15;20	10	21	B	TPV	21 days CMS
remota	200	0	1	200	2.5	20;25	10	28	A	TPV	
resinifera	2598	0	2	2975	0.2	25	5	21	A	TV	Inhibitors
rhodantha	320	0	1	320	1.5	(25)	5	21	A	TPV	
rigens	610	0	2	800	0.5	(15)	7	25	A	TPV	
rigidula	2152	0	3	2980	0.2	15;20	5	21	A	TPV	
risdonii	1950	0	1	1950	0.3	15	10	21	A	TPV	
robusta	4265	1389	11	6300	0.1	15;25	7	14	A	TPV	
robusta × *tereticornis*	2450	0	1	2450	0.1	25	7	14	A	TPV	
rodwayi	7660	0	1	7660	0.1	25	5	14	A	TPV	
rossii	1610	0	1	1610	0.3	(25)	5	28	A	TPV	

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
roycei	280	0	1	280	1.0	25	10	28	A	TPV	
rubida ssp. *rubida*	3342	0	5	5487	0.2	25	5	21	A	TPV	
rubiginosa	600	0	1	600	0.1	25;30	5	21	A	TPV	
rudderi	3260	0	1	3260	0.2	(25)	5	14	A	TPV	
rudis	6529	0	7	8375	0.1	20;25	5	14	A	TPV	
rugosa	948	0	2	1120	0.4	(25)	5	14	A	TPV	
rummeryi	2168	0	2	2520	0.2	(25)	3	10	A	TPV	
rupicola	1050	0	1	1050	0.5	20	7	21	A	TPV	
salicola	6363	0	4	9150	0.1	(15)	10	21	A	TPV	
saligna	4884	1858	34	9900	0.1	25	5	14	A	TPV	
saligna × *botryoides*	3763	0	4	6250	0.1	25	5	14	A	TPV	
salmonophloia	5930	0	3	6290	0.1	15;20	10	21	A	TPV	
salubris	3795	0	5	6450	0.2	15;20	10	21	A	TPV	
sargentii	1871	508	13	2963	0.2	20	5	15	A	TPV	
scias ssp. *callimastha*	777	0	1	777	0.1	(25)	4	20	A	TPV	
sclerophylla	655	0	4	1390	0.5	20	6	14	A	TPV	
scoparia	3650	0	3	6000	0.1	(25)	5	15	A	TPV	
seeana	6350	0	1	6350	0.1	(25)	10	21	A	TPV	
sepulcralis	260	0	1	260	2.0	(25)	7	21	A	TPV	
serraensis	550	0	1	550	1.0	20	10	30	A	TPV	
sessilis	550	0	2	630	1.0	(25)	5	14	A	TPV	
sheathiana	3980	0	2	4010	0.2	20	7	21	A	TPV	
shirleyi	210	0	1	210	2.5	(25)	5	12	A	TPV	
sicilifolia	3900	0	1	3900	0.2	(25)	5	14	A	TPV	
siderophloia	4675	0	2	6650	0.1	(25)	3	14	A	TPV	
sideroxylon	2372	0	6	3437	0.2	20	5	14	A	TPV	
sieberi	1084	0	9	1720	0.5	25	7	14	A	TPV	
similis	440	0	1	440	1.2	(25)	5	14	A	TPV	
smithii	3271	982	20	5900	0.2	20;25	5	21	A	TPV	
socialis	1125	0	5	1575	0.4	(15)	7	21	A	TPV	
sparsicoma	2350	0	1	2350	0.1	(15)	5	15	A	TPV	
sparsifolia	780	0	3	1225	0.1	25	5	14	A	TPV	
spathulata	4856	0	4	6033	0.1	20;25	5	14	A	TPV	
spectatrix	1000	0	1	1000	0.4	15	12	33	A	TPV	
sphaerocarpa	496	0	4	730	1.0	25	7	14	A	TV	Inhibitors
squamosa	440	0	1	440	1.2	(25)	5	10	A	TPV	
staigeriana	2310	0	4	2550	0.3	25;30	5	14	A	TPV	

Appendix 3.10.1 Eucalyptus continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
steedmanii	4720	0	2	7100	0.2	20	7	28	A	TPV	
stellulata	3045	0	5	4850	0.2	15;20	10	21	B	TPV	21 days CMS
stenostoma	795	0	2	1170	0.4	20	10	21	A	TPV	
stoatei	600	0	2	820	1.3	20	5	30	A	TPV	
stowardii	460	0	1	460	1.0	20;25	7	14	A	TPV	
striaticalyx	2817	0	3	3800	0.2	15;25	5	14	A	TV	Inhibitors
stricklandii	1480	0	1	1480	0.4	15;20	10	21	A	TPV	
stricta	599	0	2	660	0.5	25	5	28	A	TPV	
sturgissiana	4900	0	1	4900	0.1	20	7	21	A	TPV	
subcrenulata	8600	0	1	8600	0.1	(20)	5	21	A	TPV	
suggrandis ssp *suggrandis*	2683	0	3	5330	0.1	(15)	10	20	A	TPV	
tectifica	1590	0	2	2320	0.6	30	5	10	A	TPV	
tenella	1420	0	1	1420	0.4	25	7	21	A	TPV	
tenuipes	3518	0	2	3810	0.2	25	5	14	A	TPV	
tenuiramis	970	0	1	970	0.5	20	10	28	A	TPV	
tenuis	2185	0	2	2200	0.2	20	5	20	A	TPV	
terebra	1275	0	1	1275	0.2	(15);(20)	6	20	A	TPV	
tereticornis	6137	3077	46	15100	0.1	25;30	5	14	A	TPV	
tetragona	243	0	2	260	2.0	(25)	5	14	A	TPV	
tetrapleura	1450	0	1	1450	0.4	30	5	10	A	TPV	
tetraptera	695	0	2	1000	1.2	20;25	7	21	A	TPV	
tetrodonta	373	0	2	526	2.5	25	5	14	A	TPV	
thozetiana	3950	0	3	4200	0.1	(25)	5	14	A	TPV	
tindaliae	800	0	1	800	0.6	(25)	5	14	A	TPV	
todtiana	118	0	2	180	2.5	20;25	7	21	A	TPV	
torquata	910	0	1	910	0.6	25;20	5	14	A	TPV	
transcontinentalis	1140	0	1	1140	0.4	20	5	14	A	TPV	
tricarpa	1480	0	8	2250	0.2	(20)	10	15	A	TPV	
triflora	830	0	2	1100	0.8	(25)	10	28	A	TPV	
trivalvis	1812	0	4	3275	0.4	20	7	21	A	TPV	
tumida	1400	0	1	1400	0.1	(15)	5	20	A	TPV	
umbra											
ssp. *carnea*	1660	0	1	1660	0.9	(25)	5	14	A	TPV	
ssp. *umbra*	1120	0	4	2325		15;20	7	21	A	TPV	
umbrawarrensis	4330	0	1	4330	0.1	(25)	7	21	A	TPV	
uncinata	4150	0	3	8050	0.05	15;20	10	21	A	TPV	
urnigera	2100	0	1	2100	0.2	15	10	21	A	TPV	

Appendix 3.10.1 Eucalyptus concluded

Species	Germination per 10g [I]		No of seed-lots tested	Highest recorded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat [V]	Sub-strate [VI]	Comm-ents
	Mean	S.D.					First	Final			
urophylla	3885	1572	35	8000	0.1	25;30	5	14	A	TPV	
victrix	2938	0	2	3375	0.2	(25)	6	20	A	TPV	
viminalis											
ssp. *cygnetensis*	3044	0	4	3980	0.2	25	7	14	A	TPV	
ssp. *viminalis*	3161	1225	29	5450	0.2	25	7	14	A	TPV	
virens	7660	0	1	7660	0.1	25	5	25	A	TPV	
viridis	8099	0	4	13900	0.1	20	7	21	A	TPV	
wandoo	2755	0	2	3030	0.2	15;20	10	21	A	TPV	
websteriana	1760	0	1	1760	0.3	(25)	5	28	A	TPV	
whitei	2440	0	1	2440	0.2	(25)	5	14	A	TPV	
woodwardii	1276	0	2	1312	0.4	15;20	7	14	A	TPV	
woollsiana	10770	0	1	10770	0.05	(25)	5	21	A	TPV	
yalatensis	590	0	1	590	0.8	20	8	28	A	TPV	
yarraensis	3925	0	4	5700	0.1	(25)	7	21	A	TPV	
yilgarnensis	6125	0	1	6125	0.5	20	6	28	A	TPV	
youmanii	386	0	5	720	2.0	(25)	10	28	A	TPV	
youngiana	376	0	3	505	1.0	(25)	7	21	A	TPV	
FLINDERSIA											
australis	121	0	2	152		(25)	3	21	A	TV	
brayleyana	60	0	3	71		(30)	3	28	A	TV	
collina	151	0	1	151		25	3	28	A	TV	
maculosa	568	0	1	568	0.4	(25)	5	10	A	TV	
GEIJERA parviflora	48	0	1	48		25	5	20	D	TV	
GMELINA											
dalrympleana	21	0	1	21		(25)	14	90	A	TV	
GREVILLEA											
dryandri	104	0	1	104		(25)	8	30	A	TV	
glauca	120	0	2	120		25	6	18	A	TV	
pteridifolia	97	0	10	182		30 and 20	15	40	A	TV	Alternating temperature
refracta	2150	0	1	2150		(25)	8	30	A	TV	
robusta	345	162	59	648		30 and 20	10	30	A	TV	Alternating temperature
wickhamii	5	0	2	8		30 and 20	12	30	A	TV	Alternating temperature
HAKEA											
arborescens	58	0	1	58		(25)	6	15	A	TV	
dactyloides	515	0	1	515		20	8	51	A	TV	
leucoptera	225	0	1	225		(25)	7	25	A	TV	

Appendix 3.10.1 Germination standards continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
HARDENBERGIA											
violacea	243	0	3	271		25	3	23	G/E	TV	
HETERODENDRUM											
oleifolium	1	0	1	1	1.0	25	11	25	A	TV	
INTSIA bijuga	2	0	1	2		(30)	18	28	C	TV	
ISOPOGON											
anemonifolius	24	0	2	44	2.0	25	30	91	J/A	TV	
KUNZEA											
ambigua	71487	0	3	122530	0.01	30	4	38	A	TPV	
parvifolia	40600	0	1	40600	0.01	30	7	25	A	TPV	
LAMBERTIA											
formosa	532	0	1	532		20	10	20	A	TV	
LEPTOSPERMUM											
attenuatum	23600	0	1	23600	0.02	20	7	39	A	TPV	
flavescens	12455	0	8	15850	0.05	25;30	6	30	A	TPV	
gregarium	6026	0	3	9746	0.10	(25)	6	20	A	TPV	
javanicum	22000	0	1	22000	0.02	30	8	18	A	TPV	
juniperinum	11475	0	4	19200	0.05	(25)	7	40	A	TPV	
laevigatum	3500	0	1	3500	0.2	25	7	21	B	TPV	28 days CMS
lanigerum	9825	0	2	10150	0.05	(25)	7	35	A	TPV	
liversidgei	9575	0	2	16450	0.05	(25)	7	20	A	TPV	
longifolium	5400	0	1	5400	0.1	(25);(30)	14	30	A	TPV	
myrifolium	6220	0	2	6340	0.1	(25)	8	30	A	TPV	
petersonii	10829	3669	12	17750	0.05	25	7	21	A	TPV	
scoparium var. *rotundifolium*	5800	0	1	5800	0.1	25	7	28	A	TPV	
LEUCAENA											
leucocephala	114	0	1	114		(25)	9	25	E	TV	
LOMANDRA											
longifolia	681	0	2	785		25	32	74	J/G	TV	
LOPHOSTEMON											
confertus	9880	0	5	37775	0.1	25	6	21	A	TPV	
suaveolens	3850	0	2	7700	0.1	20	6	28	A	TPV	
LYSIPHYLLUM											
cunninghamii	21	0	4	28		(25)	5	12	H	TV	
hookerii	21	0	1	21		(25);(30)	5	10	H	TV	

Appendix 3.10.1 Germination standards continued

Species	Germination per 10g[I]		No of seed lots tested	Highest recorded	Rep Wt (g)[II]	Temp. (°C)[III]	Count days[IV]		Pre-treat[V]	Sub-strate[VI]	Comments
	Mean	S.D.					First	Final			
MACADAMIA											
integrifolia	1	0	1	1		(25)	2	7	J	TV	Soak 2 days
MELALEUCA											
acacioides											
ssp. *acacioides*	23500	0	2	30000	0.01	25	6	21	A	TPV	
ssp. *alsophila*	16413	0	4	25250	0.01	(25)	7	22	A	TPV	
acuminata	31500	0	1	31500	0.02	15	10	24	A	TPV	
adnata	44000	0	1	44000	0.02	(25);(30)	5	21	A	TPV	
alsophila	8000	0	1	8000	0.02	(30)	5	16	A	TPV	
alternifolia	56625	0	6	116000	0.01	25	5	30	A	TPV	
arcana	39000	0	1	39000	0.01	(30)	5	20	A	TPV	
argentea	6700	0	7	20100	0.1	(30)	5	30	A	TPV	
armillaris	15500	0	1	15500	0.03	25	5	28	A	TPV	
bracteata	88750	0	4	170000	0.01	30	5	28	A	TPV	
cajuputi											
ssp. *cajuputi*	43288	22198	16	93500	0.01	25;30	6	15	A	TPV	
ssp. *platyphylla*	28229	0	7	52000	0.02	25	4	20	A	TPV	
clarksonii (ms)	25750	0	1	25750	0.01	(25)	5	17	A	TPV	
dealbata	38375	0	8	85000	0.01	30	10	35	A	TPV	
decora	46000	0	1	46000	0.01	(25)	5	30	A	TPV	
decussata	34300	0	2	36200	0.01	(25)	15	24	A	TPV	
dissitiflora	16667	0	3	22250	0.01	(30)	4	20	A	TPV	
eleuterostachya	57750	0	2	66500	0.01	(25)	5	30	A	TPV	
elliptica	57000	0	1	57000	0.01	25	5	28	A	TPV	
ericifolia	29650	0	2	42100	0.01	25	10	40	A	TPV	
fluviatilis	38150	0	1	38150	0.01	(25)	15	24	A	TPV	
fulgens	39000	0	1	39000	0.01	20	14	28	A	TPV	
glomerata	29771	0	6	51500	0.02	25	7	22	A	TPV	
halmaturorum	26438	0	2	30125	0.02	(25)	7	20	A	TPV	
hypericifolia	48000	0	1	48000	0.01	20	14	24	A	TPV	
lanceolata	13180	0	5	25250	0.01	(20);(25)	7	26	A	TPV	
lasiandra	53050	0	3	83000	0.01	(25);(30)	7	21	A	TPV	
lateriflora											
ssp. *"lateriflora"*	1250	0	1	1250	0.02	(15);(20)	14	22	A	TPV	
lateritia	85000	0	1	85000	0.01	25	5	33	A	TPV	
leucadendra	17871	11985	18	49750	0.05	(30);(35)	5	21	A	TPV	
linariifolia	52885	0	7	106700	0.01	(25)	7	14	A	TPV	
minutifolia	2400	0	1	2400	0.01	30	7	22	A	TPV	
nervosa	59500	0	2	112000	0.01	30	5	21	A	TPV	

