AG403*

PLANT DISEASES ACT 1914

APPOINTMENTS

Department of Agriculture & Food,
South Perth WA 6151.

I, the undersigned Minister for Agriculture and Food, being the Minister responsible for the administration of the *Plant Diseases Act 1914* hereby appoint the following officers as Authorised Inspectors pursuant to Section 7A of the *Plant Diseases Act 1914* to carry out all the functions authorized to be performed by an Inspector under the said Act—

Ta'auta Apa
Wayne Robert Griffin
Donald George Hyland
Linda Jane Weissenberger

KIM CHANCE MLC, Minister for Agriculture and Food.

CONSUMER AND EMPLOYMENT PROTECTION

CE401

COMPANIES (CO-OPERATIVE) ACT 1943

SECTION 403

Registration of Auditors

Notice is hereby given that the following person is registered and qualified to act as an auditor pursuant to s402 of the Act with effect from 24 November 2006.

Ian John Conway

PATRICK WALKER, Commissioner for Fair Trading.

CE402*

SUNDAY ENTERTAINMENTS ACT 1979

CHRISTMAS ENTERTAINMENT

I, Michelle Roberts, Minister for Consumer Protection, acting pursuant to Section 3(2) of the *Sunday Entertainments Act 1979,* do hereby declare that the provisions of Section 3(1) of the *Act* shall not apply to, or in relation to, any person who uses any place between 12.00 noon and 12.00 midnight on Christmas Day, 25 December 2006 for the screening or viewing of any motion picture considered appropriate for public exhibition under the *Censorship Act 1996.*

Hon. MICHELLE ROBERTS, MLA, Minister for Consumer Protection.

CONSERVATION

CO401*

Wildlife Conservation Act 1950

Wildlife Conservation (Rare Flora) Notice 2006(2)

Made by the Minister for the Environment under section 23F(2) of the Act.

1. Citation

This notice may be cited as the *Wildlife Conservation (Rare Flora) Notice 2006(2).*

2. Interpretation

In this notice—

"extant" means known to be living in a wild state;

"protected flora" means any flora belonging to the classes of flora declared by the Minister under section 6 of the Act to be protected flora by notice published in the *Gazette* 9 October 1987, at p. 3855;

"taxon" includes any taxon that is described by a genus name and any other name or description.

Note: The plural form of "taxon" is "taxa".

3. Rare flora

Subject to clause 4, protected flora—

(a) specified in Schedule 1, being taxa that are extant and considered likely to become extinct or rare and therefore in need of special protection; and

(b) specified in Schedule 2, being taxa that are presumed to be extinct in the wild and therefore in need of special protection,

are declared to be rare flora for the purposes of section 23F of the Act throughout the State.

4. Application

Clause 3 does not apply to those plants of a taxon of protected flora specified in Schedule 1 or 2 that have been planted for any purpose other than such plants that have been planted for the purpose of conservation of that taxon and in accordance with approval given by the Director General.

5. Revocation

The *Wildlife Conservation (Rare Flora) Notice 2006* is revoked.

Schedule 1 — Extant taxa

[cl. 3(a)]

Division 1 — Spermatophyta (flowering plants, conifers and cycads)

1. *Acacia anomala*
2. *Acacia aphylla*
3. *Acacia aprica*
4. *Acacia aristulata*
5. *Acacia ataxiphylla* subsp. *magna*
6. *Acacia auratiflora*
7. *Acacia awestoniana*
8. *Acacia brachypoda*
9. *Acacia caesariata*
10. *Acacia chapmanii* subsp. *australis*
11. *Acacia cochlocarpa* subsp. *cochlocarpa*
12. *Acacia cochlocarpa* subsp. *velutinosa*
13. *Acacia denticulosa*
14. *Acacia depressa*
15. *Acacia forrestiana*
16. *Acacia imitans*
17. *Acacia insolita* subsp. *recurva*
18. *Acacia lanuginophylla*
19. *Acacia leptalea*
20. *Acacia lobulata*
21. *Acacia pharangites*
22. *Acacia pygmaea*
23. *Acacia recurvata*
24. *Acacia rhamphophylla*
25. *Acacia sciophanes*
26. *Acacia splendens* ms
27. *Acacia subflexuosa* subsp. *capillata*
28. *Acacia trulliformis*

29. *Acacia unguicula*
30. *Acacia vassalii*
31. *Acacia volubilis*
32. *Acacia wilsonii*
33. *Adenanthos dobagii*
34. *Adenanthos ellipticus*
35. *Adenanthos eyrei*
36. *Adenanthos pungens* subsp. *effusus*
37. *Adenanthos pungens* subsp. *pungens*
38. *Adenanthos velutinus*
39. *Allocasuarina fibrosa*
40. *Allocasuarina tortiramula*
41. *Andersonia annelsii* ms
42. *Andersonia axilliflora*
43. *Andersonia gracilis*
44. *Andersonia pinaster* ms
45. *Anigozanthos bicolor* subsp. *minor*
46. *Anigozanthos viridis* subsp. *terraspectans*
47. *Anthocercis gracilis*
48. *Apium prostratum* subsp. *phillipii* ms
49. *Asterolasia nivea*
50. *Banksia brownii*
51. *Banksia cuneata*
52. *Banksia goodii*
53. *Banksia oligantha*
54. *Banksia sphaerocarpa* var. *dolichostyla*
55. *Banksia verticillata*
56. *Beyeria lepidopetala*
57. *Beyeria* sp. Bandalup Hill (G. Cockerton 7553)
58. *Boronia adamsiana*
59. *Boronia capitata* subsp. *capitata*
60. *Boronia clavata*
61. *Boronia exilis*
62. *Boronia revoluta*
63. *Brachyscias verecundus*
64. *Caladenia barbarella*
65. *Caladenia bryceana* subsp. *bryceana*
66. *Caladenia bryceana* subsp. *cracens*
67. *Caladenia busselliana*
68. *Caladenia caesarea* subsp. *maritima*
69. *Caladenia christineae*
70. *Caladenia dorrienii*
71. *Caladenia drakeoides*
72. *Caladenia elegans*
73. *Caladenia excelsa*
74. *Caladenia harringtoniae*
75. *Caladenia graniticola*
76. *Caladenia hoffmanii*
77. *Caladenia huegelii*
78. *Caladenia melanema*
79. *Caladenia procera*
80. *Caladenia viridescens*
81. *Caladenia wanosa*
82. *Caladenia williamsiae*
83. *Caladenia winfieldii*
84. *Calectasia cyanea*
85. *Calectasia pignattiana*
86. *Calothamnus accedens*
87. *Calytrix breviseta* subsp. *breviseta*
88. *Chamelaucium griffinii* ms
89. *Chamelaucium lullfitzii* ms
90. *Chamelaucium roycei* ms
91. *Chamelaucium* sp. Hamersley (N.McQuoid 379)
92. *Chordifex abortivus*
93. *Chorizema humile*
94. *Chorizema varium*
95. *Conospermum densiflorum* subsp. *unicephalatum*
96. *Conospermum toddii*
97. *Conospermum undulatum*
98. *Conostylis dielsii* subsp. *teres*
99. *Conostylis drummondii*
100. *Conostylis lepidospermoides*
101. *Conostylis micrantha*
102. *Conostylis misera*
103. *Conostylis rogeri*
104. *Conostylis seorsiflora* subsp. *trichophylla*
105. *Conostylis setigera* subsp. *dasys*
106. *Conostylis wonganensis*
107. *Coopernookia georgei*
108. *Cyphanthera odgersii* subsp. *occidentalis*
109. *Darwinia acerosa*
110. *Darwinia apiculata*
111. *Darwinia carnea*
112. *Darwinia chapmaniana* ms
113. *Darwinia collina*
114. *Darwinia ferricola* ms
115. *Darwinia foetida* ms
116. *Darwinia masonii*
117. *Darwinia meeboldii*
118. *Darwinia oxylepis*
119. *Darwinia squarrosa*
120. *Darwinia wittwerorum*
121. *Darwinia* sp. Carnamah (J.Coleby-Williams 148)
122. *Darwinia* sp. Stirling Range (G.J.Keighery 5732)

123. *Darwinia* sp. Williamson (G.J.Keighery 12717)
124. *Daviesia bursarioides*
125. *Daviesia cunderdin*
126. *Daviesia dielsii*
127. *Daviesia elongata* subsp. *elongata*
128. *Daviesia euphorbioides*
129. *Daviesia glossosema*
130. *Daviesia megacalyx*
131. *Daviesia microcarpa*
132. *Daviesia obovata*
133. *Daviesia pseudaphylla*
134. *Daviesia speciosa*
135. *Deyeuxia drummondii*
136. *Diuris drummondii*
137. *Diuris micrantha*
138. *Diuris purdiei*
139. *Drakaea concolor* ms
140. *Drakaea confluens* ms
141. *Drakaea elastica*
142. *Drakaea isolata* ms
143. *Drakaea micrantha* ms
144. *Drummondita ericoides*
145. *Drummondita longifolia*
146. *Dryandra anatona*
147. *Dryandra aurantia*
148. *Dryandra fuscobractea*
149. *Dryandra ionthocarpa* subsp. *chrysophoenix*
150. *Dryandra ionthocarpa* subsp. *ionthocarpa*
151. *Dryandra mimica*
152. *Dryandra montana*
153. *Dryandra mucronulata* subsp. *retrorsa*
154. *Dryandra nivea* subsp. *uliginosa*
155. *Dryandra pseudoplumosa*
156. *Dryandra serratuloides* subsp. *perissa*
157. *Dryandra serratuloides* subsp. *serratuloides*
158. *Dryandra squarrosa* subsp. *argillacea*
159. *Eleocharis keigheryi*
160. *Epiblema grandiflorum* var. *cyaneum* ms
161. *Eremophila ciliata* ms
162. *Eremophila denticulata* subsp. *denticulata* ms
163. *Eremophila denticulata* subsp. *trisulcata* ms
164. *Eremophila koobabbiensis* ms
165. *Eremophila lactea*
166. *Eremophila nivea*
167. *Eremophila pinnatifida* ms
168. *Eremophila resinosa*
169. *Eremophila rostrata* ms
170. *Eremophila scaberula*
171. *Eremophila subteretifolia* ms
172. *Eremophila ternifolia*
173. *Eremophila vernicosa* ms
174. *Eremophila verticillata*
175. *Eremophila virens*
176. *Eremophila viscida*
177. *Eucalyptus absita*
178. *Eucalyptus argutifolia*
179. *Eucalyptus articulata*
180. *Eucalyptus balanites*
181. *Eucalyptus beardiana*
182. *Eucalyptus blaxellii*
183. *Eucalyptus brevipes*
184. *Eucalyptus burdettiana*
185. *Eucalyptus ceracea*
186. *Eucalyptus coronata*
187. *Eucalyptus crispata*
188. *Eucalyptus crucis* subsp. *crucis*
189. *Eucalyptus crucis* subsp. *praecipua*
190. *Eucalyptus cuprea*
191. *Eucalyptus dolorosa*
192. *Eucalyptus impensa*
193. *Eucalyptus insularis*
194. *Eucalyptus johnsoniana*
195. *Eucalyptus lateritica*
196. *Eucalyptus leprophloia*
197. *Eucalyptus merrickiae*
198. *Eucalyptus mooreana*
199. *Eucalyptus phylacis*
200. *Eucalyptus platydisca* ms
201. *Eucalyptus pruiniramis*
202. *Eucalyptus purpurata*
203. *Eucalyptus recta*
204. *Eucalyptus rhodantha* var. *rhodantha*
205. *Eucalyptus steedmanii*
206. *Eucalyptus suberea*
207. *Eucalyptus synandra*
208. *Frankenia conferta*
209. *Frankenia parvula*
210. *Gastrolobium appressum*
211. *Gastrolobium diabolophyllum*
212. *Gastrolobium glaucum*
213. *Gastrolobium graniticum*
214. *Gastrolobium hamulosum*
215. *Gastrolobium lehmannii*
216. *Gastrolobium luteifolium*
217. *Gastrolobium modestum*
218. *Gastrolobium papilio*
219. *Glyceria drummondii*

220. *Goodenia integerrima*
221. *Grevillea althoferorum*
222. *Grevillea batrachioides*
223. *Grevillea brachystylis* subsp. *australis*
224. *Grevillea brachystylis* subsp. Busselton (G.J. Keighery s.n. 28/8/1985)
225. *Grevillea bracteosa*
226. *Grevillea calliantha*
227. *Grevillea christineae*
228. *Grevillea curviloba* subsp. *curviloba*
229. *Grevillea curviloba* subsp. *incurva*
230. *Grevillea dryandroides* subsp. *dryandroides*
231. *Grevillea dryandroides* subsp. *hirsuta*
232. *Grevillea elongata*
233. *Grevillea flexuosa*
234. *Grevillea humifusa*
235. *Grevillea infundibularis*
236. *Grevillea involucrata*
237. *Grevillea maccutcheonii*
238. *Grevillea maxwellii*
239. *Grevillea murex*
240. *Grevillea phanerophlebia*
241. *Grevillea pythara*
242. *Grevillea rara*
243. *Grevillea scapigera*
244. *Guichenotia seorsiflora* ms
245. *Gyrostemon reticulatus*
246. *Hakea aculeata*
247. *Hakea megalosperma*
248. *Haloragis platycarpa*
249. *Halosarcia bulbosa*
250. *Hemiandra gardneri*
251. *Hemiandra rutilans*
252. *Hemigenia ramosissima*
253. *Hensmania chapmanii*
254. *Hibbertia priceana*
255. *Hybanthus cymulosus*
256. *Hydatella dioica*
257. *Hydatella leptogyne*
258. *Hypocalymma longifolium*
259. *Isopogon robustus*
260. *Isopogon uncinatus*
261. *Jacksonia pungens* ms
262. *Jacksonia quairading* ms
263. *Jacksonia velveta* ms
264. *Kennedia glabrata*
265. *Kennedia macrophylla*
266. *Keraudrenia exastia*
267. *Kunzea similis*
268. *Lambertia echinata* subsp. *echinata*
269. *Lambertia echinata* subsp. *occidentalis*
270. *Lambertia fairallii*
271. *Lambertia orbifolia* subsp. *orbifolia* ms
272. *Lambertia orbifolia* subsp. Scott River Plains (L.W.Sage 684)
273. *Lasiopetalum pterocarpum* ms
274. *Lasiopetalum rotundifolium*
275. *Latrobea obovata* ms
276. *Laxmannia grandiflora* subsp. *brendae*
277. *Lechenaultia chlorantha*
278. *Lechenaultia laricina*
279. *Lepidium aschersonii*
280. *Lepidium catapycnon*
281. *Lepidosperma rostratum*
282. *Lepidosperma* sp. Mt Gibson (R.Meissner & Y.Caruso 3)
283. *Leucopogon gnaphalioides*
284. *Leucopogon marginatus*
285. *Leucopogon obtectus*
286. *Leucopogon* sp. Helena and Aurora Range (B.J.Lepschi 2077)
287. *Lysiosepalum abollatum*
288. *Macarthuria keigheryi*
289. *Marianthus mollis*
290. *Marianthus paralius*
291. *Melaleuca sciotostyla*
292. *Meziella trifida*
293. *Microcorys eremophiloides*
294. *Microtis globula*
295. *Muehlenbeckia horrida* subsp. *abdita*
296. *Muelleranthus crenulatus*
297. *Myoporum cordifolium*
298. *Myoporum turbinatum*
299. *Myriophyllum lapidicola*
300. *Orthrosanthus muelleri*
301. *Pandanus spiralis* var. *flammeus*
302. *Paracaleana dixonii* ms
303. *Patersonia spirifolia*
304. *Persoonia micranthera*
305. *Petrophile latericola* ms
306. *Philotheca basistyla*
307. *Philotheca wonganensis*
308. *Pityrodia augustensis*
309. *Pityrodia axillaris*
310. *Pityrodia scabra*
311. *Pterostylis* sp. Northampton (S.D.Hopper 3349)
312. *Ptilotus fasciculatus*
313. *Ptychosema pusillum*

314. *Pultenaea pauciflora*
315. *Reedia spathacea*
316. *Rhagodia acicularis*
317. *Rhizanthella gardneri*
318. *Ricinocarpos brevis* ms
319. *Ricinocarpos trichophorus*
320. *Roycea pycnophylloides*
321. *Rulingia* sp. Trigwell Bridge (R.Smith s.n. 20.6.89)
322. *Scaevola macrophylla*
323. *Schoenia filifolia* subsp. *subulifolia*
324. *Sphenotoma drummondii*
325. *Spirogardnera rubescens*
326. *Stachystemon nematophorus*
327. *Stachystemon vinosus*
328. *Stawellia dimorphantha*
329. *Stylidium amabile* ms
330. *Stylidium coroniforme* subsp. *coroniforme*
331. *Stylidium galioides*
332. *Stylidium merrallii*
333. *Stylidium semaphorum*
334. *Symonanthus bancroftii*
335. *Synaphea quartzitica*
336. *Synaphea stenoloba*
337. *Synaphea* sp. Fairbridge Farm (D. Papenfus 696)
338. *Synaphea* sp. Pinjarra (R.Davis 6578)
339. *Tetraria australiensis*
340. *Tetratheca deltoidea*
341. *Tetratheca erubescens* ms
342. *Tetratheca harperi*
343. *Tetratheca nephelioides* ms
344. *Tetratheca aphylla* subsp. *aphylla* ms
345. *Tetratheca aphylla* subsp. *megacarpa* ms
346. *Tetratheca paynterae* subsp. *cremnobata* ms
347. *Tetratheca paynterae* subsp. *paynterae* ms
348. *Thelymitra dedmaniarum*
349. *Thelymitra psammophila*
350. *Thelymitra stellata*
351. *Thomasia glabripetala*
352. *Thomasia montana*
353. *Thomasia* sp. Green Hill (S.Paust 1322)
354. *Thryptomene wittweri*
355. *Tribonanthes purpurea*
356. *Verticordia albida*
357. *Verticordia apecta*
358. *Verticordia carinata*
359. *Verticordia crebra*
360. *Verticordia densiflora* var. *pedunculata*
361. *Verticordia fimbrilepis* subsp. *australis*
362. *Verticordia fimbrilepis* subsp. *fimbrilepis*
363. *Verticordia helichrysantha*
364. *Verticordia hughanii*
365. *Verticordia pityrhops*
366. *Verticordia plumosa* var. *ananeotes*
367. *Verticordia plumosa* var. *pleiobotrya*
368. *Verticordia plumosa* var. *vassensis*
369. *Verticordia spicata* subsp. *squamosa*
370. *Verticordia staminosa* subsp. *cylindracea* var. *cylindracea*
371. *Verticordia staminosa* subsp. *cylindracea* var. *erecta*
372. *Verticordia staminosa* subsp. *staminosa*
373. *Villarsia calthifolia*
374. *Wurmbea calcicola*
375. *Wurmbea tubulosa*
376. *Xyris exilis*

Division 2 — Pteridophyta (ferns and fern allies)

377. *Asplenium obtusatum* subsp. *northlandicum*

Division 3 — Bryophyta (mosses and liverworts)

378. *Rhacocarpus rehmannianus* var. *webbianus*

Schedule 2 — Taxa presumed to be extinct

[cl. 3(b)]

Spermatophyta (flowering plants, conifers and cycads)

1. *Acacia kingiana*
2. *Acacia prismifolia*

3. *Coleanthera virgata*
4. *Frankenia decurrens*
5. *Lepidium drummondii*
6. *Leptomeria dielsiana*
7. *Leucopogon cryptanthus*
8. *Opercularia acolytantha*
9. *Philotheca falcata*
10. *Ptilotus caespitulosus*
11. *Ptilotus pyramidatus*
12. *Taraxacum cygnorum*
13. *Tetratheca fasciculata*
14. *Thomasia gardneri*

MARK McGOWAN, Minister for the Environment.

CO402*

Wildlife Conservation Act 1950

Wildlife Conservation (Specially Protected Fauna) Notice 2006(2)

Made by the Minister for the Environment under section 14(2)(ba) of the Act.

1. Citation

This notice may be cited as the *Wildlife Conservation (Specially Protected Fauna) Notice 2006(2)*.

2. Interpretation

In this notice —

"taxon" includes any taxon that is described by a family name or a genus name or any other name or description.

Note: The plural form of "taxon" is "taxa".

3. Declaration of specially protected fauna

For the purposes of the Act, all taxa of the fauna —

(a) specified in Schedule 1, being fauna that is rare or likely to become extinct, are declared to be fauna that is in need of special protection;

(b) specified in Schedule 2, being fauna that is presumed to be extinct, are declared to be fauna that is in need of special protection;

(c) specified in Schedule 3, being birds that are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of special protection; and

Australian Tree Seed Centre Operations Manual

Brian Gunn

AUSTRALIAN TREE SEED CENTRE

CSIRO

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Brian Gunn

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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.

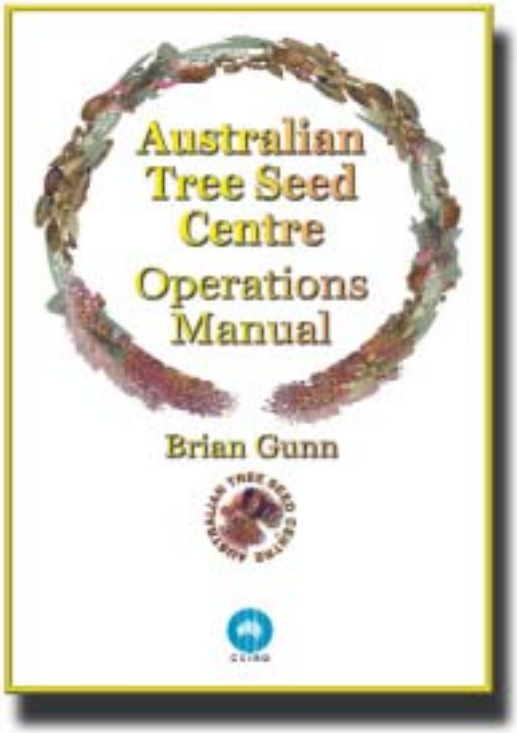
This manual has been developed from the need to document the procedures undertaken by the ATSC in seed handling from planning seed collections through to seed dispatch. It is specifically targetted at standardising procedures for staff working at the Centre as well as providing information to others 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.

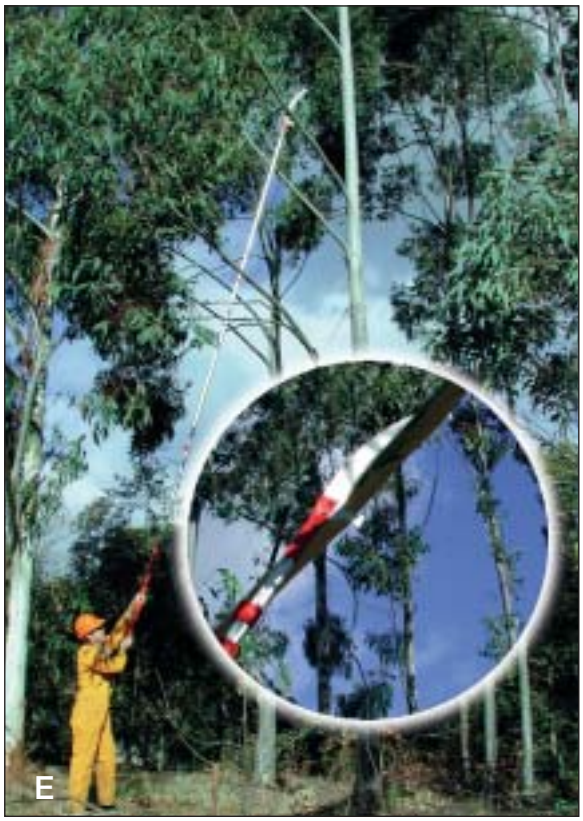
PLATE 1

(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

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(B) Seed collection data sheet (completed) 26

(C) Seed collection data sheet key 27

1.3.3 ATSC equipment checklist for the field 28–29

1.3.4 A rough guide to seed collection times of the eucalypts 30–40

***Corymbia* 31–32**

***Eucalyptus* 32–40**

1.3.5 Seed collection times of acacias, casuarinas, grevilleas and melaleucas 41–45

***Acacia* 41–44**

***Allocasuarina* 44**

***Casuarina* 44**

***Grevillea* 45**

***Melaleuca* 45**

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:	Alt (m):
SA	800

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

Veg'n structure:	Soil texture:
Open woodland	gritty sandy loam

Sp freq:	pH:
Common	6

Aspect:	Soil colour:
all	grey

Slope:	Geology:
mod-steep	Quartzite

Seed crop:	Predation status:
scattered light	

Bud:	Root sucker:
mod	

Flowers:	Coppice:
Mod(immature fruit)	Y

Association includes:	Freq:	Ht (m)
E. leucoxylon	c	22
A. quornensis	c	2
Callitris sp.	c	7
Allocas. verticillata	c	4

Comments: **Almost a pure stand on ridges and upper slopes; Fruit size much smaller than populations to the south**

Map name: **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:	Date:	Collected as Bulk:	Total:	
Larmour, Whitfeld	20.5.99	Individuals: 9	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)	Nov–Jan	Apr
var. *camaldulensis* (SA)	Oct–Nov	Mar
var. *camaldulensis* (SW QLD)	Dec–Jan	May–Sep
var. *camaldulensis* (VIC.)	Oct–Nov	Feb
var. *obtusa* (Kimberley)	Jun–July	Dec
var. *obtusa* (N QLD)		
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

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

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***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

2.4.1 Example of a completed Seed Record Card 54

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 solution as prescribed by Regen 2000® Smokemaster. Smoke water is available from Kings Park, Perth, Western Australia or under the trade name of Regen 2000. 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.

- X ray. The ATSC currently has a Hewlett-Packard Faxitron cabinet x-ray system which the manufacturer checked prior to shipment to ensure that radiation leakage is below 0.5 mR/hr at 5 cm from any external surface (Hewlett Packard 1969). Internal lead shielding reduces external radiation and interlock safety switches on the door minimises the possibility of exposure. The following safety precautions are recommended in the Faxitron Operation and Maintenance Manual:

  (1) Turn the KVP Control to zero immediately after each exposure and leave it there between exposures.

  (2) Keep the door closed at all times except during brief loading periods.

  (3) Turn the key to the OFF position at all times except during warming-up and exposure.

  (4) Periodically check to be sure that the X-ray beam is off when the door is open; you can use photographic film or a Vixtoreen pocket dosimeter as a sensor.

  A routine periodic radiation safety inspection (once a year) should be carried out on the Faxitron. The ACT Radiation Council (Tel. 6247 2899) can provide a list of persons licensed to perform installation and maintenance of X-ray equipment in Canberra.

- 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

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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	0	(25)	17	37	E	TV	Acid soak
acradenia	1017	0	8	1333	0	25	4	21	E	TV	
acuminata	345	0	2	500	0	(25)	4	21	E	TV	
adsurgens	1128	285	19	1628	0	25	9	30	E	TV	
adunca	380	0	1	380	0	(25)	6	27	E	TV	
alleniana	511	0	4	857	0	(25)	6	20	E	TV	
ammobia	981	0	2	1430	0	25	5	21	E	TV	
ampliceps	377	107	32	621	0	25	9	30	E	TV	
anaticeps	10	0	5	12	0	30	5	20	EF	TV	
ancistrocarpa	228	59	17	393	0	30	4	21	E	TV	
aneura	652	0	7	1139	0	25	4	21	E	TV	
anthochaera	209	0	1	209	0	(25)	4	21	E	TV	
aphanoclada	230	0	1	230	0	(25)	4	21	E	TV	
aphylla	618	0	1	618	0	(20)	4	21	ED	TV	
arepta	1041	0	1	1041	0	(25)	4	21	E	TV	
argyrophylla	190	0	2	271	0	(25)	8	60	E	TV	
atkinsiana	986	0	2	1180	0	(30)	4	15	E	TV	
aulacocarpa	540	0	1	540	0	25;30	5	21	ED	TV	
auricoma	310	0	1	310	0	(30)	4	21	CE	TV	
auriculiformis	417	115	139	676	0	25;30	4	26	ED	TV	
auriculiformis × *leptocarpa*	441	0	1	441	0	25;30	4	21	E	TV	
baileyana	460	0	1	460	0	(25)	4	30	E	TV	
bakeri	175	0	1	175	0	(25)	4	21	C	TV	
bancroftii	103	0	2	185	0	25	4	21	E	TV	
beauverdiana	1	0	1	1	0	(20)	5	21	G	TV	
betchei	572	0	1	572	0	(25)	3	20	E	TV	
bidwillii	30	0	2	30	0	25	7	21	H	TV	1 hour acid soak
binervata	430	0	4	458	0	(25)	4	21	ED	TV	
binervia	1075	0	2	1500	0	(25)	4	10	E	TV	
bivenosa	322	0	10	480	0	(25)	4	21	E	TV	
bivenosa × *ampliceps*	287	0	1	287	0	(25)	4	21	E	TV	
blakei	1048	0	3	1375	0	25	4	21	E	TV	
blakelyi	431	0	3	500	0	(25)	7	24	DE	TV	
blayana	156	0	6	243	0	(25)	4	21	ED	TV	
brachybotrya	320	0	1	320	0	(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	0	(25)	6	12	DE	TV	
brassii	816	0	5	1150	0	25	5	21	E	TV	
burkittii	230	0	1	230	0	(25)	5	20	E	TV	
burrowii	1627	0	8	2222	0	25	0	0	E	TV	
buxifolia	445	0	1	445	0	(25)	4	17	E & P	TV	
calamifolia	404	0	4	665	0	(25)	5	30	E	TV	
calcicola	235	0	1	235	0	25;30	4	17	E	TV	
cambagei	227	0	2	250	0	25	5	21	A	TV	
cangaiensis	339	0	1	339	0	(25)	4	21	E	TV	
cardiophylla	475	0	1	475	0	(25)	4	21	E	TV	
celsa	643	0	2	700	0	(25)	4	21	E	TV	
chinchillaensis	162	0	1	162	0	(30)	8	32	D	TV	
chrysotricha	273	0	2	520	0	(25)	4	21	E	TV	
cincinnata	823	97	11	1052	0	25;30	4	21	E	TV	
citrinoviridis	202	0	8	240	0	30	5	21	E	TV	
colei var. *colei*	740	163	46	1461	0	25	5	21	E	TV	
var. *ileocarpa*	768	0	7	888	0	25	5	21	E	TV	
complanata	86	0	2	154	0	30	4	21	E	TV	
concurrens	892	0	3	1097	0	25	3	21	E	TV	
conferta	297	0	2	545	0	(25)	5	26	E	TV	
confluens	203	0	1	203	0	(25)	7	20	E	TV	
conspersa	885	0	1	885	0	(30)	7	20	E	TV	
coolgardiensis	4475	0	2	6250	0	(20)	6	21	D	TV	
coriacea											
ssp. *coriacea*	68	0	4	114	0	25	5	25	ED	TV	
ssp. *pendens*	70	0	5	93	0	25	7	21	ED	TV	
ssp. *sericophylla*	70	30	13	108	0	25	6	26	D	TV	
covenyi	720	0	1	720	0	25	7	21	E	TV	
cowleana	758	0	7	1186	0	25	5	21	E	TV	
crassa ssp. *crassa*	867	0	3	999	0	(25)	3	20	E	TV	
crassicarpa	309	76	79	575	0	25;30	5	25	E	TV	
cretata	1053	0	1	1053	0	25;30	4	25	E	TV	
cultriformis	590	0	1	590	0	(25)	6	21	D	TV	
cupularis	806	0	1	806	0	20	4	21	E	TV	
cuspidifolia	113	0	2	116	0	(25)	3	21	CE	TV	
cuthbertsonii	46	0	6	63	0	(25)	5	24	CF	TV	
cyclops	238	0	3	270	0	(25)	7	24	E	TV	
cyperophylla	208	0	2	235	0	(30)	5	26	D	TV	
dangarensis	463	0	1	463	0	(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	0	(25)	6	23	E	TV	
deanei											
ssp. *deanei*	447	0	5	546	0	25	3	25	E	TV	
ssp. *paucijuga*	186	0	1	186	0	25	5	20	E	TV	
decora	660	0	1	660	0	25	6	25	E	TV	
decurrens	568	0	7	666	0	(25)	5	25	E	TV	
delibrata	228	0	2	266	0	30	5	25	N	TV	
denticulosa	662	0	1	662	0	20	5	20	E	TV	
dictyophleba	833	199	13	1280	0	(25);(30)	5	20	EN	TV	
dietricheana	305	0	1	305	0	(25)	5	21	D	TV	
difficilis	374	103	16	561	0	25;30	4	21	E	TV	
difformis	100	0	1	100	0	(25)	5	25	E	TV	
dimidiata	192	0	4	226	0	(25);(30)	7	25	E	TV	
diphylla	1916	0	1	1916	0	(25)	5	15	E	TV	
disparrima											
ssp *calidestris*	421	0	2	450	0						
ssp *disparrima*	416	0	6	546	0						
distans	525	0	1	525	0	25	3	24	D	TV	
doratoxylon	956	0	1	956	0	(25)	5	21	E	TV	
drepanophylla	246	0	1	246	0	25	4	15	A	TV	
drummondii	800	0	1	800	0	15	15	40	E	TV	
dunnii	19	0	4	28	0	25	10	30	N	TV	
effusa	260	0	1	260	0	(25)	7	14	E	TV	
elachantha	944	1149	36	7580	0	25	5	15	E	TV	
elata	200	36	12	248	0	(25)	3	21	DE	TV	
elongata	1095	0	1	1095	0	(25)	5	20	E	TV	
eriopoda	595	118	11	776	0	(25)	5	21	E	TV	
eriopoda × *tumida*	205	0	1	205	0	(25)	5	21	E	TV	
estrophiolata	280	0	1	280	0	(25)	4	20	D	TV	
everestii	255	0	1	255	0	(30)	2	20	D	TV	
excelsa	163	0	2	225	0	(25)	5	20	E	TV	
exilis	710	0	1	710	0	(30)	7	14	E	TV	
falcata	501	0	7	643	0	(25)	6	20	E	TV	
falciformis	193	0	8	247	0	25	4	29	E	TV	
farnesiana	65	0	1	65	0	25	4	20	E	TV	
fasciculifera	139	0	3	149	0	25	4	30	EH	TV	
fauntleroyi	730	0	1	730	0	(25)	7	21	E	TV	
filicifolia	643	0	4	863	0	(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	0	(25)	4	26	E	TV	
flavescens	224	0	5	335	0	25	5	23	E	TV	
fleckeri	140	0	2	250	0	(25)	7	21	E	TV	
flexifolia	865	0	1	865	0	(25)	5	30	C	TV	
floribunda	862	0	2	955	0	(25)	7	25	E	TV	
frigescens	462	0	1	462	0	(20)	10	30	E	TV	
fulva	576	0	5	630	0	(25)	4	22	EH	TV	
galeata	81	0	1	81	0	25	7	21	P	TV	
genistifolia	875	0	1	875	0	(25)	4	25	F	TV	
georginae	73	0	4	91	0	(25)	5	20	D	TV	
gittinsii	600	0	1	600	0	(25)	4	20	E	TV	
gladiiformis	450	0	1	450	0	(25)	4	20	E	TV	
glaucocaesia	340	0	1	340	0	(25)	7	21	GD	TV	
glaucocarpa	380	0	6	483	0	25	3	21	E	TV	
glaucoptera	540	0	1	540	0	(25)	20	40	E	TV	
gnidium	1600	0	1	1600	0	(25)	4	20	E	TV	
gonoclada	1838	0	7	2257	0	(25)	4	15	N	TV	
gracillima	316	0	2	326	0	(25)	7	21	E	TV	
grandifolia	375	0	2	450	0	(25)	7	21	E	TV	
hakeoides	161	0	2	182	0	(25)	10	30	E	TV	
hamersleyensis	520	0	2	529	0	(25)	7	15	E	TV	
hammondii	1377	0	4	1533	0	(25)	5	21	E	TV	
harpophylla	189	0	2	189	0	25	5	14	A	TV	
havilandii	1150	0	1	1150	0	30;20	5	40	E	TV	Alternating temp.
hemignosta	147	0	3	172	0	(25)	5	25	E	TV	
hemsleyi	624	89	11	828	0	30	4	21	E	TV	
hilliana	952	0	1	952	0	(30)	3	20	E	TV	
holosericea	949	209	44	1412	0	25;30	3	21	E	TV	
hylonoma	408	0	1	408	0	25	5	14	E	TV	
implexa	395	111	15	645	0	(25)	5	21	E	TV	
inaequilatera	144	0	3	170	0	(30)	5	20	E	TV	
inophloia	317	0	2	500	0	20	5	21	E	TV	
irrorata											
ssp. *irrorata*	1011	230	11	1334	0	25	5	21	E	TV	
ssp. *velutinella*	1239	0	2	1253	0	25	7	22	E	TV	
islana	130	0	1	130	0	(25);(30)	5	15	DE	TV	
iteaphylla	240	0	1	240	0	(25)	4	28	E	TV	
jennerae	112	0	4	202	0	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	0	(20)	5	20	E	TV	
julifera ssp. *julifera*	722	0	3	815	0	25	3	24	E	TV	
juncifolia	714	0	2	833	0	(25)	3	16	E	TV	
kempeana	423	0	2	465	0	(30)	4	16	E	TV	
kettlewelliae	260	0	1	260	0	(25)	10	30	E	TV	
koa	80	0	1	80	0	(25)	5	20	E	TV	
laccata	558	0	1	558	0	(25)	6	20	E	TV	
lamprocarpa	289	0	6	399	0	(30)	4	22	E	TV	
lasiocalyx	369	0	3	500	0	(20)	6	20	E	TV	
latescens	189	0	6	780	0	30	4	21	E	TV	
latzii	465	0	1	465	0	25	3	15	A	TV	
leichhardtii	209	0	1	209	0	(30)	5	35	D	TV	
leiocalyx	817	0	6	1166	0	25	4	20	E	TV	
leiocalyx aff.	894	0	1	894	0	(25)	3	26	E	TV	
leprosa	1570	0	1	1570	0	(25)	18	99	E	TV	
leptocarpa	744	279	17	1167	0	25;30	3	21	E	TV	
leptopetala	560	0	1	560	0	(25)	3	10	E	TV	
leptostachya	200	0	1	200	0	20;30	7	21	E	TV	
leucoclada											
ssp. *argentifolia*	522	0	1	522	0	25	4	28	E	TV	
ssp. *leucoclada*	516	0	3	789	0	(25)	5	28	E	TV	
ligulata	226	0	8	447	0	20;25	3	20	DE	TV	
linarioides	80	0	1	80	0	(25)	5	22	E	TV	
linearifolia	140	0	1	140	0	(25)	6	21	E	TV	
lineata	450	0	1	450	0	(25)	10	30	F	TV	
lineolata	2241	0	2	2300	0	15	7	15	E	TV	
linifolia	305	0	2	309	0	(25)	3	25	E	TV	
longifolia											
var. *longifolia*	490	0	1	490	0	(25)	13	35	E	TV	
var. *sophorae*	480	0	2	575	0	25	5	25	E	TV	
longispicata	892	0	2	917	0	25;30	5	21	E	TV	
longissima	700	0	1	700	0	(25)	7	21	**	TV	
lysiphloia	480	0	5	574	0	(25)	4	21	NE	TV	
mabellae	358	0	2	380	0	(25)	7	21	E	TV	
maconochieana	339	0	2	386	0	25	4	21	A	TV	
macradenia	414	0	2	428	0	(25)	5	21	E	TV	
maidenii	510	0	5	657	0	20;25	3	21	E	TV	
maitlandii	512	0	2	550	0	25;30	2	16	E	TV	
mangium	644	152	187	1044	0	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	0	25	5	21	E	TV	
meisneri	64	0	2	88	0	15	7	20	D	TV	
melanoxylon	616	224	43	1066	0	25;30	3	21	E	TV	
melleodora	480	0	3	650	0	25;30	3	20	E	TV	
microbotrya	94	0	3	136	0	15	3	21	D	TV	
midgleyi	537	0	3	594	0	(30)	7	21	ED	TV	
mimula	37	0	1	37	0	(30)	5	30	E	TV	
mollifolia	369	0	1	369	0	(25)	5	28	E	TV	
monticola	252	0	5	389	0	25	3	20	E	TV	
mountfordiae	329	0	3	370	0	25;30	4	20	C	TV	
mucronata	630	0	2	739	0	(25)	10	30	E	TV	
muellerana	634	0	1	634	0	(25)	7	21	E	TV	
multisiliqua	343	0	1	343	0	25	7	21	D	TV	
murrayana	150	0	7	268	0	25	7	21	E	TV	
myrtifolia	633	0	2	1075	0	20	20	37	EN	TV	
nano-dealbata	588	0	2	627	0	(25)	7	21	A	TV	
neriifolia	223	0	3	261	0	25	4	25	E	TV	
neurocarpa	958	130	11	1150	0	30;25	7	21	E	TV	
neurophylla	1885	0	1	1885	0	20	6	20	ED	TV	
notabilis	340	0	2	460	0	30;20	18	40	E	TV	Alternating temp.
nuperrima ssp. *cassitera*	256	0	2	431	0	(25)	7	21	**	TV	
obliquinervia	129	0	5	380	0	(25)	20	40	E	TV	
obtusata	360	0	1	360	0	(25)	7	20	E	TV	
obtusifolia	542	0	1	542	0	25	8	20	E	TV	
olgana	616	0	1	616	0	(30)	2	10	E	TV	
olsenii	239	0	2	290	0	25	5	20	E	TV	
omalophylla aff.	840	0	1	840	0	(25)	3	15	E	TV	
oncinocarpa	515	0	3	657	0	30	6	21	E	TV	
oraria	262	0	4	430	0	25;30	5	26	C	TV	
orites	853	0	1	853	0	(25)	7	21	CE	TV	
orthocarpa	730	0	1	730	0	(25)	3	20	E	TV	
oswaldii	76	0	2	90	0	(25)	5	10	CA	TV	
pachycarpa	22	0	5	42	0	25	3	21	E	TV	
pachyphloia	6	0	1	6	0	(25)	7	21	E	TV	
papyrocarpa	210	0	1	210	0	(25)	7	21	E	TV	
paradoxa	830	0	1	830	0	(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	0	(25)	5	21	E	TV	
parvipinnula	475	0	4	833	0	(25)	8	21	E	TV	
pellita	921	0	3	982	0	(25)	6	20	E	TV	
pendula	248	0	3	314	0	25	5	21	E	TV	
penninervis	183	0	3	295	0	25	10	26	E	TV	
peregrina	301	110	40	522	0	25;30	5	21	ED	TV	
peuce	425	0	1	425	0	(25)	3	21	A	TV	
platycarpa	37	0	9	78	0	25	5	20	E	TV	
plectocarpa	565	216	16	1260	0	30	4	21	EN	TV	
podalyrifolia	256	0	1	256	0	25	6	27	E	TV	
polybotrya	370	0	1	370	0	(25)	5	25	E	TV	
polystachya	344	0	4	618	0	25;30	5	21	E	TV	
prainii	396	0	1	396	0	20	6	20	D	TV	
pravissima	575	0	2	750	0	(25)	10	26	E	TV	
prominens	190	0	1	190	0	(25)	10	30	E	TV	
pruinocarpa	279	0	2	329	0	25	3	25	E	TV	
pruinosa	189	0	1	189	0	(25)	4	21	E	TV	
ptychophylla	760	0	1	760	0	(25)	7	21	E	TV	
pubercosta	386	0	1	386	0	25	5	21	E	TV	
pustula	449	0	1	449	0	(25)	4	14	CE	TV	
pycnantha	345	0	8	480	0	(25)	10	50	E	TV	
pyrifolia	204	0	5	230	0	(25)	3	20	E	TV	
ramulosa	266	0	1	266	0	(25)	3	10	E	TV	
reclusa ms	460	0	1	460	0	(30)	4	21	E	TV	
redolens	1123	0	1	1123	0	(20)	11	30	E	TV	
repanda	1800	0	1	1800	0	(20)	7	36	E	TV	
resinimarginea	2142	0	2	3283	0	(20)	6	20	E	TV	
retinervis	169	0	2	172	0	(30)	10	25	N	TV	
retinodes	660	0	2	800	0	(25)	7	25	E	TV	
retivenia	286	0	3	320	0	(25);(30)	5	20	E	TV	
rhodophloia	1020	0	2	1200	0	(25)	3	14	E	TV	
rhodoxylon	818	0	1	818	0	(25);(30)	5	20	DC	TV	
riceana	460	0	1	460	0	(25)	10	20	E	TV	
rigens	780	0	1	780	0	(25)	5	20	E	TV	
rothii	30	0	4	40	0	30	4	21	HE	TV	
rubida	506	0	4	688	0	(25)	5	20	E	TV	
sabulosa	432	0	4	731	0	(25)	7	21	E	TV	
salicina	140	54	15	245	0	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	0	(25)	7	21	D	TV	
saligna	430	144	17	789	0	15	5	30	E	TV	
schinoides	495	0	2	521	0	25	6	20	E	TV	
scirpifolia	398	0	1	398	0	20	7	15	E	TV	
sclerosperma	29	0	8	41	0	25	5	25	EN	TV	
sclerosperma × *ligulata*	68	0	1	68	0	(25)	5	15	FH	TV	
semirigida	220	0	1	220	0	(25)	7	28	E	TV	
sericata	40	0	1	40	0	(25)	7	21	C	TV	
sericoflora	1353	0	1	1353	0	30	2	27	E	TV	
sessilispica	1714	0	1	1714	0	20	5	20	D	TV	
shirleyi	682	0	4	999	0	25	2	20	ED	TV	
sibina	893	0	1	893	0	20	5	19	E	TV	
signata	218	0	1	218	0	(25)	7	21	E	TV	
silvestris	374	0	5	460	0	25	5	25	E	TV	
simsii	699	0	6	1170	0	30	3	21	E	TV	
sparsiflora	939	0	2	962	0	25	7	21	E	TV	
species	262	0	1	262	0	(25)	7	21	E	TV	
spectabilis	320	0	4	381	0	25	3	27	E	TV	
spirorbis subsp. *spirorbis*	554	0	3	612	0	25	7	20	D	TV	
spongolitica	830	0	1	830	0	20	7	21	E	TV	
stenophylla	85	37	11	129	0	30;25	3	25	EC	TV	
stereophylla	2270	0	1	2270	0	15	5	20	E	TV	
stigmatophylla	580	0	1	580	0	(25)	7	20	E	TV	
stipuligera	803	84	15	1000	0	(30;25)	5	21	E	TV	
storyi	341	0	2	432	0	25	7	21	E	TV	
stowardii	945	0	1	945	0	(25)	7	21	E	TV	
striatifolia	1052	0	1	1052	0	25	7	21	E	TV	
suaveolens	228	0	4	273	0	(25)	4	24	E	TV	
suberosa	24	0	1	24	0	(25)	7	30	E	TV	
subtessarogona	326	0	2	342	0	(25)	3	10	E	TV	
subulata	225	0	1	225	0	(25)	7	30	E	TV	
sylvestris	220	0	1	220	0	(25)	5	24	E	TV	
synchronicia	346	0	2	552	0	(25)	7	21	G	TV	
telmica	635	0	1	635	0	(20)	5	20	E	TV	
tenuinervis	736	0	1	736		25	7	21	E	TV	
tenuissima	1010	0	8	1666	0	(25)	4	22	E	TV	
terminalis	385	0	2	489	0	(25)	6	21	E	TV	

Appendix 3.10.1 Acacia 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			
tetragonophylla	460	0	1	460	0	(25)	5	15	CE	TV	
thomsonii	1026	209	11	1353	0	(25)	7	15	E	TV	
torulosa	231	117	30	505	0	(25;30)	5	21	E	TV	
trachycarpa	119	0	9	181	0	25	4	21	E	TV	
trachyphloia	678	0	5	865	0	(25)	5	25	E	TV	
trinervata (syn. *cunninghamiana*)	7630	0	1	7630	0	20;30	7	21	CD	TV	
trineura	1916	0	1	1916	0	(25)	8	28	E	TV	
triptera	1100	0	1	1100	0	(25)	8	20	E	TV	
tropica	560	0	2	808	0	25	5	15	E	TV	
tumida var. *tumida*	144	61	66	393	0	(25;30)	4	30	E	TV	
ulicifolia	637	0	2	675	0	25	7	21	E	TV	
umbellata	910	0	2	958	0	(30)	6	20	E	TV	
uncinata	305	0	2	430	0	(25)	6	26	E	TV	
valida (syn. *calcigera*)	21	0	1	21	0	(25)	4	21	E	TV	
validinervia	416	0	3	615	0	(25)	6	21	E	TV	
validinervia variant	310	0	2	417	0	(25)	7	21	N	TV	
verniciflua	411	0	2	682	0	30;20	5	99	E	TV	Alternating temp.
verticillata	460	0	1	460	0	(25)	4	27	F	TV	Alternating temp.
vestita	238	0	2	266	0	(25)	6	30	E	TV	
victoriae	238	90	23	421	0	25	3	21	EN	TV	
viscidula	1,090	0	1	1090	0	(30)	7	20	A	TV	
wanyu	93	0	3	136	0	(20)	6	23	E	TV	
wattsiana	442	0	1	442	0	(25)	8	60	E	TV	
xanthina	360	0	2	393	0	(25)	6	21	A	TV	
xiphophylla	135	0	4	165	0	25	4	10	A	TV	
yirrkallensis	2383	0	1	2383	0	(25)	7	21	**	TV	
ADANSONIA											
gregorii	1	0	1	1	0	(30)	6	35	C	TV	
ADENANTHERA											
abrosperma	56	0	1	56	0	(25)	4	18	CD	TV	
pavonina	22	0	1	22	0	(25)	5	18	CD	TV	
AGATHIS											
robusta	168	0	2	186	0	(25)			A	TV	
AGONIS											
flexuosa	8800	0	1	8800	0	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	0	25			E	TV	
chinensis	348	0	1	348	0	25			G	TV	
lebbeck	270	0	1	270	0	(30)	5	12	E	TV	soak overnight
ALLOCASUARINA											
campestris ssp. *campestris*	2600	0	1	2600	0	15	7	30	A	TV	
decaisneana	352	0	5	560	0	(25);(30)	3	14	A	TV	
fraseriana	680	0	1	680	0	(25)	10	30	A	TV	
huegeliana	2230	0	1	2230	0	15;20	7	35	A	TV	
littoralis	3766	0	7	5637	0	25	5	28	A	TV	
paludosa	6442	0	1	6442	0	15	12	30	A	TV	
torulosa	2025	0	4	2638	0	20	5	21	A	TV	
verticillata	572	0	10	1113	0	15	14	30	A	TV	
ALNUS											
nepalensis	7900	0	1	7900	0	(25)	7	14	A	TPV	
ALPHITONIA											
excelsa	87	0	1	87	0	25;30	4	16	CE	TV	
petriei	524	0	2	684	0	25	4	16	C	TV	
ANGOPHORA											
costata	686	0	4	735	0	20;25	4	17	A	TV	
floribunda	450	0	1	450	0	20;25	7	14	A	TPV	
ARAUCARIA											
bidwillii	1	0	2	1	0	30	5	21	A	TV	
cunninghamii	34	0	9	170	0	20;30	7	21	A	TV	
heterophylla (excelsa)	1	0	1	1	0	20;25;30	7	28	A	TV	
hunstenii	19	0	2	20	0	(25)	5	28	A	TV	
ASTARTEA											
fascicularis	1300	0	1	1300	0	(15)	25	56	A	TVP	
ASTEROMYRTUS											
brassii	1710	0	5	2650	0	(25);(30)	5	14	A	TPV	
lysicephala	19050	0	4	40100	0	(25);(30)	5	20	A	TPV	
magnifica	1550	0	1	1550	0	25	3	28	A	TPV	
symphyocarpa	3037	1216	14	5800	0	(25);(30)	5	20	A	TPV	
ATALAYA											
hemiglauca	70	0	7	132	0	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	(25)	6	28	I	TV	
BANKSIA											
integrifolia var. *compar*	378	0	1	378	0	25	7	21	A	TV	
serrata	80	0	1	80	0	25	10	30	A	TV	
spinulosa	196	0	3	300	0	30			A	TV	
BEAUFORTIA											
sparsa	30870	0	1	30870	0	25	7	26	A	TVP	
BRACHYCHITON											
populneus	45	0	2	55	0	25	6	27	D	TV	
BURSARIA											
occidentalis	170	0	1	170	0	25	36	43	B	TV	28 days CMS
spinosa var. *spinosa*	800	0	1	800	0	(15)	15	35	A	TV	
CALLISTEMON											
citrinus	85000	0	1	85000	0	30	7	21	A	TV	
linearis	215000	0	1	215000	0	30	7	21	A	TV	
macropunctatus	53,000	0	1	53000	0	30	7	21	A	TV	
phoeniceus	64000	0	1	64000	0	30	7	21	A	TV	
polandii	22000	0	1	22000	0	30	7	21	A	TV	
CALLITRIS											
intratropica	150	0	1	150	0	(30)	15	28	A	TV	
CALOTHAMNUS											
homalophyllus	5200	0	1	5200	0	20	14	28	A	TVP	
quadrifidus	7,400	0	1	7400	0	20	10	20	A	TVP	
rupestris	8900	0	1	8900	0	20	14	28	A	TVP	
CAPPARIS											
spinosa	297	0	1	297	0	(25)	12	19	A	TV	
CASSIA											
alata	207	0	1	207	0	25	1	10	G	TV	
brewsteri	64	0	1	64	0	25	5	12	CD	TV	
javanica	10	0	1	10	0	30	4	10	C	TV	
queenslandica	126	0	1	126	0	(25)	5	20	CD	TV	
siamea	204	0	2	216	0	(25)	3	20	E	TV	
CASUARINA											
collina	13200	0	2	13900	0	20	5	14	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			
cristata	1184	0	6	1590	0	25	7	21	A	TV	
cunninghamiana ssp. *cunninghamiana*	6924	0	8	12800	0	25;35	5	21	A	TV	
equisetifolia											
ssp. *equisetifolia*	2635	1569	79	10500	0	30	4	22	A	TV	
ssp. *incana*	2465	0	6	3515	0	(25;30)	7	21	A	TV	
glauca	4437	2473	17	9200	0	25	5	24	A	TV	
grandis	3663	0	2	3700	0	(25)	6	25	A	TV	
junghuhniana ssp. *junghuhniana*	11695	13365	30	81135	0	25-35	3	25	A	TV	
obesa	3678	0	7	5975	0	25	5	21	A	TV	
oligodon	14587	0	3	26562	0	(25)	9	22	A	TV	
papuanum	8750	0	1	8750	0	25	5	20	A	TV	
CATHORMION											
umbellatum var. *moniliforme*	13	0	1	13	0	(25)	8	20	GD	TV	
CEDRELA serrata	1353	0	1	1353	0	(25)	2	21	A	TV	
CHORISIA speciosa	22	0	1	22	0	(25)	5	8	C	TV	
CHUKRASIA											
tabularis	367	0	7	540	0	25	0	0	J	TV	
velutina	476	0	2	886	0	25	5	25	J	TV	
COCHLOSPERMUM											
fraseri	126	0	1	126	0	(30)	8	23	CG	TV	
CORYMBIA											
abbreviata	260	0	1	260	0	(25)	5	14	A	TPV	
bleeseri	350	0	1	350	0	30	6	10	A	TPV	
bloxsomei	760	0	1	760	0	25;30	10	14	A	TPV	
cadophora	317	0	5	481	0	(25)	5	15	A	TPV	
calophylla "rosea"	130	0	3	160	0	25	7	21	A	TV	Inhibitors
citriodora	1338	649	16	2720	0	25;30	5	14	A	TV	Inhibitors
clavigera	400	0	1	400	0	30	5	12	A	TPV	
collina	590	0	1	590	0	25	7	21	A	TPV	
confertiflora	858	0	4	1700	0	30	5	14	A	TPV	
dampieri	563	0	1	563	0	(20)	6	18	A	TPV	
dichromophloia	530	0	1	530	0	25	5	12	A	TPV	
dimorpha	1180	0	1	1180	0	(25)	5	10	A	TPV	
eremaea	775	0	2	940	0	25	5	21	A	TV	Inhibitors
eximia	457	0	2	510	0	(25)	5	14	A	TPV	
ficifolia	390	0	4	538	0	20	5	14	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			
foelscheana	350	0	1	350	0	25	5	14	A	TPV	
grandifolia	350	0	1	350	0	30	5	14	A	TV	Inhibitors
gummifera	576	0	5	730	0	30	5	14	A	TPV	
henryi	1021	0	3	1262	0	25	5	14	A	TV	Inhibitors
hylandii	880	0	1	880	0	(25)	6	26	A	TPV	
intermedia	1350	0	6	1785	0	25	5	14	A	TPV	
jacobsiana	430	0	1	430	0	30	7	21	A	TPV	
latifolia	420	0	1	420	0	20	5	14	A	TPV	
leichhardtii	970	0	1	970	0	(25)	7	15	A	TPV	
maculata	1334	326	15	1872	0	25	5	14	A	TV	Inhibitors
nesophila	770	0	1	770	0	25	5	10	A	TPV	
novoguinensis	672	0	1	672	0	25	6	15	A	TV	
papuana	710	0	1	710	0	(25)	5	10	A	TPV	
polycarpa	867	0	3	1238	0	25	5	21	A	TPV	
porrecta	120	0	1	120	0	(25)	5	14	A	TPV	
ptychocarpa	205	0	3	276	0	25	7	21	A	TPV	
setosa	233	0	2	300	0	(25)	7	21	A	TPV	
terminalis	370	0	1	370	0	(25)	5	21	A	TPV	
tessellaris	1552	0	2	1584	0	35	3	10	A	TPV	
torelliana	3861	0	8	4125	0	(25)	5	14	A	TPV	
trachyphloia	1320	0	1	1320	0	(25)	5	14	A	TPV	
variegata	1357	700	13	2620	0	25;30	5	14	A	TPV	
watsoniana	254	0	3	382	0	(25)	5	28	A	TPV	
xanthope	690	0	1	690	0	(25)	6	14	A	TPV	
zygophylla	213	0	3	264	0	(25)	7	21	A	TPV	
CUNNINGHAMIA											
lanceolata	631	0	2	914	0	(25)	3	18	A	TV	
DAVIESIA mimosoides var. *laxifolia*	615	0	1	615	0	(20)	13	57	C	TV	
DICHROSTACHYS											
spicata	250	0	2	352	0	(30)	3	20	CD	TV	
DILLWYNIA											
sericea	1420	0	1	1420	0	25	7	30	G	TV	
DOLICHANDRONE											
heterophylla	174	0	1	174	0	(25)	11	20	A	TV	
EREMAEA											
beaufortioides	840	0	1	840	0	20	14	32	A	TVP	

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			
EREMOPHILA											
maculata	1	0	1	1	0	(25)	5	30	A	TV	
ERYTHRINA											
vespertilio	13	0	1	13	0	25			CD	TV	
EUCALYPTUS											
acaciiformis	1890	0	1	1890	0	25	7	14	A	TPV	
accedens	810	0	2	1270	0	20;15	10	21	A	TPV	
acies	281	0	1	281	0	(25)	7	30	A	TV	
acmenoides	2064	0	7	2837	0	(30)	7	30	A	TPV	
aeqioperta	10100	0	1	10100	0	(20)	5	25	A	TPV	
agglomerata	2625	0	2	4350	0	15	18	28	A	TPV	
aggregata	7225	0	6	12600	0	25	7	14	A	TPV	
alba	2165	0	2	2690	0	(25;30)	7	14	A	TPV	
albens	1400	0	3	2450	0	(25)	5	14	A	TPV	
alpina	550	0	1	550	0	20	10	30	A	TPV	
amplifolia											
var. *amplifolia*	7559	0	9	17000	0	25;30	4	15	A	TPV	
var. *sessiliflora*	2500	0	1	2500	0	(25;30)	4	15	A	TPV	
amygdalina	1200	0	1	1200	0	20	3	25	B	TPV	28 days CMS
ancophila	2461	0	1	2461	0	(25)			A	TPV	
andrewsii											
ssp. *andrewsii*	1410	0	1	1410	0	(20;25)	3	20	A	TPV	
ssp. *campanulata*	1350	0	2	1450	0	(20;25)	3	20	A	TPV	
angophoroides	5740	0	1	5740	0	25	3	18	A	TPV	
angulosa	650	0	1	650	0	20	5	30	A	TPV	
angustissima	4550	0	3	8400	0	15;20	10	28	A	TPV	
annulata	4540	0	1	4540	0	15	7	21	A	TPV	
apiculata	933	0	2	1190	0	15	14	28	A	TPV	
apodophylla	6000	0	1	6000	0	25;30	7	14	A	TPV	
approximans											
ssp. *approximans*	1697	0	2	1883	0	15	10	28	A	TPV	
ssp. *codonocarpa*	1400	0	1	1400	0	(20)	12	28	A	TPV	
aquilina	400	0	1	400	0	25	10	15	A	TPV	
arachnaea											
ssp. *arachnaea*	2600	0	1	2600	0	(25)			A	TPV	
archeri	2380	0	1	2380	0	(15;20)	7	21	A	TPV	
areuacea	525	0	1	525	0	(25)			A	TPV	
argillacea	1938	0	2	2500	0	25;30	5	21	A	TPV	
argophloia	12441	0	4	14900	0	25	7	21	A	TPV	
aromaphloia	4800	0	1	4800	0	25	3	14	A	TPV	

Appendix 3.10.1 Eucalyptus (a–c) 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			
aspratilis	1563	0	2	2100	0	(25)			A	TPV	
astringens	1578	0	5	2405	0	15;20	7	15	A	TPV	
badjensis	5703	1826	11	9530	0	25	6	15	A	TPV	
baeuerlenii	1626	0	2	2442	0	25	5	14	A	TPV	
baileyana	225	0	2	240	0	25	7	21	A	TPV	
bakeri	6518	0	3	8125	0	15	10	35	A	TPV	
bancroftii	3320	0	1	3320	0	25;30	7	14	A	TPV	
banksii	1670	0	1	1670	0	30	7	14	A	TPV	
barberi	3890	0	1	3890	0	25;30	6	14	A	TPV	
baueriana	3960	0	3	7050	0	(25)	5	21	A	TPV	
baxteri	511	0	3	570	0	20;25	10	28	A	TPV	
behriana	3064	0	2	3950	0	(25)	5	14	A	TPV	
benthamii	9228	0	5	11815	0	(25)	5	12	A	TPV	
beyeri	6480	0	1	6480	0	(25)	3	14	A	TPV	
bigalerita	1470	0	2	1600	0	30	7	12	A	TPV	
biturbinata	1434	0	3	2080	0	(25)	5	15	A	TPV	
blakelyi	6870	0	1	6870	0	25;30	7	21	A	TPV	
blaxlandii	870	0	1	870	0	20;25	9	18	A	TPV	
bosistoana	4056	0	4	5000	0	25	5	14	A	TPV	
botryoides	3914	1567	14	8500	0	25	10	21	A	TPV	
brachyandra	15600	0	1	15600	0	30	6	12	A	TPV	
brassiana	3171	0	7	7460	0	25	7	14	A	TPV	
brevifolia	3284	0	2	3738	0	(25)	5	21	A	TPV	
brevistylis	785	0	1	785	0	20	5	20	A	TPV	
bridgesiana	2510	0	2	3620	0	25	8	14	A	TPV	
brockwayi	5183	0	4	7520	0	15;20	7	14	A	TPV	
brookeriana	3087	0	7	8600	0	25	5	15	A	TPV	
brownii	37550	0	1	37550	0	25	3	10	A	TPV	
buprestium	40	0	1	40	0	20	10	20	A	TPV	
burdettiana	1510	0	1	1510	0	15	10	25	A	TPV	
burracoppinensis	710	0	1	710	0	15;20	10	21	A	TPV	
caesia ssp. *caesia*	1380	0	1	1380	0	25	5	18	A	TPV	
caesia ssp. *magna*	837	0	1	837	0	20	3	15	A	TPV	
calcicola	320	0	1	320	0	(20)	10	28	A	TPV	
caleyi	1490	0	1	1490	0	20	7	14	A	TPV	
caliginosa	480	0	1	480	0	20	10	28	A	TPV	
calycogona ssp. *calycogona*	2477	0	3	3880	0	20	10	28	A	TPV	Inhibitors

Appendix 3.10.1 Eucalyptus (ca–co) 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			
camaldulensis											
ssp. *simulata*	6837	2004	12	9800	0	30	5	10	A	TPV	
var. *camaldulensis*	5084	2086	19	8600	0	25;30	5	10	A	TPV	Tropical 30°C and temperate 25°C
var. *obtusa*	7656	3390	105	21800	0	25;30	5	10	A	TPV	
cambageana	7150	0	1	7150	0	20;25	9	21	A	TPV	
cameronii	2340	0	1	2340	0	25	3	21	A	TPV	
camfieldii	950	0	1	950	0	25	7	14	A	TPV	
campaspe	2430	0	1	2430	0	15;20	10	21	A	TPV	
camphora											
ssp. *camphora*	8499	0	8	12000	0	25	7	28	A	TPV	
ssp. *relicta*	20400	0	1	20400	0	(25)	4	25	A	TPV	
canaliculata	380	0	1	380	0	(25)	5	10	A	TPV	
capillosa											
ssp. *capillosa*	3250	0	1	3250	0	(25)	0	0	A	TPV	
capitellata	400	0	1	400	0	25	7	21	A	TPV	
carnei	1400	0	1	1400	0	(25)	5	14	A	TPV	
celastroides											
ssp. *celastroides*	2030	0	1	2030	0	15;20	7	20	A	TPV	
cephalocarpa	2560	0	1	2560	0	25	5	14	A	TPV	
cerasiformis	3000	0	1	3000	0	20	5	24	A	TPV	
cernua											
(ms syn. *nutens*)	1475	0	2	1530	0	(25)	7	20	A	TPV	
chapmaniana	2320	0	1	2320	0	25	5	20	A	TPV	
chippendalei	403	0	3	522	0	(25;30)	5	20	A	TPV	
chloroclada	5650	0	2	5900	0	(25)	7	20	A	TPV	
cinerea	2926	0	3	3480	0	25	3	14	A	TPV	
cladocalyx	1537	1952	11	7180	0	20	5	21	A	TPV	
clelandii	3410	0	1	3410	0	15	10	21	A	TPV	
clivicola	2000	0	1	2000	0	(25)	0	0	A	TPV	
cloeziana	2663	0	9	11300	0	25	7	28	A	TPV	Inhibitors
cneorifolia	2410	0	3	2730	0	15	10	28	A	TPV	
coccifera	1210	0	3	1550	0	15	10	28	B	TPV	21 days CMS
comitae-vallis	3500	0	1	3500	0	20	10	20	A	TPV	
concinna	2000	0	1	2000	0	25	5	14	A	TPV	
confluens	3400	0	1	3400	0	25;30	7	14	A	TPV	
conglobata	1465	0	2	1550	0	15;20	10	21	A	TPV	
conglomerata	2225	0	1	2225	0	(25)	0	0	A	TPV	
conica	6740	0	2	9500	0	(25)	3	14	A	TPV	

Appendix 3.10.1 Eucalyptus (co–di) 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
consideniana	840	0	1	840	0	20;25	5	21	A	TPV	
cooperiana	2870	0	2	4190	0	20	10	28	A	TPV	
cordata	930	0	1	930	0	20;25	5	14	A	TPV	
cornuta	1588	0	3	2150	0	25	3	14	A	TPV	
coronata	490	0	1	490	0	15	10	21	A	TPV	
corrugata	1500	0	1	1500	0	25	3	14	A	TPV	
cosmophylla	1704	0	3	3366	0	25	5	14	A	TPV	
crebra	7933	0	3	12500	0	30	5	14	A	TPV	
crenulata	13350	0	1	13350	0	(25)	5	14	A	TPV	
croajingalensis	897	0	3	1466	0	25	4	21	A	TPV	
crucis ssp. *crucis*	1045	0	2	1600	0	25	10	28	A	TPV	
cullenii	1455	0	2	1740	0	(25)	5	21	A	TPV	
cupularis	490	0	1	490	0	25	4	14	A	TV	Inhibitors
curtisii	11243	0	3	14725	0	25	5	28	A	TPV	
cyanophylla	1240	0	1	1240	0	(20)	5	28	A	TPV	
cylindriflora	4980	0	1	4980	0	15;20	7	28	A	TPV	
cylindrocarpa	3250	0	1	3250	0	15	10	21	A	TPV	
cypellocarpa	1668	532	11	2720	0	20;25	7	14	A	TPV	
dalrympleana											
ssp. *dalrympleana*	1907	0	6	2830	0	20;25	5	14	A	TPV	
ssp. *heptantha*	3000	0	1	3000	0	(25)	5	21	A	TPV	
dawsonii	11265	0	2	14300	0	(25)	5	21	A	TPV	
dealbata	6310	0	1	6310	0	(25)	3	21	A	TPV	
deanei	5976	0	5	7900	0	20	5	21	A	TV	Inhibitors
decipiens	1310	0	1	1310	0	(25)	5	21	A	TPV	
decorticans	1640	0	1	1640	0	(25)	5	21	A	TPV	
deglupta	48700	0	7	96000	0	35	5	14	A	TV	Inhibitors
delegatensis											
ssp. *delegatensis*	908	0	9	1770	0	20	5	14	B	TPV	42 days CMS
dendromorpha	1070	0	1	1070	0	(25)	10	22	A	TPV	
densa ssp. *densa*	2175	0	2	2649	0	(15)	5	14	A	TPV	
ssp. *improcera*	1317	0	1	1317	0	(15)	5	14	A	TPV	
denticulata	3038	0	4	3550	0	15;25	7	14	B	TPV	21 days CMS N/A if seed fresh
desmondensis	1924	0	2	2587	0	20	7	14	A	TPV	
dielsii	3720	0	2	4820	0	15;20	7	21	A	TPV	
diminuta	2450	0	1	2450	0	(15)	5	25	A	TPV	
diptera	1580	0	2	1740	0	15;20	10	21	A	TPV	

Appendix 3.10.1 Eucalyptus (di–fo) 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			
discreta	3350	0	1	3350	0	(15)	14	28	A	TPV	
diversicolor	492	0	7	840	0	20;25	7	14	A	TV	Inhibitors
diversifolia	339	0	3	473	0	20;25	7	21	A	TPV	
dives	761	288	13	1364	0	15	14	35	B	TPV	56 days CMS
dongarraensis	1400	0	1	1400	0	25	10	28	A	TPV	
doratoxylon	1830	0	1	1830	0	(25)	7	21	A	TPV	
dorrigoensis	10081	0	4	20700	0	(25)	5	12	A	TPV	
drepanophylla	1984	0	9	3360	0	30	7	21	A	TPV	
drummondii	300	0	1	300	0	20	10	28	A	TPV	
dumosa	2340	0	2	3530	0	15;20	10	21	A	TPV	
dundasii	3240	0	1	3240	0	15;20	10	21	A	TPV	
dunnii	2768	1080	38	5170	0	25;30	3	10	A	TPV	
dwyeri	3680	0	1	3680	0	(25)	3	10	A	TPV	
ebbanoensis	930	0	1	930	0	(25)	5	14	A	TPV	
elata	2128	0	6	2600	0	20;25	5	21	A	TPV	
eremophila											
ssp. *eremophila*	3529	0	3	5587	0	(25)	5	21	A	TPV	
erythrocorys	250	0	3	469	0	25;30	5	14	A	TPV	
erythronema											
var. *erythronema*	2193	0	2	2310	0	15;20	10	21	A	TPV	
var. *marginata*	1510	0	1	1510	0	(25)	7	28	A	TPV	
eugenioides	1090	0	2	1160	0	20	5	28	A	TPV	
ewartiana	670	0	1	670	0	(25)	7	21	A	TPV	
exilis	373	0	2	420	0	20	15	28	A	TPV	
exserta	3363	0	3	3750	0	25	5	21	A	TPV	
falcata	1600	0	2	2600	0	15;20	7	14	A	TPV	
falciformis	800	0	1	800	0	(20)	0	0	A	TVP	
famelica	320	0	1	320	0	(20)	8	18	A	TVP	
fasciculosa	4263	0	2	5125	0	15;20	5	14	A	TPV	
fastigata	1116	0	9	1770	0	15;20	10	40	A	TPV	
ferruginea	240	0	1	240	0	30	5	14	A	TPV	
fibrosa											
ssp. *fibrosa*	1553	0	2	1980	0	20	5	14	A	TPV	
ssp. *nubila*	3535	0	2	3850	0	(25)	5	14	A	TPV	
flindersii	8500	0	1	8500	0	(25)	3	14	A	TPV	
flocktoniae	1523	0	2	1825	0	15;20	10	28	B	TPV	28 days CMS
foecunda	2253	0	4	4650	0	15	10	28	A	TPV	
forrestiana											
ssp. *forrestiana*	405	0	2	430	0	15	10	33	A	TPV	

Appendix 3.10.1 Eucalyptus (fr–ho) 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			
fraseri	1887	0	2	2520	0	(25)	10	40	A	TPV	
fraxinoides	1380	0	4	1850	0	25	7	28	A	TPV	
froggattii	3819	0	2	4437	0	20	5	14	A	TPV	
fusiformis	2825	0	2	5150	0	25	7	20	A	TPV	
gamophylla	1358	0	8	2775	0	25	5	10	A	TPV	
gardneri	1410	0	1	1410	0	20	7	21	A	TPV	
georgei	2366	0	1	2366	0	(20)	6	21	A	TPV	
gilbertensis	100	0	1	100	0	(25)	3	10	A	TPV	
gillenii	5296	0	3	7900	0	(25)	5	14	A	TPV	
gillii	830	0	1	830	0	20	5	21	A	TV	Inhibitors
gittinsii	320	0	1	320	0	(20)	10	21	A	TPV	
glaucescens	905	0	6	1218	0	20	5	10	B	TPV	28–42 days CMS not necessary if seed fresh
globoidea	1191	0	4	1540	0	20;25	7	21	A	TPV	
globulus											
ssp. *bicostata*	1004	330	22	1980	0	(25)	5	14	A	TPV	
ssp. *globulus*	675	326	156	2521	0	25	5	14	A	TPV	
ssp. *maidenii*	1518	268	21	1875	0	(25)	5	21	A	TPV	
ssp. *pseudoglobulus*	1350	0	3	2015	0	25	5	14	A	TPV	
gomphocephala	873	0	6	1302	0	25	5	14	A	TPV	
gongylocarpa	969	0	4	2287	0	(25)	5	21	A	TPV	
goniantha											
ssp. *goniantha*	1060	0	1	1060	0	15;20	7	21	A	TPV	
goniocalyx	1398	0	4	1800	0	(25)	5	14	A	TPV	
gracilis	5260	0	1	5260	0	15;20	10	21	A	TPV	
grandis	6728	4896	100	35230	0	25	5	14	A	TPV	
gregsoniana	1310	0	1	1310	0	(15)	7	21	A	TPV	
griffithsii	1620	0	1	1620	0	20	7	21	A	TPV	
grossa	3190	0	1	3190	0	15;20	10	21	A	TPV	
guilfoylei	610	0	1	610	0	(25)	5	28	A	TPV	
gunnii	3080	0	3	3920	0	20	7	28	A	TPV	
haemastoma	1330	0	2	1490	0	25	5	14	A	TV	Inhibitors
haematoxylon	200	0	1	200	0	(25)	7	21	A	TPV	
hallii	9856	0	2	11262	0	25	3	18	A	TPV	
halophila	969	0	4	1217	0	(15)	7	21	A	TPV	
herbertiana	3845	0	2	3890	0	(25)	7	21	A	TPV	
horistes	1685	0	2	1848	0	(25)			A	TPV	

Appendix 3.10.1 Eucalyptus (ho–le) 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			
houseana	8470	0	1	8470	0	(25)	5	21	A	TV	Inhibitors
howittiana	7700	0	1	7700	0	25	7	15	A	TPV	
hypochlamydea	4383	0	1	4383	0	(15)	7	22	A	TPV	
incerata	6325	0	1	6325	0	25	7	21	A	TPV	
incrassata	197	0	2	280	0	20	5	14	A	TPV	
indurata	389	0	1	389	0	(15)	19	31	A	TPV	
infera	16800	0	1	16800	0	(25)	8	31	A	TPV	
insularis	2200	0	1	2200	0	(20)	10	21	A	TPV	
intertexta	2076	0	8	3908	0	25	5	28	A	TV	Inhibitors
jacksonii	963	0	2	1336	0	20	5	28	A	TPV	
jensenii	2630	0	5	4800	0	(25)	5	14	A	TPV	
johnstonii	1026	0	3	1530	0	20;25	7	21	A	TPV	
jucunda	290	0	1	290	0	(15)	14	49	A	TPV	
jutsonii	1540	0	1	1540	0	15	7	21	A	TPV	
kartzoffiana	3277	0	3	5630	0	25	3	10	A	TPV	
kingsmillii	460	0	2	800	0	15	10	14	A	TPV	
kitsoniana	3170	0	1	3170	0	(25)	5	21	A	TPV	
kochii											
ssp. *kochii*	1453	0	5	2280	0	15	7	21	A	TPV	
ssp. *plenissima*	5417	0	2	7950	0	(15)	10	28	A	TPV	
kondininensis	3702	0	4	5013	0	15;20	10	14	A	TPV	
kruseana	2140	0	1	2140	0	20	5	21	A	TV	Inhibitors
kumarlensis	5627	0	3	7850	0	20	5	21	A	TPV	
kybeanensis	1495	0	3	2950	0	20	5	14	B	TPV	42 days CMS
laeliae	1800	0	1	1800	0	25	9	15	A	TPV	
laevopinea	465	0	3	565	0	25	7	21	A	TPV	
lanepoolei	470	0	1	470	0	(25)	7	21	A	TPV	
lansdowneana											
ssp. *albopurpurea*	1350	0	1	1350	0	(25)	10	21	A	TPV	
ssp. *lansdowneana*	2640	0	2	3180	0	15	9	23	A	TPV	
largeana	1030	0	1	1030	0	(25)	5	15	A	TPV	
largiflorens	4840	0	4	7010	0	30	5	14	A	TPV	
lehmannii	390	0	1	390	0	25	7	28	A	TPV	
leptocalyx	1750	0	2	1900	0	(20)	10	28	A	TPV	
leptophleba	1466	0	5	2220	0	25	5	21	A	TPV	
leptopoda											
spp. *leptopoda*	3090	0	1	3090	0	15	7	14	A	TPV	
lesouefii	1780	0	1	1780	0	15	10	21	A	TPV	
leucophloia	3750	0	1	3750	0	25	5	14	A	TPV	

Appendix 3.10.1 Eucalyptus (le–me) 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
leucoxylon											
ssp. *leucoxylon*	1652	0	8	2675	0	(25)	5	28	A	TPV	
ssp. *megalocarpa*	2955	0	2	3960	0	(25)	5	28	A	TPV	
ssp. *petiolaris*	1760	0	2	1800	0	(25)	5	28	A	TPV	
ssp. *pruinosa*	2624	0	5	3500	0	(25)	5	28	A	TPV	
ligustrina	1940	0	1	1940	0	(25)	5	14	A	TPV	
lirata	410	0	1	410	0	(25)	7	14	A	TPV	
litorea	5600	0	1	5600	0	(20)	8	25	A	TPV	
longicornis	2121	0	4	2760	0	15	10	21	A	TPV	
longifolia	1553	0	4	1962	0	(25)	7	28	A	TPV	
longirostrata	891	0	7	1530	0	25	5	21	A	TPV	
loxophleba											
ssp. *gratiae*	1097	0	1	1097	0	(25)	9	29	A	TPV	
ssp. *loxophleba*	6811	0	4	7825	0	(25)	5	21	A	TPV	
lucasii	3190	0	1	3190	0	(25)	7	28	A	TPV	
lucens	4750	0	1	4750	0	(25)	5	36	A	TPV	
luehmanniana	390	0	1	390	0	(25)	5	14	A	TPV	
macarthurii	6930	0	8	18300	0	(25)	5	14	A	TPV	
macrandra	1290	0	2	2300	0	20	5	14	A	TPV	
macrocarpa											
ssp. *macrocarpa*	191	0	4	250	0	20	7	21	A	TPV	
ssp. *cannonii*	500	0	1	500	0	(15)	10	28	A	TPV	
macrorhyncha											
ssp. *macrorhyncha*	517	0	6	728	0	15	10	28	A	TPV	
major	3750	0	2	5500	0	(25)	5	14	A	TPV	
malacoxylon	2520	0	1	2520	0	(25)	5	10	A	TPV	
mannensis											
ssp. *mannensis*	921	0	5	1341	0	(20)	5	14	A	TPV	
ssp. *elliptica*	2137	0	1	2137	0	(25)	7	13	A	TPV	
mannifera											
ssp. *maculosa*	6150	0	1	6150	0	(25)	5	21	A	TPV	
ssp. *mannifera*	4307	0	6	7380	0	(25)	7	21	A	TPV	
ssp. *praecox*	3569	0	2	5950	0	(25)	7	21	A	TPV	
marginata	221	0	10	560	0	15;20	10	21	A	TPV	
mckieana	2050	0	1	2050	0	(25)	5	21	A	TPV	
megacarpa	390	0	1	390	0	(25)	5	28	A	TPV	
megacornuta	1848	0	3	2070	0	15	10	21	A	TPV	
melanoleuca	1160	0	1	1160	0	25	7	14	A	TPV	
melanophitra	5800	0	1	5800	0	(15)	11	35	A	TPV	
melanophloia	1366	0	4	1600	0	25	5	14	A	TPV	
melanoxylon	2610	0	2	3320	0	15	10	21	A	TPV	
melliodora	3634	1220	14	5500	0	25	5	21	A	TV	Inhibitors
merrickiae	1048	0	2	1115	0	(25)	10	28	A	TPV	