Appendix 3.10.1 Melaleuca concluded

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
nesophila	4000	0	1	4000	0.05	(20)	14	28	A	TPV	
nodosa	57200	0	1	57200	0.02	25	6	18	A	TPV	
pauciflora	12800	0	1	12800	0.02	25	7	36	A	TPV	
pauperiflora	17000	0	1	17000	0.03	25	5	14	A	TPV	
preissiana	27500	0	2	48000	0.01	25	5	28	A	TPV	
pubescens	16000	0	1	16000	0.05	30	8	21	A	TPV	
quinquenervia	26444	16573	16	70000	0.02	30	5	21	A	TPV	
radula	25000	0	1	25000	0.02	20	14	28	A	TPV	
rhaphiophylla	29000	0	1	29000	0.02	30	8	28	A	TPV	
saligna	27625	0	4	42000	0.01	(30);(35)	7	21	A	TPV	
sericea	4500	0	1	4500	0.02	(30)	5	12	A	TPV	
squamophloia (ms)	37627	0	5	52555	0.01	25	10	26	A	TPV	
stenostachya	52000	0	1	52000	0.01	25	7	30	A	TPV	
styphelioides	33000	0	1	33000	0.02	30	7	28	A	TPV	
symphyocarpa	7200	0	1	7200	0.1	30	7	17	A	TPV	
thyoides	41083	0	3	57500	0.05	25	6	25	A	TPV	
trichostachya	12617	0	3	17200	0.05	25	7	28	A	TPV	
uncinata	21950	0	2	29700	0.05	20	14	28	A	TPV	
viridiflora	26688	11964	17	51000	0.05	30	5	28	A	TPV	
MELIA											
azedarach var. *australasica*	5	0	3	5		30	10	80	C	TV	
NOTHOFAGUS											
alpina	101	0	1	101		25	5	30	B	TV	30 days CMS
dombeyi	322	0	2	642		(25)	5	30	B	TV	90 days CMS
obliqua	98	0	2	111		25	5	30	B	TV	30–60 days CMS
pumilio	31	0	1	31		25	5	30	B	TV	90 days CMS
OCTOMELES											
sumatrana	142220	0	2	271000	0.01	25	10	39	A	TPV	
PANDOREA											
doratoxylon	883	0	1	883	0.3	25	10	16	A	TPV	
PARASERIANTHES											
falcataria	378	0	2	476		(30)	3	10	EP	TV	
lophantha	82	0	1	82	2.0	(20)	5	18	E	TV	

Appendix 3.10.1 Germination standards continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
ssp. *lophantha*											
lophantha ssp. *montana*	55	0	3	131	2.0	(20)	5	20	EP	TV	
PARINARI											
nonda	15	0	1	15		(30)	20	30	J	TV	
PAULOWNIA											
tomentosa	38167	0	1	38167	0.2	(25)	10	24	A	TV	
PETALOSTIGMA											
pubescens	5	0	1	5		(30)	11	35	CA	TV	
PINUS											
brutia	6	0	1	5.9		20	12	20	J	TV	
caribaea											
var. *bahamensis*	458	0	1	458		25	7	21	A	TV	
var. *caribaea*	426	0	1	426		25	7	21	A	TV	
var. *hondurensis*	414	0	5	528		25	7	21	A	TV	
dalatensis	7	0	1	7		(25)	13	36	P	TV	
elliottii	331	0	1	331		25	5	12	J	TV	Rinse H_2O_2
patula	851	0	2	1006		25	3	24	A	TPV	
PITTOSPORUM											
phillyraeoides	189	0	1	189		25	17	31	I	TV	
PTEROCARPUS											
dalbergioides	218	0	1	218		30	6	15	H	TV	3 min
indicus	170	0	1	170		30	6	15	H	TV	3 min
macrocarpus	102	0	2	112		(30)	5	21	A	TV	
RHODOSPHAERA											
rhodanthema	12	0	3	24		(25)	2	21	C	TV	
SANTALUM											
album	18	20	13	70		(30)	18	42	C	TV	
austrocaledonicum	68	0	1	68		25	13	20	C	TV	
lanceolatum	36	0	1	36		(25)	13	20	C	TV	
macgregorii	2	0	1	2		30	18	40	C	TV	
spicatum	5	0	1	5		(20)	13	28	C	TV	
SENNA											
costata	392	0	1	392		25	4	20	CD	TV	
oligophylla	80	0	2	109		(25)	4	20	CD	TV	
sturtii	371	0	3	414		(25)	2	14	C	TV	
SESBANIA											

Appendix 3.10.1 Germination standards continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			
formosa	271	123	17	545		25;30	3	20	EG	TV	
grandiflora	140	0	1	140		25;30	4	16	C	TV	
SINOGA											
lysicephala	9000	0	1	9000		(25)	10	22	A	TV	
SWIETENIA											
macrophylla	16	8	14	39		25	10	35	A	TV	
SYNCARPIA											
glomulifera	1593	0	5	2350		25	6	20	A	TPV	
hillii	670	0	1	670		25	4	14	A	TPV	
TAMARINDUS											
indica	15	0	1	15		(25)	14	20	C	TV	
TECTONA											
grandis	3	0	2	4		30	11	27	C	TV	
TERMINALIA											
canescens	17	0	2	22		(25)	22	30	C	TV	
THEMEDA											
triandra	710	0	3	1082	2.0	20;30	6	28	A/J	TV	Immature seeds need treatment
TOONA											
ciliata	1495	776	12	2510		20;25	5	26	A	TV	
VENTILAGO											
viminalis	154	0	2	219		(25)	7	10	J	TV	Remove samaras

Appendix 3.10.1 Germination standards continued

Species	Germination per 10g [I]		No of seed-lots tested	Highest recor-ded	Rep Wt (g) [II]	Temp. (°C) [III]	Count days [IV]		Pre-treat[V]	Sub-strate[VI]	Comm-ents
	Mean	S.D.					First	Final			

Legend

I For species with less than 10 seedlots tested only the mean number of viable seeds per 10g is given. Where the number of lots tested exceeds 10 both the mean and the standard deviation is given.

II Where the weight of replicate is not given, sampling is by a known number of seed (25 seeds/replicate).

III Temperature recommendations separated by the semicolon indicate that both temperatures have been found to be satisfactory.

Temperatures enclosed in brackets are found to be satisfactory, but a full range of temperature tests have not been made.

IV Number of days when “first” and “final” of seeds germinate.

V Pre-treatments:

A = No pre-treatment required.
B = Cold moist stratification (CMS).
C = Manual nicking/scarification.
D = Pour on boiling water (100ºC), soak until cool.
E = Boil in water (100ºC) for 1 minute.
N = Boil in water (100ºC) for 2 minutes.
F = Boil in water (100ºC) for 5 minutes.
G = Immerse in hot water (90ºC) for 1 minute.
H = Acid (H_2SO_4) scarification.
I = Rinse in flowing water for 1 hour.
K = Rinse 3% NaOCl.
P = Soak in water, ambient temperature, for 12 to 18 hours.
J = Other pretreatment (see remarks).
** = Pre-treatment not yet determined.

Optional: After pre-treatment with boiling water (codes D,E,N,F), germination may be improved by soaking seed in cold tap water for approximately 24 hours before sowing.

VI Substrate codes; TPV = filterpaper over vermiculite; TV = vermiculite.

Notes:

1 Manual nicking/scarification for acacia species can be used as an alternative to the recommended water pre-treatment.

2 8 to 12 hours of light per 24 hour cycle is standard procedure for all species listed unless otherwise indicated under “remarks”.

3 CMS*: cold moist stratification is not required for fresh seedlots.

Appendix 3.10.2 Species of Acacia for which a pre-treatment is not normally required

Acacia agyrodendon	*A. harpophylla*
A. cambagei	*A. latzii*
A. coriacea var. *pendula*	*A. maconochieana*
A. cyperophylla	*A. synchronicia*
A. distans	*A. xiphophylla*
A. georginae	

Appendix 3.10.3 Species responding to cold moist stratification (3–5ºC)

A. Species of Eucalyptus responding to cold moist stratification (Turnbull and Doran 1987)

Species	Stratification period (weeks)	Species	Stratification period (weeks)
Eucalyptus amygdalina	4	*E. pauciflora* subsp. *debeuzevillei*	4
E. delegatensis	6–10	*E. pauciflora* subsp. *niphophila*	4
E. dives	6	*E. pauciflora* subsp. *pauciflora*	3*
E. coccifera	3	*E. perriniana*	3
E. flocktoniae	4	*E. polybractea*	1*
E. glaucescens	4*	*E. regnans*	3*
E. kybeanensis	6	*E. stellulata*	3
E. mitchelliana	6		
E. nitens	3*	* Cold, moist stratification not always essential	

B. Other species that may respond favourably to cold moist stratification (requires further research for confirmation)

Species	Stratification period (weeks)	Species	Stratification period (weeks)
Acacia mearnsii	3	*Leptospermum laevigatum*	4
A. dealbata	3	*Nothofagus alpina*	4
A. alpina	3	*N. dombeyi*	12
A. kybeanensis	3	*N. obliqua*	4–8
A. pravissima	3	*N. pumilio*	12
Bursaria occidentalis	4		

Appendix 3.10.4 List of eucalypt species reported to contain inhibitors

Eucalyptus	***Corymbia***
calycogona	*citriodora*
cloeziana	*eremaea*
deglupta	*grandifolia*
diversicolor	*maculata*
haemastoma	
intertexta	
kruseana	
melliodora	
microtheca complex	
patellaris	
resinifera	
sphaerocarpa	
striaticalyx	

Appendix 3.10.5 Germination/purity test sheet

CSIRO Forestry and Forest Products
Australian Tree Seed Centre

Germination Test Sheet

Species . . . . . Seedlot/Field No . . . . . .

Origin . . . . . Alt. . . . (m) Collection Date . . . . . .

Supplier. . . . . Date received . . . . . Amount . . . . . .

Method . . . . . Rep.weight . . . . . g Replications . . . . . .

Stratification period . . . . . Start of test . . . . . Germination began . . . . . .

Av. viability for species is . . . . . /10g± . . . . . .

Based on . . . . . Tests Count days . . . . . .

Date Examined	Test Period (days)										
Number of mouldy seeds											
Weight of replicate (g)											
No. of germinations/dish											
Squash test/firm/dish	SOFT / HARD										
Individual Av. viability/10g											
Individual Av. germination %											

Calculation

Av. of . . . replications = ...

Av. viability = ... % . . . . . /10g

Av. of germination = ... % . . . . . /10g

Index

A = Albino
C = Abnormal cotyledon
R = Abnormal radicle
H = Abnormal hypocotyl
M = Mouldy seedling

Sampling Date . . . . . .

Purity Test

Purity % = Weight of pure seed x 100
Tot. wt of orig. sample

Purity % = _____ x 100

Purity _____ %

Comments: .....

.....

.....

.....

Cut Test: Viable seed . . . . . % non viable ..... %

Seed Tester: ..... Signature ..... Date .....

Appendix 3.10.6 Moisture content test sheet

CSIRO Forestry and Forest Products
Australian Tree Seed Centre

Moisture Content Test Sheet

Genus/Species ..... Seedlot/Field No .....

Origin .....

Date: ..... Time in: .....
Date: ..... Time out: .....

Method [1]: Low constant temperature oven method ❑
High constant temperature oven method ❑

Description of sample: Pure seed ❑
Seed & chaff ❑
Chaff ❑

Formula for moisture content calculation:

% Moisture content = $(M_2 - M_3) \times 100 / (M_2 - M_1)$

M_1 = Weight of dish
M_2 = Weight of dish & sample
M_3 = Weight of dish & sample after oven drying

Calculations:

Dish No. .....
M_1 ..... ( ) × 100 / ( ) =
M_2 .....
M_3 .....

Dish No. .....
M_1 ..... ( ) × 100 / ( ) =
M_2 .....
M_3 .....

Dish No. .....
M_1 ..... ( ) × 100 / ( ) =
M_2 .....
M_3 .....

Average moisture content =

Analyst ..... Comments .....
.....
.....
.....
.....

[1] Footnote:
Low constant temperature oven method 103ºC ± 2º for 17 ± 1 hour
High constant temperature oven method 130ºC for 1 hour

Appendix 3.10.7 Tolerance tables

A. Maximum tolerated range between replicates

This table based on the Poisson distribution indicates the maximum range (i.e. maximum difference between the highest and the lowest) in germination data tolerable between weighed replicates, allowing for random variation at 0.05 probability. To find the maximum tolerated range, calculate the sum of the numbers of seeds germinated in all replicates. Locate the sum in column 1 of the table and read off the maximum tolerated range in column 2.

Number of seeds germinated in the total weight of seed	Maximum range	Number of seeds germinated in the total weight weight of seed tested	Maximum range
1	2	1	2
0–6	4	161–174	27
7–10	6	175–188	28
11–14	8	189–202	29
15–18	9	203–216	30
19–22	11	217–230	31
23–26	12	231–244	32
27–30	13	245–256	33
31–38	14	257–270	34
39–50	15	271–288	35
51–56	16	289–302	36
57–62	17	303–321	37
63–70	18	322–338	38
71–82	19	339–358	39
83–90	20	359–378	40
91–102	21	379–402	41
103–112	22	403–420	42
113–122	23	421–438	43
123–134	24	439–460	44
135–146	25	>460	45
147–160	26		

ISTA (1996)

Appendix 3.10.7 Tolerance tables (concluded)

B Maximum tolerated ranges between replicates assuming a probability level of 2.5% calculated using the Binomial distributions for three, four, twelve and sixteen replicates of 25 seeds.

To find the maximum tolerated range, calculate the average percentage to the nearest whole number. Locate the average percentage and read off the maximum tolerated range against the appropriate replicate number.

Av. germination %		3 reps	4 reps	12 reps	16 reps
99	2	1	1	2	2
98	3	2	2	3	3
97	4	2	3	3	3
96	5	3	3	4	4
95	6	3	4	4	5
94	7	4	4	5	5
93	8	4	4	5	6
92	9	4	5	6	6
91	10	4	5	6	6
90	11	5	5	6	7
89	12	5	5	7	7
88	13	5	6	7	7
87	14	5	6	7	8
86	15	5	6	8	8
85	16	6	6	8	8
84	17	6	6	8	8
83	18	6	7	8	9
82	19	6	7	8	9
81	20	6	7	9	9
80	21	6	7	9	9
79	22	7	7	9	9
78	23	7	7	9	10
77	24	7	7	9	10
76	25	7	7	9	10
75	26	7	8	10	10
74	27	7	8	10	10
73	28	7	8	10	10
72	29	7	8	10	10
71	30	7	8	10	10
70	31	7	8	10	11
69	32	7	8	10	11
68	33	8	8	10	11
67	34	8	8	10	11
66	35	8	8	11	11
65	36	8	8	11	11
64	37	8	8	11	11
63	38	8	9	11	11
62	39	8	9	11	11
61	40	8	9	11	11
60	41	8	9	11	11
59	42	8	9	11	11
58	43	8	9	11	11
57	44	8	9	11	11
56	45	8	9	11	12
55	46	8	9	11	12
54	47	8	9	11	12
53	48	8	9	11	12
52	49	8	9	11	12
51	50	8	9	11	12

Williams *et al*. (1992).

Section 4

Storage

The ATSC operates an active seed store comprising approximately 800 species and 13 000 accessions with a strong focus on woody species of Australian origin together with a limited seed stock from other sources. The purpose of the seed store is to maintain seed viability for as long as possible and ensure adequate supplies of well documented germplasm representing species, provenance, individual tree and seed orchard seed for distribution to researchers both nationally and internationally and for commercial sale. Seedlots are held in stock until exhausted through consignment or as a consequence of viability loss over time. Collections are therefore ongoing in order to meet requirements for seed and to replenish diminishing stocks.

The storage life of seed is strongly influenced by the type and condition of the seed for storage, environmental conditions leading up to seed maturity and during storage. These factors are briefly discussed as follows:

Roberts (1973) classified seed into two broad physiological categories (1) orthodox and (2) recalcitrant based on storage characteristics. Orthodox seed tolerate desiccation to low moisture contents (4–10%) on a wet weight basis (w/w), are comparatively long lived if handled appropriately and tolerate being stored at sub-zero temperatures. By contrast, recalcitrant seeds are desiccation sensitive, short lived and may be intolerant of low temperatures (sub-zero for temperate species and $<18^{\circ}C$ for tropical species). Within these two categories further sub-divisions can be made. Bonner (1990) refined the categories to comprise (1) true orthodox, (2) sub-orthodox otherwise referred to as 'intermediate' between orthodox and recalcitrant in which the seed can tolerate drying to some extent, but not low temperatures (Ellis *et al*. 1991), (3) temperate recalcitrant and (4) tropical recalcitrant. As reported by Hong and Ellis (1996) and Hong *et al*. (1998), recent studies have shown that seed of certain species do not conform to the above definitions. For this reason, there are those who prefer to avoid using definitions to describe seed characteristics of species preferring to refer to specific levels of tolerance to desiccation and temperature.

The following points may have an influence on the longevity of seed in storage:

- Environmental factors leading up to seed maturation. If sub-optimal, environmental factors may have adverse effects on seed quality. Hot dry conditions for example may cause seed development to be curtailed.

- Maturity of seed at time of collection. Seed collected immature tends to lose viability more rapidly than mature seed.

- Handling of the seed between collection and processing. Adverse conditions such as high temperatures, humidity and development of fungi will damage seed.

- Injury of the seed during processing, e.g. cracked seed coat, may reduce storage life. This has been discussed under the sections dealing with Seed Collection and Seed Processing.

- Seed coat structure. Seed with hard seedcoats are more resilient than seed with a thin seedcoat.

- Seed chemistry. Oily seed tends to be harder to store than starchy seed (Bonner *et al*. 1994, Stubsgaard, 1992).

- Insects and fungi. These can destroy the seed if not controlled.

- Storage conditions. The most important factors are to control seed moisture content and storage temperature while gaseous environments may also influence seed longevity.

4.1 Principles of storage

The main factors associated with loss of seed viability in storage are (1) moisture content of the seed, (2) storage temperature and (3) storage atmosphere (oxygen) all of which have an influence on the rate of respiration. Protection against pests and diseases is also critical particularly during shipment and processing where it may be more difficult to store the fruit. In recalcitrant seed the safe minimum levels of moisture content, temperature and oxygen are all considerably higher than those for orthodox seed (Willan 1985). Deterioration in seed leads to deterioration in viability and vigour predisposing to eventual death of the seed.

4.1.1 Moisture content

A reduction in seed moisture content (MC) causes a slow down in the rate of respiration and thus reduces the rate of physiological aging. MC is probably the single most important factor in determining seed longevity. The rule of thumb for orthodox seed is—within the range of 4–14% seed storage life is approximately doubled for each 1% decrease in moisture content. In order to reach an optimum moisture content (4–8% ww for orthodox seed) it is normally required that the seed be dried down. By contrast recalcitrant seeds should be stored fully imbibed (Bonner *et al*. 1994).

Seeds with permeable seed coats either lose or absorb moisture to or from the surrounding atmosphere until the MC reaches a point of equilibrium with the humidity and temperature of the surrounding air. This is known as the equilibrium moisture content (EMC) or equilibrium with the humidity (equilibrium relative humidity (eRH)). Once EMC has been reached in the seed, it will be maintained as long as the atmospheric humidity remains constant. Should the surrounding atmospheric humidity change this will also cause the MC of the seed to adjust accordingly over time. The process of drying relates to the loss of moisture through evaporation of moisture to the atmosphere (desorption). This is in contrast to seed taking up moisture from the atmosphere (absorption). 30% relative humidity is approximately equivalent to 8% moisture content in seed.

When drying down seed, it is therefore necessary that the relative humidity of the air is sufficiently low enough to enable the seed to reach the desired moisture content. Drying facilities should allow for the control of humidity (dehumidified conditions) and temperature. The speed of drying is determined mainly by the speed at which the moisture can migrate to the surface of the seed for evaporation, the air velocity around the seed, the temperature and the relative humidity. For long term seed storage (Genebank conservation) the International Plant Genetic Resources Institute (IPGRI) recommend that seed should be dried down under conditions of 10–15% RH and 15°C (Hanson 1985).

As an alternative to dehumidified conditions, indicator silica gel can be used to dry down small quantities of seed. A weight of silica gel equal to one tenth the weight of seed is recommended (Harrington 1972). For a more accurate calculation of the amount of silica gel required refer to Stubsgaard and Poulsen (1995).

4.1.2 Temperature

The lower the temperature the lower the rate of respiration and thus the longer the life-span of the seed in storage. The rule of thumb is; between 0–50°C, seed storage life is approximately doubled for each 5°C reduction in storage temperature. Choice of storage temperature varies considerably according to species and the period for which the seed is to be stored.

4.1.3 Atmosphere

The third method for checking the rate of respiration is to exclude oxygen from the atmosphere. This method may be beneficial to orthodox seed which has a low metabolic rate of exchange but can be damaging to recalcitrant seed which requires oxygen. The method is commonly achieved by replacing oxygen with carbon dioxide, nitrogen or forming a vacuum. Shrestha *et al*. (1985) reported on the effects of controlled atmosphere storage on storage life of *Pinus radiata*. Germination capacity, energy and seed vigour were best maintained by storage in nitrogen followed by carbon dioxide. Storage in a vacuum or air were least effective, irrespective of storage temperature.

For more detailed information on seed storage refer to: Bonner *et al*. (1994), FAO (1993), Justice and Bass (1979), Stubsgaard (1992), Stubsgaard and Poulsen (1995), Schmidt (2000), Willan (1985).

4.2 Storage procedures at ATSC for orthodox seed

4.2.1 Fumigation

Before storage seed must be fumigated to kill insect pests which may damage the seed and as a quarantine requirement when sending seed overseas. Insects are known to eat seed contained in fruit or develop within the fruit emerging when conditions are suitable. Some seed infesting insects lay their eggs in the flowers; the eggs hatch in the developing fruit where the larvae feed on the fertilised ovules of eucalypts (Boland *et.al*. 1980). *Megastigmus* spp. are common seed destroyers in several species of eucalypts as for example *E. delegatensis, E. nitens* and *C. maculata* appearing as galls (hollow enlarged shells) which may appear paler in colour on the seed coat. The larval stage of a beetle, family *Bruchidae*, is known to eat *E. diversicolor* seed contained in the capsule (White 1971).

There are several chemicals used to kill insects including ethylene bromide, hydrocyanic gas, carbon disulphide all of which are toxic to humans. For this reason the ATSC fumigates seed with carbon dioxide for a period of two weeks prior to storage. This procedure is based on Bailey and Banks (1980) and following in-house trials conducted at the ATSC. The method is both effective and safe to both the viability of the seed and user. Equipment at the ATSC enables two approaches to be taken when fumigating seed with CO_2. Both methods are based on the use of laminated gas-impervious plastic bags. The simplest method is to place the seedlots in the bag and partially seal the neck using a heat sealer (three-quarters of the neck width). Compressed industrial CO_2 gas is then fed into the bag using a hose placed in the bottom until fully inflated. The gas is then turned off and the rest of the bag is sealed taking precautions to minimise loss of gas (see Plate 6A). The alternative method is to use a vacuum combined gas flush unit which is used for packaging seed for storage and dispatch. Seed is again placed in laminated bags and placed in the unit. The unit forms a vacuum by removing the air followed by a gas flush of CO_2 before the bag is finally heat sealed. For more information on the method of CO_2 fumigation refer to Sary *et al*. (1993).

Empirical evidence to date has shown that CO_2 has been effective in killing insects in the adult stages which is to be expected since respiration rates are highest during this stage of an insects life (Schmidt 2000). However, there is evidence to show that CO_2 was not effective in killing living larvae of a wasp, family *Eulophidae* (J. LaSalle pers. comm. 2001) contained inside the seed of *Corymbia maculata*. The seed had been held in storage for 5 years at 18ºC.

These findings have prompted the ATSC to consider more severe treatments to kill insects associated with eucalypts in particular seeds of spotted gums. Seed must be carefully inspected to determine evidence of living insects particularly in the larvae and egg stages through the presence of galls or other deformities to the seed. Where seed is suspected of containing living insects, then the seed is to be stored in the freezer (–18ºC) for one week followed by CO_2 fumigation. Should there be concern over the effect of freezer storage on seed viability, then run a pilot trial by placing a small sample (100 seeds) in a freezer for one week then check germination results against seed from the same seedlot which has not been placed in the freezer. If there is a significant difference between the two germination tests then freezer fumigation is not suitable.

The ATSC does not routinely treat seed for pathogens (fungi, bacteria and viruses) preferring to adopt preventative measures that ensure the seed is handled in such a manner that damage is kept to a minimum. This has been achieved by keeping the seed dry, cool and well aerated from the time of collection through to storage to minimise the possibility of fungal infection. Prior to storage, seed is well dried and stored in a dry, cool environment under hygienic conditions. Yuan *et al*. (1990) found that seed of *Acacia, Casuarina* and *Eucalyptus* species held in the ATSC seed store contained fungi that are widely distributed geographically round the world. This would indicate that there is minimal risk of inadvertently introducing fungi harmful through the international distribution of seed from the ATSC seed store.

4.2.2 Seed storage

4.2.2.1 Temperature

A number of seed storage trials conducted by the ATSC including those presented by Doran *et al*. (1987) point to the importance of temperature on storage life of seed. Table 4.1 summarises the results of trials carried out on *E. microtheca* complex, *E. deglupta, E. camaldulensis G. robusta*

Table 4.1. Percentage germination of seed following different storage times and temperatures compared with initial germination (100%) prior to storage.

Storage (yrs)	Percentage germination (%) Air conditioned room 21–24°C	Fridge 2–5°C	Freezer –15°C
	Eucalyptus microtheca		
5	20	72	86
8	10	71	100
12	0	73	89
19	0	32	92
	Eucalyptus deglupta		
3	3	37	80
5	0	9	61
9.5	0	0	2
13.5	0	0	3
19	0	0	1.5
	Eucalyptus camaldulensis		
5	100	92	95
10	82	94	96
21	74	40	98
	Grevillea robusta		
4	100	98	91
8	71	99	99
11	23	88	99
	Casuarina equisetifolia		
5	44	100	94

and *C. equisetifolia*. With the exception of *E. camaldulensis*, there is a clear indication of the benefits in storing seed at −15°C particularly in the case of the first two species that are more sensitive to storage than many other eucalypt species. In the case of *E. camaldulensis* the differences are less dramatic with only a marginal drop in germination over the first 10 years. No explanation can be given for why the seed stored at 21–24°C gave better results than at the other two storage temperatures. Despite this, other seedlots of this species are known to have deteriorated significantly at 21–24°C over a similar life span (Doran *et al.* 1987). Seed is stored under the following three temperature regimes.