Appendix 3.10.1 Eucalyptus (mi–oc) 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			
michaeliana	3280	0	2	5660	0	20	3	21	A	TPV	
micranthera	693	0	3	1089	0	(25)	7	21	A	TPV	
microcarpa	8709	4181	17	17850	0	(25)	5	14	A	TPV	
microcorys	1457	643	17	2760	0	(25)	5	14	A	TPV	
microneura	1440	0	1	1440	0	25	7	21	A	TPV	
microschema	3150	0	1	3150	0	(15)	5	14	A	TPV	
microtheca	4169	2261	17	8325	0	35	3	14	A	TV	Inhibitors
miniata	206	0	4	248	0	25	3	21	A	TPV	
mitchelliana	1142	0	2	2030	0	20	5	14	B	TPV	42 days CMS
moluccana ssp. *moluccana*	8420	0	6	15010	0	25;30	5	21	A	TPV	
moorei	3435	0	2	5570	0	(25)	7	14	A	TPV	
morrisbyi	3841	0	1	3841	0	(20)	9	15	A	TPV	
morrisii	3360	0	1	3360	0	(25)	5	14	A	TPV	
muelleriana	401	0	8	560	0	15	10	21	A	TPV	
multicaulis	910	0	2	1000	0	(25)	5	21	A	TPV	
myriadena	8675	0	2	9375	0	(15)	11	28	A	TPV	
neglecta	1150	0	1	1150	0	(25)	7	21	A	TPV	
newbeyi	1900	0	1	1900	0	20	5	14	A	TVP	
nicholii	7528	0	4	9800	0	(25)	3	10	A	TPV	
nigra (syn. *eugenoides*)	320	0	1	320	0	20	10	21	A	TPV	
nitens	2531	1445	43	7150	0	15;25	7	14	B	TPV	21 days CMS not necessary if seed fresh
nitida	1510	0	1	1510	0	15	10	28	A	TPV	
nobilis	2807	0	6	4150	0	20	5	21	A	TPV	
normantonensis	2525	0	4	3300	0	20;25	7	14	A	TPV	
nortonii	1707	0	2	1880	0	(25)	5	14	A	TPV	
notabilis	1958	0	4	2550	0	(25)	5	14	A	TPV	
nova-anglica	7360	0	1	7360	0	(25)	3	14	A	TPV	
obesa	233	0	1	233	0	(15)	5	20	A	TPV	
obliqua	598	235	11	880	0	15	7	28	A	TPV	
oblonga	1040	0	1	1040	0	20;25	7	21	A	TPV	
obtusiflora	480	0	1	480	0	20	10	28	A	TPV	
occidentalis	1570	0	10	2471	0	(25)	5	14	A	TPV	
ochrophloia	830	0	1	830	0	(25)	5	10	A	TPV	

Appendix 3.10.1 Eucalyptus (od–ph) 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			
odontocarpa	424	0	3	680	0	(25)	5	14	A	TPV	
odorata var. *odorata*	4070	0	1	4070	0	15;20	10	28	A	TPV	
oldfieldii	450	0	1	450	0	(25)	7	21	A	TPV	
oleosa	1458	0	3	2200	0	15	5	21	A	TPV	
olida	681	0	2	782	0	(25)	5	21	A	TPV	
oligantha	1170	0	1	1170	0	(25)	5	14	A	TPV	
oraria	2200	0	1	2200	0	20;25	5	14	A	TPV	
orbifolia	2320	0	2	2840	0	(25)	5	21	A	TPV	
oreades	1011	0	2	1152	0	(25)	7	28	A	TPV	
orgadophila	740	0	1	740	0	(25)	5	28	A	TPV	
ornata	1450	0	1	1450	0	(25)	10	22	A	TPV	
ovata	5942	0	8	6900	0	25	3	10	A	TPV	
ovularis	4960	0	1	4960	0	15;20	10	28	A	TPV	
oxymitra	367	0	4	550	0	(25)	3	14	A	TPV	
pachycalyx	1600	0	2	1870	0	25	5	10	A	TPV	
pachyloma	60	0	1	60	0	(25)	7	21	A	TPV	
pachyphylla	1068	0	6	2110	0	(25)	5	21	A	TPV	
paliformis	2700	0	1	2700	0	20	10	28	A	TPV	
paniculata	3885	0	4	4800	0	25	5	21	A	TPV	
parramattensis ssp. *parramattensis*	3340	0	1	3340	0	(25)	5	10	A	TPV	
parvula	4117	0	3	4710	0	(25)	5	10	A	TPV	
patellaris	1070	0	1	1070	0	30	5	14	A	TV	Inhibitors
patens	538	0	2	615	0	25	10	21	A	TPV	
patentinervis (*hybrid*)	1200	0	1	1200	0	(25)	7	14	A	TPV	
pauciflora ssp. *debeuzevillei*	1110	0	2	1280	0	(20)	7	21	B	TPV	28 days CMS
ssp. *niphophila*	1378	0	3	1575	0	20	5	10	B	TPV	28 days CMS
ssp. *pauciflora*	916	0	5	1675	0	15	7	21	B	TPV	21 days CMS
pellita	3234	1334	40	6000	0	(25)	5	21	A	TPV	
pellita × *brassiana*	1294	0	1	1294	0	(25)	7	14	A	TPV	
perriniana	3419	0	4	4220	0	20	5	10	B	TPV	21 days CMS
petraea	4850	0	2	5400	0	30	7	14	A	TPV	
petrensis	1284	0	1	1284	0	(30)	7	15	A	TV	
phaenophylla	2118	0	2	2160	0	(15)	10	36	A	TPV	

Appendix 3.10.1 Eucalyptus (ph–re) 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			
*phaeotricha**	2118	0	5	2890	0	(25)	5	14	A	TPV	
phoenicea	958	0	4	1650	0	25	5	14	A	TPV	
pileata	3260	0	1	3260	0	(25)	7	28	A	TPV	
pilligaensis	7570	0	2	7600	0	20	7	14	A	TPV	
pilularis	517	213	14	850		25			A	TPV	
pimpiniana	560	0	1	560	0	20	7	14	A	TPV	
piperita ssp. *piperita*	718	0	6	2080	0	20	5	14	A	TPV	
planchoniana	290	0	1	290	0	(25)	5	21	A	TPV	
platydisca (ms)	1280	0	1	1280	0	20	10	28	A	TPV	
platypus											
var. *heterophylla*	2173	0	2	2175	0	15;20	7	21	A	TPV	
var. *platypus*	3900	0	1	3900	0	15;20	7	21	A	TPV	
pluricaulis	1900	0	2	2700	0	(15)	10	28	A	TPV	
polyanthemos	5751	1796	13	9700	0	(25)	5	14	A	TPV	
polybractea	6208	2566	15	13600	0	15;20	10	28	B	TPV	7 days CMS
populnea	17250	0	2	19250	0	25	5	14	A	TPV	
porosa	3190	0	1	3190	0	(25)	5	28	A	TPV	
preissiana	700	0	1	700	0	15;20	10	21	A	TPV	
prominens	3050	0	1	3050	0	25	7	15	A	TPV	
propinqua	3880	0	5	4800	0	(25)	5	21	A	TPV	
pruinosa	1275	0	2	1300	0	30	5	14	A	TPV	
pryoriana	2664	0	4	4337	0	(25)	7	14	A	TPV	
pterocarpa	2300	0	1	2300	0		0	0	A		
pulchella	790	0	1	790	0	15	14	21	A	TPV	
pulverulenta	3934	0	4	6375	0	25	5	28	A	TPV	
pumila	1130	0	1	1130	0	(25)	5	14	A	TPV	
punctata	851	0	6	1450	0	25	5	21	A	TPV	
pyriformis	370	0	1	370	0	25	7	21	A	TPV	
pyrocarpa	298	0	2	340	0	(25)	7	21	A	TPV	
quadrangulata	4211	0	6	6866	0	(25)	5	21	A	TPV	
quadrans	7100	0	1	7100	0	25	5	21	A	TPV	
racemosa	933	0	2	1320	0	25	5	14	A	TPV	
radiata											
ssp. *radiata*	2008	896	30	4000	0	15;20	10	21	A	TPV	
ssp. *robertsonii*	970	0	1	970	0	15;20	10	21	A	TPV	
rameliana	175	0	1	175	0	25	0	0	A		
raveretiana	28696	0	4	39000	0	30	3	10	A	TPV	
redacta	3150	0	1	3150	0	(20)	7	22	A	TPV	
redunca	1260	0	1	1260	0	(20)	5	21	A	TPV	

Appendix 3.10.1 Eucalyptus (re–si) 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			
regnans	1218	0	5	1810	0	15;20	10	21	B	TPV	21 days CMS
remota	200	0	1	200	0	20;25	10	28	A	TPV	
resinifera	2598	0	2	2975	0	25	5	21	A	TV	Inhibitors
rhodantha	320	0	1	320	0	(25)	5	21	A	TPV	
rigens	610	0	2	800	0	(15)	7	25	A	TPV	
rigidula	2152	0	3	2980	0	15;20	5	21	A	TPV	
risdonii	1950	0	1	1950	0	15	10	21	A	TPV	
robusta	4265	1389	11	6300	0	15;25	7	14	A	TPV	
robusta × *tereticornis*	2450	0	1	2450	0		0	0		TPV	
rodwayi	7660	0	1	7660	0	25	5	14	A	TPV	
rossii	1610	0	1	1610	0	(25)	5	28	A	TPV	
roycei	280	0	1	280	0	25	10	28	A	TPV	
rubida ssp. *rubida*	3342	0	5	5487	0	25	5	21	A	TPV	
rubiginosa	600	0	1	600	0	25;30	5	21	A	TPV	
rudderi	3260	0	1	3260	0	(25)	5	14	A	TPV	
rudis	6529	0	7	8375	0	20;25	5	14	A	TPV	
rugosa	948	0	2	1120	0	(25)	5	14	A	TPV	
rummeryi	2168	0	2	2520	0	(25)	3	10	A	TPV	
rupicola	1050	0	1	1050	0	20	7	21	A	TPV	
salicola	6363	0	4	9150	0	(15)	10	21	A	TPV	
saligna	4884	1858	34	9900	0	25	5	14	A	TPV	
saligna × *botryoides*	3763	0	4	6250	0						
salmonophloia	5930	0	3	6290	0	15;20	10	21	A	TPV	
salubris	3795	0	5	6450	0	15;20	10	21	A	TPV	
sargentii	1871	508	13	2963	0	20	5	15	A	TPV	
scias ssp. *callimastha*	777	0	1	777	0	(25)	4	20	A	TPV	
sclerophylla	655	0	4	1390	0	20	6	14	A	TPV	
scoparia	3650	0	3	6000	0	(25)	5	15	A	TPV	
seeana	6350	0	1	6350	0	(25)	10	21	A	TPV	
sepulcralis	260	0	1	260	0	(25)	7	21	A	TPV	
sessilis	550	0	2	630	0	(25)	5	14	A	TPV	
sheathiana	3980	0	2	4010	0	20	7	21	A	TPV	
shirleyi	210	0	1	210	0	(25)	5	12	A	TPV	
sicilifolia	3900	0	1	3900	0	(25)	5	14	A	TPV	
siderophloia	4675	0	2	6650	0	(25)	3	14	A	TPV	
sideroxylon	2372	0	6	3437	0	20	5	14	A	TPV	

Appendix 3.10.1 Eucalyptus (si–to) 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			
sieberi	1084	0	9	1720	0	25	7	14	A	TPV	
similis	440	0	1	440	0	(25)	5	14	A	TPV	
smithii	3271	982	20	5900	0	20;25	5	21	A	TPV	
socialis	1125	0	5	1575	0	(15)	7	21	A	TPV	
sparsicoma	2350	0	1	2350	0	(15)	5	15	A	TPV	
sparsifolia	780	0	3	1225	0	25	5	14	A	TPV	
spathulata	4856	0	4	6033	0	20;25	5	14	A	TPV	
spectatrix	1000	0	1	1000	0	15	12	33	A	TPV	
sphaerocarpa	496	0	4	730	0	25	7	14	A	TV	Inhibitors
squamosa	440	0	1	440	0	(25)	5	10	A	TPV	
staigeriana	2310	0	4	2550	0	25;30	5	14	A	TPV	
steedmanii	4720	0	2	7100	0	20	7	28	A	TPV	
stellulata	3045	0	5	4850	0	15;20	10	21	B	TPV	21 days CMS
stenostoma	795	0	2	1170	0	20	10	21	A	TPV	
stoatei	600	0	2	820	0	20	5	30	A	TPV	
stowardii	460	0	1	460	0	20;25	7	14	A	TPV	
striaticalyx	2817	0	3	3800	0	15;25	5	14	A	TV	Inhibitors
stricklandii	1480	0	1	1480	0	15;20	10	21	A	TPV	
stricta	599	0	2	660	0	25	5	28	A	TPV	
sturgissiana	4900	0	1	4900	0	20	7	21	A	TPV	
subcrenulata	8600	0	1	8600	0	(20)	5	21	A	TPV	
suggrandis ssp *suggrandis*	2683	0	3	5330	0	(15)	10	20	A	TPV	
tectifica	1590	0	2	2320	0	30	5	10	A	TPV	
tenella	1420	0	1	1420	0	25	7	21	A	TPV	
tenuipes	3518	0	2	3810	0	25	5	14	A	TPV	
tenuiramis	970	0	1	970	0	20	10	28	A	TPV	
tenuis	2185	0	2	2200	0	20	5	20	A	TPV	
terebra	1275	0	1	1275	0	(15);(20)	6	20	A	TPV	
tereticornis	6137	3077	46	15100	0	25;30	5	14	A	TPV	
tetragona	243	0	2	260	0	(25)	5	14	A	TPV	
tetrapleura	1450	0	1	1450	0	30	5	10	A	TPV	
tetraptera	695	0	2	1000	0	20;25	7	21	A	TPV	
tetrodonta	373	0	2	526	0	25	5	14	A	TPV	
thozetiana	3950	0	3	4200	0	(25)	5	14	A	TPV	
tindaliae	800	0	1	800	0	(25)	5	14	A	TPV	
todtiana	118	0	2	180	0	20;25	7	21	A	TPV	
torquata	910	0	1	910	0	25;20	5	14	A	TPV	

Appendix 3.10.1 Eucalyptus 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			
transcontinentalis	1140	0	1	1140	0	20	5	14	A	TPV	
tricarpa	1480	0	8	2250	0	(20)	10	15	A	TPV	
triflora	830	0	2	1100	0	(25)	10	28	A	TPV	
trivalvis	1812	0	4	3275	0	20	7	21	A	TPV	
tumida	1400	0	1	1400	0	(15)	5	20	A	TPV	
umbra											
ssp. *carnea*	1660	0	1	1660	0	(25)	5	14	A	TPV	
ssp. *umbra*	1120	0	4	2325	0	15;20	7	21	A	TPV	
umbrawarrensis	4330	0	1	4330	0	(25)	7	21	A	TPV	
uncinata	4150	0	3	8050	0	15;20	10	21	A	TPV	
urnigera	2100	0	1	2100	0	15	10	21	A	TPV	
urophylla	3885	1572	35	8000	0	25;30	5	14	A	TPV	
vestalis (ms)	6025	0	1	6025	0	(25)	5	10	A	TPV	
victrix	2938	0	2	3375	0		0	0		TPV	
viminalis											
ssp. *cygnetensis*	3044	0	4	3980	0	25	7	14	A	TPV	
ssp. *viminalis*	3161	1225	29	5450	0	25	7	14	A	TPV	
virens	7660	0	1	7660	0	25	5	25	A	TPV	
viridans (ms)	260	0	1	260	0		0	0	A		
viridis	8099	0	4	13900	0	20	7	21	A	TPV	
wandoo	2755	0	2	3030	0	15;20	10	21	A	TPV	
websteriana	1760	0	1	1760	0	(25)	5	28	A	TPV	
whitei	2440	0	1	2440	0	(25)	5	14	A	TPV	
woodwardii	1276	0	2	1312	0	15;20	7	14	A	TPV	
woollsiana	10770	0	1	10770	0	(25)	5	21	A	TPV	
yalatensis	590	0	1	590	0	20	8	28	A	TPV	
yarraensis	3925	0	4	5700	0	(25)	7	21	A	TPV	
yilgarnensis	6125	0	1	6125	0	20	6	28	A	TPV	
youmanii	386	0	5	720	0	(25)	10	28	A	TPV	
youngiana	376	0	3	505	0	(25)	7	21	A	TPV	
FLINDERSIA											
australis	121	0	2	152	0	(25)	3	21	A	TV	
brayleyana	60	0	3	71	0	(25)	3	28	A	TV	
collina	151	0	1	151	0	25	0	0	A		
maculosa	568	0	1	568	0	(25)	5	10	A	TV	
GEIJERA parviflora	48	0	1	48	0		0	0			
GMELINA											
dalrympleana	21	0	1	21	0	(25)	14	90	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			
GREVILLEA											
dryandri	104	0	1	104	0	(25)	8	30	A	TV	
glauca	120	0	2	120	0	25	6	18	A	TV	
pteridifolia	97	0	10	182	0	30 and 20	15	40	A	TV	Alternating temperature
pyramidalis	234	0	1	234	0		0	0			
refracta	2150	0	1	2150	0	(25)	8	30	A	TV	
robusta	345	162	59	648	0	30 and 20	10	30	A	TV	Alternating temperature
wickhamii	5	0	2	8	0		0	0			
HAKEA											
arborescens	58	0	1	58	0	(25)	6	15	A	TV	
dactyloides	515	0	1	515	0	25	0	0	A		
leucoptera	225	0	1	225	0	(25)	7	25	A	TV	
macrocarpa	82	0	2	90	0		0	0			
HARDENBERGIA											
violacea	243	0	3	271	0	25	0	0	G		
HETERODENDRUM											
oleifolium	1	0	1	1	0		0	0			
INTSIA bijuga	2	0	1	2	0	(30)	18	28	C	TV	
ISOPOGON											
anemonifolius	24	0	2	44	0	25	0	0	A		
KUNZEA											
ambigua	71487	0	3	122530	0	30	0	0	A		
parvifolia	40600	0	1	40600	0	30	7	25	A	TVP	
LAMBERTIA											
formosa	532	0	1	532	0	20	0	0	A		
LEPTOSPERMUM											
attenuatum	23600	0	1	23600	0	20	7	39	A	TPV	
flavescens	12455	0	8	15850	0	25;30	6	30	A	TPV	
gregarium	6026	0	3	9746	0	(25)	6	20	A	TPV	
javanicum	22000	0	1	22000	0	30	0	0	A		
juniperinum	11475	0	4	19200	0	(25)	7	40	A	TPV	
laevigatum	3500	0	1	3500	0	25	7	21	B	TPV	28 days CMS
lanigerum	9825	0	2	10150	0	(25)	7	35	A	TPV	
liversidgei	9575	0	2	16450	0	(25)	7	20	A	TPV	
longifolium	5400	0	1	5400	0	(25);(30)	14	30	A	TPV	

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			
myrifolium	6220	0	2	6340	0	(25)	8	30	A	TPV	
petersonii	10829	3669	12	17750	0	25	7	21	A	TPV	
scoparium var. *rotundifolium*	5800	0	1	5800	0	25	7	28	A	TPV	
LEUCAENA											
leucocephala	114	0	1	114	0	(25)	9	25	E	TV	
LIVISTONA											
eastonii	1	0	1	1	0		0	0			
mariae	1	0	1	1	0		0	0			
LOMANDRA											
longifolia	681	0	2	785	0	25	0	0	G		
LOPHOSTEMON											
confertus	9880	0	5	37775	0	25	6	21	A	TPV	
suaveolens	3850	0	2	7700	0	20	6	28	A	TPV	
LYSIPHYLLUM											
cunninghamii	21	0	4	28	0	(25)	5	12	H	TV	
hookerii	21	0	1	21	0	(25);(30)	5	10	H	TV	
MACADAMIA											
integrifolia	1	0	1	1	0	(25)	2	7	J	TV	Soak 2 days
MELALEUCA											
acacioides											
ssp. *acacioides*	23500	0	2	30000	0	25	6	21	A	TPV	
ssp. *alsophila*	16413	0	4	25250	0	(25)	7	22	A	TPV	
acuminata	31500	0	1	31500	0	15	10	24	A	TPV	
adnata	44000	0	1	44000	0	(25);(30)	5	21	A	TPV	
alsophila	8000	0	1	8000	0	(30)	5	16	A	TPV	
alternifolia	56625	0	6	116000	0	25	5	30	A	TPV	
arcana	39000	0	1	39000	0	(30)	5	20	A	TPV	
argentea	6700	0	7	20100	0	(30)	5	30	A	TPV	
armillaris	15500	0	1	15500	0	25	5	28	A	TPV	
bracteata	88750	0	4	170000	0	30	5	28	A	TPV	
cajuputi											
ssp. *cajuputi*	43288	22198	16	93500	0	25;30	6	15	A	TPV	
ssp. *platyphylla*	28229	0	7	52000	0	25	4	20	A	TPV	
clarksonii (ms)	25750	0	1	25750	0	(25)	5	17	A	TPV	
dealbata	38375	0	8	85000	0	30	10	35	A	TPV	
decora	46000	0	1	46000	0	(25)	5	30	A	TPV	
decussata	34300	0	2	36200	0	(25)	15	24	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			
dissitiflora	16667	0	3	22250	0	(30)	4	20	A	TPV	
eleuterostachya	57750	0	2	66500	0	(25)	5	30	A	TPV	
elliptica	57000	0	1	57000	0	25	5	28	A	TPV	
ericifolia	29650	0	2	42100	0	25	10	40	A	TPV	
fluviatilis	38150	0	1	38150	0	(25)	15	24	A	TPV	
fulgens	39000	0	1	39000	0	20	14	28	A	TPV	
glomerata	29771	0	6	51500	0	25	7	22	A	TPV	
halmaturorum	26438	0	2	30125	0	(25)	7	20	A	TPV	
hypericifolia	48000	0	1	48000	0	20	14	24	A	TPV	
lanceolata	13180	0	5	25250	0	(20);(25)	7	26	A	TPV	
lasiandra	53050	0	3	83000	0	(25);(30)	7	21	A	TPV	
lateriflora ssp. *"lateriflora"*	1250	0	1	1250	0	(15);(20)	14	22	A	TPV	
lateritia	85000	0	1	85000	0	25	5	33	A	TPV	
leucadendra	17871	11985	18	49750	0	(30);(35)	5	21	A	TPV	
linariifolia	52885	0	7	106700	0	(25)	7	14	A	TPV	
minutifolia	2400	0	1	2400	0		0	0			
nervosa	59500	0	2	112000	0	30	5	21	A	TPV	
nesophila	4000	0	1	4000	0	(20)	14	28	A	TPV	
nodosa	57200	0	1	57200	0	25	6	18	A	TPV	
pauciflora	12800	0	1	12800	0	25	7	36	A	TPV	
pauperiflora	17000	0	1	17000	0	25	5	14	A	TPV	
preissiana	27500	0	2	48000	0	25	5	28	A	TPV	
pubescens	16000	0	1	16000	0	30	8	21	A	TPV	
quinquenervia	26444	16573	16	70000	0	30	5	21	A	TPV	
radula	25000	0	1	25000	0	20	14	28	A	TPV	
rhaphiophylla	29000	0	1	29000	0	30	8	28	A	TPV	
saligna	27625	0	4	42000	0	(30);(35)	7	21	A	TPV	
sericea	4500	0	1	4500	0	(30)	5	12	A	TPV	
squamophloia (ms)	37627	0	5	52555	0	25	10	26	A	TPV	
stenostachya	52000	0	1	52000	0	25	7	30	A	TPV	
styphelioides	33000	0	1	33000	0	30	7	28	A	TPV	
symphyocarpa	7200	0	1	7200	0	30	7	17	A	TPV	
thyoides	41083	0	3	57500	0	25	6	25	A	TPV	
trichostachya	12617	0	3	17200	0	25	7	28	A	TPV	
uncinata	21950	0	2	29700	0	20	14	28	A	TPV	
viridiflora	26688	11964	17	51000	0	30	5	28	A	TPV	

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			
MELIA											
azedarach var. *australasica*	5	0	3	5	0	30	10	80	C	TV	
NOTHOFAGUS											
alpina	101	0	1	101	0	25	5	30	B	TV	30 days CMS
dombeyi	322	0	2	642	0	(25)	5	30	B	TV	90 days CMS
nervosa	706	0	1	706	0		0	0			
obliqua	98	0	2	111	0	25	5	30	B	TV	30–60 days CMS
pumilio	31	0	1	31	0	25	5	30	B	TV	90 days CMS
OCTOMELES											
sumatrana	142220	0	2	271000	0	25	0	0	A		
PANDOREA											
doratoxylon	883	0	1	883	0		0	0			
PARASERIANTHES											
falcataria	378	0	2	476	0	(30)	3	10	EP	TV	
lophantha	82	0	1	82	0	25	0	0	E		
ssp. *montana* var. *koste*	55	0	3	131	0	(20)	5	20	EP	TV	
PARINARI											
nonda	15	0	1	15	0	(30)	20	30	J	TV	
PAULOWNIA											
tomentosa	38167	0	1	38167	0	(25)	10	24	A	TV	
PETALOSTIGMA											
pubescens	5	0	1	5	0	(30)	11	35	CA	TV	
PINUS											
brutia	6	0	1	5.9	0	20	0	0	J		
caribaea											
var. *bahamensis*	458	0	1	458	0		0	0	**		
var. *caribaea*	426	0	1	426	0		0	0	**		
var. *hondurensis*	414	0	5	528	0		0	0			
dalatensis	7	0	1	7	0	(25)	13	36	P	TV	
elliottii	331	0	1	331	0		0	0	**		
patula	851	0	2	1006	0	25	3	24	A	TPV	
pinea	11	0	1	11	0		0	0			
taeda	223	0	2	247	0		0	0	A		

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			
PITTOSPORUM											
phillyraeoides	189	0	1	189	0	25	17	31	I	TV	
PTEROCARPUS											
dalbergioides	218	0	1	218	0		0	0	J		
indicus	170	0	1	170	0		0	0	J		
macrocarpus	102	0	2	112	0	(30)	5	21	A	TV	
RHODOSPHAERA											
rhodanthema	12	0	3	24	0	(25)	2	21	C	TV	
SANTALUM											
album	18	20	13	70	0	(30)	18	42	C	TV	
austrocaledonicum	68	0	1	68	0		0	0			
lanceolatum	36	0	1	36	0	(25)	13	20	C	TV	
macgregorii	2	0	1	2		30			C		
spicatum	5	0	1	5	0	(20)	13	28	C	TV	
SENNA											
costata	392	0	1	392	0		0	0	CD		
oligophylla	80	0	2	109	0	(25)	4	20	CD	TV	
sturtii	371	0	3	414	0	(25)	2	14	C	TV	
SESBANIA											
formosa	271	123	17	545	0	25;30	3	20	EG	TV	
grandiflora	140	0	1	140	0	25;30	4	16	C	TV	
SINOGA											
lysicephala	9000	0	1	9000	0	(25)	10	22	A	TV	
SWIETENIA											
macrophylla	16	8	14	39	0	25	0	0	A	TV	
SYNCARPIA											
glomulifera	1593	0	5	2350	0	25	6	20	A	TPV	
hillii	670	0	1	670	0	25	4	14	A	TPV	
TAMARINDUS											
indica	15	0	1	15	0	(25)	14	20	C	TV	
TECTONA											
grandis	3	0	2	4	0	30	0	0	C	TV	
TERMINALIA											
bursarina	69	0	1	69	0		0	0	C		
canescens	17	0	2	22	0	(25)	22	30	C	TV	
cunninghamii	5	0	2	8	0		0	0	C		

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			
petiolaris	9	0	2	9	0		0	0	C		
volucris	161	0	1	161	0		0	0	C		
THEMEDA											
triandra	710	0	3	1082	0	20;30	0	0			
TOONA											
ciliata	1495	776	12	2510	0	20;25	5	26	A	TV	
sureni	2875	0	1	2875	0	25	0	0	A		
VENTILAGO											
viminalis	154	0	2	219	0	(25)	7	10	J	TV	Remove samaras

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”.

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 % = $\frac{\text{Weight of pure seed}}{\text{Tot. wt of orig. sample}} \times 100$

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 moisture content ❑
High moisture content ❑

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 moisture content: 103ºC ± 2º for 17 ± 1 hour

High moisture content: 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.

Species routinely stored at 18–22ºC **115–128**

Species routinely stored at 3–5ºC **129**

Species routinely stored at –15 to –18º **130**

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 18–22°C 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 3–5°C 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
oligodon	100	2	73	1	3	1
Corymbia						
tessellaris	100	1	69	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
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 –15°C to –18°C 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

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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	651	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

CSIRO

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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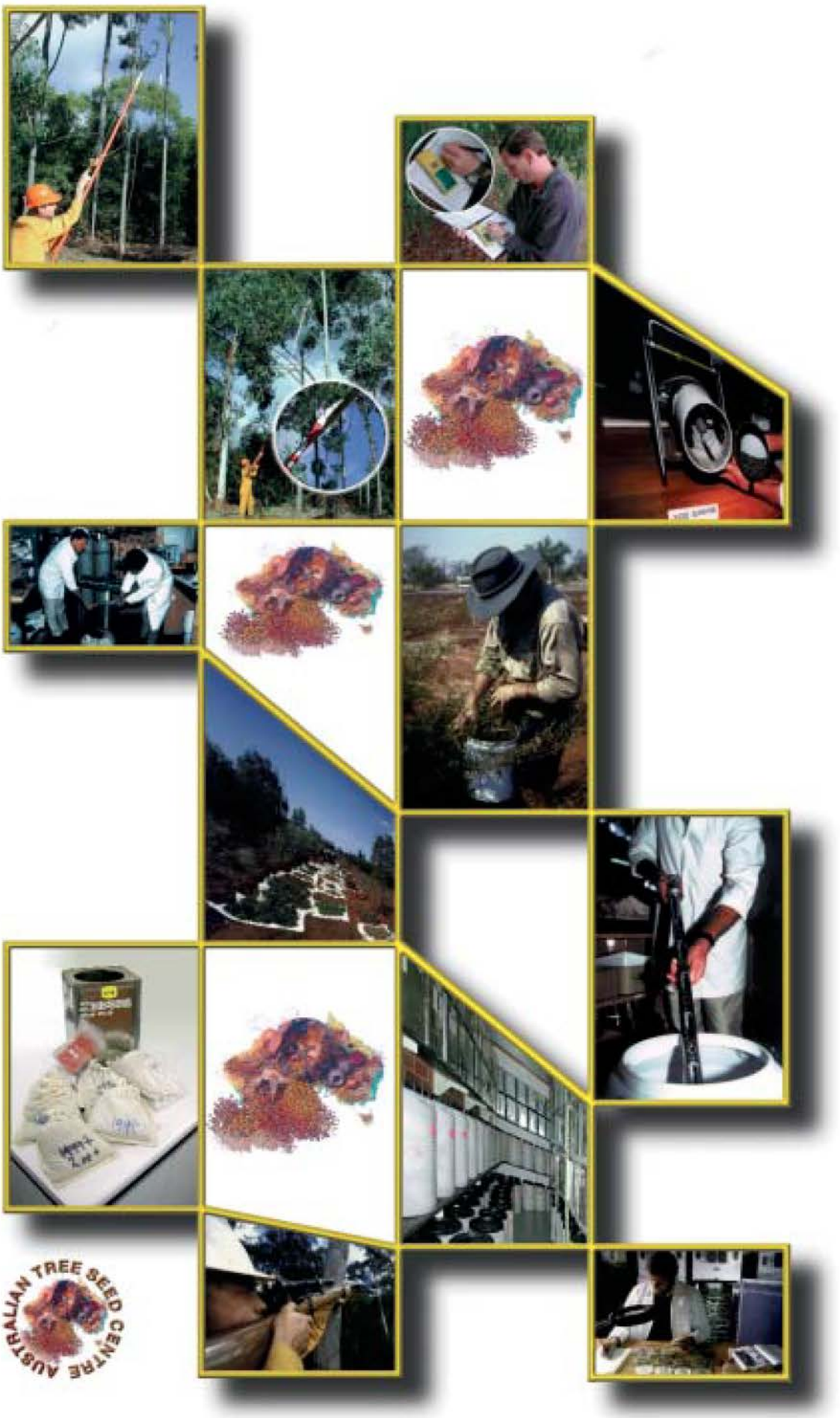
AUSTRALIAN TREE SEED CENTRE

Delivery and Assessment Strategy

Department of Environment and Conservation

Name of RTO	**Department of Environment and Conservation**
Course Title	**Flora Management Course**
Target Groups	DEC staff who require knowledge of flora conservation both in the field and theory or those who view it as an area for career and knowledge development.
Duration of Course	Four and a half days. Beginning 8am on the Monday and finishing 1pm on the Friday
Location	Albany Combination of approximately 50% classroom time and 50% field component
Purpose of Course	To provide departmental staff with field based knowledge and skills to implement flora conservation through an understanding of management issues and techniques
Alignment of course with competency standards and their codes	RTD4504A Monitor Biodiversity
Towards which qualification	Attainment of the Unit RTD4504A will contribute towards a Certificate IV in Conservation and Land Management
Texts/references	INTRODUCTION INCLUDING FLORA CONSERVATION • Hopper, S.H., Chappell, J., Harvey, M., George, A. Eds 1996. *Gondwanan Heritage: Past, Present and Future of the Western Australian Biota.* Sydney. Surrey Beatty. • Lindemeyer, D. and Burgman, M. 2005. Practical Conservation Biology. CSIRO Publishing. Melbourne. • Coates, D. J. and Atkins, K. (2001) Priority setting and the conservation of Western Australia's diverse and highly endemic flora. *Biological Conservation*. 97, 251-263 • Coates , D.J. and Dixon K. (2007) Current Perspectives in Plant Conservation Biology. *Australian Journal of Botany* 55 (in press) • Yates, C. J., Coates, D. J., Elliott, C. and Byrne, M. Composition of the pollinator community, pollination and the mating system for a shrub in fragments of species rich kwongan in south-west WesternAustralia. *Biodiversity and Conservation,* 1-18. • Byrne M., Elliott, C. P., Yates C. J. and Coates, D. J. Extensive pollen dispersal in a bird-pollinated shrub, *Calothamnus quadrifidus* , in a fragmented landscape. *Molecular Ecology* 16, 1303-1314 LEGISLATION (SPECIES AND COMMUNITIES BRANCH AND THREATENED FLORA LEGISLATION) • Brown, A., Thomson-Dans, C., Marchant N. eds. 1998. *Western Australia's Threatened Flora. Perth*: Department of Conservation and Land Management • Cropper, S.C. 1993. *Management of Endangered Plants.* Melbourne. CSIRO. • Australian Department of Premier and Cabinet. 1997. *Wildlife Conservation Act 1950*. http://www.slp.wa.gov.au/index.html [Section 23] • United Kingdom. International Union for Conservation of Nature and Natural Resources. 2001. *IUCN Red List of Threatened Species: Categories and Criteria.* http://www.iucnredlist.org/info/categories_criteria

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Pathogen of the month
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Participant resources	Participants will be supplied with a file which includes session notes, PowerPoint's, handouts, schedule etc Participants should bring pen, paper, hand lens and secateurs. Appropriate field apparel will be required for the field based component and may include but not be limited to helmet, gloves, insect repellent, sunscreen, warm clothing and wet weather gear etc.
Pre-requisites	There are no pre-requisites for this course
Workplace Safety and Health	Departmental personnel will operate in accordance with occupational safety and health guidelines and organisational procedures. They will be required to demonstrate safe-working practices at all times and to operate in accordance with any relevant legislative requirements and applicable Australian Standards.

Key Principles	The organisation is committed to developing training that takes into account the language, gender, culture, access and support strategies that allow for equitable learning for all participants.
Recognition	Participants who have completed current and appropriate training or through prior learning and experience believe that they have gained the pre-requisites and course content stipulated for this course, may be granted Recognition of Prior Learning based on that claim. Evidence of prior learning may include a combination of the following, which assess all aspects of the relevant Units of Competency and course content: • Evidence of current competency • Projects or assignments • Written presentations • Oral and written tests • Demonstrations
Mutual Recognition	Department of Environment and Conservation endorses the requirement to recognise relevant student achievements to ensure that "Statements of Attainment" and Qualifications issued by other Registered Training Organisation's and Australian Quality Framework Qualifications issued by other Registered Training Organisations are portable between Registered Training Organisations and across the state.
Appeals Process	Department of Environment and Conservation is committed to providing all participants with the opportunity to lodge an appeal against an assessment outcome or process if the person undergoing assessment feels they have been disadvantaged or discriminated against. The participant has 12 months to appeal after the results have been given. The appeals procedure applies to: • Assessment conducted within a course • Assessment or decisions within a skills recognition process
Course Delivery Modes	The delivery of this course should incorporate a range of effective teaching strategies; using on-the-job examples and group learning activities. Strategies may include: • Syndicate exercises and group work • Individual exercises • Training room presentations and activates • Demonstrations • Activities • Audio/ visual presentations • On the job training • To ensure access and equity it is important that teaching strategies are modified when required.

Course Content	The following topics should be addressed: • Introduction to Western Australia Flora (1hr 30mins)) • Legislation and the role of Threatened Species and Communities Branch (1hr 30mins) • Introduction to flora of the area- Field (3hrs) • Weed management (1hr 20mins) • Survey techniques (1hr) • Monitoring techniques (1hr) • Plant ID and the WA Herbarium (1hr lecture, 2hrs practical) • Field component including: quadrats, transects, priority flora, DRF survey and monitoring (all day- 9hrs) • Ex situ conservation (1hr 30mins) • Translocations (1hr) • Plant diseases (1hr 15mins) • Phytophthora- Field (1hr 30mins) • Seed collection- Field (1hr 30mins) • Recovery catchments (45mins) • Threatened Ecological Communities (1hr 15mins) • TEC- Field (1hr)
Session titles and approximate session timings	See above
Learning Outcomes	Upon completion of this course, the participant will be able to:
Learning Outcome 1.	Demonstrate an understanding of the patterns of Western Australian Flora
Learning Outcome 2.	Understand and outline the key roles of Species and Communities Branch and Threatened Flora legislation
Learning Outcome 3.	Understand and explain the reasons for surveying and the techniques utilised in the field
Learning Outcome 4.	Demonstrate an understanding of long term management, monitoring and recovery of threatened flora
Learning Outcome 5.	Demonstrate an understanding of the understanding of the WA Herbarium, Regional Herbarium, FloraBase and other electronic keys
Learning Outcome 6.	Outline the reason, strategies and processes of ex-situ seed conservation
Learning Outcome 7.	Demonstrate and understanding of plant translocations including procedures and management plans
Learning Outcome 8.	Demonstrate knowledge of the three major disease groups in WA- *Phytophthora*, Armillaria and Canker
Learning Outcome 9.	Demonstrate an understanding of Threatened Ecological Communities including databases, recovery processes and examples.
Purpose of Assessment	The assessment is used as both a knowledge summary for the participants and a way to assess whether the participant is competent in the Unit RTD4504A
Assessment Task(s) (in summary)	Theory Assessment Day 2- Summarises and assesses the knowledge gained from the first two days of the course. Theory Assessment Day 5- Summarises and assesses the knowledge gained from the course, predominantly days three to five. Practical Assessment Checklist- Assesses the actions of the participants in the field.

Assessment Methods:

Units of Competency	A	B	C	D	E	F	G	H	I
RTD4504A Monitor Biodiversity	✓	×	✓	×	×	×	✓	×	×

KEY	A	Demonstration	C	Interview	E	Role play	G	Written test
	B	Questioning	D	Scenario-problem solving	F	Case study-fault finding	H	Critical incident report
	I	Post Course assessment						

Assessment Validation Process	The processes used to validate assessment activity in this program are: • Workshops on assessment policy and processes to be held after each course, for the first year, for RTO staff. • Client satisfaction surveys request information on satisfaction with assessment tools and processes. • At internal audit samples of assessment process used in each course are reviewed. • Course custodian convenes annual meeting of assessment panel comprising subject specialists to review evidence-gathering tools. • Moderation meetings attended by all assessors to ensure validation of judgements made on assessments and assessment tools after each course for the first 12 months
Physical Resource requirements for Delivery and Assessment	Facilitation of this program will require: • An environment conducive to learning including comfortable seating, adequate lighting, temperature control and noise control, etc. • Access the appropriate field sites • Access to field specialists • Field equipment as required- field notes, flora/ survey forms, hessian bags, GPS, maps, plant presses, syringes/ spray packs/ phosphorous for dieback session • Computers and internet access/ electronic keys for plant ID session • Appropriate reading material • Other teaching aids as required
Delivery and Assessment staff requirements	**Program area** / **Staff** / **Delivery/Assessment** / **Workplace Assessor** / **Workplace Trainer** / **Vocational Training** Course Custodian / Val English / ✓ **Other human resource requirements:** Due to the diverse topics covered in the Flora Management Course, the Course Custodian will utilise CALM staff specialists in the delivery of each session. These specialists will present course material and assist in the field component of the course, and where necessary assist in the assessment of participants, under the supervision of the Course Custodian.
Schedule	Refer to Flora Management Course Schedule
Course Custodians Endorsement	
Date	

YEAR	PRESUMED EXTINCT	NUMBER DELETED	NUMBER ADDED
1991	53		
1992	43	10	
1993	40	4	1
1994	39	3	2
1995	39	0	
1996	27	12	
1997	25	2	
1998	23	2	
1999	22	2	1
2001	17	6	1
2002	16	1	
2003	15	1	
2004	15	0	
2005	14	1	
2006	14	0	
		44	5

DELETIONS:

24 Rediscovered in the field
9 Recent collections discovered in Herbarium collection (curatorial discoveries)
11 Deleted due to taxonomic revision

ROYAL BOTANIC GARDENS KEW

WAKEHURST PLACE

A Field Manual for Seed Collectors

SEED COLLECTING FOR THE

MILLENNIUM SEED BANK PROJECT,

ROYAL BOTANIC GARDENS, KEW

Contents

Introduction

Planning a seed collecting expedition
- authorisation
- prioritising species
- tools and equipment

Collecting in the field
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- sampling strategy
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- data collection
- care of collections in the field

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Annex 1: Species covered by UK phytosanitary regulations

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Annex 3: MSBP field data form

Annex 4: DHL air waybill

References

INTRODUCTION

The Millennium Seed Bank Project International Programme

The Millennium Seed Bank Project (MSBP) International Programme is a nine year global conservation programme (2001-2010), conceived, developed and managed by the Seed Conservation Department at the Royal Botanic Gardens, Kew. The two principal aims of the Programme are to:

- Collect and conserve 10% of the world's seed-bearing flora (some 24,000 species), principally from the drylands, by the year 2010.
- Develop bilateral research, training and capacity-building relationships worldwide in order to support and to advance the seed conservation effort.

An integral element of the collecting programme is the development of collaborations with partner institutions all around the world. These partnerships have as their basis the precepts of the Convention on Biological Diversity, in which resources and responsibility are shared equitably by all parties through technology transfer, benefit sharing and capacity building. The MSBP currently (year 2001) has formal links with seed bank and conservation institutions in the USA, South Africa, Western Australia, Mexico, Chile, Madagascar, Egypt, Lebanon, Burkina Faso, Namibia and Kenya, and is in the process of developing partnerships in many other countries throughout the world.

The purpose of this manual

This Manual of Seed Collecting is part of the MSBP's information-sharing process, and is designed to provide general guidelines regarding seed collecting practice and to provide specific practical details relevant to the collection of seed for the MSBP. It is envisaged that this booklet will be used by the MSBP's own seed collectors and by MSBP collaborators if they wish. It is written with the understanding that different institutions and projects will have different priorities and protocols, which they may wish to adhere to, and is not meant to be the definitive guide to seed collecting. This booklet is therefore best regarded as a guide to the practice followed by the MSBP. This is a living document, which will be updated and expanded periodically, and it is hoped that our partners throughout the world will contribute to this process.

PLANNING A SEED COLLECTING EXPEDITION

Aims

The aims of the MSB collecting programme can be defined as the establishment of verified and well documented seed collections of wild species, each of which truly represents the genetic variation within the population from which it was sampled. The collections then act as a basis for conservation or, where authority has been given, as a source of material to *bona fide* institutes worldwide for all aspects of biological study.

The target established by RBG Kew for the Millennium Seed Bank project is the conservation of at least one population sample from 24,000 seed-bearing plant species, primarily from the drylands, that are not yet represented in the existing seed bank. Although a significant proportion of the genetic variation of many outbreeding[1] species can be adequately conserved

[1] Outbreeding: reproduction is most commonly achieved by cross-pollination, not self pollination.

in this way, it is hoped that this project will also form the basis for much wider future sampling across the genotypic range of these species.

Authorisation

Collecting permits

The Royal Botanic Gardens Kew honours the letter and spirit of the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and other international, regional, national and sub-national laws and policies concerning biodiversity. RBG Kew is wholly committed to the principles of Prior Informed Consent (PIC) and mutually agreed terms. RBG Kew recognises the sovereign rights of states over their own biological resources and the authority of national governments to determine access to genetic resources, subject to national legislation. It also acknowledges the interests of other stakeholders, including indigenous and local communities and farmers, in biological resources and associated information. In practice this means that before any seed is collected, it is subject to PIC in the form of access agreements, permits from local authorities, and permission from land owners. For an illustration of RBG Kew's approach to these issues, including a model Material Acquisition Agreement between a Botanic Garden and a partner institution, follow links from the following Web site: http://www.rbgkew.org.uk/conservation/index.html

CITES

Seeds of all CITES Appendix 1 species, and seeds of Appendix 2 cacti from Mexico, are subject to CITES controls. In addition, dried herbarium specimens from all Appendix 1 and many Appendix 2 species are controlled. It is essential that the up to date CITES summary list is consulted before, during and after the expedition to ensure that no attempt is made to collect or to export controlled material without the relevant permits. Current lists of controlled taxa can be found in CITES publications or public web sites e.g. the UK CITES authority at http://www.ukcites.gov.uk/intro/cites_species.htm, and guidance for Kew staff is available on the internal web at http://web/CAPS/notice.html. The MSBP CITES liaison officer is Janet Terry, and non-RBG Kew staff should email her at j.terry@rbgkew.org.uk if they have any CITES related queries.

Plant Health

Phytosanitary permits are usually required for both the export of plant material from the country of origin and also for import into the UK. For exporting from the country of origin, the procedure is often specified in the Collecting Permit, and may necessitate separate application documents, a visual inspection of the seeds, and payment. Sufficient time should be allowed at the end of the expedition to follow this procedure. Where collected species are subject to phytosanitary regulations in the UK (Annex 1), a phytosanitary certificate should be obtained from the country of origin and presented, together with an RBG Kew letter of authority, to UK Customs. Material subject to phytosanitary regulations and destined for the Millennium Seed Bank should be sent to Janet Terry, Curation Section, Millennium Seed Bank Project, Wakehurst Place, Ardingly RH17 6TN, U.K. (email: j.terry@rbgkew.org.uk)

Prioritising species

The Millennium Seed Bank Project, working together with its partner institutions throughout the world, attempts to prioritise which plant species it collects and stores. The prioritisation criteria will vary from country to country depending on the partner's needs, but most commonly will include:

Orthodox seeds	i.e. Seeds which retain their viability after drying, and which are therefore likely to be bankable
Indigenous or endemic species	i.e. Species native to an area, and neither introduced nor a pan-tropical weed
Endangered, threatened or vulnerable species[2]	i.e. Species of restricted distribution or threatened on a local, national or global scale
Economically important species	i.e. SEPASAL[3] species or otherwise valued/used by local people
Species suitable for research	i.e. Species targeted by RBG Kew/collaborator research projects
Seed not widely available	i.e. Seed not already in the bank or available through the List of Seeds or from commercial sources.
Rare seeds[2]	i.e. Often difficult to find high quality or quantity seed of this species in this region

Identifying priority species before a field trip will usually involve a great deal of research. Not only will species have to be prioritised according to the various criteria above but, once selected, information will be needed on localities and phenology. It is essential to know when a species is likely to be in seed, and because of the uncertainties of the weather, this will vary from year to year. This means that herbarium data can only give the collector an estimate of when any particular species is likely to be in seed. Locality information on herbarium sheets may also be out of date. If possible, it is best to make contact with someone local who can provide up to date information on seeding and localities.

RBG Kew's Geographical Information System (GIS) Unit is currently exploring new methods of planning collecting trips, using information from herbarium sheets, digital maps and remote sensing data. It has already had some success in identifying habitats undergoing rapid degradation and which are therefore a priority for seed collecting expeditions (Almond, 2000). Further work will concentrate on using satellite data to provide real time information about phenology as a precursor to seed collecting missions. In addition, research into using environmental data to predict species distributions is ongoing (Sawkins *et al.*, 1999).

Tools and equipment

A checklist of tools and equipment necessary for a typical seed collecting expedition is given in Annex 2. Some key essentials are as follows:

Identification aids: Targeting of species is pointless if the plants can't be recognised in the field. Regardless of whether local expertise is available, floras or identification guides should be taken whenever possible. Where these are not available, photocopies of herbarium sheets make a good substitute. If opportunistic collections are to be made, identification tools will be needed in combination with an up to date seed list, a list of seed bank collections for the

[2] See Annex 5 for guidelines on collecting rare and threatened plants
[3] SEPASAL = Survey of Economic Plants from Arid and Semi-Arid Lands

region, previous expedition reports and a list of SEPASAL species for the region. In this way, duplication can be minimised, and species can be effectively targeted in the field.

Field data forms: Many institutions will prefer to use their own field data forms. If not, an example of the Millennium Seed Bank Project's field data form is reproduced in Annex 3. To accompany this, the collector will need the key to vegetation types. Local maps may also be useful, although use of the Geographical Positioning System (GPS) will, in most cases, make the recording of details about maps unnecessary.

Collecting equipment: Equipment not covered in the checklist will include medical supplies and, depending on the destination, camping gear and extra collecting equipment such as protective clothing, secateurs and loppers.

COLLECTING IN THE FIELD[4]

Plant identification and herbarium vouchers

It is critical to the value of the seed collections that the species is accurately identified, thus collectors are requested to enter comprehensive identification notes on the field data form. If a local expert is not available to identify species, plant identification guides should be used instead. Floras are often incomplete and, in many cases, are more appropriate to herbarium identification. Most useful, where they are available, are local guidebooks with plenty of colour illustrations. Photocopies of herbarium specimens may also be useful for identifying target species. Where opportunistic collecting takes place, the collector will need to refer to the Seed List and an up-to-date list of species collected in the region, in order to limit the risks of duplication.

Quality herbarium specimens are valuable additional outputs of the collecting programme, and collectors are encouraged to take at least three representative herbarium specimens for each seed collection made (see below). Collectors wishing to learn the correct technique should either try to accompany an experienced botanist taking specimens in the field, or should try to attend a training session run as part of this project (see Table 1). Literature available to consult includes Bridson and Forman (1992). In the unlikely event that specimens cannot be taken to accompany a seed collection, RBG Kew is able to prepare a cultivated voucher from most taxa with the exception of large shrubs and trees. For these latter species, and where it is not possible to take herbarium vouchers, verification in the field by an acknowledged named expert will be sufficient for the needs of this project.

Table 1: Notes on good herbarium voucher collection (from Herbarium Techniques Course, RBG Kew).

NOTES

Good voucher specimens should be:
1. carefully selected plant material
2. well preserved
3. accompanied by an unambiguous collection number
4. accompanied by good collection data

1. Careful selection of plant material
Material should be fertile. Material should be representative of:
- population; collect all or range of phenotypes, or collect an average specimen and note range.
- individual - some of top, middle and base if not possible to collect whole plant:
- Underground parts if possible
- Bark/wood
- Heterophylly (e.g. juvenile foliage with stipules)
- Developmental stages (leaf buds, young leaves, flower buds)
- Male and female flowers
- Different flower forms
- Points of attachment, i.e. preserve arrangement of organs
- Loose collections useful. Place in capsule as extra material.

Use discretion regarding the amount of plant material to take – non-destructive sampling. Number of duplicates - 2 minimum; 5 ideal. GOLDEN RULE: Look at and plan sampling of plant before cutting bits off.

[4] See Annex 5 for guidelines on collecting rare and threatened plants.

2. Well preserved
Araceae and fleshy parts in spirit
Palms and Pandanaceae bases of leaves important
Wax papers for delicate tissues
Details of special conditions for collecting and preserving plant parts in different families in Herbarium Handbook

3. Numbering
Good idea to produce book with numbers on it already in which to put your notes. Helps avoid danger of number duplication. Keep simple 1- X

4. Good collection data
Minimum:
- locality, including country
- altitude
- habitat
- description of plant - concentrate on things lost in sampling, e.g. smell, colours, life form, 3 dimensional structures
- collector's name
- collection number
- date of collection

NOTE: use of GPS co-ordinates can be a security risk in the case of endangered species

Additional data:
- name (e.g. vernacular)
- ecology (associated species)
- detailed morphological data (see below)
- frequency of occurrence
- economic data
- conservation status

Morphological data:
- habit/height/spread
- underground parts if not collected
- stems and trunks - buttresses, bark, latex etc.
- stipules
- fresh size, shape, colour of inflorescence, flowers, fruits, seeds

Voucher specimens should bear the same number as the related seed collection, and should ideally include flower, fruiting structure, vegetative parts and roots of annuals. Ideally the specimens should be dried daily using portable driers. Where this is not possible, the specimens should be kept warm and dry and the absorbent paper should be changed frequently. Within the constraints of the expedition and the permits granted, herbarium specimens may also be taken from significant species where no seed is available for collection.

The specimens will be forwarded by the collector, the project co-ordinator or RBG Kew, (as agreed locally), to local specialists, or other specialists recommended by RBG Kew for verification. RBG Kew will provide printed herbarium labels derived from the original field data to attach to the mounted herbarium specimens. Following verification, herbarium vouchers will be lodged in the following order of priority, firstly: the local herbarium responsible for the identification, secondly: RBG Kew Herbarium, thirdly: other local herbaria.

Targeting a population for sampling

Following identification of a target species for collection, the collector must decide whether the population[5] is suitable for sampling. It is often helpful to make a preliminary visit to the site to assess the populations, to confirm the identification, to estimate the likely harvesting date and potential seed production. The most important factors in deciding whether to collect from a population are as follows:

- The population is likely to be genetically distinct (defined, for example, by soil, climate, altitude, pollinator's range, physical barriers to genetic mixing).
- The population has not already been adequately sampled and conserved by the seed bank(s).
- The population is wild, self-sown and not planted or cultivated.
- At least 50 individuals can be sampled randomly and evenly.
- 10,000 to 20,000 seeds can be collected within the time constraints. In practice, these quantities can often be achieved in less than two 'collector-hours'.
- The seed is ripe, i.e. preferably still on the plant, and about to be shed.
- Seeds are not subject to extremely high levels of damage, predation or abortion.

The fulfilment of all of these criteria is an ideal. In practice, small populations (less than 50 individuals) or those that will yield less than 1000 viable seeds may be collected when larger, more productive populations are not easily available. Local criteria such as imminent threat of destruction of a population or particular local interest in a population may also be important.

Sampling strategy

For many potential *users* and *uses* of the collection, it is important to maximise the number of alleles present within the sample, by capturing the greatest proportion of those alleles represented in the field population[6]. According to Brown and Marshall (1995), at least one copy of 95% of the alleles occurring in the population at frequencies of greater than 0.05 can be achieved by sampling from:

- 30 randomly chosen individuals in a fully outbreeding sexual species, or
- 59 randomly chosen individuals in a self-fertilising species.

As the reproductive biology of most target species has not been studied, and as the capture of rarer alleles would require a markedly increased sample size, **collectors are advised to sample from *in excess of 50 individuals*, *from within a single population*, where available.**

This analysis suggests that, with care, a single population seed sample collected in this way would possess the potential for re-establishment at that site and perhaps for establishment at many other sites within the natural range of the species. The probability of successful re-establishment at the original site would be increased by reflecting the *allelic frequencies* present in the population, however this would entail sampling from a much larger number of individuals (200+) than suggested above.

In order to increase the probability of conserving material that can be successfully established elsewhere within the natural range of the species, collectors would need to make additional population samples. Some land managers may wish to pursue this approach in addition to the basic 'single population' sampling.

[5] In this document, 'population' is used to describe any occurrence of a species, delimited by geographical boundaries.

[6] A discussion document is available from Simon Linington if more detail is required on this subject.

In the event that additional information is available, the sampling strategy can be modified accordingly and notes made on the field data form to record the sampling used.

Seed collection

Following identification of a population suitable for sampling, before collecting the seed, the collector should:

- Carefully examine a small, representative sample of seeds using the cut test and (for smaller seeds) a hand lens. This will enable the collector to estimate the frequency of empty or damaged seeds, and confirm that seeds are mature. **Note**: Research shows that fully-formed but slightly under-ripe seed can often be successfully conserved if entire seed-heads and a short length of stem are collected and allowed to ripen in a well-ventilated environment.

If there are enough seeds ready for collecting, the following protocol should be used:

- Collect mature, dry seeds into either cloth or paper bags (the latter well secured with tape). Cloth bags should be tied correctly, i.e. around the neck, not just pulled together.
- Collect entire seed heads of awned or similar species into paper bags.
- Collect fleshy fruits directly into plastic bags, and allow them to aerate. Fleshy fruits can decompose rapidly, and poor storage can lead to mould-infested seed collections.
- In general, seed cleaning should be left to seed bank staff. However, if seeds can be liberated from their fruits quickly and easily, e.g. by shaking the open fruits over a container, please carry this out (time permitting) and make a note on the field data form.
- Sample randomly and evenly from as many plants as possible across the extent of the population, maintaining a record of the number of individuals sampled. This captures the widest possible genetic diversity from the plant population sampled.
- Where the population exhibits a pattern of local variation, it is preferable to use stratified random sampling, sampling separately from each microsite. Stratified random sampling, which keeps ecotypes separate, goes further in ensuring that alleles of particular ecological significance are collected. Brown and Marshall (1995) state that for outcrossing species, at least one copy of 95% of the alleles occurring at a frequency greater than 0.05 can be obtained by sampling from 30 individuals selected randomly. For self-fertilising species, one would need to sample from a minimum of 59 individuals to achieve the same genetic representation.
- As a rule collect no more than 20% of the available seed on the day of collection. This ensures that the population sampled is not endangered by the planned seed collecting. The only exception to this is if a population is going to be destroyed.
- Ideally collect 10,000-20,000 viable seeds. This enables maximum use of the collection, i.e. so that: (i) a part of the collection can be conserved in the country of origin; (ii) sufficient seed is available for initial germination and viability testing; (iii) viability monitoring can be undertaken at the seed bank for many decades and (iv) a substantial sample can be conserved as a long-term safeguard against loss of the wild population, and as a resource for ecological, genetic and botanical study.
- Collections of between 500 and 5000 seeds are welcomed by the MSB, although distribution opportunities will be limited. Collections of less than 500 species are welcomed from species that are either threatened or of restricted distribution. In these cases there will be limits to the quantities available for germination and viability tests.
- Where a population is very small (less than 10 individuals) the harvest from each plant should be kept separate at collection and processing, and this should be indicated on the field data form. This will ensure that the full genetic diversity of particularly vulnerable plant populations can be successfully released at a later date.
- Above all, RECORD WHAT YOU DO.

Data collection

The collection of data associated with the species or populations from which seed is taken is a vital contribution to knowledge about these plants. Habitat information such as rainfall, altitude, slope, landform, aspect, geology, vegetation physiognomy, associated species and soil characteristics have important implications for restoration ecology and amelioration applications. Population characteristics (phenology, number of plants, % of population producing seed, pollination and dispersal mechanisms, predation etc.) are useful data for conservation authorities, and information about the plants themselves (form, height, flower/fruit morphology etc.) is required by taxonomists and systematists.

The Millennium Seed Bank primary data form is reproduced in Annex 3. If collectors prefer instead to use field data forms or formats already in use by their organisation, please ensure that *as a minimum*, the essential data fields indicated by **bold** are completed.

Table 2: the MSBP data fields explained

Date collected	The date of collection is very useful in phenological studies and should always be included.
Collection number	Collection numbers should be consecutive and chronological. Ideally, the same number should be used for seed and voucher. Try to avoid gaps in the number sequence, and if you do have gaps, e.g. through spoilage of a specimen, do not re-use the number; mark it as void in your records.
Collectors	All active participants should be recorded.
Country	No explanation necessary
Province/State	No explanation necessary
Local situation	Directions to the locality, e.g. '211 km from Pretoria on N1 to Pietersburg.' This information helps relocate a population without the use of a GPS.
Latitude/Longitude	Lat/longs are determined with a portable Geographical Positioning System (GPS). RBG Kew usually uses the Garmin 12XL model, but not exclusively. Ideally, the GPS datum WGS84 should be used. If another datum is used, please state which in the box provided. GPS co-ordinates are generally accurate to 10-15 m.
Altitude	An altimeter is more accurate than a GPS. Some more expensive GPS's have a built in pressure altimeter. The Seed Bank database accepts altitude measurements in feet or metres.
Habitat code	A key to vegetation physiognomy relevant to this field is available from the MSBP. Collectors may prefer to use a local or regional physiognomic classification, in which case this field should be left blank.
Habitat and associated species	If an alternative physiognomic classification is being used, it should be inserted here.

	Associated species give important detail to the habitat description.
Modifying factors	Factors which may impact on the species collected. These may be the result of position (e.g. roadside), land use (e.g. browsing, wood cutting) or susceptibility to elements (fire, flooding etc.).
Land form	The level of detail required here is at the collector's discretion. At the very least, a description of local topography should be provided (e.g. flat, undulating, mountainous etc.).
Slope	An estimate in degrees or an indication of steepness (e.g. 30º, slight slope etc.).
Aspect	If a collection is made from a slope, the aspect (i.e. the direction the slope is facing) should be recorded. This information gives an indication of sun, shelter etc. experienced by the plant.
Land use	No explanation necessary. Examples include: pastoral, protected area etc.
Geology	No explanation necessary. This information can be found either in the field or from geological maps.
Soil colour, ***texture*** *and pH*	Soil colour charts (e.g. Munsell) may be used if available. If not, an ocular estimate of soil colour is a useful record. Soil texture (sand/loam/clay) is best estimated by rolling a sample of soil between finger and thumb. Soil pH can only be measured with the use of a pH meter; these are available from the MSBP if required.
Drainage	This information gives an idea of how much water is available to a plant population, and also provides clues as to the origin of the soil, e.g. well drained colluvial soil, poorly drained illuvium etc.
Family, genus, species, infra-specific	No explanation necessary. This is a field identification. Verified herbarium identifications should be detailed in the spaces provided on the back of the form.
Number of voucher duplicates	Two voucher specimens is a minimum; one for the MSBP and one for a herbarium in the country of origin.
Area sampled	No explanation necessary. Area must be given in m^2.
Number of plants sampled	This information, together with the number of plants found, gives an idea of what percentage of the population has been sampled. This is important information in genotypic sampling.
Number of plants found	i.e. an estimate of the size of the population.
% population producing seed	No explanation necessary.
Seed harvesting (early, mid, late season)	No explanation necessary.

Seeds collected from (plants, ground, both)	No explanation necessary.
State of seeds (moist, dry, both, other)	No explanation necessary.
*Herbarium data, including **plant height***	See Table 1 above.
Ethnobotanical data	If vernacular names are provided, the language should always be noted.

Care of collections in the field

In general, **the seed collections should be kept in a cool, dry place** prior to dispatch to the seed bank but they should not be frozen. Care should be taken that seed collections do not overheat, for example by being left in a vehicle in full sun. Exposure to such sustained high temperatures can badly damage the seed collections. Attempts should be made to maintain ventilation around the collections at all times and the collecting vehicle should be parked in the shade, or at the very least, the windscreen shaded.

Damp collections should, as soon as possible, be spread out on newspaper to dry naturally, either outside in the shade or in a well ventilated room, before dispatching material to RBG Kew.

In a few cases where, for example, seeds have been collected fully mature within dry, bulky fruits or capsules, it may be relatively straight-forward and rapid to carefully open the fruits and to separate the seed by hand ready for shipping. In most cases, it is best to leave the task of cleaning the collections to RBG Kew or national seed bank processing staff who have the full range of facilities necessary to carry out this task.

Fleshy fruits may require careful handling, partial cleaning and rapid dispatch to the seed bank: contact either RBG Kew or the appropriate International Co-ordinator as soon as possible for advice.

SHIPPING SEED COLLECTIONS TO KEW

In general, **it is critical to the successful conservation of the seed that it is dispatched to the seed bank as soon as possible after collection**, together with the completed field data forms, by air freight. Voucher photos, and herbarium specimens may be forwarded to the appropriate authority at a later date, and any other additional information may be sent to RBG Kew, or to the project co-ordinator quoting the collector's name and the number given to the seed collection

Seed bags should be clearly labelled (inside and out) and then securely packaged for shipping to RBG Kew. The following packaging is recommended, either:

- Canvas or thick cotton sealable sack
- Woven PVC or nylon airfreight sack
- Sturdy cardboard box (secured with string to permit customs inspection and resealing) into which cotton (not paper) seed bags have been placed,

The following packaging is NOT recommended:

- Any non-breathable bags or containers made from plastic or PVC-backed fabric

The following procedure is recommended for packing a seed shipment:

- Pack seeds at the last minute before shipping
- Record details about each collection and the number of bags being packed into the box. Keep a copy of this information, and put the original in the box.
- Use polystyrene (styrofoam) or other suitable materials to fill any voids in the boxes
- Fill in the air waybill for each batch being shipped, and keep a copy (see Annex 4)
- Seal the boxes and attach address and customs labels
- Measure and weigh boxes
- Phone the Air Freight company

RBG Kew has an account with DHL for the sole purpose of express shipping seed collections and appropriate field data to Kew for processing. In the event that DHL do not serve your area, please contact either Kew or the project co-ordinator to agree an alternative arrangement.

Pre-printed DHL air waybills are available from the MSBP. An example of a correctly filled out DHL air waybill is given in Annex 4.

Annex 1: Species covered by UK phytosanitary regulations

SEEDS FROM NON-EU COUNTRIES WHICH ARE CLASSED AS 'QUARANTINE' MATERIAL

Origin – all third countries

Solanum – true seed of potato)	**Both these species are**
Vitis)	**totally prohibited**
Allium cepa	
Allium porrum	
Allium schoenoprasum	**All of these**
Beta vulgaris	
Capsicum	**species require a**
Helianthus annuus	
Lycopersicon lycopersicum	**phytosanitary**
Medicago sativa	
Oryza	**certificate**
Phaseolus	
Prunus	
Rubus	
Zea mays	

Origin- Argentina, Australia, Bolivia, Chile, New Zealand and Uruquay

Cruciferae)	**These species**
Gramineae)	**all require a**
Trifolium)	**phytosanitary certificate**

For a complete list of restricted species, which includes fruits and plant material please see 'The Plant Health Guide for Importers'. The following fruits require a phytosanitary certificate when imported into the U.K. from the countries shown:

FRUITS FROM NON-EU COUNTRIES WHICH REQUIRE A PHYTOSANITARY CERTIFICATE

Annona)	
Cydonia)	
Diospyros)	**All**
Malus)	
Mangifera)	
Passiflora)	**non-European**
Prunus)	
Psidium)	
Pyrus)	**countries**
Ribes)	
Syzygium)	
Vaccinum)	

FRUITS WHICH REQUIRE A PHYTOSANITARY CERTIFICATE FOR IMPORT INTO THE U.K.

Citrus and hybrids (must be free from leaves and peduncles))	**All**
Fortunella and hybrids (must be free from leaves and peduncles))	**third**
Poncirus and hybrids (must be free from leaves and peduncles))	**countries**

Annex 2: Checklist of tools and equipment for seed collecting

Expedition to: **Dates of visit:**

RBG Kew collector(s):

Collaborating institute:

Contact name and fax no.:

Collecting permit:

Documents

Visa(s)		Copy of convenio	
Letter of invitation from collaborators		Primary data forms	
Letter of introduction from RBG Kew		List of SEPASAL species for region	
Seed collecting instructions		List of seed bank collections for region	
Key to vegetation types		Previous expedition reports	
Current seed list		Flora/identification guides	
Customs letter for import of seed into UK		Maps where available	
Customs letter for temporary export of equipment		International Driving Permit	
CITES regulations		Vaccination certificate	

Seed collecting equipment

		Quantity Suggested	**Quantity supplied**
Herbarium press & straps		2	
Flimsies		50	
Blotters		20	
Cloth bags	-sack	5	
	-large	20	
	-medium	20	
	-small	10	
Paper bags	-large	20	
	-medium	10	
Cardboard envelopes		15	
Polythene bags	-large	5	
	-small	5	
Numbering tags		300	
Altimeter		1	
GPS		1	
Secateurs		1 pr	
Gloves		1 pr	

Other equipment from store

Date equipment supplied: Date returned:

Annex 3: MSB COLLECTION DATA FORM (Bold type= Obligatory Fields) Serial Number

Date Collected **Collection no**

Collector(s)

SITE DATA

Country

Province/State

Local Situation

Latitude **GPS used (YES/NO)** **If no, see over.**

Longitude

Altitude GPS Datum WGS84 or

HABITAT DATA

Habitat Code

Habitat and

Assoc. Species

Modifying Factors

Land Form

Land Use Slope°

Geology Aspect

Soil Colour Soil pH

Soil Texture **Drainage**

COLLECTION DATA - If collection has been verified, please see over.

Family

Genus

Species

Infra-specific

No. of Voucher Duplicates **Area sampled (m^2)**

No.of Plants Sampled % population producing seed

No. of Plants Found

Seed Harvesting (*early, mid, late season*) Please circle. Seeds Collected from (*plants, ground, both*)

State of seeds (*moist, dry, both, other*)

HERBARIUM DATA

Plant Habit *Tree Shrub Liana Erect herb Creeping herb Climbing herb* **Plant Height (m)**

Other descriptors

ETHNOBOTANICAL DATA

Vernacular name Language

Use - *please circle*. Food Food Additive Animal Food Bee Plant Invertebrate food

Materials Fuel Social Use Vertebrate Poison Non-Vertebrate Poison

Medicine Environmental Use Gene Source

If GPS not used, please state method	
Map Publisher	
Series	
Scale	
Co-ordinates	
Date	

If collection has been verified please complete sections below:

Material verified	
Verified by	
Institute	
Date	

Annex 4: DHL air waybill

ANNEX 5: COLLECTING SEED FROM RARE AND THREATENED PLANT SPECIES

When collecting rare and threatened species, the collector needs to think about a number of factors before going into the field. To start with, it is necessary to think about what seed samples will be used for. If seed is to be used only for research, only a few seeds may be needed compared to, for example, the numbers of seed needed for reintroduction and establishment of a self-sustaining population. The collector also needs to think about potential seed losses due to mortality during experimentation, reintroduction or establishment, and compensate for anticipated losses during collecting.

Once in the field the collector needs to consider a number of other factors:

1) For developing germination and propagation protocols, or to examine seed behaviour, use existing ex situ material if available. If wild populations must be sampled, begin with small collections from the largest and most secure populations. For developing reintroduction protocols, make the smallest collections possible to address the management questions being posed in experimental reintroduction.

2) To increase the probability of successful, self-sustaining populations of threatened plant species, collect from as large and diverse an array of founders as is prudent. If possible, collect and maintain separately seeds from each maternal line.

3) Where possible, spread the collection out over two or more years, especially for small populations.

4) For species with 50 or fewer populations, collect from as many populations as possible. For species with more than 50 populations, collect from as many as possible up to 50. For populations with 50 or fewer individuals, collect from all known individuals; for populations with more than 50 individuals, collect from 50.

5) For populations of species with extremely low overall numbers, particularly those (a) that have 10 or fewer reproductive individuals and a poor history of recruitment, or (b) are known to be in rapid decline, collection of seed should be made at the discretion of the licensed collector. The decision about how much to collect should be based on as much information as possible, including species autecology, nature of threat, ex situ conservation facilities and knowledge base available etc.

6) Record as much additional information about the population as possible, including:

- Total number of plants
- Number of juvenile plants
- Number of adult plants
- Number of dead plants
- % of plants flowering/fruiting in the last season
- Seed production (per fruit and per individual)
- Threats to habitat
- Threats to species

7) Avoid destructive sampling. Consider carefully whether herbarium vouchers are essential to the naming and classification of the plant sampled. Do not take herbarium samples if it will reduce the population's capacity for survival – take photos and detailed notes instead.

References

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Department of Environment and Conservation

Flora, Fauna and Ecological Community Data Searches

DEC's Species and Communities Branch provides a service (free to DEC staff and not-for-profit organisations) that allows you to find out if there are any Threatened Fauna, Declared Rare Flora (DRF) or Threatened Ecological Communities (TEC's) at a particular location you are working at or planning to visit. The service also covers Priority Flora and Fauna species and some Priority Ecological Communities.

Search requests

E-mail or fax your request to the relevant contact shown below. Include the contact details of a relevant person so we can quickly clarify any problems. You will be provided with the information and sent an invoice, which will show details on how to pay.

Please include a brief locality description of the area in your request in order for us to confirm that the coordinates are accurate. You will also need to state why you need the information and how you will be using the information.

Cost

Fauna searches: $150 + GST (if additional search areas are requested at the same time they are charged at a rate of $50 each (plus GST).

Flora searches*: Standard search $200 + GST (hard copy sent in the post).

Standard search emailed $300 + GST. (excel table, word document)

GIS search $300 + GST (Arcview shapefile).

Any additional search requested at the same time incurs an additional $50 + GST

Ecological Community searches: Standard search $100 + GST (if additional searches are requested at the same time they are charged at a rate of $50 each (plus GST)).

GIS Search $200 + GST (hard copy and shapefile)

Search results can be emailed, presented in an excel file or printed and posted as hard copies. **Please specify the format in which you would prefer the data supplied – the default format is hard copy posted.**

Spatial area

In order to conduct a search of the DEC databases, you will need to provide your request in one of the following formats. A polygon location must be provided for Ecological Communities:

Point Location (see Figure 1) – Provide the **latitude and longitude** of a position central to the area of interest. We will then conduct a search within a radius appropriate to the location and provide you with a report. The radius of the area will vary depending on the location. For example, there are far more records in the south-west of the state than the arid interior and therefore a radius of 5 km may be satisfactory to encompass a representative range of records in the south west but this may need to be expanded to a 50 km radius where records are fewer.

Polygon Location (see Figure 1) – Provide the **latitude and longitude** (in degrees latitude and longitude) of the upper left and lower right corners of a polygon that defines the area of interest. A buffer may be created around the polygon if it only defines the area of interest, or if the buffer provided is not considered adequate to determine potential flora or fauna in the area.

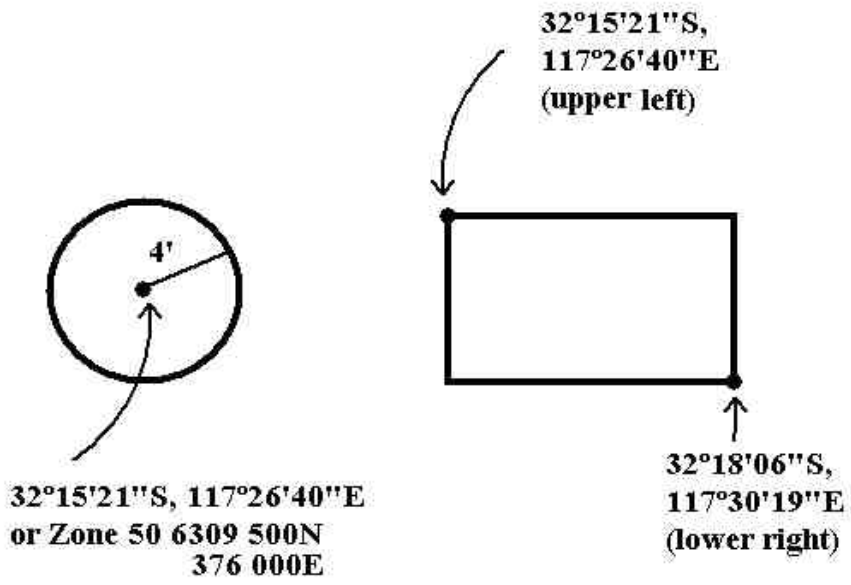


Figure 1 Example of point and polygon locations.

MGA co-ordinates - you can provide the location details in MGA co-ordinates, but please remember to indicate the Map Zone (i.e. 49, 50, 51 or 52) and ensure that the co-ordinates have the correct number of digits in the northings (7 digits) and eastings (6 digits). **Note, this co-ordinate system is not acceptable for Flora search requests.**

ArcView Shapefile – Provide the area of interest in the form of a shapefile ensuring all the extensions that makeup a shapefile are included.

Time frame:

Up to ten (10) working days, depending on staff availability. Please ensure that you keep this in mind when submitting your request for a search.

Additional information

The searches cover the immediate area of interest and include a buffer to show what other flora or fauna of interest may be in the area.

The interpretation of such results should take into account the variations in surveys undertaken in various areas, and the lack of data may be more a reflection of the lack of survey, rather than the lack of threatened fauna and flora occurring in the area. The information supplied should be regarded as an indication only of the threatened fauna and flora that may be present and may be used as a target list in any surveys undertaken. Thus, the data provided should be regarded as a first step, and should be used to assist in planning any survey work.

***Flora searches**

The information provided is collated from the following three databases:

1. The Threatened Flora Database (DEFL) - data consists of validated populations of declared rare flora and some Priority flora (mainly in the south west areas). Data is given as centroid geopoints, with the ability to provide specific information on request where sites are within an area of specific interest.

2. The WA Herbarium (WAHERB) - data is of herbarium specimens collected in the area, and includes un-validated historical specimens, which gives an indication of potential flora, plus reasonable coverage of the Priority flora. Please note: the development of the PERTH Herbarium and its database was not originally intended for electronic mapping (eg. GIS ArcView). The latitude and longitude coordinates for each entry are not verified prior to being data based. It is only in recent times that collections have been submitted to PERTH with GPS recorded latitude and longitude coordinates. Therefore, be aware when using this data in ArcView that some records may not plot to the locality description given with each collection.

3. The Declared Rare Flora and Priority Flora Database (Access database) - a species list and general distribution of flora within the general area of interest.

Summary

In summary, the information required to conduct a search is:

1. Who - Your name/company/university and contact details.
2. What - format you would like the data in (hard copy or electronic).
3. How - you plan to use the data (for what purpose).
4. Where - what area would you like searched – please provide central coordinates, opposite corners of a rectangle encompassing the area of interest, MGA co-ordinates (**except for flora searches**) or an Arcview shapefile.

Contacts

Fauna Kellie Mantle – kellie.mantle@dec.wa.gov.au

Flora Bridgitte Long – bridgitte.long@dec.wa.gov.au

Both Kellie and Bridgitte can be contacted at the DEC's Species and Communities Branch Phone 9334 0455, Fax 9334 0278

Ecological Communities Monica Batista – monica.batista@dec.wa.gov.au

Phone Monica 9334 0116, Fax 9334 0300

Although we can often complete search requests sooner, **please allow 10 working days**.

	DECLARED RARE FLORA		PRIORITY CODES				TOTAL NO. OF TAXA
REGION	R	X	1	2	3	4	
Kimberley	4	0	51	43	35	5	138
Pilbara	2	0	41	34	55	7	139
Goldfields	15	0	90	41	65	20	231
Midwest	114	1	194	171	239	74	793
Swan	58	0	42	54	84	77	315
South West	46	1	23	33	66	49	218
Warren	21	0	15	47	51	37	171
Wheatbelt	116	4	120	140	178	85	643
South Coast	93	5	112	196	188	141	735
Unknown		3	2	-	-	-	5
STATE*	378	14	615	634	654	331	2626

* species may occur in more than one DEC Region.

KA: PRIORITY

Department of Environment and Conservation

RARE FLORA REPORT FORM

TAXON: _____ **DEFL POPULATION No.:** _____

DRF ❒ Priority Species: P____ Partial Survey ❒ Full Survey ❒ New Population ❒

FROM: _____ **TITLE**: _____ **SURVEY DATE:** _____/_____/_____

REGION: _____ **DISTRICT:** _____ **SHIRE:** _____

LOCATION: _____

_____

_____**Reserve No**: _____

LATITUDE: _____°_____′_____″ S **LONGITUDE:** _____°_____′_____″ E **Map Used:** _____

GPS DATUM: AGD84 ❒ GDA94 ❒ GDA94-Compatible (e.g. WGS84) ❒ Unknown ❒ None ❒

LAND STATUS: Nature Reserve ❒ Private ❒ Gravel Res. MRD ❒ Rail Reserve ❒
National Park ❒ Pastoral Lease ❒ Gravel Res. Shire ❒ Rd. Verge Shire ❒
State Forest ❒ UCL ❒ Other Shire Res. ❒ Rd. Verge MRD ❒
Water Reserve ❒ Other ❒ Specify: _____ SLK _____ to _____
Landowner/manager present during inspection: ❒

LANDFORM: Hilltop ❒ Cliff ❒ Slope ❒ Valley ❒ Swamp ❒
Outcrop ❒ Breakaway ❒ Low Plain ❒ Gully ❒ Riverbank ❒
Ridge ❒ Sand Dune ❒ Flat ❒ Drainageline ❒ Lake Edge ❒
Firebreak ❒ Other ❒ Specify: _____

ROCK TYPE: Laterite ❒ Granite ❒ Dolerite ❒ Limestone ❒ Other:_____

ROCK FORM: Sheet ❒ Boulder ❒ Fluviatile Gravel ❒ Concretionary Gravel ❒

SOIL TYPE: Sand ❒ Loam ❒ Clay ❒ Peat ❒ Gravel ❒

SOIL COLOUR: Red ❒ Brown ❒ Yellow ❒ White ❒ Grey ❒

SOIL CONDITION: Moist ❒ Inundated ❒ Dry ❒ Saline ❒ Other: _____

VEGETATION CLASSIFICATION (Muir's): _____

ASSOCIATED SPECIES:_____

_____

_____

No. of PLANTS: Mature: _____ Seedlings: _____ Dead**:** _____ Actual ❒ Estimate ❒ Area Occupied: _____
(Leave blank if unable to observe, or no attempt made to count plants)

REPRODUCTIVE STATE: Clonal ❒ Flower bud ❒ Flower ❒ Immat. fruit ❒ Fruit ❒ Old Fruit ❒ Vegetative ❒

POLLINATORS: Native bees ❒ Honey bees ❒ Other insects ❒ Birds ❒ Mammals ❒
Other observations: _____

CONDITION OF POPULATION: Healthy ❒ Moderate ❒ Poor ❒ Disturbed ❒ Comment:

_____

_____

_____

POTENTIAL THREATS: Firebreaks ❒ Mining ❒ Recreation ❒ Roadworks ❒ Grazing ❒ Weeds ❒
Salinity ❒ Disease ❒ Prescribed Burning ❒ Other ❒ Comment:_____

FIRE HISTORY: Not known ❒ Burnt in 19____ Summer ❒ Autumn ❒ Winter ❒ Spring ❒

FENCING: Not Required ❒ Fenced ❒ Required ❒ Replace/Repair ❒

ROADSIDE MARKERS: Not Required ❒ Present ❒ Required ❒ Replace ❒ Reposition ❒

OTHER COMMENTS (include action taken/required):_____

_____

_____

_____

_____

VOUCHER SPECIMEN: Regional Herb. ❒ District Herb. ❒ WA Herb. ❒ Other ❒

_____

ATTACHED: Map ❒ Mudmap ❒ Illustration ❒ Photo ❒ Field Notes ❒

COPY SENT TO: Regional Office ❒ District Office ❒ Other ❒ Specify: _____

Signed: _____ Date: _____/_____/200____

NOTE: Map or further information may be attached or given on the back of this form.