Air-conditioned room (18–20°C, RH ~ 30–60%)
The majority of seedlots and particularly those within the genus of *Acacia, Corymbia* and *Eucalyptus* with a long shelf life are stored under these conditions. Whilst these conditions are not ideal for seed storage, consideration has been given to staff who require to access the store regularly on a daily basis. For seed to be stored under these conditions, they must be able to maintain viability for at least ten years without significant loss in viability (<40% over 10 years). It is anticipated that during this time, most if not all of the seed within a seedlot will have been dispatched.

Cool room (3–5°C)
Seed that does not store well at room temperature is kept in the cool room (Table 4.2.) In addition to species listed in Table 4.2, seedlots which are regarded as 'irreplaceable or of high genetic value' should also be stored in the cool room. A number of species in Table 4.2 for example *E. benthamii,* have been included largely for this reason. Since there is no control on relative humidity (RH ~90%), it is important that seed be dried down to a moisture content of below 8% and stored in laminated plastic bags in airtight containers. The cool room is divided into two sections, one for seed in quarantine and the other for routine storage.

Table 4.2. Species required to be stored at 3–5°C (updated 20 July 1999)

Eucalyptus	***Acacia***	**Other genera**
alba	*argyrodendron*	*Albizia*
benthamii	*coriacea*	*Allocasuarina*
corrugata	*cyperophylla*	*Atalaya hemiglauca*
delegatensis	*distans*	*Araucaria* MC >7%
diversicolor	*georginae*	*Backhousia*
leptopoda	*latzii*	*Callitris*
lesouefii	*maconochieana*	*Casuarina*
leucoxylon	*synchronicia*	*Coniferae*
melliodora	*xiphophylla*	*Cunninghamia*
lanceolata		
miniata		*Grevillea*
moluccana		*Melia*
muelleriana		*Pterocarpus*
obliqua		*Syzygium*
polyanthemos		*Tectona grandis*
pruinosa		
regnans		
sideroxylon		
tetrodonta		
urophylla		
Corymbia		
papuana		
tessellaris		
torelliana		

Freezer (−15°C to −18°C)
Used for storage of specific species as listed in Table 4.3 below. For species or seedlots considered 'irreplaceable or of high genetic value' as discussed under cool room storage, it may be prudent to store in the freezer that portion of seed surplus to anticipated requirements in the next five years. Other requirements for freezer storage includes seed specifically set aside for long term genetic conservation purposes and storage trials. Seed stored at this temperature must have a moisture content in the range of 5–7% and be kept in sealed laminated plastic bags.

Table 4.3. Seed stored in the freezer at −15°C to −18°C

Acacia cambagei	*E. deglupta*
A. harpophylla	*E. microtheca* complex
Agathis	*Flindersia*
Araucaria (MC <7%)	*Khaya senegalensis*
Eucalyptus coolabah	*Toona*
E. cyanoclada	

Appendix 4.3 provides an indication of the effects of seed storage on the germination capacity of 519 species held in the ATSC seed store. The table has been divided into three sections according to the temperature at which each species has been stored i.e. 18–20ºC, 3–5ºC and –15 to –18ºC.

4.2.2.2 Control of seed moisture and atmosphere

Standard practice is for processed seed to be placed in storage in airtight containers without further drying down. This method has been effective in maintaining seed viability and vigour at an acceptable level for most seedlots held in the seed store for up to approximately 10 years. However, the loss of vigour and viability of seed beyond this time has been more dramatic reducing the quality of the seed to an unacceptable level.

In an attempt to maintain the viability and vigour of seed at an acceptable level beyond ten years, a policy of drying seed down to a moisture content of below 8% has been introduced. One method for attaining the required seed MC is to use a cupboard dryer with an electric fan and thermostatically controlled heater mounted at the bottom and vent at the top. Seed contained in standard calico bags or paper envelopes are placed on racks. The fan forced air dryer located in the air-conditioned seed store (19–22°C, RH 25–45%) runs for an initial period of approximately one week to bring the seed down to a moisture content of about 8–9%. The dryer's heater is then turned on to a temperature of 24–26°C for a further period until the moisture drops below 8%. Alternative drying equipment is being assessed which can control both temperature and relative humidity.

Once the seed has reached the desired moisture content, the seed is placed in a vacuum chamber which has the option of either vacuum packaging the seed or combining with a gas flush of CO_2.

4.2.3 Recalcitrant seed storage

A number of species, particularly those found in the rainforest, have fleshy or moist seed with a relatively high moisture content at maturity (>20%) and are sensitive to moisture loss. These seeds have a comparatively high metabolic rate and are difficult to store for any length of time (several months to over a year).

Given the variable nature of recalcitrant seed and limited experience in their handling, it is not possible to provide clear procedures for their handling and storage. A protocol has been developed by DFSC-IPGRI (1999) for assessing seed characteristics which will provide information on the storage life and method of storing the seed. The following points are provided as a baseline approach to handling recalcitrant fleshy fruit.

- Determine the initial moisture content. Seed cut into 5 mm thick slices and tested using the low temperature oven method.
- Immerse in water for 24 hours to kill insects.
- Determine whether the seed can be dried down safely without significant loss of viability (>10%). If drying does not have a detrimental effect, it may be possible to store the seed for longer compared with seed stored in the fully imbibed state.
- Test for germination. This may take several months.
- Australian species should generally be stored at 3–5°C.
- Keep seed in plastic bags that allow free air exchange (not laminated plastic). Moist seed

that is likely to dehydrate under these conditions should be stored in a moist substrate (moist vermiculite or sawdust).

- Seed should be tested for viability every 3–6 months.
- Seed should be distributed as soon as possible following collection and processing.

4.2.4 Maintaining seed identity in storage

All seedlots must be clearly labeled with at least the seedlot number and collector's number for individual tree lots prior to storage (Plate 6B). For large bulk lots (over 60 kg) the seed is placed directly in containers with a label placed both inside the container and another on the outside (Plate 6C). For all other orthodox seedlots, the seed is packaged in calico bags or paper envelopes, sealed in laminated plastic and placed in containers. Containers (18 L) are filled with individually identified seedlots to a weight of approximately 6 kg. The seedlot number is recorded on both the package and the outside of the container. Containers are also numbered sequentially. The location of the seedlot is recorded on the seed database. Where there are a number of packages or containers involved for a single seedlot, this should be indicated (e.g. 1 of 4, 2/4, 3/4, 4/4).

Once the seed has been exhausted from the store, the seedlot weight will show '0' on the seed database. The seedlot number is removed from the container and the Seed Record Card is placed in the 'Dead Card System'. However, the record of the seedlot is still maintained in the system including the seed database.

The following is a summary of the steps that must be taken when documenting and storing seed. The person responsible for each task is indicated in brackets:

- ensure the seedlot is clean and supported by appropriate source information (seed collector for own collections otherwise seed tester)
- enter the seedlot in the register and allocate seedlot number to all related documentation and seed (seed collector for own collections otherwise seed tester)
- write out a seed record card using information from provenance data sheets (seed collector for own collections otherwise seed tester)
- weigh seed and record weight on card and provenance data sheets (seed collector for own collections otherwise seed tester)
- conduct seed germination tests (seed tester)
- fumigate (orthodox) seed for two weeks with CO_2 (seed tester)
- seed placed in storage with seedlot number securely attached to the seed storage container (seed dispatcher)
- provenance data sheets filed once completed (seed tester or seed collector for own collections)
- record card placed in system (blue box on lab bench) for use in seed database entry (seed tester)
- payment for private seedlots. Immediately on receipt of seed from accredited suppliers, otherwise following satisfactory germination and purity test results (seed tester).
- completion of germination test. Information on viability and treatment placed on card, provenance data sheet (seed tester) and seed database (seed database entry person).

PLATE 6

(A) Prior to storage, seed is fumigated with carbon dioxide for a period of two weeks.

(B) Seed is routinely packaged and placed in airtight containers. The seedlot number is recorded on the package and container.

(C) Seed is stored in 18L or 60L metal or plastic airtight containers.

Section 4 Appendix

4.3 Appendix to Section 4

4.3.1 Effect of storage time on viability of seed

The following table provides an indication of the effects of seed storage on the germination capacity of 519 species held in the ATSC seed store. This effect has been measured in terms of storage age and temperature. The germination percentage of viable seed for each species at the time of entry into the seed store and subsequently at five year intervals has determined its storage capacity.

The germination results for all recorded seedlots for each species have been averaged and converted to a percentage. The initial germination percentage value for each seedlot within each species is a reference to its germinative capacity assessed as 100%. Subsequent retest data has been calculated after 5 and 10 years of storage. The following table has been divided into three sections according to the temperature at which each species has been stored.

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
Species routinely stored at 18–22ºC in airtight containers						
Acacia						
acradenia	100	7	95	7		
adsurgens	100	12	93	12		
ammobia	100	1	54	1¡		
ampliceps	100	9	92	9		
anaticeps	100	1	100	1		
ancistrocarpa	100	13	84	13		
aneura	100	3	67	3		
anthochaera	100	1	100	1		
aphanoclada	100	1	100	1		
aphylla	100	1	100	1		
arepta	100	1	85	1		

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
argyrophylla	100	2	66	2		
atkinsiana	100	2	91	2		
auriculiformis	100	72	82	72	73	7
bancroftii	100	2	49	2	30	1
betchei	100	1	100	1	100	1
bidwillii	100	1	63	1		
binervata	100	1	87	1	22	1
bivenosa	100	3	99	3		
blakei	100	1	100	1		
blakelyi	100	3	84	3		
blayana	100	1	69	1		
brachystachya	100	1	100	1		
brassii	100	2	88	2		
calamifolia	100	3	85	3		
cangaiensis	100	1	100	1		
chrysotricha	100	1	72	1		
cincinnata	100	8	93	8		
citrinoviridis	100	7	85	7		
colei var. *colei*	100	22	96	22		
colei var. *ileocarpa*	100	5	85	5		
conspersa	100	1	98	1		
coriacea ssp. *pendens*	100	2	59	2		
coriacea ssp. *sericophylla*	100	8	75	8		
cowleana	100	3	82	3		
crassa ssp. *crassa*	100	1	100	1		
crassicarpa	100	27	93	27	87	3
cretata	100	1	90	1		
cupularis	100	1	86	1		
cuthbertsonii	100	4	100	4		
cuthbertsonii aff.	100	1	90	1		
cyclops	100	1	57	1		
dangarensis	100	1	82	1		
dealbata ssp. *dealbata*	100	12	82	12		
deanei ssp. *deanei*	100	1	50	1		
decurrens	100	3	91	3		
delibrata	100	1	100	1		
dictyophleba	100	9	81	9		

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
difficilis	100	8	96	8		
dimidiata	100	2	88	2		
disparrima ssp. *calidestris*	100	1	96	1		
disparrima ssp. *disparrima*	100	4	99	4		
dunnii	100	2	38	2		
elachantha	100	24	92	24		
elata	100	3	68	3		
eriopoda	100	6	87	6		
filicifolia	100	1	94	1		
fulva	100	3	88	3		
glaucocarpa	100	3	87	3		
gonoclada	100	3	94	3		
gracillima	100	1	100	1		
hamersleyensis	100	1	100	1		
hammondii	100	2	100	2		
hemsleyi	100	5	95	5		
hilliana	100	1	100	1		
holosericea	100	33	90	33		
implexa	100	7	76	7		
inaequilatera	100	1	83	1		
irrorata ssp. *irrorata*	100	3	97	3		
irrorata ssp. *velutinella*	100	2	71	2		
jennerae	100	2	87	2	64	1
julifera ssp. *julifera*	100	1	100	1		
juncifolia	100	1	94	1		
kempeana	100	1	85	1		
laccata	100	1	91	1		
lamprocarpa	100	1	83	1		
latescens	100	2	75	2		
leptocarpa	100	4	64	4		
leucoclada ssp. *argentifolia*	100	1	73	1	61	1
leucoclada ssp. *leucoclada*	100	1	80	1		
ligulata	100	1	100	1	86	1
longispicata	100	1	72	1		
lysiphloia	100	3	94	3		
mabellae	100	1	98	1		

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
mangium	100	70	90	70	84	14
mearnsii	100	47	88	47	83	10
melanoxylon	100	16	82	16		
melleodora	100	3	98	3		
midgleyi	100	2	82	2		
mountfordiae	100	1	100	1		
nano-dealbata	100	1	0	1	0	1
neurocarpa	100	5	96	5		
notabilis	100	1	100	1		
nuperrima ssp. *cassitera*	100	1	1	1	1	1
obliquinervia	100	1	100	1	100	1
obtusifolia	100	1	59	1		
olsenii	100	1	60	1		
omalophylla aff.	100	1	67	1		
oncinocarpa	100	2	55	2		
pachycarpa	100	3	100	3		
parramattensis	100	2	74	2	74	1
parvipinnula	100	4	98	4	88	3
pellita	100	3	96	3		
peregrina	100	28	86	28		
platycarpa	100	1	100	1		
plectocarpa	100	4	93	4		
pruinosa	100	1	77	1	77	1
pycnantha	100	1	75	1		
pyrifolia	100	3	92	3		
redolens	100	1	89	1		
repanda	100	1	65	1		
resinimarginea	100	2	59	2		
retinervis	100	2	95	2		
retinodes	100	1	82	1		
retivenia	100	2	84	2		
rhodophloia	100	1	95	1		
rigens	100	1	93	1		
sabulosa	100	1	91	1		
salicina	100	6	67	6		
saligna	100	2	88	2	82	2
schinoides	100	2	95	2		