Please return completed form to Director General, DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: PLEASE FORWARD TO ADMINISTRATIVE OFFICER, FLORA, SPECIES AND COMMUNITIES BRANCH

THREATENED FLORA IN W.A.

TRAINING NOTES

Prepared by Dr K Atkins
Species and Communities Branch
Department of Environment and Conservation
Locked Bag 104
BENTLEY DELIVERY CENTRE WA 6983

21 December 2006

Western Australian Flora

Western Australia has a rich flora, with some 12,500 vascular plant species, about 10,000 of which are formally named. This is about half of the total Australian flora. Some areas are particularly rich, for example, over 800 species are known from the Lesueur area near Jurien Bay, over 1,200 from the Stirling Range National Park, and about 1,400 species from the Fitzgerald River National Park. These three areas are the most species rich, and represent over a quarter of the flora of Western Australia.

On an international scale, by comparison the flora of Western Australia is ten times the total British vascular flora of 1200, and represents some 4.8% of the estimated world vascular flora of 250,000 species.

The Western Australian flora is also unique, with the majority of species being endemic, that is, found nowhere else in the world. 79% of the 6,000 species in the south-west, for example, are endemic to Western Australia.

Part of the reason for the high level of species diversity and uniqueness, especially in the south west agricultural region, is because this landform is extremely old, and has largely weathered in-situ. This has meant that the soils and habitats in the region tend to be a mosaic, and the flora in them have evolved in isolation over a very long time period. The result is a complex series of different evolutionary paths across the landscape.

Threatened Flora

Western Australia also has a large number of plant species that are threatened, or potentially threatened, with becoming extinct. A third of Australia's total of threatened plant species are from Western Australia, while the proportion rises to 46% if rare and poorly known species are included.

There are many reasons for the occurrence of threatened flora. These may relate to natural or evolutionary factors, or to artificial influences resulting from human activity.

Species that are very rare may be threatened as a consequence of their low numbers, that is, they may become extinct through the chance loss of some individuals. Species may be naturally rare because they are dependant on specific, limited habitats, or because they are part of an evolutionary process: either newly evolving species (it is estimated that 40% of W.A.'s flora has evolved from hybridisation), or species that are naturally declining through changed environmental conditions (e.g. relict Gondwanan flora).

The clearing or degrading of bushland is a major threatening process - referred to as habitat loss. Not only does this threaten existing populations, but it also limits the opportunities for the establishment or expansion of populations. Degradation processes include grazing, fertilizer and herbicide drift, weed competition, inappropriate fire regimes and the introduction of pests and diseases. One of the most significant threats to species and habitats is *Phytophthora* dieback.

Given the great species and habitat diversity of the southwest agricultural region, it is not surprising to find that many of the threatened species in this State are from this region. This can be seen from the table of comparison of threatened, poorly known and rare species between DEC regions (Attachment 1), whereby the Midwest, Wheatbelt and South Coast Regions account for nearly three quarters of the species. The State map of the distribution of the threatened flora (Attachment 2) shows that the concentration of populations is in the agricultural regions of the wheatbelt and the western coastal plain - both extensively cleared landscapes.

Roadside Vegetation

Uncleared roadverges represent tracts across the landscape of the original vegetation. In areas that have been extensively cleared, as in the wheatbelt, these vegetation strips represent significant areas of remnant vegetation. More importantly they contain a random selection of vegetation types, whereas remnants on adjoining lands tend to be more selective, with specific vegetation types associated with arable soils in particular being poorly conserved.

Road verges hence have a proportionately higher number of restricted habitats and rare species of flora. The narrowness of many of these road reserves, coupled with the road maintenance activities to which they are subjected also means that many of these rare species are also threatened.

A quarter of threatened flora populations in Western Australia are found on road verges, with over three quarters of these being along roads managed by local authorities, the remainder being along main roads. Population sizes along the local authority-managed roads tend to be several-fold smaller than those found on other land tenures, including main roads, which demonstrates the difficult task in managing rare flora on these roadsides, where a large number of small populations are involved.

Declared Rare Flora

Existing legislation uses the term "rare flora". It is necessary to continue to use the term "declared rare flora" when quoting the legislation until it is changed, but the term is used for species that are threatened, rather than just rare in numbers. DEC Policy Statement No 9 (Conservation of Threatened Flora in the Wild) lists the policies and strategies for the management of declared rare flora.

Legislation

Rare flora is defined in subsection 23F(1) of the Wildlife Conservation Act as "flora for the time being declared to be rare flora for the purposes of this section." Further clarification is provided in subsection 23F(2):

> "Where the Minister is of opinion that any class or description of protected flora is likely to become extinct or is rare or otherwise in need of special protection, he may, by notice published in the Government Gazette declare that class or description of flora to be rare flora for the purposes of this section throughout the State".

The Schedule of Declared Rare Flora

The Schedule (list) of Declared Rare Flora is reviewed annually.

Plants which are protected flora declared under the Wildlife Conservation Act may be recommended for gazettal as declared rare flora if they satisfy the following criteria:

i) The taxon (species, subspecies, variety) is well-defined, readily identified and represented by a voucher specimen in a State or National Herbarium. It need not necessarily be formally described under conventions in the International Code of Botanical Nomenclature, but such a description is preferred and should be undertaken as soon as possible after listing on the schedule.

ii) Have been searched for thoroughly in the wild by competent botanists during the past five years in most likely habitats, according to guidelines approved by the Director General of DEC.

iii) Searches have established that the plant in the wild is either:

a) rare;

or

b) in danger of extinction (including presumed extinct);

or

c) deemed to be threatened and in need of special protection.

(Plants which occur on land reserved for nature conservation may be considered less in need of special protection than those on land designated for other purposes).

or

d) presumed extinct.

iv) In the case of hybrids, or suspected hybrids, the following criteria must also be satisfied:

a) they must be a distinct entity, that is, the progeny are consistent within the agreed taxonomic limits for that taxon group;

b) they must be [capable of being] self perpetuating, that is, not reliant on the parent stock for replacement; and

c) they are the product of a natural event, that is, both parents are naturally occurring and cross fertilisation was by natural means.

That status of a rare plant in cultivation has no bearing on this matter. The legislation refers only to the status of plants in the wild.

Plants may also be deleted from the schedule of declared rare flora.

There are currently 378 extant, plus 14 presumed extinct, taxa of declared rare flora as listed in the 2006 schedule. Taxa are managed at infraspecific levels, ie at subspecies or variety level.

"Taking" Declared Rare Flora

In the Wildlife Conservation Act (subsection 6(1)) the following definition is given:

> ""to take" in relation to any flora includes to gather, pluck, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means;"

Thus, taking declared rare flora would include not only direct injury or destruction by human hand or machine but such activities as allowing stock to graze on the flora, introducing pathogens that attack it, altering soil moisture or its inundation regime, allowing air pollutants to harm foliage etc.

In the case of declared rare plants which need fire or disturbance for regeneration, burning or disturbance at an appropriate time may not adversely affect the survival of the population. However, if existing plants would be injured, it constitutes "taking" under the Act. Therefore, Ministerial approval is required prior to causing a disturbance which affects any species of rare flora.

The Department of Environment and Conservation has statutory responsibilities for rare flora conservation. This is a major commitment because:

i) Western Australia has a flora that is exceptionally rich in localised and rare endemic plant species. Moreover, areas where rare species are concentrated coincide predominantly with the wheatbelt and other areas where there has been extensive clearing or modification of the native flora.

ii) Section 23F of the Wildlife Conservation Act prohibits the taking (injury or destruction) of declared rare flora by any person on any land throughout the State without the consent in writing of the Minister. A breach of this provision may lead to a fine of up to $10,000. The flora provision of the Act are binding on the Crown.

iii) The Act prescribes that declared rare flora be protected on all categories of land throughout the State.

Priority Flora

In addition to the schedule of DRF, DEC maintains a supplementary listing referred to as the Priority Flora List. This lists those flora which may be rare or threatened but for which there is insufficient survey data available to accurately determine their true status, and those taxa which have been determined as being rare, but are currently not threatened. 2,234 taxa were listed as priority flora in December 2006.

The Priority Flora are ordered according to the perceived urgency for further survey.

The Priority List assigns top priority for survey to those plants whose known populations are few and on land under threat (Priority 1). Second are taxa with few populations known, and which occur on lands considered secure for conservation (eg. nature reserves, national parks, water reserves - Priority 2). Priority 3 taxa have several known populations, some of which occur on secure conservation lands, or the taxa is deemed to be not under immediate threat. And lastly, taxa that have been adequately surveyed and found to be secure but require monitoring to check that their conservation status doesn't change are assigned Priority 4. Full definitions are provided in Attachment 3.

Priority Flora do not have the same level of protection as Declared Rare Flora, but should be managed in a similar manner until their status has been confirmed as being not rare or threatened.

The Need to Conserve Rare Flora

Western Australia's rare flora needs to be conserved for many reasons under the broad headings of ultruism, aesthetics and economics.

Altruistically we should conserve all species of flora because they are discrete entities and deserve to persist. Such an argument, however, depends solely on the beliefs of the individual.

From an aesthetical point of view, species conservation means that the public is able to keep seeing the species, and enjoying the sight in itself, and the total landscape effect. Again beauty is in the eye of the beholder.

In an economical sense, rare flora represent a largely untouched resource with unknown potential. The value of most of our species of rare flora (and more common species) for drugs and medicines, foods, genetic additives, horticultural species etc is unknown. This resource should therefore be maintained for its future potential.

Species abundance changes through time. Rare species may either be declining towards extinction, or they may be in early developmental stages and could eventually become relatively common as climatic changes occur. Thus the rare flora of today may be essential elements of future vegetation structures.

Such vegetation - climatic changes normally occur over extended periods, measured in geological time. With current unnatural global climatic changes being predicted, however, such vegetation changes will need to occur at a rate faster than can be naturally accommodated by speciation. Thus there will be a selection pressure on existing species to maintain vegetation compositions. Rare species will have as much chance of being able to persist under new climatic regimes as more common species. It is therefore imperative in areas of remnant vegetation such as in the wheatbelt, and along isolated road reserves, that options for future vegetation development be maintained by retaining the current diversity of species.

Wildlife Management Programs

DEC's Policy Statement No 44 deals with Wildlife Management Programs. Such Programs are prepared for the management of individual species or groups of species. For threatened flora management, two types of Wildlife Management Programs have been prepared:

DEC Region or District summary status programs which document the current population status of the species in an area, and recommend management and research actions. These have been prepared for all Regions and Districts in the South West Land Division; and

Species Recovery Plans (and Interim Wildlife Management Guidelines or Interim Recovery Plans) which document the current knowledge for a species and provide detailed strategies for the management or recovery of the species. Full Recovery Plans have also been prepared for selected taxa, ie *Acacia anomala*, *Banksia cuneata*, *Eucalyptus rhodantha* and *Stylidium coroniforme*.

Threatened flora are ranked into the categories Critically Endangered, Endangered and Vulnerable (refer to DEC's Policy Statement No 50 - Setting Priorities for the Conservation of Western Australia's Threatened Flora and Fauna), depending on the degree of threat to the taxon, and hence the urgency for management action. Interim Recovery Plans are prepared within one year of ranking for all taxa listed as Critically Endangered.

Management Strategies

Many remnants are on lands set aside for purposes other than flora conservation. Flora conservation can thus be a potential inhibition to the normal operation of that land, whether it be a road reserve, farmland, urban area or other land purpose. Good planning and land management can however achieve flora conservation without inhibiting the other uses, and at the same time provide soil conservation, aesthetics and other valuable benefits. Current Main Roads practices are a good example of this.

Rare flora management on road verges presents some specific problems. These problems are related to the purpose to which these reserves are set aside, and to the constraints presented by their size and shape. Such management constraints are also found with many other vegetation remnants.

The shape and size of many remnants results in an insidious, but equally threatening, impact on the flora as does inappropriate landuse practices. Weeds, fertilizer, herbicides, feral animals and fire are some of the major influences on remnants, over which the land manager may have limited control.

Again the use of appropriate procedures to deal with incursions or reduce the incidence of incursions from adjoining lands will reduce their impact.

Weeds and feral animals are perhaps the more difficult management problems in terms of preventing incursions and treating areas after colonization has occurred. Methods are being developed for managing these problems, but there is still a long way to go in developing management techniques that are sensitive to the environment that is being protected.

Some management notes are:

Grazing - fence areas off.

Fire - ensure fire frequency and seasonality is ecologically based, that is, is not too frequent to promote exotic weeds, and allows the native plants to set seed etc. Areas of native bush do not need to be regularly 'cleaned up'.

Rabbits - use of explosives to destroy warrens without damaging the vegetation.

Weeds - minimise disturbance (including fire) and fertilizer drift to reduce weed growth. Use of selective herbicides that do not affect the native flora. Careful use of sprays when treating encroaching weeds such that the native vegetation and rare flora is not affected.

Accidental destruction - mark areas, especially where works are undertaken, e.g. roadsides or firebreaks. Rationalise, and block off, access tracks.

Exposure - maintain a healthy area of bush, especially around the rare flora, to provide protection and ensure a continuation of the remnant.

Fungal pathogens (dieback) - restrict access, promote hygiene.

One specific aspect of threatened flora conservation and recovery is the collection and storage of propagating material, the propagation of such material, and the establishment of new populations in the wild, or enhancement of existing populations. This is addressed in DEC's Policy Statement No 29 - Translocation Threatened Flora and Fauna. DEC collaborates with Botanic Gardens and Parks Authority in this area. Research is being undertaken into storage techniques (including cryostorage), and methods of propagating some of the species.

Management strategies being undertaken by DEC also include the searching for, documentation and monitoring of rare flora populations; the maintenance of a rare flora database; land acquisition; and research into the biology, ecology and management of rare flora.

Confidentiality

The precise location of rare flora populations is kept confidential. This is designed to protect the plants from illicit taking, and from damage either to the plants or the habitat by people wishing to view them. Rare flora locations on private property especially are treated confidentially to safeguard the rights of the property owner who might otherwise be subject to enquires from interested individuals.

Locations of rare flora are provided where this is deemed to be in the better interests of the plants. Thus, for example, land owners/managers, mining tenements holders, local authorities etc. are informed of rare flora populations on, or adjacent, to their operations. Requests for rare flora locality data should be directed to DEC so that the reason can be vetted, and a record kept of such requests.

POPULATION MONITORING

Rare Flora Report Forms

DEC has a standard report form (RFRF) used to record flora population details (Attachment 4). This form is in four main sections: location, habitat, biology and management/administration. The standard form is used to facilitate the computerisation of the data, and also allows the observer to omit re-recording data previously gathered.

Certain information in the form is regarded as essential to be filled in, while other information may be omitted if the observer does not have the time, or if the information has been previously recorded and no change is evident. For example, information that may be omitted includes site and habitat details where previously recorded. Essential information includes location details (for identifying the population being monitored), the condition of the population and any threats observed. Population size counts should also be included, but if time does not allow this, then a report on only the condition and threats is preferable to no report at all.

Information from the RFRF's is entered into DEC's threatened flora database. This database can then be used for determining what threatened flora populations occur in an area, whether it be a grid square, a shire or a DEC District. Data manipulations based on location, habitat, biology or management considerations can also be undertaken for research or management purposes.

What Constitutes a Population?

A population is a discrete group of interbreeding individuals of a species. In the current situation of fragmented vegetation remnants, it is difficult to say what groups of individuals were once interconnected as a population, and which were not.

For the purpose of rare flora management and monitoring, populations are defined as management units of closely associated plants. It is largely up to the observer whether another group of plants nearby are also in the population, are a subpopulation, or are a separate population.

Each population or subpopulation should have a separate RFRF filled in. It should thus be considered when deciding on populations whether it is warranted filling in a separate form, and whether the populations would be distinguishable on a larger scale plan, or in the database by their latitudes and longitudes.

Where populations extend over different land purposes they are divided into subpopulations to allow interpretation of rare flora data on a landuse basis. For example, a single population extending from a road reserve into adjacent private property or a national park will be separated into subpopulations to record the occurrence on these different land management areas, and hence this will provide a clearer picture of the conservation status of this population.

Methods of Counting Plants

Where few plants are present, the individuals should be counted. As the number of plants increases, the ease of counting depends on the size/distinctiveness of the plants, the nature of the terrain, and the density of the associated vegetation. Once all individuals cannot be counted, an estimate needs to be taken.

Estimates can be done by several means, but the most reliable is to delineate the area covered by the population (in m^2) and then record the plant density. The product of these will then give the estimate of population size. Plant density can be calculated by traversing the population and estimating the number of plants per unit area, or by counting the number of plants in a selection of set areas and then multiplying the average of these to give the total population estimate.

Population Location

Locations should be described in relation to known features, such as towns, roads, named hills, named lakes etc. (e.g. 3.5km SW of Moora, and 250m east along Smith Road from the intersection with Brown Road). Vehicle trip meters should be used to calculate distances from these features where roads exist. Estimates should be as accurate as possible, and preferrably have the site referenced to a local marker to assist rediscovery (e.g. near the corner fence post, or adjacent to rock outcrop). Where a population is found along a road, the individuals or clumps may be recorded as trip meter readings from a given point (e.g. a road intersection) and appended to the report form.

Population location information needs to be detailed enough to not only allow relocation, but to permit the determination of land ownership or vesting. This is essential for management purposes, as the land manager needs to be informed of the presence of rare flora if it is to be protected and managed.

Populations should be marked on maps, and the latitude and longitude (map grid reference) calculated. Latitudes are found on the sides of the map, and give the values south of the equator. Longitudes are found on the top and bottom of the map, and give the values east of the Greenwich mean line. On some maps Australian Map Grid (AMG) references may be given. These are similar to latitude and longitude, but are measured in metres, rather than degrees. While latitude and longitude are preferred, if they are not available, AMG may be used.

The grid reference is determined by measuring out horizontally to the side of the map to get the latitude, and then measuring vertically to get the longitude. The exact value is estimated by subdividing the distance between the given values. Each degree is made up of 60 minutes ('), and each minute is made up of 60 seconds ("). Thus, Perth for example, is at the coordinants 31º 57' 00", 115º 52' 00".

Access to Private Property and Other Lands

The owners or managers of private property and other lands have the right to control access to their property and to know who and why people are entering their property. DEC staff should take these rights very seriously and ensure that landowners, leaseholders or managers either know of the intention to access the area, or have previously agreed to an entry procedure.

Where volunteers require access to other lands, DEC will arrange for that access, and the protocol for any future access requirements. Where practicable, the land occupier should still be contacted before enterring as a matter of courtesy. In some situations this may not be possible, e.g. absentee landowners, or where the population is remote from the house.

When operating on other lands, normal protocol should be observed, i.e. gates should be left as found, stock should not be scared, rubbish should not be left, produce (e.g. mallee roots or mushrooms) should not be removed.

Definitions

Flora - any plant which is native to the State (or which is declared by the Minister to be flora under the Wildlife Conservation Act), including any part of the plant and all seeds and spores.

Protected Flora - flora declared under the act to be protected flora for the purposes of the Act, and currently includes all flowering plants, conifers and cycads (Spermatophyta), ferns and fern allies (Pteridophyta), mosses and liverworts (Bryophyta), and fungi, algae and lichens (Thallophyta).

Taxa (singular taxon) - a level of classification. In the current context it refers to the lower level of specificity for which a plant species has been subdivided to, either species, subspecies or variety.

Vascular Plants - plants with a developed fluid conducting system (higher plants), i.e. flowering plants, cone bearing plants and ferns.

Non-vascular Plants - plants without a specialised fluid conducting system (lower plants), i.e. mosses, fungi and algae.

Presumed extinct - not collected or otherwise verified in the wild over the past 50 years despite thorough searching, or whose only known populations have been destroyed more recently.

Endangered - in serious risk of disappearing from the wild within one or two decades if present landuse and other causal factors continue to operate.

Vulnerable - not presently endangered but at risk over a longer period through continued depletion, or which largely occur on sites likely to experience changes in landuse which would threaten the survival of the species in the wild.

Threatened - presumed extinct, endangered or vulnerable.

Rare - used where the species is rare but not considered threatened. May be represented by a relatively large population in a very restricted area, or by smaller populations spread over a wider range. 2000 plants may be used as a guide to rarity, but this is dependant on the biology of the species.

ATTACHMENT 1

SUMMARY OF PLANT TAXA WITH PRIORITY FOR CONSERVATION

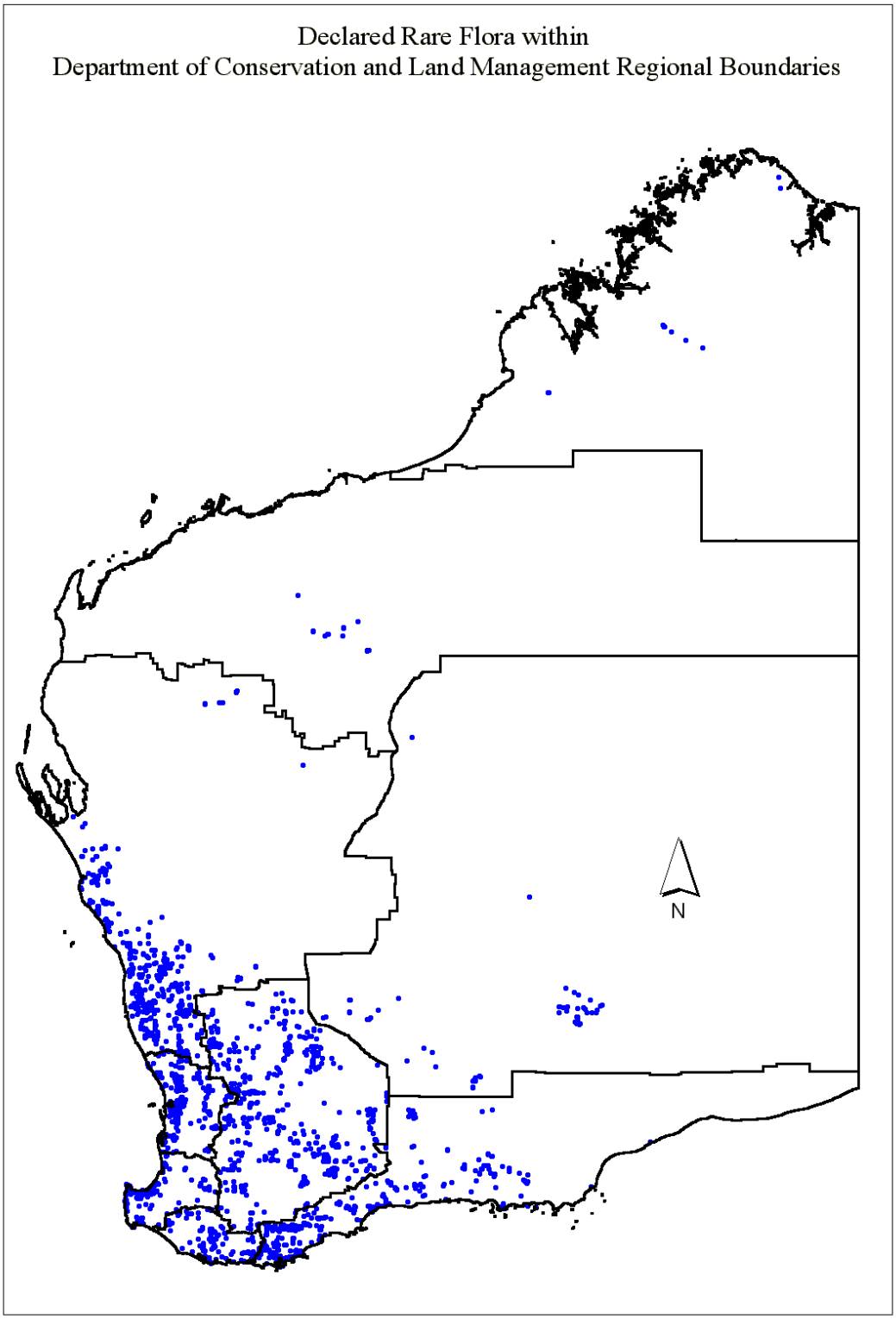
BY DEC ADMINISTRATIVE REGIONS

21/12/2006

	DECLARED RARE FLORA		PRIORITY CODES				TOTAL NO. OF TAXA
REGION	R	X	1	2	3	4	
Kimberley	4	0	51	43	35	5	138
Pilbara	2	0	41	34	55	7	139
Goldfields	15	0	90	41	65	20	231
Midwest	114	1	194	171	239	74	793
Swan	58	0	42	54	84	77	315
South West	46	1	23	33	66	49	218
Warren	21	0	15	47	51	37	171
Wheatbelt	116	4	120	140	178	85	643
South Coast	93	5	112	196	188	141	735
Unknown		3	2	-	-	-	5
STATE*	378	14	615	634	654	331	2626

* species may occur in more than one DEC Region.

ATTACHMENT 2



ATTACHMENT 3

PRIORITY FLORA CONSERVATION CODE DEFINITIONS

1: Priority One - Poorly known Taxa

Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

2: Priority Two - Poorly Known Taxa

Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

3: Priority Three - Poorly Known Taxa

Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.

4: Priority Four - Rare Taxa

Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

ATTACHMENT 4

Department of Environment and Conservation

RARE FLORA REPORT FORM

TAXON: _____ **DEFL POPULATION No.:** _____

DRF ❒ Priority Species: P____ Partial Survey ❒ Full Survey ❒ New Population ❒

FROM: _____ **TITLE**: _____ **SURVEY DATE:** _____/_____/_____

REGION: _____ **DISTRICT:** _____ **SHIRE:** _____

LOCATION: _____

_____

_____ **Reserve No**: _____

LATITUDE: _____°_____′_____″ S **LONGITUDE:** _____°_____′_____″ E **Map Used:** _____

GPS DATUM: AGD84 ❒ GDA94 ❒ GDA94-Compatible (e.g. WGS84) ❒ Unknown ❒ None ❒

LAND STATUS: Nature Reserve ❒ Private ❒ Gravel Res. MRD ❒ Rail Reserve ❒
National Park ❒ Pastoral Lease ❒ Gravel Res. Shire ❒ Rd. Verge Shire ❒
State Forest ❒ UCL ❒ Other Shire Res. ❒ Rd. Verge MRD ❒
Water Reserve ❒ Other ❒ Specify: _____ SLK _____ to _____
Landowner/manager present during inspection: ❒

LANDFORM: Hilltop ❒ Cliff ❒ Slope ❒ Valley ❒ Swamp ❒
Outcrop ❒ Breakaway ❒ Low Plain ❒ Gully ❒ Riverbank ❒
Ridge ❒ Sand Dune ❒ Flat ❒ Drainageline ❒ Lake Edge ❒
Firebreak ❒ Other ❒ Specify: _____

ROCK TYPE: Laterite ❒ Granite ❒ Dolerite ❒ Limestone ❒ Other:_____

ROCK FORM: Sheet ❒ Boulder ❒ Fluviatile Gravel ❒ Concretionary Gravel ❒

SOIL TYPE: Sand ❒ Loam ❒ Clay ❒ Peat ❒ Gravel ❒

SOIL COLOUR: Red ❒ Brown ❒ Yellow ❒ White ❒ Grey ❒

SOIL CONDITION: Moist ❒ Inundated ❒ Dry ❒ Saline ❒ Other: _____

VEGETATION CLASSIFICATION (Muir's): _____

ASSOCIATED SPECIES:_____

_____

_____

No. of PLANTS: Mature: _____ Seedlings: _____ Dead**:** _____ Actual ❒ Estimate ❒ Area Occupied: _____
(Leave blank if unable to observe, or no attempt made to count plants)

REPRODUCTIVE STATE: Clonal ❒ Flower bud ❒ Flower ❒ Immat. fruit ❒ Fruit ❒ Old Fruit ❒ Vegetative ❒

POLLINATORS: Native bees ❒ Honey bees ❒ Other insects ❒ Birds ❒ Mammals ❒
Other observations: _____

CONDITION OF POPULATION: Healthy ❒ Moderate ❒ Poor ❒ Disturbed ❒ Comment:

_____

_____

_____

POTENTIAL THREATS: Firebreaks ❒ Mining ❒ Recreation ❒ Roadworks ❒ Grazing ❒ Weeds ❒
Salinity ❒ Disease ❒ Prescribed Burning ❒ Other ❒ Comment:_____

FIRE HISTORY: Not known ❒ Burnt in 19____ Summer ❒ Autumn ❒ Winter ❒ Spring ❒

FENCING: Not Required ❒ Fenced ❒ Required ❒ Replace/Repair ❒

ROADSIDE MARKERS: Not Required ❒ Present ❒ Required ❒ Replace ❒ Reposition ❒

OTHER COMMENTS (include action taken/required):_____

_____

_____

_____

VOUCHER SPECIMEN: Regional Herb. ❒ District Herb. ❒ WA Herb. ❒ Other ❒ _____

ATTACHED: Map ❒ Mudmap ❒ Illustration ❒ Photo ❒ Field Notes ❒

COPY SENT TO: Regional Office ❒ District Office ❒ Other ❒ Specify: _____

Signed: _____ Date: _____/_____/200____

NOTE: Map or further information may be attached or given on the back of this form.

Please return completed form to Director General, DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: PLEASE FORWARD TO ADMINISTRATIVE OFFICER, FLORA, SPECIES AND COMMUNITIES BRANCH

LAND FOR WILDLIFE

Wildlife Notes

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT No. 4 September 1997
Information Notes for the *Land for Wildlife* Scheme in Western Australia

Seed collection from native plants

Keywords:	seed, selection, picking, seed types, storage, wildflowers.
Location:	South-west WA
Authors:	Keith Bradby & Vicky Morris

Each picking situation presents its own challenges. Once you have learnt the basic principles, you then have to start using your own ingenuity. Be observant and adaptable, as virtually every plant will require some modification to the general technique of collection. A good guiding principle to seed collection is firstly to obtain the correct license for picking, and secondly to ensure that your actions will not harm the plant from which you are taking the seed, and that the seed you harvest will be usable for your purposes.

SEED SELECTION

You first need to identify the species of flora that you require seed from. This may be through literature or matching up soil types. You then must locate a suitable population of the plant species you are after. This will need to have sufficient seed for your purposes, and be in an area that you can legally pick from. Ideally, collection should be from a decent-sized area of bush if possible with no roadside collection.

The seed needs to be checked for ripeness and for the level of insect attack. For ripeness, cut a fruit capsule or pod open and check the seed for `firmness', much as you would a grain crop. The level of insect attack will vary, but in many areas where there are few small birds, it is not unusual for most seed to be full of small grubs. This can make it impossible to collect large quantities of viable seed. It maybe worthwhile to note that the most accessible seed is not necessarily the best.

To preserve a broad genetic base in your future plantings, it is important that you get your seed from more than one plant, and pick from as many as possible. It is also important to bear in mind the end purpose of the seed. If it is to rehabilitate a salty area, pick your seed from those plants that are closest to the salt, as they may carry increased salt tolerance. If it is for a garden, some of the plants you are picking from may have a special feature such as a more attractive "weeping" habit than others, or unusual flower colours. Keep in mind that approximately


Hakea cristata
Snail hakea

80% of the resulting plants will take after the seed-bearing plant rather than the pollen-producing plant, especially if collecting from gardens.

If your purpose is to rehabilitate an area of local bushland, remember that in Western Australia the regional variation within plant species can be considerable, so it is important to pick your seed from similar habitat as close as possible to the area you are intending to replant.

EQUIPMENT

Depending on the nature of the plant you are collecting seed from and the type of collection method you intend to use, there are a few basic tools which will be necessary. A first-aid kit is a must with any activity in case of emergency (for example, some people are allergic to certain types of plants; some plants are very prickly and could cause injury). A container to transport the collected seed will be required, as well as some form of labeling the species collected and the date and area of collection (many species produce similar looking seed). Eye protection, a sieve, a pair of secateurs or pruning saw and perhaps a ladder may be useful when collecting seed-bearing stems. The best results are obtained when the equipment for collection is kept scrupulously clean and serviced, which also helps prevent spreading any infections from one seed source to another. Blunt and dirty secateurs will be more likely to cut you than the plant!

PICKING

Fruit types

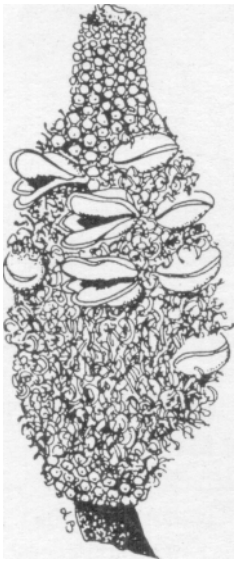
The seed `container' in the bush has a variety of forms, ranging from large woody fruits (eg. *Hakeas, Banksias),* smaller 'nuts'(eg. *Eucalyptus,* sheoak), pods (eg. wattles), or tiny swollen ovaries (eg. *Calytrix)* at the base of shrivelled flower parts.

Successful seed picking generally tries to mimic the natural mechanisms used by the plant to release the seeds from their containers, with the seed ending up where we want it, not where the plant would otherwise spread it.

Based on how they release their seed, most plants fit into one of three main groups:

1. Fire openers - these store the seed for various periods (often several years), only releasing it after the plant is burnt in a bush fire, eg. *most Banksias, Xylomelum spp,* and some *Hakeas*.
2. Drying openers - these can hold the ripe seed for extended periods, but eventually the fruit dries out and the seed falls, eg. *Eucalyptus spp, Melaleuca* spp.
3. Once-a-season producers - these drop their seed (or sometimes throw it!) once the seed has ripened after flowering, eg. *Anigozanthus* (Kangaroo Paws), *Acacias, Kennedias.*

1. FIRE OPENERS



Winged Seed

Banksia attenuata
Slender Banksia

The most obvious of these is the *Banksias,* which have a woody cone with numerous follicles (the woody seed-containing `eyes') which, when cracked by heat, open to release two winged seeds and a central woody separator. The seeds are ripe about twelve months after flowering - look for fruits where the follicles are hard and brown.

The easiest way of collecting the seed from fire openers is to follow a fire, picking the fruits (cones) as soon as possible after the fire has passed. This method is not generally recommended for the average casual picker as hazards in the form of ash beds do occur! It is generally best to get the seed within 24 to 48 hours, depending on weather conditions. (It will drop faster in higher temperatures). Care should be taken, however, to ensure sufficient fruit are retained on the plants for regeneration after the fire. It is recommended that only 1 in 10 fruit are harvested after fire.

Banksia fruit can also be piled into a heap (1-2 bags per heap) and soaked with approximately 3-5 litres of mixed kerosene and sump oil and set alight to create the heat required to open the follicles. When alight the heap should be turned with a rake. It must be noted, however, that temperatures over 60 degrees Celsius are destructive to seed, so as soon as you notice the follicles start to open remove the cones from the heat.

The aim is to evenly subject each nut to intense flash heat. Have a hose handy to thoroughly wet the nuts after the follicles have cracked. And be careful, singed eyebrows regrow reasonably fast, but singed skin is painful and the scars can be permanent!

Whether collected burnt, or burnt after collection, only a certain amount of seed falls out straight away. The fruits generally require a period of successive wetting and drying before they drop all their seed.

As long as the weather is not too cold or wet (ie. for more than two days), the best method is to place the fruits outside on a well drained surface which will hold the seed. Most seed should be out within 3-4 weeks - the rest probably isn't worth bothering about. Possibly the best surface for drying on is shade cloth as it lets the moisture, dust, and ash, but not the seeds, through.

During wet periods the nuts could be spread in the warmest part of your shed, and shifted out into the rain for a day every few weeks.

It is also possible to remove seed in a microwave oven, but it is easy to `cook' and so kill them, therefore this method is not recommended.

Other bushes burnt to collect the seed include *Dryandras, Petrophiles and lsopogons*. Fruiting heads can be laid on the ground and given a thin spray of petrol. The leaves often provide much of the heat once they are started, and you need to wet them down before the fire affects the seed.

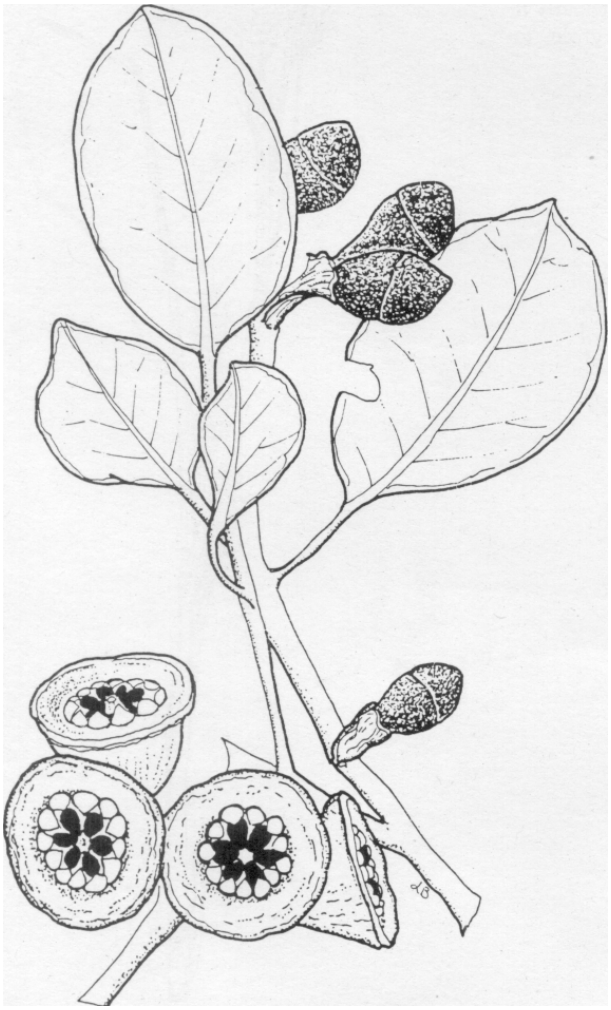
2. DRYING OPENERS

The main types of these are the smaller woody fruits that open from central valves to release a much finer seed, such as *Eucalyptus spp, Allocasuarina spp* and *Melaleuca* spp, and the woody fruits which split to release two seeds, such as *Hakeas.*

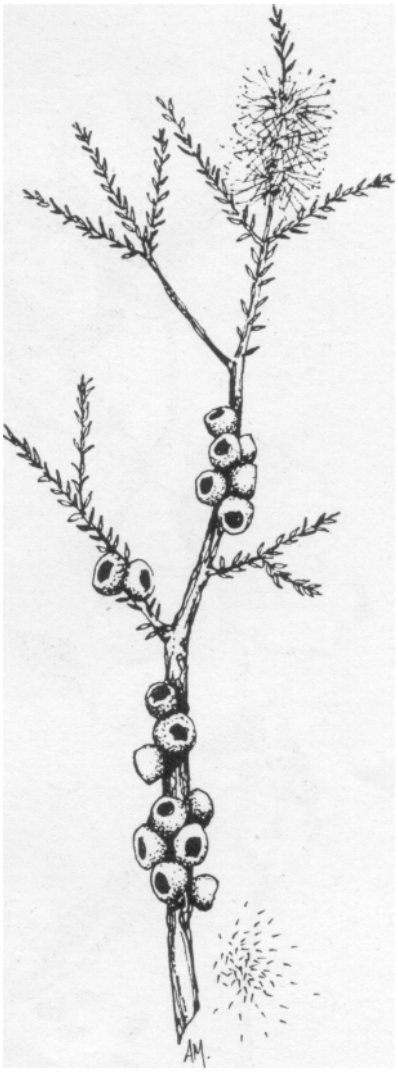
They generally ripen about 12 months after flowering, although some species can take 2 - 3 years to mature, such as *Callistemon phoeniceus,* which may contain several years' seeds along their stems. The fruit hardens, generally loses its green colour, and the valves, or join, becomes clearly defined. The seed can be checked for dryness and good colour by cutting through the "nut".

To release seed, place stems and branchlets holding ripe fruit on a tarpaulin in a warm dry place. If drying the fruit outside, the use of fine weed mesh is good insurance because if it rains, the moisture will drain away. The seed will drop within 3-4 days in summer, longer in cooler weather. Ensure that strong winds cannot blow away the released seed. Note that no heat treatment is required for this group, which also includes *Kunzeas, Grevilleas* and *Hardenbergias.*

Remember to leave at least two thirds of the fruits on each plant for natural regeneration.



Eucalyptus preissiana
Bell-fruited mallee



Melaleuca brevifolia
Dwarf salt honey-myrtle

3. ONCE-A-SEASON PRODUCERS

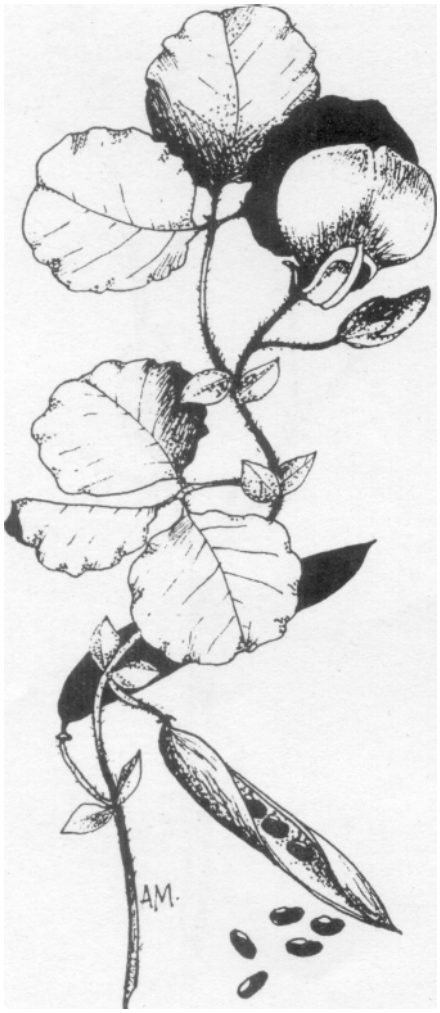
These are often the very hardest to collect seed from. Most of these plants makeup the spring profusion of flower and drop their seed between the middle of October and the middle or end of January. Although there are many, many different types of fruit and seed release mechanisms involved, which you can never completely work out, the basic principles are reasonably simple.

You generally have to try to assess when the seed will be ripe. This requires regular checks on the ripening progress. It's a skill you will only get better at with experience.

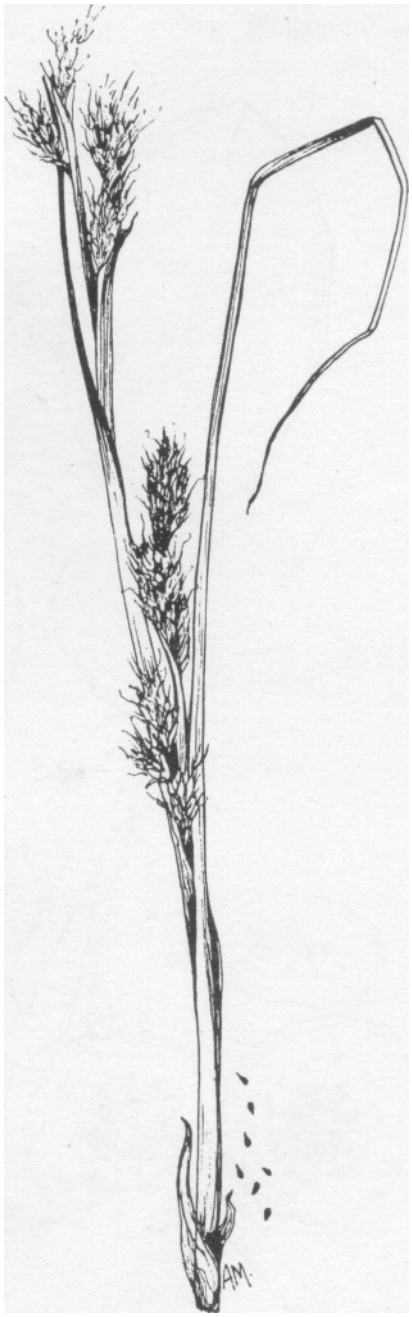
Generally cool weather means seed will ripen slowly, but beware of those few hot days toward the end of December and the New Year, particularly if it's also windy.

The seed can go from green, to pickable, to lying on the ground faster than you thought possible, and generally all the species you are trying to pick will choose the same hot spell to ripen.

Even under reasonable conditions, patches of a species will often ripen unevenly. On the same plant seed can be ripe, ripening and green. You have to make a judgment on the best time, but generally `later' is better. Early ripened seed is often unviable. Green seed should be left on the bush for regeneration of the species irrespective of the ripeness, some seed should be left on each plant that is harvested from.



Kennedia prostrata
Running postman



Gahnia trifida
Coast saw-edge or cutting grass

The main picking methods are:

Tarping

Many seeds and pods can be shaken off the bush when ripe. Spread tarps underneath, and either shake the bush or hit the pods with a stick or a piece of flexible pipe. A garden rake is often useful for combing the pods off. Depending on the species, tarping can generally only be done after the morning dew has dried off and, with the larger trees, before a breeze or a wind comes up. This is quite often difficult to do, as the wind often blows away the seed or the tarp! A few heavy rocks may help keep the tarp in place.

Binning

Smaller bushes can often be stripped by hand into large plastic rubbish bins.

Stem cutting

Often wattles and similar plants grow too close to the ground for tarping. In this case, stems holding ripe seed need to be cut and laid on a mesh, where the seed can be threshed off by walloping them with a pitchfork. Note that only seed bearing stem ends should be cut, and some leaves left on the plant below the cut to assist regrowth. No more than a total of 3 0% should be removed from any one plant. This ensures that sufficient stems with leaves remain on the plants to enable them to recover.

Some plants, such as *Kennedias,* ripen very unevenly. When some pods are ripe the stems can be cut and laid in a cool place (often under shade cloth) and many of the remainder will ripen by drawing on the moisture in the stems. Seeds that `pinch out' are unviable and can generally be winnowed out.

Stem cutting is often also the most effective way to collect small fruit. Occasionally, as with kangaroo paws, the seed pod is collected when it starts to open, but then `freezes' and won't open to release all the seed. The fruits need to be dried thoroughly, and then crushed to free the seed. This can be done by hand, by placing the pods on a concrete floor and walking over them, or by running them through a small thresher.

Desperate measures

If you got to your patch too late, then don't despair. With wattles and other plants with large hard seeds it is sometimes possible to sweep or shovel the seed off the ground, so that the dirt and leaf litter can be sieved out. Small battery-operated vacuum cleaners may prove useful for this task.

DRYING, CLEANING AND STORING

For much of the year drying can be done outside, and moisture from any rain or dew helps the fruit `work' the seed out. Any clean surface will do to dry your seed on. The most effective is the rolls of woven polythene weed mesh, which retains the finest seed, but lets any rain or moisture through (plastic bags are NOT appropriate).

The stems or pods should be spread reasonably thinly on the mesh or tarpaulins, and turned every few days. Extreme care should be taken to ensure that the mesh or tarp is secured down against strong winds, and that sand and dust will not be blown or walked onto tarps holding fine seeds. Some pods, such as *Kennedias,* need shade cloth or fly wire over them to stop the seed `pinging' everywhere as the pods explode open.

Even when it is on your tarp there can be a bit of competition for the seed. Ants are often very appreciative of your effort in bringing so much seed to a convenient point for them, and you may need to shift the seed, or spread an ant deterrent, or spray a surface insecticide around the tarp. Occasionally some birds will browse over your pods, but these are rarely a cause for concern, unless it is a mallee fowl on a tarp of its favourite wattle.

Once the stems or pods have been removed, the remaining material can be hand sieved, which generally requires a number of different sized sieves. Light material can generally be winnowed out *(a la* peasant grain cleaning techniques). With a number of species, such as *Banksias* and *Dryandras,* the seed will sink if placed in water, and much of the other material can be skimmed from the top of the water.

If the seed is for a local revegetation project using the direct seeding method it does not need to be very clean, unless you want to know the weight to use per hectare. However, be warned that seed mixed with other material soon becomes bug infested. Producing a perfectly clean seed sample can be quite laborious, and is only really necessary if you want to sell the seed, or store it for an extended period.

Before storing seed, even if only for a short period, make sure that it is perfectly dry. If possible, spread a thin layer over a tarp or metal tray and leave in a warm position for a day or two.

Clean seed will keep for varying lengths of time if stored properly and regularly checked. Many species will last quite a few seasons, however some species *of Grevillea* will not. Store seed in a rodent-proof, dry, almost airtight container in a cool, dark and dry place (even your fridge). A small piece of Shelltox pest strip, renewed every six months or so, will kill any bugs that may appear.

If you are selling seed (for which you will need a license) it needs to be perfectly clean. Some seeds clean relatively easily, others need machine cleaning or even picking through by hand. If selling to a seed firm, discuss this with them, as they can probably arrange the final cleaning for you.

Cleaning up

Using the simple approaches outlined in this leaflet, it is possible to collect quite large quantities of seed. In doing so, you will also collect a much greater amount of stems or pods. Even after you have taken most of the seed away, these will still contain seed, and can be quite useful for regeneration.

If tarping on site, the residue should always be spread thinly over the site, so that it does not become a fire hazard. Wherever possible, the residue (and your screenings) should be spread over the area you are regenerating, as it will provide useful ground cover, and organic matter, as well as adding some extra seed.

RULES AND REGULATIONS

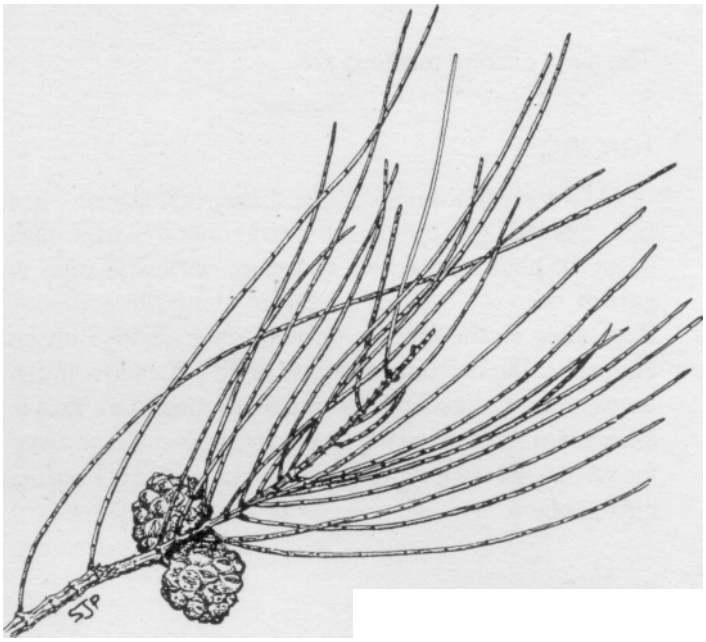
by Sarah McEvoy

The laws governing flora conservation are contained in the Wildlife Conservation Act and its regulations, which are administered by the Department of Conservation and Land Management.

Flora native to Western Australia is protected under this Act, which means that regulations exist regarding the harvest of that flora. Certain flora that is considered to be threatened with extinction is declared as rare flora under the Act, and such flora is given special protection, and may not be harvested without the permission of the Minister for the Environment, on any lands.

Protected flora other than declared rare flora may be harvested for seed as specified below. On Crown land seed can only be taken where the person taking the seed holds a license issued by CALM. There are two types of Crown land licenses which may apply to people wishing to harvest seed. A Commercial Purposes license is required if the flora is to be taken for a commercial purpose (which would include minesite rehabilitation, or any circumstance where the seed picker obtains any gain, either direct or indirect, from disposing of the seed). The fee for this license is $100.00 per annum.

Where the harvesting of seed is for non-commercial propagation, such as local rehabilitation by a community group, a Scientific or Other Prescribed Purposes license can be obtained. The fee for this license is $10.00 per annum.



Allocasuarina fraseriana
Common sheoak

Even when a license is held, all pickers must obtain the permission of the land manager before picking in any vested Crown land (eg, State Forest, Water Reserves, etc). Both the Commercial Purposes license and the Scientific or Other Prescribed Purposes license generally preclude the taking of flora from the conservation estate - ie, National Parks and Nature Reserves.

On private land, protected flora can only be taken by the owner or occupier of the land, or by a person who has the owner or occupier's consent to take the flora. If the flora is to be sold, the owner or occupier must hold a Commercial Producer's or Nurseryman's license. The fee for this license is $25.00.

Further specific conditions are attached to each license and are designed to ensure that sustainable harvesting occurs. For further information about licensing contact CALM's Wildlife Branch on (08) 9334 0455.

About the Authors

Keith Bradby and Vicki Morris have collected seed commercially and for use in revegetation projects for many years.

Sarah McEvoy is a consultant ecologist, who formerly worked for CALM as Flora Industry Botanist.

Diagrams by
Anne Miles from What Seed is That, Greening Australia (South Australia)
Louise Burch from Banksias of the Wellstead District and Eucalypts of the Wellstead District, Wellstead Land Conservation District Committee. Margaret Pieroni and Sue Patrick from 'Leaf and Branch', Trees and Tall Shrubs of Perth, CALM. Used with permission.

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All correspondence should be addressed to: The Editor 'Wildlife Notes', CALM Wildlife Branch, Locked Bag 104, Bentley Delivery Centre, WA 6983. Phone: (08) 9334 0530, Fax (08) 9334 0278

LAND FOR WILDLIFE
VOLUNTARY NATURE CONSERVATION

Wildlife Notes

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

No.15 April 2005

Information Notes for the *Land for Wildlife* Scheme in Western Australia

Tree Hollows and Wildlife

Keywords:	fauna, habitat, hollows
Location:	south-west Western Australia
Author:	Penny Hussey

INTRODUCTION

Tree hollows are essential to provide shelter and breeding sites for many native animals. Australia-wide, it is estimated that around 300 species of vertebrates use hollows at some time and many of these are now endangered, in part because of the removal of hollow-bearing trees. The hollows provide refuge from the weather and predators, and safe sites for roosting and breeding. In order to maintain this essential wildlife habitat, it is important to retain both living and dead hollow-bearing trees.

HOW DO HOLLOWS FORM?

Hollows form as trees age. Over time, the trees are subject to various natural forces such as fire or storm that cause injury to the protective bark. While the living, outer sapwood may remain healthy, wood-rotting fungi and termites gain access to the heartwood, beginning the decay process. In Western Australia, fire often contributes to the initial cause of injury, as well as, by burning decayed wood, enlarging existing hollows. Wildlife can also renovate hollows using beaks, teeth or claws.

HOW LONG DO HOLLOWS TAKE TO FORM?

Only old trees have hollows. Research has shown that jarrah, wandoo and salmon gum rarely form hollows before they are 120-150 years of age. A hollow large enough for a black cockatoo (which requires an entrance hole 25cm in diameter) will only be found in a tree that is even older than that.

WHICH TREE SPECIES PRODUCE HOLLOWS?

Most species of eucalypts produce hollows, if they live long enough. In the wetter south-west of WA, jarrah, wandoo and flooded gum produce the best hollows, while inland wandoo and salmon gum are the most important hollow-bearing trees in the wheatbelt.

An owlet nightjar dozes in a wandoo hollow

As the climate becomes more arid, many eucalypts adopt a mallee growth form. In this, the long-lived old part of the plant is the woody lignotuber (mallee root) that forms at or just below the soil surface. The aerial stems of the mallee die during fire or severe drought, and are replaced by shoots from the lignotuber. If damaged, it too can decay and become hollow, and this may be used by mardos, other small marsupials or rodents and animals as large as chuditch and brush-tail possums. Some mallees are rather vulnerable to termites, and even apparently healthy living stems can be completely hollow. Though didgeridoos were not traditionally made by Aboriginal people in the south-west of WA, in other parts of Australia an experienced instrument maker knew which mallee species were likely to have hollow stems and, by tapping the stem, could determine which one had been hollowed out sufficiently for use.

DIFFERENT TYPES OF HOLLOWS

Eucalypts often have hollows in living or dead branches in the crown or high in the main trunk. These sites usually arise where a branch has been lost, thus exposing heartwood to decay and sometimes fire. At the base of the trunk a fire scar may burn in each succeeding fire until there is a

completely hollow butt. Dead trees or branches can twist under stress and so longitudinal cracks or fissures form. Branches or whole trees may fall, leaving hollow logs lying on the ground.

Animals select hollows according to their own individual needs. Factors such as the size and shape of the entrance hole and the interior cavity, as well as the degree of insulation, affect how and when a hollow is used. Rufous treecreepers, for example, require an entrance hole no larger than 5cm, and it can be quite close to the ground, whereas the regent parrot (smoker) needs a 16cm hole high up. Therefore, a range of hollow sizes and shapes is necessary to support a variety of wildlife.

WHICH ANIMALS USE TREE HOLLOWS?

In the south-west of WA, possums, phascogales and bats are our most important arboreal hollow-using mammals, though low hollows and hollow logs on the ground are also used by numbats, chuditch, echidna and numerous mouse-sized animals. Hollow-butted trees often shelter kangaroos and wallabies.

Australia-wide, 15% of all the land birds use hollows. These 114 species include parrots, cockatoos and lorikeets, ducks, treecreepers, owls, owlet-nightjar, kingfishers, pardalotes, martins and woodswallows. Most only use the hollows seasonally while they are rearing their young, but some, for example owls, also use them as roosting sites.

Many reptiles, especially some skinks and geckos, are arboreal and may use hollows, but in the south-west of WA the most obvious reptilian hollow user is the black goanna which, besides hunting other hollow-dwelling fauna, will regulate its body temperature while resting by choosing a warmer or cooler position within the hollow. Carpet pythons also hibernate in hollows, sometimes up to 10 metres off the ground.

There have been very few studies of the invertebrate use of tree hollows, but even a cursory inspection will show that they are used by many different organisms, including the termites that help create them.

PROBLEMS WITH PESTS

Unfortunately, some introduced species also use hollows and so compete with native wildlife. Feral honeybees are the most important of these.

Research is showing that the endangered forest red-tailed black cockatoo and Baudin's cockatoo are being displaced from nesting hollows by feral bees. Since these long-lived birds are very choosy about their nesting site, returning to the same hollow year after year, this take-over by bees may mean the end of a pair's capacity to breed.

CAN ARTIFICIAL HOLLOWS HELP?

Where suitable hollows are not present, enterprising animals can make use of unusual sites – for example pygmy possums have been found nesting in the emptying chute of a grain silo, and pardalotes in the horizontal pipe which formed the top bar of a childrens' swing!

Where hollows are scarce, such as in timber plantations and recent revegetation, artificial hollows such as nest boxes may be used to encourage hollow-using fauna to use the area. Design features such as the nest box dimensions, the material used and the location of the box will influence the species that will use them. (For detail, see Wildlife Note No. 3 "Nest boxes for Wildlife".)

Nest boxes are not a substitute for natural hollows. They are most often used by common species such as twenty-eight parrots or wood ducks, or appropriated by pests such as feral honeybees. Nevertheless, designed and placed with care, they can be a useful tool to help threatened hollow users; as the large boxes being installed as part of the Carnaby's cockatoo recovery programme are demonstrating. A nest box placed where it can be observed from the verandah can also provide a lot of interest for the householder.

WHAT CAN YOU DO?

Natural tree hollows are essential for the survival of many wildlife species but, as mentioned before, they only form in very old trees. Therefore, managing your land so as to protect existing hollow-bearing trees within remnants, or even individual paddock trees if they contain hollows, is an important management goal. Hollow trees near watercourses and wetlands are especially important for ducks. When doing any revegetation, include local native trees that produce hollows - even though those hollows will not begin to be useful until your grandchildrens' time! If preparing an area for revegetation, leave hollow logs to retain this essential habitat for ground-dwelling animals. Finally, if there are very few natural hollows, consider installing nest boxes.

ACKNOWLEDGEMENT

The text of this 'Wildlife Note' is adapted with permission from "Wildlife needs natural tree hollows", *Land for Wildlife* (Victoria) Note No 6, Dec. 1990. Thanks also to Ken Atkins, Avril Baxter and Peter Mawson for helpful comments on earlier drafts.

ABOUT THE AUTHOR

Penny Hussey is Senior Project Officer *Land for Wildlife*, based at the Department of Conservation and Land Management, Kensington, WA.

FURTHER READING

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"Logs have life inside: music and education kit." 2001. Environment Australia. Canberra.

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LAND FOR WILDLIFE
VOLUNTARY NATURE CONSERVATION

Wildlife Notes

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

No.16 April 2005

Information Notes for the *Land for Wildlife* Scheme in Western Australia

Paddock Trees and Wildlife

Keywords:	fauna, habitat, hollows
Location:	south-west Western Australia
Author:	Penny Hussey

INTRODUCTION

In many parts of the south-west of Western Australia, past clearing practices have left trees isolated singly or in small clumps within paddocks. These 'paddock trees' perform a number of ecosystem services that contribute to sustainable natural resource management.

Farmland with paddock trees is often termed 'parkland cleared', as this type of treed landscape was deliberately created in gentleman's parks in Europe, and for many people it represents the most aesthetically appealing type of farmland. This landscape beauty is important for personal well-being and it also helps to define the overall character of an area, giving a distinctive 'sense of place'.

Sheep enjoy the shade.

Of course, trees retained within natural vegetation is the ideal situation for wildlife habitat but this is not possible across all parts of a landscape that has been extensively developed for agricultural purposes. In some areas, especially in the south-west's wool belt, paddock trees perform an important role in wildlife conservation.

WHY ARE PADDOCK TREES VALUABLE FOR WILDLIFE CONSERVATION?

Paddock trees are often old – they may be the only old trees remaining in an area - and have holes and hollows, perching, roosting and nesting sites, that are very valuable for a number of species, particularly birds.

Many native birds depend on them for feeding, breeding and roosting - the endangered Muir's corella, found around Lakes Muir and Unicup in the wetter south-west, depends almost entirely on scattered paddock and roadside trees, while in the wheatbelt, Carnaby's cockatoo relies heavily upon salmon gums in bush remnants amidst farmland and on road and rail reserves.

Because of the extra nutrients contributed by the farming operation, the trees may have especially nutritious foliage, or flower very heavily. Thus they can provide large resources for native fauna, either directly or because the birds eat the insects supported by the trees. Research has shown that a single marri or jarrah tree may support up to 440 different species of invertebrates! Marri is very important in this respect, as marri flowers in summer, when little else is in bloom, and provides a vital carry-over resource for nectar-eating birds such as honeyeaters.

As well as being important refuges and breeding sites in their own right, paddock trees may also provide stepping stones for other, bush-dependant fauna to move between isolated bush patches that would be too small to sustain them on their own year-round. Maintaining this landscape connectivity is vital to the survival of many animals.

HOW VALUABLE ARE PADDOCK TREES TO LANDHOLDERS?

Paddock trees, together or in small groups, can be valuable to a stock operation as they provide shade and shelter from inclement weather, thus reducing stress. Beneath the trees there is a more stable microclimate so that the soil is relatively cooler in summer and warmer in winter. Groups of trees cut the wind, so that the windchill factor is always less in shelter. In summer, even a single tree may provide much needed shade.

These factors combine so that stock in paddocks with shelter do not need to use as much energy to regulate their body temperature, thus they use feed more efficiently for growth. Sheltered off-shears wethers require only about one third of the amount of supplementary feed to maintain bodyweight compared to those that are unsheltered. Cold stress reduces wool growth, limits liveweight gains and reduces dairy cattle milk yields. Heat stress reduces liveweight gain in cattle and reduces wool growth in sheep. At lambing time, good shelter can literally save lives.

Many of the birds that use paddock trees are insectivorous, such as magpies, large honeyeaters and cuckoo-shrikes. Grey fantails, willy wagtails and mudlarks can often be seen swooping out and taking insects stirred up by stock, including blowflies. On the topmost branches woodswallows and rainbow bee-eaters perch between bouts of spectacular aerial manoeuvres while they take high-flying insects. At night, nocturnal hunters such as owls swoop to catch mice. Paddock trees also provide vital habitat for a number of species of bats that forage over open areas. These bats are significant predators of night-flying insects,0 one bat can consume up to 600 small flying insects in an hour. Without somewhere close by to roost or perch, this natural pest control will not happen, other than close to areas of remnant vegetation.

Paddock trees are often prolific nectar producers and so valued by apiarists as well as nectar-feeding birds.

Groups of trees contribute to the stability of the water table in their vicinity. In other words, they use the water where it falls, so that it does not contribute to waterlogging or salinity downslope. These qualities will be most significant if the trees are on recharge areas such as ridges and the fringes of rock outcrops.

DON'T THEY GET IN THE WAY OF MACHINERY?

It is true that as machinery has increased in size, the presence of paddock trees in predominately cropping paddocks has become more difficult to deal with. It is harder to deviate from a straight line to go around them, and during this manoeuvre some ground will be treated twice, an inefficient practice. In pasture paddocks this issue does not arise.

Nevertheless, the retention of strategically placed paddock trees, especially clumps of trees, can provide a range of benefits to wildlife and the farm enterprise, while having a minimal impact on the farm operation. The removal of a few selected trees may be an option in some situations, but this should be carefully planned so that unnecessary tree removal is avoided. It may be possible to determine which individual trees, or groups of trees, have the greatest wildlife value. Large trees with hollows are always important. Trees that form stepping stones between patches of remnant vegetation will also have a high value.

MANAGING PADDOCK TREES

Stock camping beneath trees compacts the soil, decreases water infiltration and may damage surface roots as well as raising the soil nutrient level. This may cause stress to the trees and render them less able to cope with droughts. In areas such as lambing paddocks, where shelter is a vital resource, one tactic is to fence groups of trees for 5 years, to allow the natural soil processes to recover, then remove the fence and place it around another group of trees. For some tree species, such as marri or flooded gum, this will also permit the survival of regenerating seedlings, thereby building a more sustainable tree cluster for longer-term benefits.

Stock will damage the bark on the lower part of the tree trunk – rams, horses and camels are notorious for this – to such an extent that they can kill the tree. If these isolated trees are to be retained, it will be necessary to erect a fence a couple of metres out from the trunk, or wrap chicken netting directly around it.

But nothing lives for ever. As part of the long-term farm plan, new groups of trees should be planted where they can provide the greatest benefit to farm production as well as wildlife habitat. The management of paddock trees for long-term benefit is as much a part of good property management as actions such as the maintenance of good soil structure or weed control.

SUMMARY

Scattered trees within farmland contribute to a sustainable agricultural system as well as to the aesthetics of the landscape and provide important resources for wildlife. They should be managed so as to continue to contribute to the local ecosystem.

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Photo: Avril Baxter.

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FURTHER READING

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LAND FOR WILDLIFE VOLUNTARY NATURE CONSERVATION

Wildlife Notes

GOVERNMENT OF WESTERN AUSTRALIA
DEPARTMENT OF Conservation AND LAND MANAGEMENT Conserving the nature of WA

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Information Notes for the *Land for Wildlife* Scheme in Western Australia

The Use of Fire in Small Remnants

Keywords:	fire, regeneration, remnant bushland
Location:	south-west Western Australia
Authors:	Penny Hussey and Avril Baxter

INTRODUCTION

Many landowners see a need to "clean up" their bushland by putting a fire through it to reduce the fire hazard and hopefully cause regeneration. However, in these altered landscapes the result may not be what we expect.

With flammable vegetation, dry summers and sources of ignition, it is not surprising that fires are an important component of ecosystems in south-west Australia. Over millions of years, native plants and animals have evolved various strategies to cope and persist in this fire-prone environment.

> If we wish to use fire for any reason at all, but especially for nature conservation, we need to be aware that the bush community's response to that fire may be very different to the response which would have occurred prior to European settlement.

Today, however, trying to manage fire in small isolated remnants of native vegetation, while at the same time trying to conserve that bushland and all its native flora and fauna, presents an enormous challenge.

In this Wildlife Note we explore some of the issues and consequences of using fire in small remnants and provide a checklist to help you in your decision-making.

WHY BURN BUSHLAND?

Planned fire may be prescribed to remove a perceived fire hazard or to promote regeneration ('ecological renewal').

Removing a perceived fire hazard

In areas where there is danger to life and property from wildfire, for example adjoining houses, fuel reduction for safety is a vital consideration. For example, burning sections during the cooler months of the year when the fire can be more easily contained and may go out overnight could be a suitable regime.

Nevertheless, conservation of the values of the natural community should be included in the fire management plans and compatible strategies considered, such as burning sections in rotation, and having permanent low fuel zones adjacent to the infrastructure being protected.

Promoting regeneration

Nothing lives for ever. All living things must reproduce a new generation; in vegetation communities we call this 'regeneration'. Without regenerative processes, a gradual decline of mature plants will eliminate them from an area, leaving no replacement seedlings. Work done in almost all south-west Australian vegetation communities shows that a 'disturbance factor' induces regeneration. One such disturbance factor could be fire.

There are two ways in which trees and shrubs respond to fire:

a) the whole plant is killed and a new generation grows from seed (reseeders) or
b) only parts of the plant are killed, and new growth arises from stem or rootstock (resprouters).

Fig. 1: Very soon after a fire, Kingias can be seen resprouting. No seedlings have yet germinated.
Photo: N. Burrows.

On extremely infertile and difficult soils, the most important role of fire may be in recycling nutrients. Without rapid decomposition by fungi or termites, or extensive leaf herbivory where the fauna recycle nutrients in their wastes, the nutrients remain held in living and dead plant material, so there is little left in the soil to fuel new growth. Both reseeder and resprouter plants take advantage of this release of nutrients to grow rapidly after fire.

EFFECTS OF FIRE ON NATURAL COMMUNITIES

The effect of fire on natural communities depends on many factors. Some of the most important are the frequency between fires, the season, its intensity, climatic events before and after the fire, the patchiness of the fire, the condition, size and connectivity of the bushland and the fauna present.

Fig. 2: Fire can change the composition of a plant community. The wandoo woodland in Wyalkatchem Nature Reserve had not burnt for over 60 years, and the ground layer consisted of perennials, grass-like plants and everlastings, as can be seen in the front of the photo. A very hot fire in the summer of 1999 through part of the reserve caused a massive germination of shrubs, which dominate the regeneration area. This change in community structure can clearly be seen in the centre of the photograph. Photo: P. Hussey

EFFECT OF FIRE ON NATIVE PLANT COMMUNITIES

Fire frequency

Fig. 3: Fire frequencies can affect vegetation communities. A fire in the 1960s led to the regeneration of sheoaks throughout this area. However, a fire four years later, which was stopped at the roadway, killed the regenerating sheoaks which had not been able to set seed, leaving room for powderbark wandoos, from a mature stand at the top of the ridge that had not been affected by the fire, to colonise the area. Photo: A. Baxter.

For many plants to persist after a fire, they must be able to reach maturity and set seed (the reseeders). Since plants vary in the length of time they take to do this, it follows that the frequency of the fires will have a distinct effect on the composition of the vegetation community. For example, in woodlands, the understorey follows a cyclical pattern of growth / decline / renewal, often on a shorter timescale than the tree species.

As a general rule of thumb fire intervals should be at least twice as long as it takes the slowest maturing plant to flower and produce seed, and before older plants are no longer able to reproduce.

Fire season

The time of the year in which the fire occurs will make a considerable difference. There are three possible fire seasons: midsummer/autumn, winter, spring/early summer.

Midsummer / early autumn fires

These fires are usually intense and difficult to control, they will consume most of the above ground material and most likely burn down mature trees. In doing so they remove herbivores (eg sap sucking insects) and parasites (eg mistletoe or dodder) from the population. Heat penetration of the dry soil is maximised, which will break the dormancy for some buried seeds such as wattles and peas. The chemicals produced by the fire will also encourage germination (see Fig. 2).

If the season is kind, then seeds which are stimulated to germinate by these fires will be supported by winter rain and plants that resprout from lignotubers will have water available to manufacture new food, using the released mineral nutrients to fuel the new growth. In adverse seasons the soil surface is exposed to potential wind and water erosion both from the bushland and into it from surrounding paddocks.

Winter fires

These low intensity fires will leave patches of unburnt vegetation. However, the new seed crop within the burnt patches may be destroyed before maturity, and plants such as everlastings and orchids, which have not evolved adaptations to survive fire during their growing season, will be damaged. Also, the fire may not trigger germination of the native seed stored in the soil, but could encourage the growth of grass weeds if they are present in the system.

Fig. 4: A winter burn in weedy bushland encouraged the growth of exotic grasses. Photo: A. Baxter

Spring/early summer

These fires are low to moderately intense, depending on the air temperature and humidity, the amount and moisture content of the fuel and soil, and the wind strength. Some of the tree crowns will be scorched and some patches may be left unburnt. They will destroy that year's seed crop for many plants. Seeds on the surface will be stimulated to germinate, but the fire may not be hot enough to crack the dormancy of buried seed. They also encourage the growth of already established perennial grass weeds such as veldt grass. Germinating plants may not survive until the autumn break of the season. However plants that resprout will grow well over summer and out-compete seeders.

We recommend autumn burning for most regeneration burns, especially where regrowth of wattle and pea thickets is important. If, however, the potential intensity of the fire is a management concern, then the fire can be timed for after the first winter rains, which will reduce the fire intensity, but be prior to the active plant growth.

Climatic events

The impact of unpredictable climatic events is enormous. Heavy rain after a fire can remove the ash, its mineral nutrients and germinating seed from the site. Weed seeds and artificial fertilisers can also be blown or washed in from surrounding paddocks. Regenerating plants can be affected by prolonged dry periods or frost, especially on granites and sandy soils.

Patchiness of fire

Burning small patches at a time creates an uneven aged bushland which has many advantages for both plants and animals. Seeds from unburnt patches can reinvade the burnt areas and recently burnt patches can be used as a break for the next planned fire. This more diverse environment generally makes it more resilient to fire – a case of not putting all your eggs in one basket!

> A 'safe' plan is to use only small patches of fire within a remnant, to create a mosaic of vegetation of different ages which maximises the resources for fauna and makes the remnant more resilient to fire.

EFFECT OF FIRE ON NATIVE FAUNA

Fire may kill some animals, whilst those that survive by sheltering in burrows may die of starvation or predation soon afterwards. If the remnant is connected to or near other bushland, then recolonisation can occur. If the whole block is burnt and migration is not possible, the animal may go locally extinct. Hence, burning small patches within a remnant to create a mosaic of different ages will allow animals to persist in an area.

The fire frequency that favours particular animals varies considerably from animal to animal. Some animals require long unburnt vegetation, for example, mallee fowl which require leaf litter for nest building are more common in mallee and broombush which has not been burnt for more than 40 years. A study in the Fitzgerald River National Park found that capture rates of honey possums were low for four to five years after a fire and peaked at 30 years - this pattern follows the amount of cover available.

Winter fires will disrupt the breeding cycle of some animals and spring fires may kill some young animals, for example nesting birds.

Hollows are also very important. Ironically, fire consumes hollows in trees and logs on the ground, and it creates them. Many animals including bats and 18% of Australian birds have been shown to use tree hollows for nesting or cover; numbats and some lizards need hollow logs on the ground. For these animals, the effects of fire can improve or destroy the habitat that they require. To save hollows, you may need to remove any debris that has accumulated against the trunks of favoured trees and around logs on the ground.

EFFECT OF FIRE ON SMALL REMNANTS

Disturbance is a key factor in opening up the bush to change, and fire is a major disturbance.

Small bush remnants are very often isolated and subject to far more disturbing factors than they would have suffered prior to European settlement, putting the natural communities under great stress. They are less resilient and often degrade to a simpler community.

Generally, the greater the 'edge-to-area ratio', the more effect the stress factors will have and the more quickly the bush is likely to degrade. Linear strips such as roadsides are the classic example.

Weeds

Having opened up the bushland it is very easy for weed invasion to occur at the edges and quickly cover the whole patch. Many introduced plants – especially pasture and crop weeds – enjoy disturbance and will displace native disturbance opportunists such as everlasting daisies. Similarly perennial/woody weeds, such as tagasaste, will displace shrub species.

This leads to a change in community structure, which will provide different resources for fauna and in turn respond differently to fire.

Many weeds will change the fire's characteristics including its readiness to burn, how easily it will spread, and the temperature at ground level. Bunch grasses which evolved in southern Africa under a regime of annual burning (eg African love grass, tambookie, veld grass), cause a massive change in the fire response when they come to dominate the ground layer of Western Australian communities. Veld grass in banksia woodland is a good example of this bad problem.

You can use the period immediately after a fire, (whether the fire was planned or unplanned) to undertake control of some difficult perennial weeds such as African love grass or bridal creeper. They will respond to the fire with rapid growth from underground reserves, often before native plants have started to resprout or seeds to germinate. Thus they can be hit immediately with a knock-down herbicide, without danger of damaging desirable native plant regeneration. In addition, because the fire opens up

an area, it is easier to reach dense infestations, and to locate all sites for control work.

WHEN NEVER TO USE FIRE FOR REGENERATION

When the soil is buried by wind-deposited material

Sometimes the natural soil surface (including rootstocks) is covered by a non-wetting layer of soil (usually sand), straw, weed seeds and sheep droppings blown in from an adjoining paddock. This prevents heat cracking the buried seeds and the chemicals leached from combustion products from reaching seeds and so stimulating germination. Buried rootstocks will often not regrow. Such a site, very common along sandplain roadsides, is gone for ever.

During or immediately after a severe drought

In this case, the plants are already under extreme stress and being forced to regenerate could totally exhaust those that resprout from lignotubers and so lead to death. Similarly there may not have been good seed set in previous years. Give the bush a couple of years of average conditions in which to recover.

When a locust plague is predicted for the following year!

SOME MANAGEMENT PRINCIPLES

The correct use of fire can stimulate regeneration and regrowth in bushland, thus creating habitats for fauna.

There is no need to "tidy up" the bush; some standing dead vegetation is beneficial in your bushland, providing habitat for many animals. As a general rule, if more than fifty percent of the understorey shrubs are dying or dead, the area is ready for a regeneration fire.

Successful regeneration of reseeder species is dependent on the availability of viable seed. Before burning an area of bushland, monitor the plants over the previous year to ensure that they have produced viable seed. Not all plants produce seed each year and this can affect the success of the regeneration. Other species may be able to regenerate from soil seed stores. Knowing your plants can help to plan a successful regeneration burn.

If all the shrubs are gone (eg after a long period of grazing or a long period without fire) some of the small seeds which could have been stored in the soil may be absent. You may need to introduce more seed into the system, preferably from a similar site nearby. The best way to test this out is to set up a small trial area and monitor regeneration.

Similarly, if there is not sufficient woody debris on the bushland floor, it may not carry a fire of sufficient intensity to promote regeneration of seeds such as wattles or peas, which are stored in the soil seed bank for many years.

A mosaic of small patch burns will create a greater variety of habitats for animals and allow them to recolonise an area as it regenerates. It will also prevent major losses to the bushland's resource if detrimental climatic events occur after the fire. If this is not possible, a combination of 'heap burns' (bonfires) and direct seeding is recommended, on-going in different locations every year (see Fig 5).

Aboriginal people used to burn bushland to *attract* grazing animals. Heavy grazing pressure can undo all the good the regeneration burn has done! Therefore after using fire, check immediately to ensure that fences are intact and stock excluded. Rabbits need to be controlled and in some instances (and under a specified management plan) kangaroos culled.

Follow the prohibited and restricted burning times for your area. Remember, nothing said here can override a landholder's responsibility under the Bushfires Act and the Fire and Emergency Services Act. You are obliged to keep the fire under control and on your property. If it escapes you could be answerable for the damage caused.

Essentially, to keep your bushland healthy, planned fire is a management tool you may need to consider. But before you get out the matches, work through the attached checklist.

Whatever strategy is chosen, there will inevitably be gains and losses. Though we may plan as well as we can, the result of fire in your small remnant is in the lap of the gods!

A cautionary tale - fires can be deceptive. A landholder reported:

"On a cool May morning I lit a small fire on a 2.5ha block of bush. It burnt slowly and gradually went out. Thinking this was a very good result, I went off to town for about three hours. On returning, I found a blaze that required neighbours and the volunteer fire brigade to attend."

'Hot' fires severely damage existing trees and can affect fauna. In relatively small remnants they are neither practical nor desirable. Piling dead material into low heaps and then burning them can create the same effect in a manageable way.

Fig 5: Brushing on ashbed trial, Muresk College of Agriculture. A 'tidy-up' bonfire was burnt on this site, then a week or so later, a seed-bearing branch from a nearby York gum was placed onto the ashbed. Three years later, this vigorous young tree is the result.
Photo: P. Hussey

Small Remnant Fire Management Checklist

1. *What do you hope to achieve by burning this bushland?*
   - ☐ protection of human property from wildfire?
   - ☐ promote regeneration of the vegetation community?
   - ☐ or both?

   The answer will dictate what type of fire you use.

2. *Does the whole remnant need to be burnt, or will a smaller burn satisfy the objective?*
   - ☐ whole remnant
   - ☐ smaller burn

   A smaller burn minimises the possibility of irreversible ecological failures (eg should a severe drought occur in the seasons following the fire).

3. *Can small areas be burnt over several years to create a mosaic of vegetation of differing ages?*
   - ☐ yes
   - ☐ no

   Vegetation at different stages of growth is ideal for the maintenance of resources for fauna.

4. *Is the remnant connected to other remnants by a suitable bush corridor?*
   - ☐ yes
   - ☐ no

   This will influence how fauna can get away from the fire, or return to regenerating areas.

5. *If it is not connected, can a bush corridor be planted prior to any burn being undertaken?*
   - ☐ yes
   - ☐ no

   Consider the needs of, for example, small birds, and design the corridor to facilitate their movement.

6. *Are the major plant species setting seed?*
   - ☐ yes
   - ☐ no

   If not, regeneration will be impeded. Allow twice the length of time to first seeding of the slowest growing plants for an appropriate interval between fires.

7. *Are there weeds in the bush?*
   - ☐ yes
   - ☐ no

   Control prior to the burn.

8. *Is there a nearby source of weed seed?*
   - ☐ yes
   - ☐ no

   Leave a buffer between the source of the seed and the area to be burnt.

9. *Is spread of Phytophthora or other plant diseases possible?*
   - ☐ yes
   - ☐ no

   Take appropriate precautions.

10. *Is Declared Rare Flora, Threatened Fauna or a Threatened Ecological Community present?*
    - ☐ yes
    - ☐ no

    Consult CALM.