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
scirpifolia	100	1	41	1		
sclerosperma	100	1	100	1		
shirleyi	100	1	65	1		
sibina	100	1	73	1		
silvestris	100	2	90	2	80	1
simsii	100	2	99	2		
stipuligera	100	10	89	10		
telmica	100	1	44	1		
tenuissima	100	7	87	7		
thomsonii	100	6	98	6		
torulosa	100	14	87	14		
trachycarpa	100	1	72	1	72	1
trachyphloia	100	2	63	2		
trineura	100	1	90	1		
tropica	100	1	100	1		
tumida var. *tumida*	100	34	90	34		
umbellata	100	1	97	1		
valida (syn. *calcigera*)	100	1	95	1		
validinervia variant	100	2	92	2		
victoriae	100	12	93	12		
wanyu	100	1	71	1		
wattsiana	100	1	100	1		
yirrkallensis	100	1	100	1		
Asteromyrtus						
lysicephala	100	1	96	1		
symphyocarpa	100	1	98	1		
Banksia						
integrifolia var. *compar*	100	1	100	1		
Bursaria						
occidentalis	100	1	100	1		
Corymbia						
cadophora	100	3	92	3		
calophylla 'rosea'	100	2	92	2		
citriodora ssp. *citriodora*	100	6	79	6		
citriodora ssp. *variegata*	100	10	97	10		
confertiflora	100	1	79	1		

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
dampieri	100	1	100	1		
dimorpha	100	1	69	1	69	1
eremaea	100	1	100	1	100	1
ficifolia	100	1	100	1		
henryi	100	2	98	2	78	1
hylandii	100	1	91	1	91	1
intermedia	100	3	88	3	83	3
maculata	100	5	95	5		
novoguinensis	100	1	100	1		
polycarpa	100	1	74	1	74	1
ptychocarpa	100	1	100	1	100	1
watsoniana	100	2	88	2	82	2
xanthope	100	1	100	1	97	1
zygophylla	100	2	95	2	91	1
Cunninghamia						
lanceolata	100	1	0	1		
Eucalyptus						
accedens	100	1	71	1		
acies	100	1	100	1	100	1
acmenoides	100	5	96	5	61	5
aeqioperta	100	1	77	1	72	1
aff. *drepanophylla*	100	1	100	1		
agglomerata	100	1	21	1	21	1
aggregata	100	4	97	4		
albens	100	2	83	2	62	2
amplifolia var. *amplifolia*	100	8	90	8	79	7
amplifolia var. *sessiliflora*	100	1	54	1		
ancophila	100	1	69	1		
andrewsii ssp. *campanulata*	100	1	77	1	77	1
angustissima	100	1	69	1	30	1
apiculata	100	1	100	1	37	1
apothalassica	100	1	73	1	73	1
approximans ssp. *approximans*	100	1	99	1	88	1
arachnaea ssp. *arachnaea*	100	1	88	1		
arenacea	100	1	91	1	72	1
argillacea	100	1	100	1	91	1

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
argophloia	100	2	68	2	45	1
aspratilis	100	2	81	2	53	2
astringens	100	4	77	4	62	3
badjensis	100	6	78	6		
baeuerlenii	100	1	100	1		
baileyana	100	1	81	1	46	1
bakeri	100	2	99	2	90	2
baueriana	100	2	16	2	6	1
baxteri	100	1	100	1	100	1
behriana	100	1	67	1	67	1
bigalerita	100	1	81	1	52	1
bosistoana	100	3	67	3		
botryoides	100	7	86	7	70	4
brassiana	100	5	91	5	84	4
brevifolia	100	1	94	1	86	1
brevistylis	100	1	100	1		
bridgesiana	100	1	52	1		
brockwayi	100	2	62	2	62	2
brookeriana	100	5	55	5		
caesia ssp. *magna*	100	1	81	1	81	1
calycogona ssp. *calycogona*	100	2	100	2		
camaldulensis ssp. *simulata*	100	8	89	8		
camaldulensis var. *camaldulensis*	100	11	91	11	87	4
camaldulensis var. *obtusa*	100	68	78	68	69	38
camphora ssp. *camphora*	100	6	89	6		
capillosa ssp. *capillosa*	100	1	83	1	49	1
carnea	100	1	100	1	61	1
cerasiformis	100	1	100	1	53	1
cernua (ms syn. *nutens*)	100	1	73	1		
chloroclada	100	1	100	1	100	1
cinerea	100	2	64	2	57	2
cladocalyx	100	7	79	7	68	4
clivicola	100	1	100	1		
cloeziana	100	5	95	5		
cneorifolia	100	2	58	2	33	1
coccifera	100	2	84	2		

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
conglobata	100	1	100	1	77	1
conica	100	1	71	1	71	1
coolabah	100	2	66	2	54	2
cooperiana	100	1	100	1	90	1
cornuta	100	2	72	2	49	2
cosmophylla	100	1	44	1	31	1
crebra	100	2	95	2	91	1
croajingalensis	100	1	21	1		
crucis ssp. *crucis*	100	1	78	1	78	1
cullenii	100	1	45	1	45	1
curtisii	100	2	86	2	86	2
cypellocarpa	100	5	77	5		
dalrympleana ssp *dalrympleana*	100	3	81	3		
deanei	100	4	83	4		
deglupta	100	4	81	4		
densa ssp. *densa*	100	2	45	2	0	1
denticulata	100	4	83	4	73	3
desmondensis	100	1	60	1	25	1
dielsii	100	1	99	1		
diminuta	100	1	51	1	24	1
diptera	100	1	86	1		
dives	100	7	74	7		
dorrigoensis	100	2	100	2		
drepanophylla	100	1	68	1	56	1
dumosa	100	1	100	1		
dunnii	100	20	89	20	78	13
elata	100	5	70	5	55	4
eremophila ssp. *eremophila*	100	2	12	2	12	2
erythronema var. *erythronema*	100	1	100	1	87	1
eugenioides	100	1	78	1	74	1
exilis	100	1	82	1	82	1
exserta	100	2	87	2	82	2
falcata	100	1	42	1		
falciformis	100	1	75	1		
famelica	100	1	100	1	100	1
fastigata	100	7	92	7		

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
fastigata × *obliqua*	100	1	100	1		
fibrosa ssp. *fibrosa*	100	1	84	1	84	1
fibrosa ssp. *nubila*	100	1	100	1		
foecunda	100	3	51	3	51	3
forrestiana ssp. *forrestiana*	100	1	63	1		
fraseri	100	1	80	1		
fraxinoides	100	1	80	1	72	1
froggattii	100	1	75	1		
fusiformis	100	2	92	2	87	2
gamophylla	100	6	98	6	94	6
georgei	100	1	35	1	35	1
gillenii	100	2	83	2	83	2
glaucescens	100	3	74	3		
globoidea	100	1	100	1	87	1
globulus ssp. *bicostata*	100	12	93	12		
globulus ssp. *globulus*	100	49	92	49	81	9
globulus ssp. *maidenii*	100	12	88	12		
globulus ssp. *pseudoglobulus*	100	2	65	2	57	2
gomphocephala	100	2	57	2	38	2
gongylocarpa	100	2	77	2	57	2
goniocalyx	100	3	85	3	77	3
grandis	100	43	90	43	77	16
hallii	100	2	83	2		
halophila	100	3	82	3	79	3
herbertiana	100	1	91	1	88	1
horistes	100	2	55	2		
hypochlamydea	100	1	93	1	88	1
incerata	100	1	62	1	44	1
incrassata	100	1	100	1	53	1
infera	100	1	100	1	100	1
intertexta	100	7	81	7	59	5
jacksonii	100	1	81	1		
jensenii	100	3	93	3	36	3
johnstonii	100	2	77	2	69	2
kartzoffiana	100	1	8	1		
kochii ssp. *kochii*	100	1	100	1		
kochii ssp. *plenissima*	100	1	58	1		

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
kondininensis	100	3	64	3	53	3
kumarlensis	100	3	69	3		
lansdowneana ssp. *lansdowneana*	100	1	100	1		
latisinensis	100	1	80	1	68	1
leptocalyx	100	1	66	1	66	1
leptophleba	100	1	81	1	33	1
leucoxylon ssp. *leucoxylon*	100	4	71	4	30	4
leucoxylon ssp. *megalocarpa*	100	1	92	1	67	1
leucoxylon ssp. *petiolaris*	100	1	64	1	33	1
leucoxylon ssp. *pruinosa*	100	4	63	4	23	4
litorea	100	1	29	1	16	1
longicornis	100	3	94	3		
longifolia	100	3	94	3	87	3
longirostrata	100	3	100	3		
loxophleba ssp. *gratiae*	100	1	100	1	100	1
loxophleba ssp. *loxophleba*	100	3	95	3	83	3
lucens	100	1	100	1	100	1
macarthurii	100	6	96	6		
macrandra	100	1	100	1	70	1
macrocarpa ssp. *macrocarpa*	100	3	91	3		
macrorhyncha ssp. *macrorhyncha*	100	1	100	1		
major	100	1	100	1	70	1
mannensis ssp. *mannensis*	100	3	31	3	31	3
mannifera ssp. *elliptica*	100	1	100	1	100	1
mannifera ssp. *mannifera*	100	5	92	5	90	5
mannifera ssp. *praecox*	100	1	100	1	100	1
marginata	100	3	67	3		
marginata ssp. *'thalassica'* ms	100	1	10	1		
mediocris	100	1	100	1	94	1
megacornuta	100	2	98	2	87	1
melanophloia	100	2	99	2	85	1
melanoxylon	100	1	100	1		
melliodora	100	9	68	9	29	8
merrickiae	100	1	100	1	100	1
michaeliana	100	1	100	1		
micranthera	100	1	100	1	74	1

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
microcarpa	100	16	87	16	62	16
microcorys	100	9	90	9	79	3
mitchelliana	100	1	100	1		
moorei	100	1	100	1		
morrisbyi	100	1	100	1		
multicaulis	100	1	75	1	62	1
myriadena	100	2	80	2	46	2
newbeyi	100	1	92	1	74	1
nicholii	100	3	90	3		
nitens	100	30	84	30	69	10
nobilis	100	2	87	2		
normantonensis	100	2	93	2	45	2
nortonii	100	1	87	1	87	1
notabilis	100	2	69	2	69	2
nudicaulis	100	1	100	1	78	1
obliqua	100	5	79	5	63	4
occidentalis	100	8	92	8	63	7
odontocarpa	100	2	87	2	87	1
oleosa	100	1	100	1	100	1
orbifolia	100	1	86	1	50	1
oreades	100	1	97	1	97	1
ornata	100	1	28	1	28	1
ovata	100	2	100	2	37	1
oxymitra	100	3	98	3	98	3
pachyphylla	100	5	92	5	81	4
paniculata	100	2	79	2		
patens	100	1	72	1		
pauciflora ssp. *debeuzevillei*	100	1	100	1		
pauciflora ssp. *niphophila*	100	2	62	2		
pauciflora ssp. *pauciflora*	100	3	65	3		
pellita	100	24	85	24	81	7
pellita × *brassiana*	100	1	100	1		
pellita × *teriticornis*	100	1	58	1		
petraea	100	1	86	1	42	1
phaenophylla	100	2	76	2	57	2
phoenicea	100	3	84	3		
pilligaensis	100	1	96	1	54	1

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
pilularis	100	11	89	11	67	4
piperita ssp. *piperita*	100	1	95	1	79	1
platypus var. *heterophylla*	100	1	100	1		
platypus var. *platypus*	100	1	100	1	95	1
pluricaulis	100	2	62	2	33	1
polyanthemos	100	11	64	11	27	10
polybractea	100	3	72	3		
propinqua	100	3	80	3		
pruinosa	100	1	94	1	94	1
pryoriana	100	3	98	3	91	3
pulverulenta	100	1	100	1		
punctata	100	2	81	2		
pyrocarpa	100	1	100	1	100	1
quadrangulata	100	4	85	4		
quadrans	100	1	85	1	37	1
racemosa	100	1	88	1	73	1
radiata ssp. *radiata*	100	17	75	17		
raveretiana	100	3	79	3	54	3
redacta	100	1	92	1	56	1
rigens	100	1	58	1	45	1
rigidula	100	2	85	2	84	2
robusta	100	6	88	6	71	5
robusta × *tereticornis*	100	1	79	1	79	1
rubida ssp. *rubida*	100	4	79	4		
rubiginosa	100	1	83	1	67	1
rudis	100	6	81	6		
rugosa	100	1	90	1	42	1
rummeryi	100	1	58	1	30	1
salicola	100	3	95	3	77	3
saligna	100	20	82	20	73	5
saligna × *botryoides*	100	3	91	3		
salmonophloia	100	1	53	1	53	1
salubris	100	4	94	4		
sargentii	100	11	81	11	68	9
scoparia	100	1	94	1		
sessilis	100	1	51	1	33	1
sheathiana	100	1	100	1	91	1

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
sicilifolia	100	1	96	1	86	1
siderophloia	100	4	90	4	71	4
sideroxylon	100	2	64	2		
sieberi	100	7	76	7	64	6
smithii	100	12	88	12		
socialis	100	4	89	4	78	4
spathulata	100	3	69	3	39	3
spectatrix	100	1	75	1		
sphaerocarpa	100	2	52	2	52	1
staigeriana	100	2	98	2	60	2
steedmanii	100	1	86	1	46	1
stellulata	100	4	90	4		
stoatei	100	1	64	1		
striaticalyx	100	2	100	2	62	1
stricta	100	1	34	1	22	1
suggrandis ssp. *alipes*	100	1	84	1		
suggrandis ssp. *suggrandis*	100	2	100	2	100	1
tardecidens	100	1	90	1		
tenuipes	100	1	96	1	81	1
tenuis	100	2	100	2	50	1
terebra	100	1	100	1	100	1
tereticornis ssp. *tereticornis*	100	26	80	26	67	17
tetragona	100	1	100	1	36	1
tetraptera	100	1	40	1	40	1
thozetiana	100	2	77	2	54	2
todtiana	100	1	80	1		
tricarpa	100	1	38	1		
trivalvis	100	3	90	3	52	3
umbra	100	1	100	1		
victrix	100	1	79	1	76	1
viminalis ssp. *cygnetensis*	100	3	100	3	100	3
viminalis ssp. *viminalis*	100	19	87	19	84	8
virens	100	1	69	1		
viridis	100	3	75	3	63	3
wandoo	100	1	48	1		
woodwardii	100	1	48	1	46	1
yarraensis	100	4	92	4		