11. *Are there special flora/fauna habitat features present, eg a wetland, or hollows in logs or trees?*
    - ☐ yes
    - ☐ no

    They may need to be specially protected.

FURTHER READING

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Fire Management Plan
Name of bushland: .....

OBJECTIVES

ISSUES

Problem	Solutions

PLAN OF ACTION

What	Who	When

MONITORING AND EVALUATION

What	Date	Results

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FloraBank

GUIDELINES 5

SEED COLLECTION FROM WOODY PLANTS FOR LOCAL REVEGETATION

Australian National Botanic Gardens

Natural Heritage Trust
Helping Communities Helping Australia
A Federal Government Initiative

Bushcare

Greening Australia

CSIRO
FORESTRY AND FOREST PRODUCTS
Australian Tree Seed Centre

What constitutes a good seed collection strategy depends greatly on the ultimate purpose for planting vegetation. In a short guideline such as this we cannot cover all the possible purposes. This guideline focuses on collecting good quality seed from woody native plants for use in revegetation. It is primarily intended for people who carry out revegetation, regeneration or the rehabilitation of degraded sites in their local area. The situation for non-woody plants such as native grasses and sedges can be more complex and less is known about how we should approach seed collection strategies; however, the principles outlined in Brown and Briggs (1991) are a useful starting point.

This guideline provides you with a working approach to issues about provenance (seed origin), collecting local seed, and using non-local seed. We provide collection strategies that aim to maximise the genetic quality of the seed you collect for the purpose you have identified.

Good quality implies that seed has been collected in a sustainable way from a known, well-documented location and contains the same levels of genetic diversity and viability as the plants from which it was collected.

Revegetation work is a long-term investment and it pays to get it right at the beginning. The seed used in the initial stages will greatly influence success. The initial genetic material cannot be changed unlike, say, management and tending activities, which may be refined over time to improve on poor establishment. The collection of good seed from an appropriate source is of fundamental importance and may ultimately determine the success or failure of a planting program. Seed is a relatively low-cost item compared to other establishment and management activities; that is, the cost of planting is the same whether you use high or low quality seed, but the consequences of using poor quality seed can have dramatically disappointing results.

FloraBank promotes ecologically sustainable collection practices so that seed is not over-collected from any population and damage to the natural environment is minimised.[1] FloraBank has developed a Model Code of Practice to provide guidance to community seed collection operations and seedbanks on these issues. The collection of native need is covered in detail in FloraBank Guideline 6, *Native seed collection methods*. Information on plantings involving rare and threatened species is given in *Guidelines for Translocation of Threatened Plants in Australia* and *Germplasm Conservation Guidelines for Australia* by the Australian Network for Plant Conservation.

[1] Seed collection is not benign and even the best collectors may cause some damage to plants.

Provenance

The term provenance is used to refer to seed collected from a natural population. Provenance collections are distinguished from cultivated seed sources such as plantations or ornamental plantings. The latter are usually referred to as 'seed sources' or in some cases the term 'land race' is used (see Eldridge *et al.* (1993) for more information). It provides a basic approach to describe genetic diversity below the species level. Provenance is also used to describe patterns of genetic variation exhibited by a species over its geographic range. These patterns are often closely associated with the ecological conditions in which the species has evolved. When a number of provenances of a species are planted out at the same site it is usual to find differences in survival and growth performance (and possibly other characteristics) between provenances. Because the patterns of genetic diversity can be difficult to quantify and delineate, provenance is difficult to define in a precise geographical way. Provenance is a very useful starting point for plant breeding but it is also an essential concept in seed collections for other purposes. Provenance provides information on genetic diversity which enables decisions to be made about how a seedlot should be used or its suitability for particular purposes.

Collecting locally is usually best

Collect seed *as locally as possible* from natural populations for use in revegetation and rehabilitation plantings wherever possible, having regard to a range of plant and planting site characteristics and how they may change as we move further away from the local area to collect seed. This is a precautionary approach, in the absence of detailed information on gene flow and genetic diversity.

Naturally occurring remnant vegetation is usually the best source of material for revegetation. Generally, in these natural communities, plants have evolved to suit local environmental conditions and have a desirably broad genetic base. Ecologically and genetically, local seed complements other plants and animals in the area, and poses the least potential threat of genetic contamination.

Local collection for revegetation projects has many benefits:

- Local plants will be naturally adapted to local conditions. This is important for establishing new plant populations and many seed users have practical experience of better performance from local plants in terms of survival and growth.
- Using local plants will promote genetic and ecological sustainability of local vegetation. In so doing, the genetic integrity and unique characters of vegetation remnants are maintained, thereby enhancing biodiversity.
- Use of local plants reduces the potential for hybridisation between the cultivated species and other species in surrounding areas.
- Using local plants and keeping long-term records about collection localities builds on the capacity to collect, use and better manage the vegetation that grows in the local area.
- The use of local plant material is vital to the rehabilitation of important conservation areas or where there is likely to be interaction with local wildlife.

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

As well, local plants may only occur in small and isolated or fragmented remnant patches, or as isolated individual plants in cleared land. Dieback, salinity or other environmental pressures may affect them. Seed crops may be negligible due to poor pollination, growth may be poor and the survival prospects bleak. It may be difficult to collect sufficient seed from local plants.

What is 'local'?

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

In extreme circumstances it may be necessary to combine (or bulk) seed from a wide area to provide sufficient quantity or sufficient genetic material for long-term viability in the replanted population, but this should only be done with expert advice.

What characteristics should you look for?

By observing and gathering information on factors known to influence variation in plants you can make more informed decisions about whether to collect seed of a certain species from a certain site for use in local revegetation. Compare notes about these characteristics with other collectors, botanists and 'bushies'.

The *main factors* to observe are the environmental conditions present at the site when collections are made. We know that plants adapt naturally over long periods to these conditions and they may be very relevant to the distribution pattern of a species. Some species, such as River Red Gum, occur mainly in narrow, almost continuous bands along watercourses and may not vary over a section of a stream, a whole tributary or even a complete river system. Other species, such as Snow Gum, occur on mountain slopes at different elevations and may not vary over a range in elevation.

Try to closely match conditions present at the planting site to those of the collection location. To do this, you must keep accurate records about the collections and where and how the seed is used. You can't tell by looking at the seed (with rare exceptions) where it has come from, so your only link is through the records you keep. See FloraBank Guideline 4, *Keeping records on native seed*, for a full description of what records to keep and how to keep them. In addition, such information, when linked with the performance of subsequent plantings, can help determine the best seed sources.

It is fundamental to record the species, collection site, number of plants sampled, date and collector.

You should consider (or use a system that is based on and records) the following factors at both seed collection and planting sites:

- latitude
- altitude
- position in the landscape (ridge, mid-slope and so on)
- soil type
- vegetation type
- average rainfall and spread throughout the year
- average temperature and maximum degrees of frost.

The *Australian Soil and Land Survey Handbook: Field Handbook* (McDonald *et al.*, 1998) is a very detailed, standardised approach to field data capture, well suited to this purpose. Much of its content can be simplified to suit the end-user. Some mapping may already be available for your region to make the task easier. At the broadest level, bioregions and subregions have been defined for Australia and are useful. At a much finer level of resolution, land systems are a well accepted approach to classifying broad variation in the landscape as a composite of soil, vegetation, landform and climate – see the *Australian Soil and Land Survey Handbook: Guidelines for Conducting Surveys* (Gunn *et al.*, 1998). Land systems may already be identified for your region (typically at 1:50,000 scale) by State agriculture, environment or land management departments. The Forestry Tasmania Eucalypt Zoning System provides a system for consideration by Tasmanian collectors and is based on altitude, dryness and coldness factors.

There are three *lesser* factors to observe, but they are generally less obvious and therefore less useful than the above.

- Species breeding systems are a key to variation, though you need botanical skills to understand and identify these. Pollen dispersal mechanisms, seed shape, size and weight, fruit and seed dispersal mechanisms and the viable life of seeds may all have a significant

bearing on plant variation. For example, catchment boundaries may form 'divides' for species that disperse their fruit or seed in water whereas this may not be the case for those that are dispersed by fauna, birds or insects. The extent of outcrossing (mating among unrelated plants of the same species), self-fertilisation (pollination of an individual plant with its own pollen), or a mixture of both, affects gene flow between populations, which in turn determines how genetically different one population will be from the next. Gene flow is a major factor in determining differentiation between populations and thus affects the delineation of provenance boundaries.

- The pattern of distribution of the species is useful as a guide. If a species occurs continuously over an extensive area of fairly uniform environmental conditions there is likely to be minimal provenance variation and geographically large provenance boundaries. So, one may more confidently collect from further afield. By contrast, where a species has a similarly extensive range but is fragmented and environmental conditions vary greatly, there is likely to be considerable provenance variation and geographically narrow provenance boundaries. So, it is generally less likely that plants from further afield will be similar. Species confined to drainage lines or river systems may have less provenance variation within a catchment than between catchments.
- Variations in plant form, structure and function are sometimes obvious to the naked eye; for example, dramatic variations in flower, fruit or seed size, plant structure or growth habit. Botanical classifications (taxonomy) sometimes recognise such variations in plant form or function within species. Classifications of genus and species are always changing and even in common genera such as *Acacia*, new species are recognised. If the form, structure or function of a species shows marked variation from those of the local area, they cannot be considered as local plants.

Know your plants well before you collect

If you decide to collect seed yourself you will need background information on the target species. Can you accurately identify the target species and its flowering, seeding and seed ripening times? You usually need to travel about to obtain exact location details and to assess seeding times.

Gather and file information on the target species for collection including:

- botanical description
- identifying keys
- distribution
- occurrence in the local area
- flowering, fruiting and seeding times (including seed ripening period)
- fruit or seed located within hand's reach (two metres) or above
- approximate numbers of fruit per plant
- approximate number of seeds per fruit
- uneven fruit ripening on single plants
- safety precautions (allergenic or poisonous plants).

This information will be a valuable resource for future collections if it is kept up to date. Detailed information can be sought from regional and state herbarium records, field botanists, foresters, beekeepers or other seed collectors on identification and variability of species, flowering and seeding times and population locations.

Correct species identification is vital and you should also be aware of variation in appearance of the species. Several excellent field guides are available (see references). If you are in doubt, forward a botanical specimen (leaves, fruits and flowers or buds

pressed between sheets of newspaper or blotting paper) together with a description of the tree's location, size, general appearance and bark to your nearest herbarium for checking. Taking a voucher specimen for all collections is good practice as taxonomy of the species may change over time and labelling errors can also occur. However, the more seedlots you collect, the more work this creates and the more space is required for storage.

Obtain the best genetic quality possible

The seed collected from individual plants is usually combined or 'bulked' together to form a seedlot and mixed to an homogeneous blend. Similar quantities should be collected from each plant so that no individual is favoured or under-represented in the genetic make-up of the seedlot. The way we sample individual plants at the collection location strongly influences the genetic quality of seed collected. Here are five important things to watch for in the way you collect:

1. Ideally, look for local plants that are in healthy and viable natural populations and are large enough to provide sufficient seed by sustainable and responsible collection methods. Carefully assess populations prior to seed collection. Be aware that, in some instances, what appears to be 'natural' vegetation in State Forests, reserves and road verges has been planted in the past.
2. Ensure the target species is uniformly distributed, with a mature seed crop of preferably at least moderate quantity.
3. Make sure of plant identification. If there are any doubts about identity it is essential to keep seed separate until it can be accurately identified from a voucher specimen.
4. Collect seed from at least 10 to 20 widely spaced, healthy parent plants (not diseased) across the population.
5. Wherever possible, aim to collect from genetically unrelated plants, thus increasing the capture of genetic variability of the population; that is, from plants that are unlikely to be breeding with one another. This may be difficult for many reasons – and be aware that even in large, natural populations there may be high levels of inbreeding and genetic structuring. It has been demonstrated that seed with high levels of inbreeding can produce progeny with reduced survival, growth and capacity to contend with environmental stresses. So, it is important to keep two things in mind and follow some basic guidelines:

- *Closely spaced, neighbouring plants are likely to be closely related.*
  Collect seed only from plants separated from one another by a distance of at least twice the plant height. This means you should collect from trees spaced at least 100 metres apart and shrubs at least 50 metres apart. In addition, consider the impact of pollen dispersal distances and transport mechanisms (wind, water, insects and so on) between plants.
- *Isolated plants are less likely to breed with other unrelated plants*
  Avoid collecting from reproductively isolated individual plants, even if they carry heavy seed crops. If you don't have any option but to collect from isolated plants, then make sure you bulk this seed with that from other local plants (of that species) to achieve increased genetic diversity in the mix. Also consider taking cuttings for propagation purposes as these are a genetic copy of the parent plant.

Use responsible collection practices

You should ensure that ecologically sustainable collection practices are used and seed is not over-collected from any site or population. Seed collection should not jeopardise the natural functions of a population; for example, its regeneration after fire. Damage to the natural environment should be kept to the very minimum possible. Ensure that vegetation is not unnecessarily damaged or understorey plants trampled. Nesting sites, tree hollows and other recognised animal habitats should not be disturbed.

Collect no more than 20 per cent of the seed crop or fruit on any individual plant. Remove no more plant material (branches and so on) than required. Collectors should adjust these guidelines downwards in circumstances where this quantity might adversely affect a population; for example, where other collectors have taken seed prior to your arrival. If more seed is required, increase the number of individuals you sample. In some areas there are limits to the resource for collection and this must be recognised.

FloraBank has produced a *Model Code of Practice for community-based collectors and suppliers of native plant seed* in the interests of promoting responsible collection practices. We strongly encourage you to adopt this Code or a version of it tailored to your needs. It communicates important messages about the ethics, standards and practices of seed collectors.

Selecting non-local seed

Seed of non-local species may be required when local site conditions have been highly modified and the original or local vegetation will no longer grow. For example, reduced growth may be due to extreme salinity or acidity or changes in insect and animal predation. Revegetation (at least initially) may depend on using species that are unaffected by, or tolerate, such conditions. Certain rainforest species are notoriously difficult to re-introduce to cleared land without some initial protection – sometimes provided by non-local species. In other cases, amenity or commercial considerations may encourage the use of non-local species.

When using or collecting non-local seed (not local provenance) a rule of thumb is to obtain seed from other areas (other provenances) with environmental conditions that most closely match your planting site (see above).

The most important environmental characteristics to consider in matching origin and planting sites are:

- average rainfall and rainfall seasonality;
- mean maximum, mean minimum and absolute minimum temperatures; and
- some basic soil attributes such as texture and pH.

If you are not in a position to collect non-local seed for yourself, there are commercial seed collectors and suppliers who stock well documented, genetically representative seedlots. Many collect seed using good seed collection protocols and, if they do not have your target provenance in stock, they may be contracted to make collections to your specification. A list of Australia-wide government and private seed suppliers is available at the Australian Tree Seed Centre website (www.ffp.csiro.au/tigr/atscmain/index.htm) or through the Yellow Pages.

It is important to provide any contracted collector with a specification that includes the species and locations for collection, the minimum number of plants and the spacing between plants. Appropriate documentation for the seedlots should be provided by the collector.

Collections from planted sources

Seed production areas and seed orchards are an alternative source of good seed for planting programs. Seed production areas refer to plant populations established with the primary or secondary objective of seed production. While dedicated seed production areas (and seed orchards) are still uncommon, it is more likely that some stands of existing revegetation in your area are used for seed harvesting. You should avoid collecting seed from planted trees unless you know that they can be used for seed harvesting. This means that the seed origin is known and it originated from preferably 10 to 20 plants sampled according to the guidelines above. Of paramount importance is the standard of genetic integrity of seed produced from these stands.

Seed production areas are becoming more common and, if managed well, are a viable option for sourcing local as well as non-local seed for revegetation programs. Seed production is much like other long-term horticultural or forest crops, with the exception that we know relatively little about the cultivation and seed production capability of many native plants. Good production requires careful planning, management and harvesting (see FloraBank Guideline 7, *Seed Production Areas*).

Bibliography and references

FloraBank is seeking to assist in the training of collectors and revegetation practitioners and we are very interested in your feedback on the usefulness of this guideline and any further requirements you may have. Readers are encouraged to access the following references. Many provide a wider range of information on seed collection methodology and protocols than the brief outline given above, others provide information on topics such as seeding times and assessment of soil characteristics.

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Your Comment

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

Written by Warren Mortlock and the Australian Tree Seed Centre

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FloraBank

GUIDELINES 6

NATIVE SEED COLLECTION METHODS

Australian National Botanic Gardens

Natural Heritage Trust
Helping Communities Helping Australia
A Federal Government Initiative

Bushcare

Greening Australia

CSIRO
FORESTRY AND FOREST PRODUCTS
Australian Tree Seed Centre

Seed collection is an activity that can be undertaken by people of all ages and skill levels, and can be very satisfying. Any robust person with some basic knowledge and equipment can easily and inexpensively collect native seeds. For those involved in community revegetation projects, seed collection is a great way to learn more about the plants being used and gives communities greater ownership of all stages in the revegetation cycle.

However, collecting native seed on a larger scale (for example, in every season and for a wide range of plants) is a demanding endeavour. Making such an activity cost-effective adds an extra element of difficulty. There may be many natural, logistical and bureaucratic hurdles to overcome – one could spend a lifetime learning to collect native seed efficiently in one region; only a handful of people can do it for the plants of their whole State, or of Australia.

This guideline provides an overview of how to approach seed collection and the manual and mechanical collection methods that can be used. It stresses the importance of preparation and planning for seed collection and the need to collect mature seed.

We assume that you already have some experience of collecting native plant seed and a basic knowledge of how to accurately identify flora in the field, understand plant reproduction, seed biology and ecology, and when and where to collect seed. You can find out more about these subjects from various sources, such as standard botanical references, textbooks, field keys and local knowledge. There are also other guidelines from FloraBank that provide important information about seed collection. They include:

- Guideline 4: *Keeping records about native seed collections*
- Guideline 5: *Seed collection from woody plants for local revegetation*, and
- *Model Code of Practice* for community-based collectors and suppliers of native plant seed.

Planning ahead

Detailed early planning of the seed collection trip is essential. Planning can help overcome natural difficulties to collection (for example, seed located in tall trees, unpredictable seed maturation or sporadic seed set). Planning can also help avert any bureaucratic or logistical problems that could be encountered ahead of collection (for example, that sufficient people and resources are on hand to harvest in the naturally short collection window presented by nature, or that you are adequately equipped to collect in remote or difficult to access areas).

No amount of planning can change seasonal conditions, such as naturally poor seed viability, lack of rain or high levels of seed predation by insects, but planning can ensure you are aware of these conditions and that you respond well to them.

For small collections all you may need is a standard approach and a checklist of equipment, but detailed planning is required for large collections at remote sites. Your objectives should be clear and detailed to a level where you can match them up to resources at your disposal.

Make sure you get and give adequate notice.

Collectors need to be given adequate notice from seed users to properly plan collections and guarantee seed availability. Collectors require at least six months', but 12 months' notice is preferable.

Target species for collection

You should have a very clear idea of the species you wish to collect and which of those are priorities. To develop such a list you need to consider the purpose for collection and any specific requirements.

You should include a variety of shrubs, trees, ground covers, native grasses and wetland plants in your species list.

You may be able to obtain seed of the species you require through commercial or amateur collectors and suppliers. Those you cannot obtain reliably from other sources become your target species for collection.

Learn about the species you collect

You should gather as much information as you can on the target species you intend to collect, including:

- botanical description
- identifying keys
- distribution
- occurrence in the local area
- flowering, fruiting and seeding times
- whether the fruit/seed is located within hand's reach (2 metres) or above
- approximate number of fruit per plant
- approximate number of seeds per fruit
- approximate time from maturity to seed shedding (weeks, months)
- whether there is uneven fruit ripening on single plants
- safety precautions (allergenic or poisonous plants)

Detailed information on identification and variability of species, flowering and seeding times, and population locations can be sought from regional and State herbarium records, field botanists, foresters, beekeepers or other seed collectors. Keep the accumulated information together and add your own field observations. This will be a valuable resource for future collections if it is kept up-to-date.

Correct species identification is vital, so you should be aware of the natural variability in appearance (morphology) of the target species. Several excellent field guides for various parts of Australia are available (see Bibliography and references). If you are in doubt about identification, forward a botanical specimen (leaves, fruits and flowers or buds pressed between sheets of newspaper or blotting paper) together with a description of the plant's location, size, general appearance and bark to your nearest herbarium for checking. Many Botanic Gardens, herbaria, TAFE colleges and some community groups run plant identification workshops which provide a good introduction to field identification.

Competition in collection

Seed collection is a way of life and a source of income for many people. There is a very healthy commercial seed collection industry in Australia. Information on collection locations, species collection times and other important background knowledge provides the commercial edge for many of these people, so don't be surprised if some are reticent to share this type of information with you.

Decide how much seed to collect

You should decide how much seed you will need of each species and the likely number of plants that will need to be sampled to obtain this amount. In good seeding years it may be desirable to collect more than your current requirements and place the extra in storage for the poorer seed years. Remember that seed put in storage must be fully mature and handled with more care during the extraction processes.

Decide where to collect

FloraBank Guideline 5: *Seed collection from woody plants for local revegetation* stresses the importance of using local indigenous plants in revegetation and rehabilitation work. These provenances complement other plants and animals in the area (ecologically and genetically), and pose the least threat of genetic contamination.

It is also important in revegetation work to match the environmental conditions at the collection site to those of the planting site. Guideline 5 covers seed quality and which plants are best for collecting seed.

Suitable collecting sites should be identified through a combination of local knowledge, publications and advice from staff from relevant organisations (such as State herbaria, national parks, and State and local government departments). You might also refer to books that show species distributions and botanical surveys (conducted, for example, as part of an environmental impact assessment on major development projects). Conduct field reconnaissance to determine the exact location of your target seed population. Where plant densities are low (a few plants per hectare), you may want to mark the location of individual plants on maps or by using a handheld Global Positioning System (GPS) instrument.

Obtain permission from landowners and local authorities, and according to State legislation. Permits are required for collecting on public land and also for some species on private land. Initial enquiries can be directed to the following:

- Queensland Environment Protection (formerly the Department of Environment) and Department of Primary Industry
- New South Wales National Parks Service and State Forests
- Australian Capital Territory Parks and Conservation Service
- Victorian Department of Natural Resources and Environment
- South Australian State Vegetation Committee
- Tasmanian Parks and Wildlife Service, and Forestry Tasmania
- Western Australian Department of Conservation and Land Management, and
- Northern Territory Conservation Commission.

Alternatively, contact your forest service or State herbarium.

You should find out the conservation status of the species and whether special permission is required to collect its seed (for example, in the case of declared rare or endangered flora).

Seed collection opportunities sometimes arise in association with forestry operations, land clearance, road realignment and major building or construction projects. You should keep a regular watch on such operations through contacts at your local council or in State government. Be aware that the collection rights to these areas may be allocated exclusively to particular collectors via public tender or other processes.

Decide when to collect

In a good year, seed quality is better than usual and harvesting is easier. Early spring to late summer can be an especially busy time for collectors. Decide when to collect by first checking the literature for guidance on flowering and seeding times, and talking to knowledgable locals. Some publications now show seed collection times and can be of great assistance (for example, Bonney 1994).

Each collector should build up a record of collection times over a period of years. From these records, a monthly seed collection schedule may be drawn up as an indicator for the future, although from year to year, seasonal factors may cause variations in flowering, seed set and ripening times.

In most cases there is an optimum time for collection, but a margin of weeks or even months may be available. If possible, visit plant populations regularly to check on seed ripeness and availability. It is especially useful to build up records of those species that keep seed on the plant for longer periods. This helps in planning a single visit to a location at a convenient time for collection and allows for seed from many species that retain seed to be collected at that time.

Some species ripen and shed seeds within a few days (for example, some Grevillea species). Here the greatest problem is missing the seed fall altogether, so frequent reconnaissance is required to check for seed ripeness. More collectors are often needed to obtain the quantity of seed required, and seed is more likely to be picked while immature. Allow for the fact that heatwaves and bursts of hot windy weather can accelerate ripening and seed drop in some species (for example, wattles).

Opportunistic seed collection is necessary where seed set is irregular or heavily influenced by seasonal factors. For example, many native grass species commonly produce seed after summer rain but are less reliable in the cool season. Maturation of seed on a single plant and single seed head is uneven. Harvesting is best undertaken when some seed is beginning to drop but most is still attached. A delay of a couple of days may mean most seed is lost to the ground (Reu 1996).

Because of the difficulties in obtaining good seed set information, it is worth observing and making a few notes about the flowering and seeding of non-target species for a time when they may be needed. Notes on the field collection sheet about associate species can serve this purpose.

Types of fruit and seed

Woody capsules:
including the genera Angophora, Callistemon, Eucalyptus, Leptospermum, Melaleuca.

Papery capsules:
including the genera Bursaria, Convulvus, Dodonaea, Lomandra, Wahlenbergia.

Seed pods:
including the genera Acacia, Brachychiton, Daviesia, Dillwynia, Glycine, Hardenbergia, Indigofera, Jacksonia, Pultenaea.

Drupes:
including the genera Acmena, Astroloma, Eleocarpus, Persoonia, Leucopogon.

Berries:
including the genera Atriplex, Dianella, Polycias, Tetragoni.

Seed follicles:
including the genera Hakea, Grevillea and Banksia.

Nuts:
including the genera Baumea, Carex, Cyperus, Eleocharis, Ghania, Isolepsis.

Grains:
including the genera Spinifex, Stipa, Themeda, Danthonia.

Achenes:
including the genera Bedfordia, Bracyscome, Helichrysum.

Cones:
including the genera Cyprus, Casuarina, Allocasuarina, Exocarpus.

Collect mature seed

It is essential that fully mature (ripe) seed be collected. This can be difficult. It requires the collector to determine when the seed is mature and to time the harvest accordingly. The interval between bud formation and maturity of seeds and fruits varies greatly (even between species in a single genus) from a few weeks to as long as several years. Many trees and shrubs (for example, Acacia, Grevillea and Cassia) shed their seeds within weeks of maturity, while others retain fruit and seed for months (for example, Casuarinas) or years (for example, some of the ash group of Eucalyptus). The latter may build up a large store of seeds.

The number of flowers and fruits produced may vary greatly from year to year and from stand to stand of trees, and is both genetically and environmentally controlled. Some species show genetically determined cycles in the timing and number of seeds they produce and have big seed years when bumper crops are available for collection. Local environmental factors such as rainfall, insects and fungi can modify this cycle.

Signs of maturity

Crop maturity varies over the natural distribution of a species due to factors such as latitude, altitude, distance from the coast, and weather conditions during flowering and seed set. Determining maturity is often based on experience. Good records of past collection times are, of course, a great assistance.

Characteristics to observe include the size and colour of the fruit, whether the embryo is firm and swollen and whether the seed coat collapses when cut.

Capsules, seed heads or cones in many species change colour near to maturity (often from green to grey or brown) and reach full size, turn dry and woody when mature.

In Eucalypts the seed may be viable prior to capsule maturity but is not released until the capsule is mature. Cutting Eucalypt capsules (gum nuts) through the middle with secateurs will expose the seed, which will be coloured brown or black if ripe. Most eucalypts can be collected if the capsules are brown and the outlines of the valves are readily visible on the top. Look for seed that has already been shed from mature fruit as this indicates that other fruit is mature. Alternatively, place a sample bag of fruit in a warm place. If seed is shed from the fruit within a couple of days, they are ready for collection.

Capsules, pods, follicles and cones usually open or split on maturity, allowing seeds to be shed and dispersed by wind and other agents. Some capsules, follicles or cones form discernible valves when the seed is ripe.

Pods and papery capsules become dry and brittle as they mature, as do seed heads that contain grains, nuts and achenes.

Pods of some species burst open when dry and discard seeds away from the plant. Collect these pods just as they change colour. Acacia (wattle) seed may be mature before the pods open and, while some species will hold their seed even when the pods have opened, it is better to make the collection just as the pods are opening. Some seed may be lost but it will be a lot easier to extract the remainder. The extraction of mature seeds from green pods requires greater effort.

The ease with which the grains, drupes, berries or achenes may be removed is also an indicator of maturity. They should release with gentle pressure when mature.

Fleshy fruits like those of many rainforest species soften, wrinkle and dry when they mature and sometimes also change colour (for example from green to red, orange, yellow, blue or black): this attracts fruit-eating birds and mammals which then act as agents for seed dispersal. Colour change is a good guide to seed maturity for Dianella, Santalum and Solanums. In many rainforest plants, seeds are fully mature (even germinated in some cases) before they drop from the tree. The seed from these species needs to be sown quickly after collection and cannot be stored even for short periods.

You can scratch the surface of the seed follicles of Banksia cones, which are soft and green when seeds are immature and turn brown and hard when the cones are ready for collection. Some species, such as some of the Banksias and Hakeas, require extreme heat (for example, a stint on the barbeque) to encourage the capsules to open and release the seed.

Get the right equipment and resources

The equipment you need depends on the frequency and quantity of your seed collection activities. Provided your safety is not compromised, you can 'make do' with less specialised equipment if you only occasionally collect small quantities of seed. However, it is not recommended that you improvise or make do with climbing gear. Specialised equipment makes collection easier and increases productivity if collections are more frequent and the amount of seed collected is large. Equipment needs also vary according to the type of vegetation. For example, you need more specialised equipment to collect from tall trees in wet forests than, say, arid-zone bushland.

You will need a sound (possibly four-wheel drive) vehicle that will get you to the collection sites safely and carry substantial loads if required.

Useful equipment

(More versatile 'standard' equipment is indicated with italics.)

- Trailer with high wire-mesh cage, or sturdy roof-rack with ladder
- Extension ladder, fruit-picker's ladder, climbing equipment and ropes
- *Telescopic pole pruner, pole and rope saws, aluminium extension pole (fruit knocker), throwing rope with weight*
- *Flexible saw, bow saw*
- *Secateurs, long-handled secateurs*
- *Kitbag, woolpacks, tarpaulins, fruit-picker's bags, calico drop-sheets, thin stockings or bags for enclosing plants*
- Petrol-driven garden blower/vacuum
- *Binoculars, hard hats, safety glasses, gloves*
- Bow and arrows, or catapult with line, or rifle and ammunition (with appropriate licences and permits)
- *Plant identification books*
- *Plant press, newspaper and boxes for specimens, tags*
- *Maps, compass,* handheld Global Positioning System (GPS) instrument
- *Field collection data sheets, booking boards and writing gear,* camera and film.

It may be worth developing your own checklist to suit the type of collections and areas in which you carry out most of your work.

Play it safe!

Safety is of paramount importance and amateur collectors should not be too ambitious in their collection activities. Think about safety and vary the precautions you take to suit local conditions, tree species and collection methods. Make sure that all equipment is in top condition and properly serviced. It is advisable to work as a team, wear safety goggles, appropriate clothes, safety hat and footwear; and take a first-aid kit. Seeds can often be collected safely from the ground or by using a stepladder, but if you plan to climb high trees, take extra care. For some people, tall trees may be too difficult to collect seed from safely and should be left to professional collectors. Defer to the experts or work with them when the going gets tough.

Seed collecting methods

Natural seed fall (seed traps)

Large seeds or fruits that fall to the ground when mature can be collected by laying tarpaulins or plastic sheeting beneath the plants. These sheets may be raised on purpose-built frames and funnelled into a container to retain the seed. This technique is useful with low shrubs, especially those that are prickly (for example, Acacia victoriae), and some rainforest species, but is unsuitable for species which have fine seeds that are dispersed by wind (for example, Eucalypts and Melaleucas). The technique is normally used when seed collection times are unknown and crops may be missed.

Drop sheets should not be used if there is a likelihood of seed from nearby plants (of the same or different species) contaminating the collection (see Guideline 5 on how to avoid sampling seed of neighbouring plants). Seed traps should be checked fairly frequently, as the seed is susceptible to predation and rotting if left for too long. Take care when clearing a trap, as it is possible for snakes or biting insects to take up residence!

Another technique is to collect seed as it dehisces by enclosing the plant fully or partially in breathable lightweight fabric (Murphy and Dalton 1996). The fabric is tied around the plant stem or branch and the bag left in place. This technique is useful for small shrubs and bushes that are less than a metre in height, especially at low plant densities and where seed is shed quickly or progressively over a period, or where shedding times are uncertain.

Both techniques suffer from insect attack (especially by ants) and wind can remove seed from drop sheets. Soil, leaf litter and other material must be sieved out to obtain pure seed and yields are often lower with drop sheets than by other collection methods. A drop sheet or enclosure bag, when left in place to collect seed, may free the collector for other work. For most collections you should not use plastic to store or transport seed or plant material as it causes the material to sweat and go mouldy. An exception can be made in the case of fleshy fruit where it is important that the seed does not lose its moisture.

From within hand's reach

Collection by hand

The safest and most advantageous way to collect seed is when it is within hand's reach of a person standing safely on the ground (usually fruits below two metres in height). Wearing a bag with a wide rigid mouth allows the collector's hands to be kept free. Seed from small plants low to the ground, or from low branches, may be easily collected by hand, though in some cases (such as with prostrate groundcovers) this process may be tedious and yield little seed. Try to collect from fruit in the middle or upper portions of the plant rather than the lower portions.

Plants with pods (Acacia, Davesia, Hovea, Kennedia, Lotus, Pultenea, Senna): Using gloved hands, strip pods from branches into a belly bag or container, or shake the plant to dislodge seed or pods and collect them on a drop sheet placed under the plant. With acacias for example, when the pods are brown and split along the margins, beat the branches with a stick. This will dislodge the seeds and pods, which will fall onto the drop sheet, which you can bundle for transport by tying its opposite corners.

Plants with woody fruits (Allocasuarina, Banksia, Callistemon, Callitris, Eucalypt, Hakea, Melaleuca): In most cases remove small branches or, where necessary, remove individual fruit using ordinary secateurs. Seed release and extraction is often easier if the capsules are left attached to small branches – secateurs are very useful for this purpose.

Plants with fleshy fruit (Dianella, Kunzea, Scaevola, Solanum): Pick fruit off the branches by hand when ripe.

Plants with seed heads, such as sedges (Gahnia, Lepidosperma), daisies (Olearia, Helichrysum and Cassinia) and native grasses (Microlaena, Danthonia, AstreblaThemeda, Bothriochloa, Dichanthium, Stipa): Strip seed heads off their stems by running a cupped hand along the seed heads in an upward motion, or cut them off with secateurs.

Mechanical harvesting

Perhaps the most widely used and versatile mechanical harvesters are the brush-cutter and the portable vacuum.

A brush-cutter is useful for the quick harvesting of native grasses (removing seed head from the stem), especially if fitted with some form of catcher. Alternatively, the cut material may be raked and gathered in a collection bag or vacuumed.

The petrol-driven garden blower/vacuum is a recent addition to the seed collector's toolkit. Some models duct incoming material through a macerating fan blade before depositing into the collection bag, others do not. It is generally better not to damage seed material as it is vacuumed but for some species this may be desirable. A portable vacuum is especially useful for collecting from small, low plants or those with profuse and fine seed, which may be easily vacuumed either from the plant or from the ground immediately below the plant.

Be careful not to contaminate the seed collection through inadvertent collection of non-target species. It is also very easy to over-collect from individual plants, leaving nothing for ecological function.

A quick method suitable for some Acacias is to lay a drop sheet in the back of a utility or trailer and back it up to one side of the tree, which is then shaken, or its branches knocked, to release the pods.

Mechanical harvesting of native grasses has developed rapidly in recent years. A range of vehicle-mounted techniques have been tried for harvesting chaffy grass seed direct from the plant. A common approach that has had limited success is a beater harvester, which uses rotating timber or metal paddles to knock seed off seed heads. In the last decade the advent of rotating brush harvesters has led to greater success. These use a soft brush that is upward rotating at the leading edge and has a collection box at the trailing edge of the brush. Some use a vacuum to deliver seed to a hopper box, which may then be located away from the brush. Brush harvesters may be mounted in front of a tractor or towed by a four-wheel drive vehicle. Another technique that may be useful is slashing and baling grass seed using a hay baler. For a full discussion of harvesting native grass seeds see Loch and Clark (1996) and Reu (1996).

From above hand's reach

Above two metres in height, a collector requires either a device to provide longer reach or an elevated platform to stand on.

Although a variety of long-handled tools (including saws) can be used, the most effective are long-handled secateurs. There are also telescopic pole pruners, but any pole longer than four or five metres is difficult and tiring to handle. Used in combination with a three-legged fruit picker's ladder, long-handled secateurs provide a range to about 10 metres. Pole pruners are difficult to use safely from a ladder, but are easier from a fixed roof-rack atop a vehicle.

Another widely-used tool is a lead casting weight (fishing tackle) attached to a strong braided nylon cord (25 metres of five millimetre sash cord or nylon rope) which is thrown over branches up to about 12 metres above the ground. Once the branch is 'lassoed' in this way, the collector has the option of pulling the branch down using the cord (if the branch has a diameter of less than 50 millimetres), or hauling a rope over the branch to do the same thing, or attaching a flexible saw blade to the line and sawing through the end part of the branch. A rope saw uses either a chainsaw blade or a flexible saw with a cord attached at either end. This method needs two operators, and branches may fall close by. Cutting causes much less damage to the plant and you have more control over the portion of the branch that is removed. It is more suited to horizontal branching habits. Branches that grow at narrow angles to the upright are less suitable.

Harvesting from trees above 10 metres is the most difficult and dangerous type of seed collection. You should wear a hard hat and safety goggles. Take precautions to avoid injury from falling limbs or fruit. Your options are to use a rope saw, bow and arrow or rifle from the ground, or to climb into the tree and use hand tools.

If you are not up to this, you can take advantage of clearing operations (forestry, development, mining, building, power line clearance) to collect seed. You may even collect seed from fallen branches following a wild storm or from the pruning operations (along roadsides and power lines) of councils and authorities. Trees should not be felled simply for harvesting seeds, however if a tree is being cut down for other reasons, any seeds present can be salvaged. In some districts, the easiest and cheapest way to collect large quantities of seed is to visit local clearing or timber harvesting operations. Obtain permission beforehand, select good parent trees and, of course, take care with safety. The quantity of seeds can be worth the effort. Seed in the heads of fallen trees will shed very quickly so it is necessary to keep up-to-date with operations in your area to avoid disappointment (for example, on a hot day in most coastal Eucalypt forests, seed will begin shedding within 12 hours of the tree being felled).

Using a bow and arrow is time-consuming and more suitable if trees are bearing heavily or are in high demand. Rifles are very effective for collecting small amounts of seed from a large number of trees and, for this reason, are commonly used in research collections. The technique is safe compared to climbing, but requires great care and specialised training as well as special licences and permits. The technique is limited to sparsely populated areas and it can be expensive (ammunition and rifle servicing costs). Climbing taller trees may be possible, but agility and special attention to safety are required. Common aids include climbing irons, safety belts and portable or mounted ladders. An extension ladder may be fixed to a tree to aid climbing up to about 12 metres into the first branches. Successful adaptations to caving and abseiling equipment have been made which have greatly increased the safety of climbing at the cost of outright speed. Climbing also brings the collector into much closer contact with falling branches. Great care is needed when removing seed-bearing branches from within the tree crown.

Preparing material for transportation

Collection activities may yield pure seed, fruit only, or leaves and branches with fruit attached. The latter may need to be cut, beaten or trampled to reduce its bulk for transport. A large crop should be bagged for transport. The CSIRO uses calico collecting sheets (two metres square) with corners tied diagonally; close-weave calico bags for small seeds; or hessian sacks for large seeds.

Avoid prolonged transport periods for green fruits, especially in hot weather, as the high moisture content encourages micro-organisms, fermentation and overheating. This can reduce the seeds' capacity to germinate.

It is essential to label bags and bundles carefully. The identity of each bag or container of plant material should be established by a collector's name or initials and a field collection number. See Guideline 4 for seed collection record-keeping details.

Bibliography and references

Florabank is seeking to assist in the training of collectors and revegetation practitioners and we are very interested in your feedback on the usefulness of this guideline and any further requirements you may have. Readers are encouraged to access the following references. Many provide a wider range of information on seed collection methodology and protocols than the brief outline given above, others provide information on topics such as seeding times and assessment of soil characteristics.

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Your Comment

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

Written by the Australian Tree Seed Centre and Warren Mortlock

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DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

Western Wildlife

LAND FOR WILDLIFE

NEWSLETTER OF THE *LAND FOR WILDLIFE* SCHEME

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FIRE, *FRAUS* AND THE CORD RUSH

from a paper by Bert Main

LARGE tussocks of the cord rush, Ecdeiocolea monostachya, *are a familiar sight among shrubs throughout the northern agricultural area and the wheatbelt. They are so common and widespread that no-one considered that they may be in danger. However, some long-term observations by Prof. Bert Main have raised some very worrying points.*

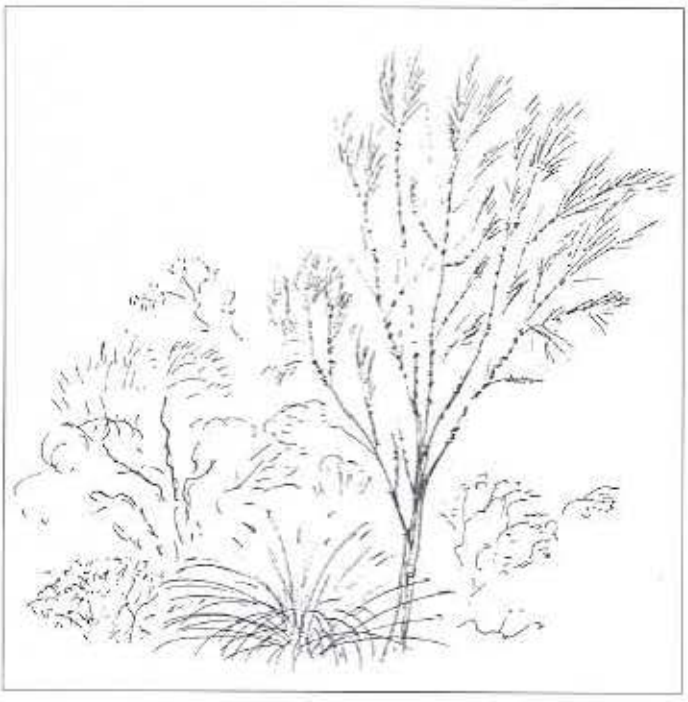
The Web of Life is not at all simple – causes and effects interact together so that long-term results do not always match predictions – management needs care, even 'doing nothing' may not prevent local exinctions ...