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
yilgarnensis	100	1	22	1	22	1
youmanii	100	1	72	1		
youngiana	100	2	95	2	71	2
Flindersia						
australis	100	1	100	1		
brayleyana	100	1	99	1		
Leptospermum						
juniperinum	100	1	100	1		
lanigerum	100	2	94	2	84	1
liversidgei	100	1	100	1		
petersonii	100	4	97	4		
polygalifolium	100	3	100	3	96	3
Lysiphyllum						
cunninghamii	100	2	100	2		
Melaleuca						
acacioides ssp. *acacioides*	100	1	29	1	29	1
acacioides ssp. *alsophila*	100	2	80	2	67	1
adnata	100	1	85	1	68	1
alternifolia	100	1	100	1		
argentea	100	6	85	6		
bracteata	100	2	61	2	61	2
cajuputi ssp. *cajuputi*	100	3	96	3		
cajuputi ssp. *platyphylla*	100	3	89	3		
dealbata	100	4	99	4		
decora	100	1	93	1	93	1
decussata	100	2	89	2	80	2
dissitiflora	100	2	92	2		
glomerata	100	1	100	1		
halmaturorum	100	1	84	1		
lanceolata	100	2	100	2		
lasiandra	100	2	91	2		
leucadendra	100	11	93	11		
minutifolia	100	1	25	1		
nervosa	100	1	100	1		
quinquenervia	100	6	96	6		

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
trichostachya	100	1	100	1		
viridiflora	100	7	94	7		
Sesbania						
formosa	100	2	100	2		
Species routinely stored						
at 3–5ºC in airtight containers						
Acacia						
cambagei	100	1	100	1		
coriacea ssp. *coriacea*	100	1	100	1		
distans	100	1	88	1		
georginae	100	1	44	1	1	1
synchronicia	100	1	100	1		
xiphophylla	100	3	56	3	34	3
Albizia						
lebbeck	100	1	81	1		
Allocasuarina						
decaisneana	100	3	100	3		
fraseriana	100	1	56	1	53	1
littoralis	100	3	83	3		
verticillata	100	10	88	10	83	4
Atalaya						
hemiglauca	100	1	27	1		
Callitris						
columellaris	100	1	100	1		
intratropica	100	1	100	1		
Casuarina						
cristata	100	2	67	2	67	1
cunninghamiana ssp. *cunninghamiana*	100	4	83	4		
equisetifolia ssp. *equisetifolia*	100	61	91	61	90	25
equisetifolia ssp. *incana*	100	4	94	4	85	4
glauca	100	14	97	14	87	12
grandis	100	2	76	2	65	1
junghuhniana ssp. *junghuhniana*	100	22	88	22		
obesa	100	6	81	6	71	4

Appendix 4.3.1 Effect of storage time on viability of seed

Species	Germination		Germination after 5 yrs in storage		Germination after 10 yrs in storage	
	Initial germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested	Germination (%)	No. of seedlots tested
oligodon	100	2	73	1	3	1
Corymbia						
tessellaris	100	1	69	1		
torelliana	100	2	66	2		
Eucalyptus						
alba	100	1	79	1		
benthamii	100	3	82	3		
delegatensis ssp. *delegatensis*	100	7	69	7	28	4
diversicolor	100	4	90	4	73	4
microtheca	100	13	77	13	73	12
miniata	100	1	84	1		
moluccana ssp. *moluccana*	100	2	73	2	71	1
muelleriana	100	6	78	6	66	6
regnans	100	2	94	2	94	2
urophylla	100	20	94	20	87	6
Grevillea						
dryandri	100	1	100	1		
pteridifolia	100	7	93	7		
robusta	100	11	98	11		
Santalum						
lanceolatum	100	1	100	1		
Toona						
ciliata	100	1	26	1		
Species routinely stored at –15ºC to –18ºC in airtight containers						
Acacia						
harpophylla	100	1	98	1	77	1
Araucaria						
cunninghamii	100	1	100	1		

Section 5 Quarantine Procedures

Australia is free of many weeds, pests and diseases of plants and animals that adversely affect other countries. This is due largely to our geographic position as an island country and our strict quarantine laws. The importation of seed involves a very real risk to the introduction of pests or diseases with serious implications for agricultural industries. All seed consignments entering Australia are therefore subject to quarantine control, inspection and treatment where necessary by the Australian Quarantine and Inspection Service (AQIS) (see AQIS web site at: http://www.aqis.gov.au/.

Under Australian Quarantine regulations there are three main categories for seed:

- **Unrestricted seed** includes some pasture, vegetable and flower seed where quarantine risks are considered minimal. This type of seed is subject to inspection and treatment if necessary. No permit is required.

- **Restricted seed** includes a range of agricultural and forestry seeds where serious diseases and pests could be introduced into Australia. There are two types of restricted seeds for quarantine purposes, i.e. restricted seed for sowing in Quarantine and restricted seed for processing. Permit to import is required.

- **Prohibited seed** is not allowed entry into Australia unless for specific scientific purposes under strict controlled facilities. Permit to import is required.

Many agricultural seeds are classified as restricted seed for sowing and includes seed of Australian species imported from other countries. Restricted seed is generally grown in a Quarantine glasshouse and resulting seed released provided there are no diseases found during growth.

5.1 Tree seed

All tree seed is subject to quarantine and is inspected on arrival in Australia and treated as necessary.

Species of the following genera require permission to import from AQIS. *Callistemon, Campomanesia, Eucalyptus, Corymbia, Eugenia, Jambosa, Marlierea, Melaleuca, Myrcia, Myrciaria, Paivea, Pimenta, Psidium* and *Syzygium.*

Seed of these genera may carry the serious fungal pathogen *Puccinia psidii* (Guava rust) that occurs in USA (Florida), Central and South America, Caribbean, India, Pakistan and Bangladesh. Seed of the above genera imported from these countries may only be imported with a 'Permit to Import' which will include the conditions of minimum quantity and to be grown in post-entry quarantine. Seed of the above genera from other countries will be limited to 100 grams and requires a fungicidal treatment (dusted with Erex seed fungicide) on arrival to Australia.

Plants grown in quarantine require careful monitoring for fungal disease. Those plants that are considered to be free of disease can be released from quarantine though remaining seed will be stored under quarantine and cannot be used in Australia. This process is time consuming and expensive and effectively eliminates these countries as a source of bulk seed for planting in Australia.

Quantity restrictions do not apply to seed from New Zealand but such seed must be accompanied by a phytosanitary certificate endorsed 'Seed New Zealand grown'.

5.1.1 Acacia seed

The importation of any plant or parts of plants including seed of any species of *Acacia* is prohibited except by permit. Therefore, prior to importation a permit must be secured to facilitate the entry to Australia. Those species that do not pose a risk as potential weeds will be granted permission to import with no quantity limit. Prohibited species will only be allowed to be imported for specific research purposes. A list of prohibited *Acacia* species is available on request from CSIRO Quarantine Unit at Division of Plant Industry in Canberra or refer to the AQIS web site.

5.1.2 Coniferous seed

Coniferous seed including *Pinus, Pseudotsuga, Larix, Juniperus, Cupressus, Chamaecyparis, Cupressocyparis* and *Araucaria.*

Seed of these genera are inspected on arrival and treated as necessary. To facilitate entry the seed should be free from impurities including needles and be free of prohibited material. The seed will not be fumigated unless live insects are found. *Cedrus* seed may be treated with Phosphine as methyl bromide may damage this type of seed.

Treatment of coniferous seed of all species depends on extraction process. Seed that has been heat extracted and phytosanitary certificate endorsed may be released after inspection. Acceptable extraction treatments are:

54°C for 86 hours
60°C for 24 hours
66°C for 8 hours

Seed not heat extracted will be im mersed in 1.0% sodium hypochlorite solution containing 1% available chlorine (Milton) for 10 minutes, dried and released.

5.2 CSIRO quarantine facilities

CSIRO has an authorised Quarantine Officer and approved quarantine facilities including quarantine glasshouses, +2°C and −18°C room refrigerators, seed laboratory, growth cabinets etc. Consultation with the CSIRO Quarantine Officer is encouraged prior to importation of plant and animal products. The aim of the CSIRO Quarantine service is to facilitate the entry of research materials including seed to Australia at reduced costs to CSIRO while maintaining compliance with Australian Quarantine laws. The service supports research efforts and provides free advice and import facilitation at cost.

The ATSC operates an approved quarantine storage facility at +3°C and −18°C under the supervision of AQIS. The facility is used for restricted seed requiring storage prior to re-export. All seed imports should be consigned to the CSIRO Quarantine Officer for documentation, treatment and dispatch. All records must be retained for AQIS auditing purposes. The ATSC approved storage facility has restricted access and must be kept locked.

All imports and inquiries may be directed to:

CSIRO Plant Introduction/Quarantine Officer
CSIRO Plant Industry
GPO Box 1600
Canberra ACT 2601

Tel.: (W) (02) 6246 5483 or
(AH or emergency) 015 263262
E-mail: Gary.Orr@pi.csiro.au

Seed sent out of the country must be supported by a phytosanitary certificate unless not required by the recipient country.

5.3 Exporting seed to Western Australia

Under the Western Australian Quarantine and Inspection Service (WAQIS) ‘Seed import requirements’ consignments of seed to WA must be accompanied by an original Seed Analysis Certificate, identifying the seed and seed contaminants. In the case of the ATSC, the certificate should be issued by an inspector authorised by the exporting State or Territory quarantine authority. Certification can be checked prior to export by faxing the WAQIS Seed Officer. The Seeds Officer will advise you of any problems. If consignments arrive in WA with incorrect certification, or without certification, they are subject to sampling and analysis on arrival. For more detailed information refer to the Western Australia’s Seed Import Requirements or contact WAQIS Seeds Officer (Greg Croker) at:

Market Square
280 Bannister Road
CANNING VALE WA 6155

Tel: 041 054 2455
Fax: 08 9353 5789
Email: gcroker@agric.wa.gov.au

In the case of seed sent by the ATSC, seeds should be accompanied by the consignment note which indicated the species and the ATSC ‘Certificate of Seed Quality and origin’ which must be stamped with the Quarantine stamp and signed.

Section 6 Documentation Associated with Seed Supply

An important part of the ATSC's activities is the supply of well-documented seed to clients both nationally and internationally. In 1999 for example, 370 consignments were sent to over 300 organisations comprising one or more seedlot. An accurate and well-defined documentation process is therefore an essential part of supplying seed. This ensures accurate information relating to the seed is conveyed to the customer and the same information is maintained on the ATSC system.

6.1 The Process

The starting point for most consignments begins with a request for seed. These range from very general requests seeking advice on what species to plant through to requests for specific seed sources or seedlots. The next step is determining the seedlots and seed weight to be included in the consignment. A quotation (Appendix 6.1) is then generated which will include the cost of supplying the seed, including freight and additional charges. Quotations are generated irrespective of whether a payment is required. An expanded list of quoted seedlots (Appendix 6.2) can also be provided on request. The seed is then reserved for a set period of time (3 months) during which time the customer can accept, reject or request an alteration to the seed order.

For orders requiring payment, the customer is required to pay for the seed before the ATSC will process the order unless prior arrangements have been agreed upon. If required, an invoice can be raised for the customer to facilitate payment. Payment can be made by cash, cheque made payable to 'CSIRO Forestry and Forest Products', ATSC, credit card (Visa, MasterCard or Bankcard). or telegraphic transfers to be credited to the Division's bank account (as shown on the quotation form).

The seed order is then packaged with the species, seedlot number and seed weight clearly written on the outside of each seedlot. The seed is sealed in laminated plastic bags and parceled up in a secure envelope or other suitable container that will not break open during shipment. A copy of the Consignment Note and Seed Certificate together with explanation of codes used in seed consignments (Appendix 6.3), Material Transfer Agreement (Appendix 6.4) must be enclosed with the seed consignment.

Other optional documents include:

- Seed Order Form mainly to assist with packing seed since it indicates where the seed is stored;

Tax Invoice Form used for orders within Australia (GST related) and when overseas customers specifically request an invoice.

The list of quoted seedlots, quotation and invoices associated with the order is generated from the seed database which keeps a record of seed stocks on hand and where seedlots have been sent. However, there is a requirement to maintain a hard copy filing system of all documentation as follows.

- A copy of all correspondence relating to the order should be stapled together and placed on the appropriate (e.g. country, project) ATSC file.

- One copy of the quotation to be placed on the quote file. Orders that do not require payment should still be generated as a quotation and then stamped indicating the funding source (e.g. DAT). When the quote is accepted and the money has been received, the order should be placed in the order box.

- A copy of the ATSC Materials Transfer Agreement (MTA) must be included with the

seed shipment. Appendix 6.4 provides an example of the ATSC MTA together with an explanation on the reasons for its development.

- A minimum of two additional copies of the Consignment Note must be made. The original copy of the Consignment Note and Seed Certificate is sent with the seed, one copy placed on the Stats file and second copy attached to the accompanying correspondence for filing in the appropriate ATSC file.

- Most overseas countries, except Great Britain and France, require a Phytosanitary Certificate for seed that originated in Australia. Phytosanitary Certificate forms containing five copies are supplied by the Department of Agriculture, Fisheries and Forestry.

(1) Original contained in an envelope attached to the outside of the parcel

(2) One copy placed inside with shipment.

(3) One copy filed in the Phytosanitary Certificate folder.

(4) One copy sent to the customer by mail.

(5) One copy sent to AQIS.

Note: For seed sent by DHL courier, an additional copy is included in the envelope attached to the outside of the parcel.

- For re-exporting seed a 'Phytosanitary Certificate For Re-export" form should be used in the same way as for Phytosanitary Certificates (see above).

- A Customs Declaration sticker to should be placed on parcels sent by post overseas.

- Copies of all the shipping documents are also sent under separate cover, to the customer.

6.1.1 For orders sent by DHL Courier

- An Airway bill is filled out together with a Commercial Invoice (one copy of each should be included for with filing).

- Airway Bill and Commercial Invoice are placed with the original Phytosanitary Certificate plus 1 copy in a clear DHL pouch attached to the parcel. The parcel is placed in the FFP dispatch bay with a copy of the Airway Bill filed in the dispatch office. DHL must be informed when a parcel is ready for dispatch. Some countries have pricing conditions placed on goods entering the country. These have been documented on the DHL price list but if in doubt check with DHL http://www.dhl.com/main_index.html. A copy of all dispatched documents are sent separately to the customer by airmail.

6.1.2 Australian Tree Seed Centre Pricing Policy

The price of seed from the Australian Tree Seed Centre varies between species and between provenances and depends on the quantity of seed ordered. One of four price categories is allocated to a seedlot when it arrives in store. The price category reflects the rarity of the species, the ease of collection, the relative abundance of seed and the demand for a particular species or provenance. Prices range from $1 for the majority of seedlots to $6 per gram for difficult and costly seedlots. In addition to the cost of seed, which is normally sold as a minimum of 5g, there is a $20 handling fee for each seedlot.

Due to the complex nature of the pricing policy the ATSC prefers to provide individual quotations for specific requests for seed. Clients should be aware that there is a $20 handling charge for each seedlot regardless of the quantity ordered.

Section 6

Appendices

6.2 Appendices to Section 6

Appendix 6.2.1 Quotation form

Australian Tree Seed Centre

CSIRO Forestry and Forest Products
PO Box E4008, Kingston ACT 2604, Australia
ABN 41 687 119 230, Telephone (61-2) 6281-8211, Fax (61-2) 6281-8266, Email atsc@ffp.csiro.au
Bank: Account 231327, WESTPAC Bank, Woden Centre, Woden Plaza ACT 2606, Australia

Quotation

Sylvatech Australia Pty Ltd
GPO Box 1826
Darwin
N.T. 0801
Australia

Our Reference: **ATSC-003-058**
Your Reference:
Date of Issue: **23-Jul-01**
Quote No: **010719**
Quoted By: **ver033**
Quote Validity: **90 days**

Seedlot No	Species	Quantity (g)	
19735	*Acacia mangium*	100	140.00
20133	*Acacia mangium*	100	100.00
20135	*Acacia mangium*	100	100.00
	Total	300	340.00

CSIRO makes no representations and gives no warranties about the seed listed in this quote, and as far as applicable law permits excludes all implied conditions and all warranties, including that the seed is of merchantable quality or fit for a particular purpose.

The Australian Tree Seed Centre is an Australian Government, non-commercial, seed supplier which relies on donor agencies and project funds for its operation. In order to continue to provide seed for research and general plantings it is necessary to charge non-project users a fee to cover the collection, testing, storage and dispatch of seed. Different seedlots are charged at different rates to reflect differences in ease of collection, processing and time in storage. This quotation reflects these charges and costs for non-profit operation.

Payment must be made in advance by credit card, bank cheque or bank transfer to account above. Letters of credit not accepted. Make cheques payable to "CSIRO Forestry & Forest Products, ATSC".

As seed availability is limited, CSIRO reserves the right (at CSIRO's option) not to accept an order, or to substitute seed of the same provenance or geographic region.

CSIRO limits its liability to (at CSIRO's option) replacing the seed or replacing the seed with similar seed of equivalent value.

If paying by Credit Card enter the details below and fax to the number shown above.

☐ Mastercard
☐ Visa
☐ Bankcard

Card No. _____
Name _____
Expiry _____
Signature _____

_____
for Officer in Charge
Australian Tree Seed Centre

Appendix 6.2.2 Expanded list of quoted seedlots

Expanded List of Quoted Seedlots Date 23-Jul-01 Page: 1

Lot	Species	Tree No.	Location	State	Lat.	Long.	Alt.	Parent	Viab. /10g	Qty. (g)
19735	*Acacia mangium*		POHATURI PROV WP	PNG	085200	1425300	40	50	708	100
20133	*Acacia mangium*		BITURI	PNG	084000	1424300	45	0	661	100
20135	*Acacia mangium*		POHATURI	PNG	085200	1425300	40	0	647	100

Appendix 6.2.3 (A) Consignment note and seed certificate

CSIRO

Australian Tree Seed Centre
CSIRO Forestry & Forest Products
PO Box E4008
Kingston ACT 2604 Australia

Telephone: (61-2) 6281-8211
Facsimile: (61-2) 6281-8266
Email: atsc@ffp.csiro.au

Consignment Note and Seed Certificate

Sylvatech Australia Pty Ltd
GPO Box 1826
Darwin
N.T. 0801
Australia

Our Reference: **ATSC-003-058**
Your Reference:
Quoted By: **ver033**
Quote No: **010719**
Sponsor: **EXCH**
Code:
Import Permit: **N**

Seedlot No	Species	No. of Parent Trees	Quantity (g)	Origin							Viable Seeds/10g	Pre Treatment
				Locality	Latitude		Longitude		Alt M			
					Deg	Min	Deg	Min				
19735	*Acacia mangium*	50	100	POHATURI PROV WP	PNG	08	52	142	53	40	708	G
20133	*Acacia mangium*	0	100	BITURI	PNG	08	40	142	43	45	661	E
20135	*Acacia mangium*	0	100	POHATURI	PNG	08	52	142	53	40	647	E

Appendix 6.2.3 (B) Explanation of codes used in seed consignments

Explanation of Codes Used in Seed Consignments

Localities

NSW	New South Wales	**QLD**	Queensland
SA	South Australia	**TAS**	Tasmania
VIC	Victoria	**WA**	Western Australia
NT	Northern Territory	**ACT**	Australian Capital Territory
PNG	Papua-New Guinea	**IND**	Indonesia
MLA	Malaysia	**FIJ**	Fiji

Pre-Treatments

A	=	No pre-treatment required.	**G**	= Immerse in hot water (90°C) for 1 minute.
B	=	Cold moist stratification.	**H**	= Acid (H_2SO_4) scarification.
C	=	Manual nicking/scarification.	**I**	= Rinse in flowing water for 1 hour.
D	=	Pour on boiling water (100°C), soak until cool.	**K**	= Immerse in hot water (90°C) for 1 minute, 3% NaOCl rinse.
E	=	Boil in water (100°C) for 1 minute.	**P**	= Soak in water, ambient temperature, for 12 to 18 hours.
N	=	Boil in water (100°C) for 2 minutes.	**J**	= Other pre-treatment (see germination sheet).
F	=	Boil in water (100°C) for 5 minutes.	**	= Pre-treatment not yet determined.

Optional

After pre-treatment with boiling water (codes D,E,N,F), germination may be improved by soaking seed in cold tap water for ~24 hours before sowing.

NB. Where the number of viable seeds/10g is recorded as '0' this indicates that a germination test has not yet been conducted.

All Seed Has Been Fumigated with Carbon Dioxide and/or Carbon Disulphide.

If the seed is to be stored for long periods keep it in an air-tight container in cool conditions.

CSIRO makes no representations and gives no warranties about the seed listed on this consignment note, and as far as applicable law permits excludes all conditions and warranties, including that the seed is of merchantable quality or fit for a particular purpose.

Certifying Officer _____ Date _____

Appendix 6.2.4 (A) Material transfer agreement

Forestry and Forest Products
Australian Tree Seed Centre

Banks Street, Yarralumla, ACT 2600, Australia
Postal Address: PO Box E4008, Kingston ACT 2604, Australia
Telephone: (02) 6281 8211 (International + 61 2 6281 8211)
Facsimile: (02) 6281 8266 (International + 61 2 6281 8266)
E-mail: atsc@ffp.csiro.au
http://www.ffp.csiro.au/tigr/atscmain/index.htm

Material Transfer Agreement

1. CSIRO's Australian Tree Seed Centre collects and maintains germplasm and information on Australia's flora for the benefit of Australians. The Centre conducts research, or assists others to conduct research, which adds to collective knowledge of the performance and utility of Australian forest genetic resources.

2. Australia has signed and ratified the Convention on Biological Diversity and pursuant to this Convention, the Australian Tree Seed Centre is committed to "*the fair and equitable sharing of benefits arising out of the utilisation of genetic resources*" as well as facilitating access to genetic resources under Australian ownership on '*mutually agreed terms*'.

3. Use of the germplasm in this consignment from CSIRO ("**Material**") is subject to this Material Transfer Agreement. The terms, obligations and acknowledgments of the Agreement itemised below apply once the Recipient removes the Material from its packaging.

4. The Recipient acknowledges that CSIRO provides the Material to the Recipient solely for the purposes of growing and testing for wood and non-pharmaceutical products.

5. It is mutually agreed that the Recipient will:

   (a) - acknowledge the origin of the Material in all published and distributed information;

   (b) - allow CSIRO access to assessment data and information on the characterisation procedures and performance of the Material;

   (c) - allow CSIRO access, for research purposes, to germplasm samples from plants grown from Material included in this consignment;

   (d) - take reasonable steps to ensure that these conditions are met in any subsequent deployment of the Material; and

   (e) – use the Material at its own risk.

6. Nothing in this Agreement affects existing proprietary intellectual property rights in respect of the Material.

Please direct any inquiries about this Agreement to:

Officer in Charge
Australian Tree Seed Centre
CSIRO Forestry and Forest Products
PO Box E4008
Kingston ACT 2604
AUSTRALIA

Appendix 6.2.4B Background to the decision by CSIRO Forestry and Forest Products to adopt a Material Transfer Agreement (MTA) for dispatch of forest genetic resources

Australian trees are of great social, environmental and economic importance in many other countries. The international trade in the germplasm of these trees and their relatives has been active for over 200 years. Australia has traditionally imposed no restrictions on the export of tree seed. A number of State and Federal groups are now examining this passive policy in the light of Australian responsibilities and commitments under the Convention of Biological Diversity (CBD), questions regarding ownership and access and emerging issues related to bio-prospecting.

Considerable regulation regarding access to land and collection of seed exists within Australia. However there appears to be little regulation regarding sale and export of seed. In a recent study, *Native Seed in Australia,* completed by the FIoraBank Project[1] frequent concerns were raised at discussion forums and by questionnaire respondents about the problems of regulation, royalty and permit systems and their significant impacts on seed collection. There are considerable differences in regulatory approach between the States. Seed collection may fall under the jurisdictions of land management and flora protection legislation, forest production royalty systems, and interstate export and import regulations, requiring that a collector be conversant with many requirements in each State. There are often considerable fees attached to approvals and permits.

Regulatory authorities and some members of the native seed industry increasingly promote certification for native seed collectors. Commercial rather than community collectors appear to be the main target of such moves. CSIRO considers that community collectors and seedbank operators can do much to deliver real improvements in standards of practice and quality control through a voluntary code of conduct rather than moving to demonstrate competence through a certification scheme.

Recommendation 11 from the Florabank study was that Commonwealth, State and local governments should review regulations relevant to native seed to:

- *provide greater conformity in regulatory approaches within and between levels of government;*
- *introduce performance based controls rather than restrictions on collection;*
- *Commonwealth, State and local governments should be more aware of the role that reserves, crown lands and in particular National Parks have as gene banks for revegetation. Governments should look at ways of facilitating greater access to these genetic resources (seed) for revegetation;*
- *Commonwealth and State governments should introduce restrictions on the importation of native seed for revegetation purposes. Restrictions should not apply to seed imported for research, horticulture, floriculture, plant breeding or silvicultural purposes.*

Currently there are over 30 private companies that actively export seed of Australian forest trees and the export industry in native seed is worth over $10 million annually. In addition, three State agencies (Queensland Department of Primary Industry, Forestry Tasmania and the WA Department of Conservation and Land Management), one Federal agency (Australian Tree Seed Centre (ATSC), CSIRO Forestry and Forest Products), Botanic Gardens and private individuals consign seed to overseas clients. Seeds of Australian trees and wildflowers are also sold freely at *Australiana* outlets at international departure terminals. There is no mechanism for ensuring that Australia can gain access to information regarding the performance of these

[1] F1oraBank is funded under the Bushcare program of the National Heritage Trust and is managed by Greening Australia on behalf of its partners CSIRO Australian Tree Seed Centre, the Australian National Botanic Gardens and Greening Australia.

forest genetic resources once they have been planted or gain access to subsequent generations of germplasm. Following an examination of a number of options, CSIRO Forestry and Forest Products, through the ATSC, has adopted the concept of a Material Transfer Agreement.

In the absence of a nationally consistent strategy regarding international access to Australian forest genetic resources and with the knowledge of Australia's obligations and commitments under the CBD, the Australian Tree Seed Centre will attach the MTA to all its consignments of Australian native seed. The MTA covers access to seed for wood and non-pharmaceutical products only. It is expected that any use for bio-prospecting for pharmaceuticals would be covered by other agreements. It is expected further, that the MTA will be modified in due course to accommodate emerging State policies and any nationally agreed policy on forest genetic resources. Some further points regarding this MTA include:

- The MTA has been kept deliberately short and simple so that non-English users are aware (in principle at least) of their obligations.

- The MTA is consistent with the spirit and content of the CBD. Most of the countries with which CSIRO regularly exchanges seed are signatories to the CBD and accept its guiding principles.

- The MTA is consistent with other similar instruments currently in use by the Consultative Group on International Agricultural Research (CGIAR)—the concept will not be ‘new’.

- The MTA is based on the extensive experience of the ATSC in sharing Australian forest genetic resources and reflects common current practice of seed recipients providing information on species' performance.

- The *mutually agreed terms* that we seek are not unreasonable and within the scope of existing practice. Should these terms be imposed on Australian users in reciprocal exchange of genetic material they will not be onerous.

- We have deliberately avoided questions of resource ownership as this is unclear in Australia with a number of different State agencies, private owners, Aboriginal communities and others expressing strong interest in resource ownership.

- The MTA is an inexpensive option to protect Australian interests and will be relatively easy to administer.

- The MTA can be easily adapted should State agencies which deal in exchange or sale of forest genetic resources wish to use it for their purposes

It is expected that the ATSC will accumulate and disseminate information and repatriate germplasm on behalf of the many owners of Australia’s forest genetic resources. The Standing Committee on Forestry has been informed of this development.

Glossary

Most entries have been taken from Boland *et al*. (1980)[1], Eldridge *et al*. (1993)[2], Doran *et al*. (1983)[3], Willan (1985)[4] and Hong *et al*. (1998)[5].

Absorption (of seed) Uptake of moisture until the seed comes into equilibrium with the moisture of the surrounding air. See also desorption and equilibrium relative humidity

Areole (of seed) The area encompassed by the pleurogram. The differences between the areole and the remainder of the face may be slight differences in colour, surface texture or fracture lines[3]

Aril (of seed appendages) A pulpy structure which grows from some part of the ovule or funicle after fertilisation and covers part or the whole of the seed[3]

Bipinnate (of compound leaves) Twice pinnately divided; twice compound[3]

Capsule Dry, usually many-seeded fruit composed of two or more fused carpels that split at maturity to release their seeds as in *Eucalyptus*[4]

Carabiner A metal safety clip, used by climbers with ropes, which can be locked in the closed position as an insurance against accidental opening during climbing and fruit harvesting[4]

Chaff In eucalypts, sterile particles derived from infertile or nonfertilised ovules[1]

Cotyledon Seed leaf or primary leaf of the embryo[1]

Deciduous Of leaves, bark, etc. falling regularly at the end of the growth period[1]

Dehiscence Opening of the fruit by splitting along definite lines[1]

Desorption (of seed) Loss of moisture from the seed until it comes into equilibrium with the moisture of the surrounding air. *See also* absorption and equilibrium relative humidity

Dormancy (of seed) A resting or quiescent condition. In acacias dormancy is frequently imposed on a non-dormant embryo by the 'hard' seed coat which prevents water from reaching the embryo[3]

Dormancy (embryo) Dormancy as a result of conditions within the embryo itself; inhibiting substances, incompletely developed embryo. Syn: internal dormancy[4]

Drupe A stone-fruit such as a plum; the pericarp fleshy or leathery, containing a stone with one or more seed[4]

Embryo The rudimentary plant formed within the seed. It consists of an axis bearing an apical meristem or plumule, radicle and one or more cotyledons[5]

Endosperm The nutritive tissue contained in some seed in addition to the embryo; not present in eucalypts[1]

Epigeal Germination in which the cotyledons are forced above the ground by the elongation of the hypocotyl as in *Eucalyptus*[4]

Equilibrium relative humidity Seed will desorb or absorb water until it reaches equilibrium moisture content with the relative humidity of the surrounding air. This relative humidity, where the moisture content of the seed is stable, is called the equilibrium relative humidity.

Fermentation The process of chemical changes in organic substances caused by the catalytic action of a "ferment", which may be an independent plant such as yeast or bacteria, or an enzyme. May be accompanied by the production of heat and of toxic substances, hence the fermentation of fleshy fruits may adversely affect the seeds which they contain[4]

Follicle A dry dehiscent fruit formed from a single carpel, dehiscing along the ventral side only[4]

Funicle = *funiculus* (of seed appendages) The 'umbilical cord' of the seed, attaching it to the pod. When detached from a mature seed near the seedcoat it leaves a scar (the hilum)[3]

Germination Growth of the embryo in the seed until the emergence of the embryonic radicle through the seedcoat. In seed testing, the capacity of the embryo to emerge from the seedcoat with those essential structures which indicate a potential to produce normal plants[1]

Germination capacity Proportion of a seed sample that has germinated normally in a specified test period, usually expressed as a percentage. *Syn:* Germination percentage. It should be noted that in some earlier literature the term "Germination Capacity" has been used to express the total of the seeds which germinate plus the ungerminated but sound seeds (on cutting test), as a percentage of the seeds sown[4]

Germination energy That proportion of germination which has occurred up to the time of peak germination, or the time of maximum germination rate, or up to some pre-selected point, usually 7 test days. (The critical time of measurement can be chosen by several means) [4]

Germinative capacity Percentage of seed that germinate during the whole of the germination test period[1]

Hard seeds Seeds with thick and tough testas which delay water penetration and germination[3]

Hypocotyl That part of the axis of a germinating embryo which is between the cotyledon and the radicle[4]

Hypogeal (germination) Germination in which the cotyledons remain in the seed below the ground while the epicotyl elongates[4]

Indehiscent (of fruit) Not opening at maturity[3]

Intermediate seed storage behaviour A category of seed storage behaviour intermediate between those defined as orthodox and recalcitrant. Mature whole seeds are able to tolerate desiccation to seed moisture contents in equilibrium at 20°C with about 40–50% relative humidity but further desiccation often reduces viability and always results in more rapid deterioration in subsequent hermetic storage the more the seeds are dried below this value[5]

Land race A land race develops when exotic trees are introduced in a new environment: Genetic changes take place in the population of trees over one or more generations of selection by natural or human agencies; a land race of poor quality develops when the first planting was from a poorly adapted provenance or, worse, from the seeds of a single tree[2]

Mesocarp Middle layer of the pericarp; the pulp of berries and drupes[4]

Micropyle (of seed) In mature seeds, a plugged opening[3]

Moisture content The amount of water present in a material e.g. wood, soils or seeds. May be expressed in terms of weight of moisture as a percentage of the material's oven-dry weight ("dry-weight basis") or, preferably in the case of seeds and fruits, as a percentage of the material's wet weight including water ("wet-weight" or "fresh-weight basis")[4]

Nut Dry, indehiscent, one-seeded fruit with a woody or leathery pericarp developing from an inferior compound ovary[4]

Orthodox Term used to describe species of which the seeds can be dried down to a low moisture content of around 5% and successfully stored at low or sub-freezing temperatures for long periods[4]

Orthodox seed storage behaviour Mature whole seeds not only survive considerable desiccation (to at least 5% moisture content) but their longevity in air-dry storage is increased in a predictable way by reduction in seed storage moisture content and temperature[5]

Periodicity The tendency, in an individual, stand or species, to produce seed at more or less regular intervals of more than one year[4]

Phenology (Study of) relations between seasonal climatic changes and periodic biological phenomena such as flowering, fruiting, leaf flushing and dormancy[4]

Phenotype All characteristics of a plant, morphological, anatomical and physiological as determined by the interaction between genotype and environment[4]

Phyllode A leaf whose blade is much reduced or absent, and whose whole petiole and rhachis have assumed the functions of the whole leaf[3]

Plumule Primary bud of a plant embryo situated at the apex of the hypocotyl; portion of the

seedling axis above the cotyledons, consisting of leaves and an epicotyl, which elongates to form the primary stem[4]

Plus tree A tree appearing distinctly superior to the average on a similar site. The superior character(s) are specified as plus for volume, quality, disease resistance etc.[1]

Pod A superior, one-celled, one- or many-seeded dehiscent fruit of two valves. Resembles the follicle in being dehiscent and formed from a single carpel but differs from it in dehiscing on both sides[4]

Precuring The deliberate storage and slow air drying under shade of fruits and contained seeds in order to tender them more suitable for subsequent operations, e.g. kiln drying, extraction and storage[4]

Provenance The original geographic source of seed or propagules[1]

Pure seed That component of a seedlot which consists of seeds of the designated species. According to ISTA rules, it includes not only mature, undamaged seeds but also undersized, shrivelled, immature and germinated seeds provided they can be positively identified as the designated species, and pieces of seed resulting from breakage which are more than half their original size. Excludes seeds of other species, wings of coniferous seeds, seeds of coniferous or leguminous species with seedcoats entirely removed, broken seed particles less than half the original size and other matter such as stones, twigs and leaves[4]

Purity Proportion of clean, intact seed of the designated species in a seedlot, usually expressed as a percentage by weight[4]

Radicle The rudimentary root of the embryo[1]

Recalcitrant seed storage behaviour Mature whole seeds are unable to tolerate more than a limited amount of desiccation, for example to moisture contents in equilibrium at 20°C with about 96–98% relative humidity[5]

Relative humidity (of air) amount of water vapour present as a percentage of the maximum amount of water vapour air can contain at a given temperature

Scarification Disruption of seed coats, usually by mechanical abrasion or by brief chemical treatment in a strong acid, to increase their permeability to water and gases, or to lower their mechanical resistance[4]

Seed The dispersal or germination unit of a fertilised ovule[3]

Seed orchard A special plantation of highly selected trees, isolated to minimise contamination with pollen from outside sources, and managed for maximum seed production[2]

Seedlot An indefinite quantity of seed having uniform quality, produced at a specific location and collected from a single crop[1]

Serotinous Fruit or cones that remain on the tree without opening for one or more years (e.g. *Allocasuarina verticillata*)

Squash test A simple, indirect test of viability, by which seeds are first allowed to imbibe water and are then squashed with a pair of forceps to reveal the condition of the embryo. The number of seeds appearing fresh and healthy per unit weight of seed plus chaff (in eucalypts) or per 100 (in larger seeds) provides a rough estimate of viability[4]

Stratification A pre-germination treatment to break dormancy in seed and to promote rapid uniform germination; the seed are exposed to moisture at a temperature just above freezing point (1–5°C) for a specified time[1]

Testa The outer coat of the seed; usually hard and tough, but may be soft in some species[4]

Thresh To separate, by any mechanical means, e.g. rubbing, shaking, trampling, stamping, beating or intermittent pressure, the grains of any cereal from the husks and straw, especially by beating with a flail. Applied also to the separation of other than cereal seeds from their fruits[4]

Viable of seed, able to germinate[1]

Vigour Those seed properties which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions[4]

Working sample A reduced seed sample taken from the submitted sample in the laboratory, on which some test of seed quality is made[4]

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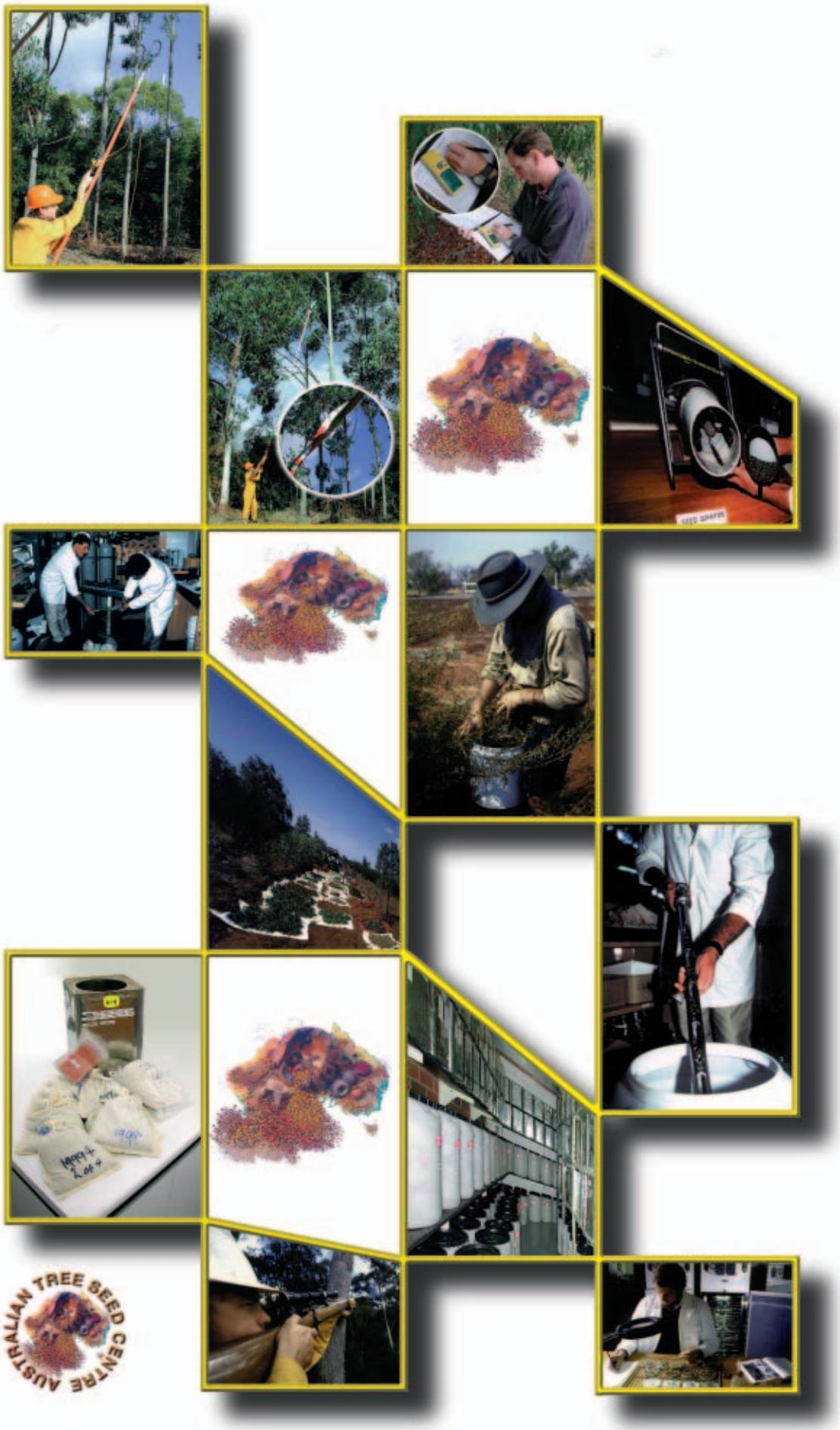
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