Ghost moth Fraus simulans

Life history

Cord rush forms a large, long-lived tussock. Seedlings have only been observed after fire.

The larvae of the ghost moth *Fraus simulans* create burrows up to 24cm deep within the tussock, from which they emerge to cut and feed on the leaf blades. Debris from feeding is webbed to form a large spacious vestibule at the burrow entrance and this is quite easy to see if you look carefully. Pupation takes place in March or April and, like other ghost moths, the pupal cases remain protruding from the upper surface of the vestibule after the adult has emerged, usually during rain in the first week in May. Mating follows and, at night, usually when light rain is falling, the female lays the eggs as she walks, flutters or flies close above the soil. After hatching, the larvae spend the first few stages of their life foraging among debris and leaf litter, before choosing a tussock in which to burrow. Within the burrow, the larvae are safe from summer heat, and also, if deep enough, from bushfires.



Cord rush with black tamma (Allocasuarina acutivalvis) in the wodjil. From "Between Wodjil and Tor" by Barbara York Main.

From 1967, Prof. Main has observed a number of sites where the plant and the moth occur, in order to try to understand its natural history – that is, the effect of the interrelationship between all the plants, animals and physical effects which occur at the site. In particular, he wanted to know what effect the herbiverous moth had on the survival rate of cord rush, the effect of fire on both, the ability of the moth to reinvade disturbed areas, and the effect of present management practices on the whole community.

The importance of this work is that it is long-term. Most studies of such detail – for a PhD for example – take three years and then end (or the funding runs

continued on page 3

Greetings everyone!

THANK you all for the great response to our questionnaire, you were very positive and made a lot of helpful comments. They will be very useful in enabling us to continue to develop the sort of magazine you want to read. As promised, some feedback on the survey results follows. We were delighted that 100% of respondants found Western Wildlife (WW) 'interesting and informative' – 94% 'agreed strongly'. The style of design and layout found favour with 91%, while 87% thought it covered most of the topics they were interested in. 78% read it 'from cover to cover', 31% read only the articles that interest them.

96% kept WW for future reference but several people noted that they couldn't do that if they *also* passed the magazine to others in the local community. Good point! Please note, you can reproduce articles from WW in other publications – see box on this page. Relating to this too, several people requested an index, one person suggesting it be on the front page, like our Victorian counterpart. In the original design, I rejected that as I felt it detracted from the appearance of the publication. But we'll try for one elsewhere, see below. A culmulative index is kept in each *Land for Wildlife (LFW)* office, if you'd like one, please ring.

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EDITORIAL

We were very pleased with the responses to the last two questions in this section, as 74% said that they had used the info from WW to help manage their land, while many of the 26% who were neutral or disagreed with the answer commented that they were 'an advisor' or 'didn't have any bush to practice on'. The final question 'since receiving WW, I have had a better appreciation of my bushland' had 55% agree strongly, 27% agree slightly, 15% neutral and 3% disagree – several of the latter giving the same sort of reasons for their answer. This is most heartening, as it means we are not just providing information, you are actually finding it USEFUL – this is what *LFW* is all about.

With regard to which topics you are interested in, it was no surprise that fauna (100%), flora (99.5%) and revegetation (99%) elicited the most positive response. Other popular topics were weeds and research (97%), practicalities (96.5%) and *LFW* News (93.5%). (Many people commented that they wanted to read more about what other *LFWers* are doing, we will do this wherever possible.) The least popular topic, at 73%, was funding, which was not expected. Perhaps those of you who are eligibable for grants hear enough about them from elsewhere?

Several people put in a plea for colour pics, though one person did add "if it can be afforded". The short answer is, it can't. As you know, we provide all our information free, adding colour to the magazine would be too costly. But we will follow up someone else's suggestion to ensure that pic captions include comment on colour, that's a very good idea. There were also some requests for WW to be in electonic form – this may not happen for some time, but we will continue to consider this option.

We received lots of helpful suggestions about what you would like to see in the magazine, including: soil micro-organisms, practical fauna care, how to identify 'little brown birds' (I need this too – Ed!), native aquatic life, *native* weeds, difficult flora propagation, fire retardant plants, prototype management plans, tips on 'teaching' bush values, more on the 'spiritual' dimension, occasional articles on significant regional bushland areas, the views of politicians and political parties and legislation.

The most thought-provoking comment undoubtedly came from Bruce Ivers of Kojonup, who wrote: "I wish to replace normal farming enterprises with multi-species perennial (shrub/tree) crops (preferably Australian natives) that make 4 times the gross margin of canola. (a) What are the products of these crops and who buys them? (b) What are the management systems needed to grow them? (c) If you don't know the answer, when are we going to start to solve this puzzle?" In all our dreams, Bruce! We promise, if we get even a whiff of a possibility, we'll share!

What about the negatives? Well, there were some, mostly on the design of the questionnaire. It was done in five columns because that is a standard statistical method, even though a yes/no answer would be simpler. And several people took me to task for very poor english, columns were headed 'disinterested' when what was meant was 'uninterested'. I copied the wording from elsewhere and didn't check - *mea culpa*!

A detailed analysis of the responses has been prepared and if you would like a copy, ring me. Please keep the suggestions coming, I really appreciate the feedback.

The winners of the Landscope Calendar were:

Sue Witham, Broomehill
D. & J. O'Dwyer, Margaret River
J. & L. White, Darkan
Neville Sparrow, Darlington
Robyn Soullier, Yandanooka.

Penny Hussey

Fire, Fraus *and the Cord Rush continued from page 1*

out!). In nature, this is not long enough to show real trends.

The results provide a fascinating insight into what is actually happening in our wheatbelt remnants.

Bungulla Nature Reserve (site 1)

Like most others, this central wheatbelt Nature Reserve is an island within cropland. In 1967, when the study started, the study site was a low heath dominated by cord rush and surrounded on all sites by a tall shrubland of black tamma, hakea, grevillea and wodjil (wattles), growing on sandy soils over lateritic clay. Since then the only disturbance has been due to the feeding activities of rabbits, kangaroos, echidnas - and locusts in 1990-91.

The cord rush and the moth are both favoured by the shade caused by the wattles, but grazing by an increased number of moth larvae eventually killed the cord rush. Drought and grazing killed seedling hakeas and grevilleas. The wattles aged and gradually died out. Black tamma seedlings survived in all the areas where plant death had left a space, and their needles smothered and killed ground vegetation, including cord rush. Thus the entire community on this site has changed to one dominated by black tamma – with important implications for other fauna.

Durokoppin Nature Reserve (site 2)

This site was on high ground, on sandy laterite, in a thicket dominated by tamma, wattle and grevillea, with a cord rush understorey. It was burnt with a low intensity patchy fire in the late summer of 1988.

Some of the tussocks survived the fire and a number of seedlings germinated in the first winter after it. They survived summer heat and water stress in the shade of still standing burnt shrubs. However,

FAUNA

drought and grasshoppers eliminated much of the regrowth. Nine years after the fire, one young plant provided enough food (12 leaf blades) to support one moth larva through to adult, although none of the seedlings had yet flowered. Note that seedling recruitment did not replace fire-induced mortality of established tussocks – ie there are now fewer cord rush plants at this site.

Durokoppin Nature Reserve (site 3)

There were two study sites here, one within an area of regrowth in an area that had been cleared and cropped in the 1930s, and another on never-cleared land close by. The vegetation in both sites was typical kwongan on yellow sand, with woody pear over cord rush. The regrowth area was experimentally burnt in a very hot fire in the summer of 1989.

There was little change to the unburnt site, except that some of the shrubs died and black tamma invaded in small numbers.

Some tussocks survived the very hot burn, but very few cord rush seedlings germinated and none survived the summer. However germination and establishment of shrubs was good. Three years after the fire, pupal cases in regenerating tussocks showed that moths had re-colonised the area from the adjacent unburnt areas. Superficially the area looks excellent, but there are far fewer cord rushes than before.

East Yorkrakine Nature Reserve (site 4)

A gently sloping north-facing sandplain with similar, but sparser, vegetation to the other sites. A very hot experimental burn was conducted in the summer of 1991.

After 2 years, about 30% of the tussocks had survived the fire but none had flowered or set seed. Moths had also invaded from adjacent unburnt areas and started to re-use the regenerating tussocks. Three years after the fire, one reached adulthood. A very large number of seedlings germinated in the spring after the fire but, on the shadeless seedbed, by seven years later, all had died.

Conclusions

This study shows that cord rush regenerates after fire, but it needs to be a low intensity, patchy one and even then, regrowth is very slow. Large cord rush plants are thus likely to be as old, or older than the shrubs in the same community. The moth, *Fraus*, can invade burnt areas from adjacent unburnt ones but it takes a minimum of 9-10 years under favourable conditions before a seedling can support a moth larva to maturity. It is even longer before the seedlings themselves will set seed. To preserve both the moth and cord rush in a small reserve may be very difficult.

Thus one should not become complacent about biodiversity conservation. Even apparently common flora and fauna may not be safe. The risks faced by them will only become apparent when life history and other biological requirements are known.

Ecosystems are dynamic, not static, and we need as much long-term data as we can gather, to make decisions for the survival of biodiversity based based on the best possible information.

Emeritus Professor A.R. (Bert) Main can be contacted through the Dept of Zoology, UWA.

REVEGETATION

Summer active native grasses support agriculture and wildlife

by Avril Baxter and Heather Adamson

THE recent wet summer has led to a proliferation of our summer active native perennial grasses and *Land For Wildlife* member Roy Butler has enjoyed watching the grass grow.

In 1992, shortly after veterinarian Roy Butler moved to Merredin to join Agriculture WA, he and his wife Judith bought 33 ha of cleared farmland on the outskirts of town. The previously cropped and grazed paddock became home to a couple of horses and under this grazing regime, native perennial grasses persisted and started to spread.

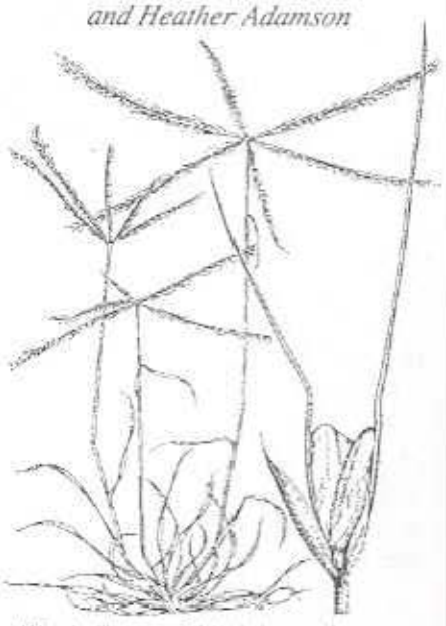
Eight years later, Roy's permanent pasture consists of perennial native grasses *Enteropogon acicularis* (curly windmill grass), *Chloris truncata* (windmill grass), *Enneapogon polyphyllus* (canary grass) and *Aristida contorta* (bunched kerosene grass). Being summer active, these grasses provide the bulk of summer feed. When they become dormant during winter, clovers, sub-clovers, medics, barley grass, rye grass and the native perennial spear grasses provide lush winter feed.

In 1997 Roy bought some Dorpino sheep (a cross between a South African meat sheep and wool growing merinos) to manage the pasture and obtain some useful data. The sheep are grazed in rotation over four paddocks that average 8 ha each.

Roy began monitoring the sheeps' condition in November 1999. Most ewes lost weight until the end of December then started to gain an average of 89g/head/day. Lambs gained an average of 95g/head/day throughout this time.

The feed value of the actively growing native grasses compares well with more traditional feed. In late January *Enteropogon acicularis* had a dry digestible matter (DDM) of 66% and 19.6% crude protein (CP). *Enneapogon polyphyllus* had 62.1% DDM and 15% CP.

Roy concluded that in the eastern wheatbelt, stock can benefit from the inclusion of summer active native perennial grasses and in years of summer rainfall, supplementary feeding may be reduced. This may remove some of the anguish farmers feel when watching the nutrition stored in winter grown pastures being washed out by summer rains.



Windmill grass, Chloris truncata.

Roy is most impressed with the mix of species in his pasture.

He sees the main benefits being water use over summer. The native grasses dry out the soil profile and allow it to absorb more of the winter rains before the excess seeps to the ground watertable. Wind and water erosion is negligible.

Animal life is certainly on the increase. Grasslands provide seeds, nesting material, nesting sites and cover. Grasshoppers, caterpillars, moths, native cockroaches, spiders, ants, crickets and bees abound. Ground nesting birds such as brown quail and Richards's pipit thrive in the area along with robins, willie wag tails, white fronted chats, magpies, mudlarks, bobtails, western blue tongue lizards, western bearded dragons, field mice and rats. This allows larger birds such as barn owls, nankeen kestrels, black-shouldered kites, butcher birds and brown falcons to hunt continually over the grassland feeding on smaller prey.

Roy is most impressed with the mix of species in his pasture, which make use of different climatic conditions. This year's summer rains have lead to a green pasture heavily dominated by *Chloris truncata*. This grass lives for about three years and sets large amounts of seed which germinate very quickly after summer rains while the longer lived *Enteropogon acicularis*, can produce green leaves in the hottest and driest summers. Within the system, winter legumes provide nitrogen for stock and summer pasture growth.

Roy sees it as a robust system. There is always something "on offer" and encourages other farmers to investigate it's use within their own system.

Through his work with Agriculture WA, Roy is investigating the use of *Chloris truncata* as a summer growing native grass sown with serradella on acid yellow sands. In this mix the windmill grass provides soil cover to stabilise the erodible sands and make use of any summer rain and the serradella will provide winter feed and a nitrogen source for the grass.

After hearing of Roy's success, last year Bruce Rock farmer Michael Buegge stopped spraying *Chloris truncata* out of a paddock which has been continuously cropped since 1997. It has proliferated with this summer's rain at the expense of other summer growing weeds such as paddy melons. Michael sees this as an advantage, he can crop over the windmill grass but would have had to spray the melons which get caught in the knife points of his seeding equipment. Michael also believes

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ECONOMIC ASPECTS OF BIODIVERSITY

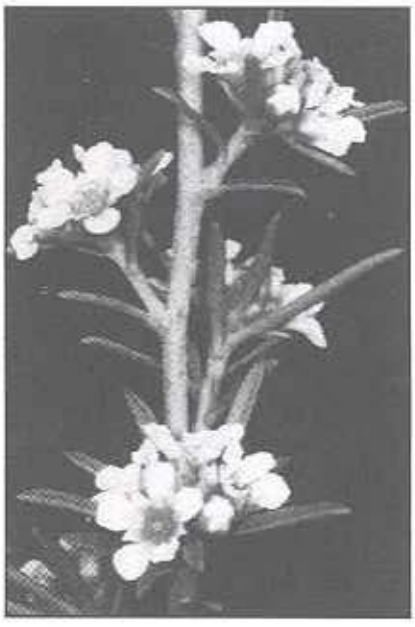
AGONIS OIL AND THE CURSE OF POTENTIAL!

By Chris Robinson

IN 1996 when I was working on a bush management project to increase cut flower production on the south coast, I became aware of a very interesting species (as yet undescribed) of *Agonis*. Commonly called coarse teatree, it flowers in late summer and is picked for both fresh and dry flowers, mostly for export. As a field botanist I was most fascinated by the beautiful scent the leaves produced when squashed or rubbed in the hand. The plant was a vigorous grower and was likely to have a fair amount of this oil. I thought, maybe this plant has some commercial ***potential*** for essential oil. The mobile oil mallee still came to town and I extracted a sample of this lovely oil. QEII Medical Centre tested it against *Melaleuca alternifolia* (eastern states teatree) oil and found it to have an excellent level of antimicrobial ability. It was also analysed at WA Chemistry Centre.

The ***potential*** was there all right, but how could we transform that into commercial reality?

After finding funds last year to employ a consultant to investigate the potential of this oil, it is now apparent that the road to converting it to a broader market place reality is a long and very expensive one. Only the big pharmaceutical companies may have the capacity to fund product development and TGA (Therapeutic Goods Act) approval. We didn't have enough oil for them to even start to test it (+100 litres). Another obstacle is the vested interest already in *Melaleuca alternifolia* oil, which has massive plantations and tax driven research and product development on the East Coast.



Agonis sp. Coarse Teatree.
Photo: C.Robinson

Currently the best prospect may be to develop a smaller local industry based on local cultivation, extraction and processing into an innovative range of products that do not require TGA listing such as soaps and other products which do not make therapeutic claims. Already there is a landholder growing this plant as a row crop (for flowers) and at least four south west firms interested in using this oil in a range of products, which can capitalize on its great perfume and antimicrobial character. There is interest too in expanding current distillation capacity, which could be used for other products.

The challenge for me in 2000 is now to assist that group to explore ways to increase production of the oil through expanded cultivation and distillation and the critical product development.

Maybe this time we can convert the ***potential*** of a fascinating local species to provide a real option for rural diversity and a contribution to a sustainable environment.

Chris Robinson is a Development Officer at AGWA, ALBANY. He can be contacted on 9892 8486.

?

Do you want to be a part of this?

Do you live from Pemberton across to Manypeaks and have wet peaty-sand heathlands on your property? Perhaps you already harvest coarse teatree (*Agonis* sp.) or fine teatree (*Agonis parviceps*) for cutflowers? If so, you have the right conditions for this project. You might like to learn more about the potential - ring Chris for further detail. In addition, LFWOs Jenny Dewing, 9761 2318, (for Manjimup Shire) and Sylvia Leighton, 9842 4500, (south coast) have information on managing these two species in remnant vegetation.

continued from page 4

that if this winter starts off wet, then he will still be able to seed the paddock, which with the absence of windmill grass could have been too wet. This year the *Chloris truncata* had a crude protein level of 14.2% and digestible dry matter of 63.4%.

There are many questions to be answered. Will the grass carry over any diseases, will it make sandy soils non-wetting, will it mean that winter crops get off to a later start due to a decrease in stored soil moisture? Farmers with an interest in perennial agricultural systems may have to drive the research.

Michael Buegge has Chloris truncata *seed for sale Ph/Fax 9061 1298. Roy Butler can be contacted on 9081 3111 (wk) 9041 2818 (ah).*

FAUNA

THICK-BILLED GRASSWRENS

by Belinda Brooker

Grasswren performing a 'dodgem-car' display to draw predators away from the nest.

Map showing present and former localities of the grasswren in Western Australia.

WHY have Thick-billed Grasswrens disappeared from the wheatbelt, and from most of their former range in pastoral areas? This was one of the questions I set out to try to answer as I studied the ecology of five bird species at Shark Bay for my PhD thesis.

Though probably never common, Thick-billed Grasswrens (*Amytornis textilis*) once occurred over the wheatbelt and much of the adjacent pastoral area (see map). However, the bird has not been seen in the wheatbelt since 1910, and in WA now only occurs near Shark Bay. They are small, active birds, spending most of their time on or near the ground.

Grasswrens feed on both bare soil and among leaf litter, searching for invertebrates and plant food. They are particularly partial to ants of *Crematogaster* species, but they also take spiders, termites, beetles, moth/butterfly larvae and bugs. Grasswrens also consume vegetable food, in particular the fruits of *Enchylaena tomentosa* (ruby saltbush) and *Rhagodia eremaea* (tall saltbush). Both of these plants produce a orange/red succulent fruit with a black seed which remains intact and easily recognisable in the scats – seed dispersal for the plant, presumably.

Grasswrens pair up and establish a territory of between 1.2 to 2.0 ha, in which they breed and live throughout the year. They defend the boundaries of their territories by song and by chasing intruders.

The birds start beeding in winter or early spring; in this arid area, the onset of breeding may be related to good rains in a previous month. They build a deep, cup-shaped nest towards the centre of a climbing plant or shrub, usually between 20 and 70 cm above ground. In dense vegetation the nest may not be covered, but in more open situations a hood is constructed over it. The nests consist of woven strips of bark, dry grass and flowering stems of *Ptilotus obovatus* (cotton bush), sometimes with strips of fine bark around the entrance. They are lined with narrow strips of bark, fine grasses and occasionally plant down such as *Ptilotus* flower heads. The female builds the nest and the male feeds her during the pre-laying period and incubation. One to four eggs are laid. The nestlings are fed the same food as adults, but with a higher proportion of caterpillars.

Nests sometimes failed because of predation, probably by the mulga snake or Gould's monitor. Although cuckoos exist in the area, during this study I did not record them parasitising grasswren nests. It seems from this study that the degree of nesting cover was an important determinant of nesting success. This may provide a pointer as to why these birds have declined elsewhere in WA.

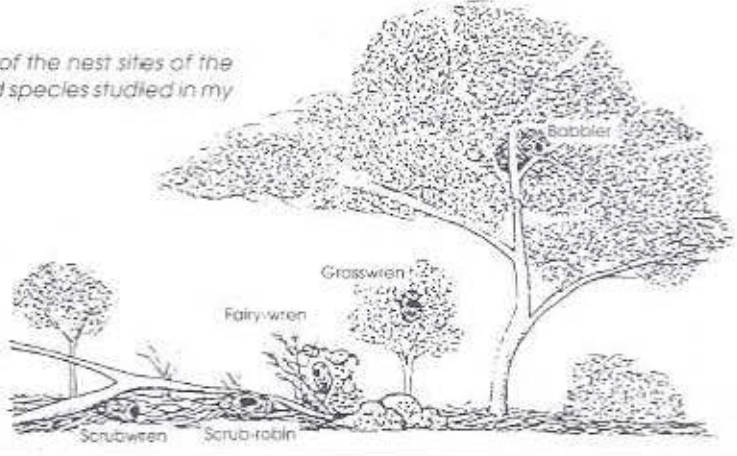
The grasswren has a preference for litter substrates in which to forage, and it prefers to nest in dense low shrubs. It may also eat the seeds of plants which are selectively grazed by stock. In the wheatbelt, grazing has removed the litter layer, and often the shrubs as well. Even in the pastoral region, grazing by sheep, goats and rabbits has significantly changed the shrub community, especially its density at low level, making it not only less suitable for grasswrens but exposing them to more predation.

In summary, it is not possible to attribute the decline of the Thick-billed Grasswren to any single factor, rather, it appears likely that an interaction of several features of it's life history made it sensitive to disturbance. If this bird is ever to expand back into some of its former range, land management will need to alter to permit leaf litter accumulation and dense low shrub growth.

(Nb: For an illustration of the Cocktail Ant, Crematogaster *sp, see Western Wildlife 3/1)*

Belinda Brooker is a zoologist who has, until recently, been working on recovery plans at CALM, Woodvale. She can be contacted on 9387 4223.

Sketch of the nest sites of the five bird species studied in my thesis.



FAUNA

THE WEED WITH WINGS: RAINBOW LORIKEETS

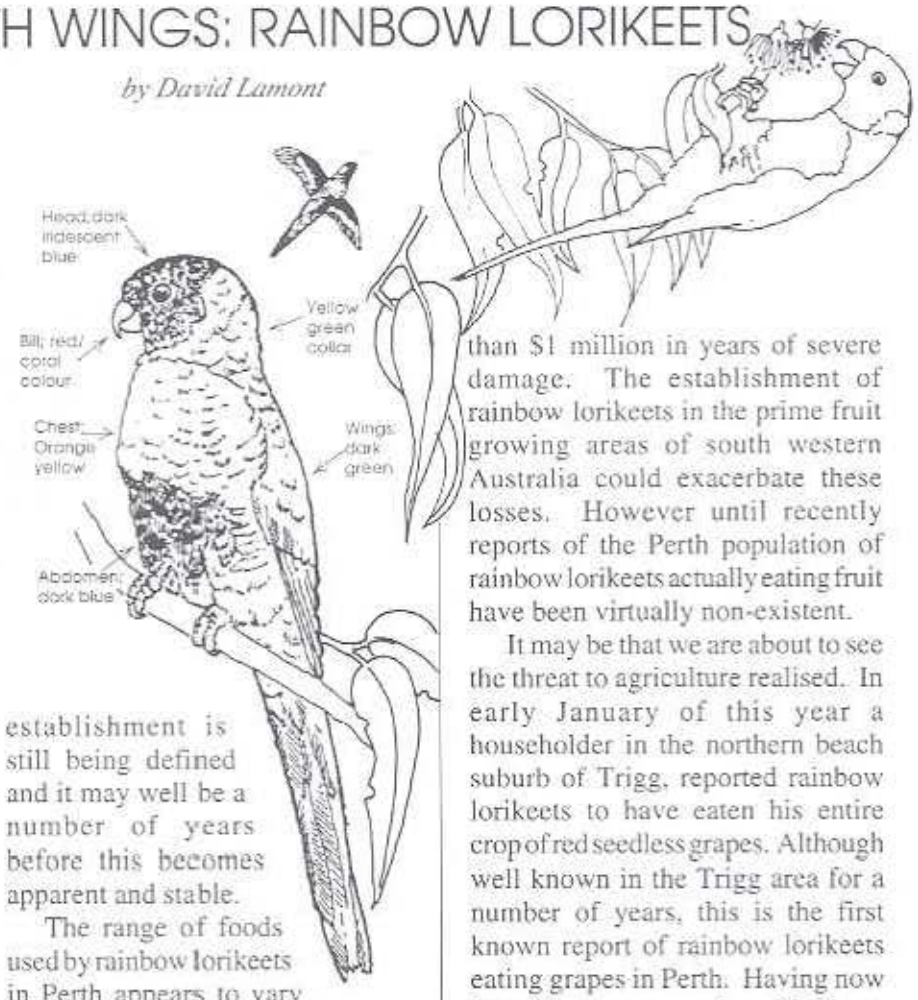
by David Lamont

IN recent years there has been concern about the increasing population of rainbow lorikeets in Perth. Post-graduate research, completed in 1997, investigated the impact of this bird on the conservation and agricultural areas of south western Australia.

This research found that critical elements for their successful establishment in Perth have been:

- the existence and continued expansion of an under-utilised and evolving niche, consisting of a mosaic of mature exotic and native vegetation
- the generalist tendencies of rainbow lorikeets with regard to diet and nest requirements and their aggressive nature
- their 'native' status and colourful plumage which has evoked ready community acceptance
- inaction by government agencies whilst their population numbers were low.

Rainbow lorikeets are now well established in the Perth urban area, being found within a coastal strip from Fremantle to Mullaloo, ~50 km south to north. They are also present along the Canning River at Kelmscott and nearby at Armadale. Areas adjacent to the Swan River from Perth to Midland and also along the Helena River to Hazelmere, ~ 30 km from the coast, have also been colonised. Based on sightings from previous years there appears to be a contraction of the range, in some locations. In 1992 rainbow lorikeets were noted at Gooseberry Hill, Darlington and Middle Swan but despite concerted attempts to locate rainbow lorikeets at these localities none were observed during my survey. Earlier this year (2000) there has been a sighting of rainbow lorikeets at Darlington and at Northam feeding amongst marri blossom. The extent of their establishment is still being defined and it may well be a number of years before this becomes apparent and stable.



The range of foods used by rainbow lorikeets in Perth appears to vary little from that described for the bird within its natural range in eastern Australia. Blossom from eastern states Eucalypts such as *E. maculata, E. citriodora* and *E. cladocalyx* were highly favoured and have been a significant factor in rainbow lorikeet establishment in Perth. The blossom of local Eucalypts, e.g. tuart, marri, flooded gum and jarrah are also taken freely. During field observations rainbow lorikeets were noted feeding from more than 20 species of plants, with seeds, fruits, nectar, pollen and flower parts being eaten. A high proportion (77.1%) of the food taken was of an exotic origin, i.e. not native to the Perth region.

Implications for Agriculture

Parrot damage to commercial fruit crops by parrots has occurred in WA for more than 50 years, with annual cost being estimated at more than $1 million in years of severe damage. The establishment of rainbow lorikeets in the prime fruit growing areas of south western Australia could exacerbate these losses. However until recently reports of the Perth population of rainbow lorikeets actually eating fruit have been virtually non-existent.

It may be that we are about to see the threat to agriculture realised. In early January of this year a householder in the northern beach suburb of Trigg, reported rainbow lorikeets to have eaten his entire crop of red seedless grapes. Although well known in the Trigg area for a number of years, this is the first known report of rainbow lorikeets eating grapes in Perth. Having now learnt that grapes can be utilised as a component of an already diverse diet, it may be only a matter of time before commercial grapes growing near Perth are utilised. Reports from South Australia suggest that rainbow lorikeets are quickly developing as the principal pest species of commercial orchards there.

Rainbow lorikeets have been gazetted as an unprotected species under the Wildlife Conservation Act, 1950, and as such may be taken by prescribed methods. However they have not been gazetted as a declared species under the Agriculture and Related Resources Act. 1976, and this can not occur until it is demonstrated that they are a threat to agriculture.

David Lamont is Executive Officer for the Roadside Conservation Committee. He researched rainbow lorikeets for his Masters Degree. He can be contacted on 9334 0423.

RESEARCH

IMPACT OF CLIMATE CHANGE ON THE DISTRIBUTION OF THE GENUS *DRYANDRA*

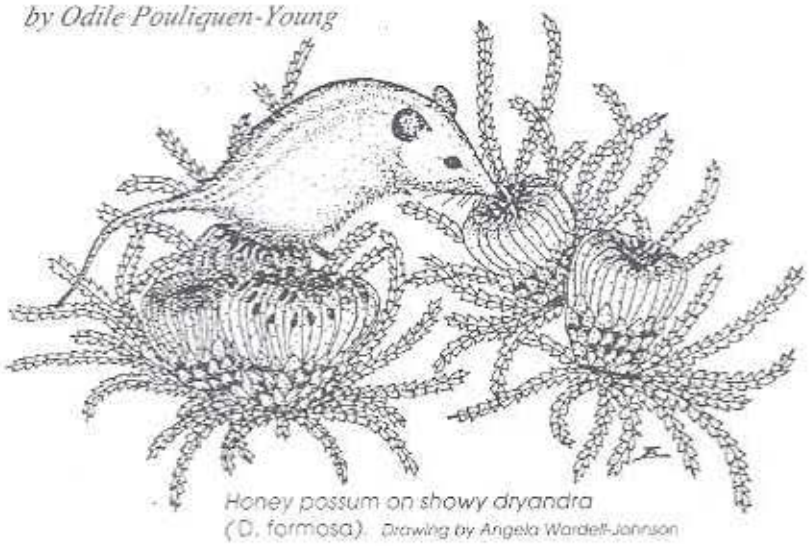
by Odile Poulicquen-Young

CLIMATE change has the potential to become the most important threat to the world's biodiversity to date. Realistically, it is unlikely that the rate of production of anthropogenic greenhouse gases is going to be slowed down enough in the next 50 years to delay climate change. We should seriously begin to look now at what impacts climate change will have on the natural environment, especially in those parts of the world with a high endemic biodiversity such as the south-west of WA.

The immediate consequence of the enhanced greenhouse effect is to increase global temperatures. This in turn has an impact on regional temperatures and rainfall patterns, in short on regional climate. Some researchers are arguing that climate change could already be responsible for the lower rainfall patters of the last few decades in the south-west. Whether climate change has already put its mark on the region, or is going to be of more importance in the next century, is a matter of debate. Whatever the case, those species which have evolved to take advantage of specific climate patterns such as the Mediterranean winter rainfall, will have to adapt to changing climatic conditions.

In 1996, CSIRO climate change scenario based on estimates of greenhouse gas emission rates indicates a further decrease in rainfall over the whole south-west, particularly in summer. There is a marked southern shift of the regional isotherms and a contraction of the lower temperature areas of the region. As global temperature increases, changes in the region's climate are more noticeable.

Because we do not know much about the requirements of native plants, the easiest way to estimate the impact that climate change may have on native species is to look at how the species' distribution will respond to changes in local temperature and rainfall. To do that, the species' current distribution was matched to a set of climatic variables using a specialised computer software specifically designed for Australian conditions, to define the species' climatic envelope. This envelope is much larger than the species' real distribution which is usually constrained by other things than just climate. For plants, the main element constricting the distribution of species is the type of soils that it prefers. By adding for each species its preferred soils to its preferred climate, we obtained what we called the species' 'environmental envelope'.



Honey possum on showy dryandra (D. formosa). Drawing by Angela Wardell-Johnson

We use the CSIRO climate change scenario with three different global temperature increases: 0.5°C, 1°C and 2°C depending on the rates of emission of the greenhouse gases, an increase of +0.5°C should occur between 2015 and 2045, while a +2°C would happen between 2070 and post-2100. For each of these global temperature increases, the CSIRO scenario gives the expected changes in local temperature and rainfall over grid boxes of about 125 km by 125 km.

Our results on the 92 species of the endemic genus *Dryandra* indicate that we can expect a range of responses to climate change (Table 1). It is clear that a reduction of the species' distribution areas is

*Table 1. Responses of Dryandra species to climate change (n=92). Overlap between current and predicted environmental envelopes: *>75%, **<50% Some species display multiple types of responses to climate change.*

Response types	Number of species		
	+ 0.5°C	+ 1°C	+ 2°C
1. Decline within current environmental envelope*	64	36	16
2. Decline with partial** or total displacement between current and predicted environmental envelopes	2	4	12
3. Total disappearance	26	43	61
4. Increase in environmental envelope area	1	1	0
5. Contracts from the north	55	40	27
6. Contracts from the east	15	20	7

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by far the most common response. There is also a trend for the impacts of climate change to be more severe as global temperatures increase.

Most researchers expect that species will move to track their preferred climate. After the last glaciation, trees and other plant species from Europe and North America migrated northwards (and some are still doing so) as ice sheets have retreated. Our results do not show any such large scale movement. Instead, 26 dryandras disappear at +0.5°C, raising to 61 species at +2°C. These species will not be able to find their preferred environmental envelope anywhere in WA. This important result is due to the fact that most dryandras have very specific soil requirements and that their preferred soil types are not widespread. Because of the southern shift of the isotherms, the decline that most species experience within their current environmental envelope occurs through a contraction of the northern part of their distributions.

Another important result is the influence the size of the species' current environmental envelope has on its vulnerability to climate change. All the species whose environmental envelopes are currently less than 1000 sq km disappear very rapidly (Table 2). The largest species are much more 'resistant' to climate change: no species with a current environmental envelope covering more than 50 000 sq km disappear at +0.5°C and only one of these species disappears at +2°C.

This result is due to two factors: (1) the larger the environmental envelope of a species, the wider the range of climate parameters it can be found under and the less likely climate change will exceed these parameters completely; (2) the larger the species' distribution, the more soil types it is likely to prefer so that its predicted climatic envelope under climate change is going to coincide with at least some of its preferred soil types.

This effect of size is independent of location. Whether from the south or north of the region, species with a very small environmental envelope disappear extremely quickly.

Table 2. Impact of three global temperature increases on Dryandra species ranked by area of current environmental envelope.

Current area (sq km)	No. of species at current climate	No. of species which disappear at:		
		+0.5°C	+1°C	+2°C
0 – 1 000	25	25 (100%)	25 (100%)	25 (100%)
1 000 – 5 000	14	1 (7%)	9 (64%)	12 (86%)
5 000 – 10 000	22	0	6 (27%)	15 (68%)
10 000 – 50 000	21	0	3 (14%)	8 (38%)
> 50 000	10	0	0	1 (10%)
Total	92	26	43	61

Table 3. Proportion of Dryandra species whose environmental envelope lies within native vegetation areas over 50 ha, under current climate and three global temperature increases.

Proportion of the species' environmental envelope within native vegetation areas	Proportion of species within native vegetation areas at:			
	Current climate	+0.5°C	+1°C	+2°C
0 – 25%	44%)	43%)	43%)	51%)
25 – 50%	41%) 85%	48%) 91%	47%) 90%	26%) 77%
50 – 75%	5%	6%	4%	6%
75 – 100%	9%	4%	6%	17%
Number of species	92	66	49	31

85% of dryandras have less than 50% of their current environmental envelope within large blocks of native vegetation (State Forests, protected areas and remnant vegetation areas of more than 50 ha). Because the species do not move markedly with climate change, this proportion does not change much under climate change (Table 3). What reserve system we have now will need to be greatly upgraded if we want to improve the conservation status of surviving dryandras under climate change.

If we assume that the responses of the distribution of dryandras to climate change are likely to be the same for other endemic plants in the south-west, this study has several implications for the development of conservation strategies aimed at counter-acting climate change in the region. Some of these implications are noted below.

- Rare or restricted plant species endemic to the south-west will be extremely vulnerable to climate change: they will suffer most and much earlier than more widely distributed species.
- The current centres of plant diversity in the south-west (Stirling Ranges and Northern Sandplains) are also very vulnerable because of the high number of restricted species found only there.
- Ecosystems with a high plant diversity are not going to gain species by migration, but instead are going to lose all their restricted species first.
- Because most plant species do not move under climate change, expanding the current system of reserves should take precedence over the design of corridors across the region.
- Because species migration is unlikely, it is not possible to define specific climatic refuges where species may concentrate under climate change. However, our study indicates that the Stirling Range region may act as a climatic refuge for those species currently extending eastwards along the south coast.

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LFW NEWS

Visit of SA Minister for the Environment.

IN January, the South Australian Minister for the Environment, the Hon Dorothy Kotz, visited WA and asked to see *Land for Wildlife*. We took her to visit a large property - Russell and Pat Lord's at Goomalling – and a small one, Jenny and Mike Mackintosh's at Mt Helena, with lunch at Toodyay in between. We intended to show her remnants, reveg, streamlining, rare flora work etc etc, but were beaten by the weather.

It was one of those days when the heavens opened! As we drove up to the Lords' we could see lightening bolts smashing into paddocks alongside the house! Inside, there was no electricity and it rained so hard that we could hardly hear ourselves talk. At Toodyay, Rae Paynter, Dawn Atwill and Desrae and Wayne Clarke joined us for lunch. The rain was so heavy the loo flooded and the restaurant's roof leaked! At the Mackintoshs' it was gloomy and sodden, though, for a short while, not actively wet.

At the Lords' - Claire Hall, Russell Lord, Mrs Kotz, Ashley, Pat, Stephen Lord, Bob Huston.

Nevertheless, I think the Minister was impressed by the energy and enthusiasm shown. She said she learnt a lot about salinity too! SA are thinking that they may start a *LFW* programme, but it is not a high priority at the moment. Many thanks to everyone for your help.

Penny Hussey

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- This study did not take into account the ecological and physiological adaptability of species. We assumed that the current distribution of dryandras coincide precisely with their rainfall and temperature requirements for reproduction and/or regeneration. However it is well known that plant species can live and reproduce under a wider range of climatic conditions than those under which they are found in the wild. To improve the chances of plant species surviving climate change, some rare species from the northern part of the region could be transplanted south of their current distribution as a safeguard.

Although not a high priority threat at the moment, climate change has the potential to impact on a wide range of conservation issues including revegetation strategies, weed demography and distribution, type and amount of agricultural production (hence native vegetation clearing and management), jarrah dieback, fire patterns, native mammal re-introduction strategies, reserve location, salinity (through changes in rainfall patterns) etc. Latest climate change models indicate that the reduction in rainfall over the region could be even greater than predicted by the CSIRO 1996 model. Climate change is really a global threat both in its geographical extent and in its likely impacts. Whatever mitigation strategies against greenhouse gases, we should also be thinking of adopting strategies which will help us and our environment adapt to climate change.

Further reading: 'Dryandras – they are not all prickly shrubs' M. Pieroni, WW 2/4.

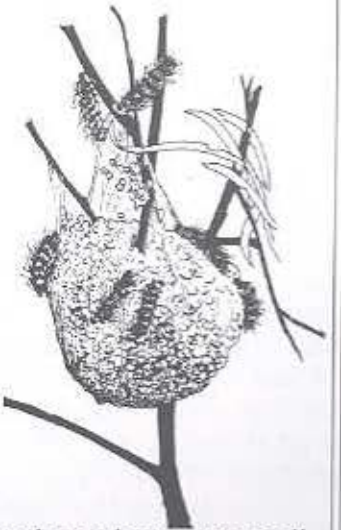
The research was funded by the Greenhouse Assessment Team, Australian Greenhouse Office, Environment Australia, while Odile was Senior Research Officer at the Institute for Science and Technology Policy, Murdoch University. *Odile can be contacted on (08) 9572 3615 and email: oyoung@iinet.net.au*

BUSH DETECTIVE

Who made this bag?

DON'T TOUCH!

It contains irritating small spines which can get under your skin.



You have been warned!

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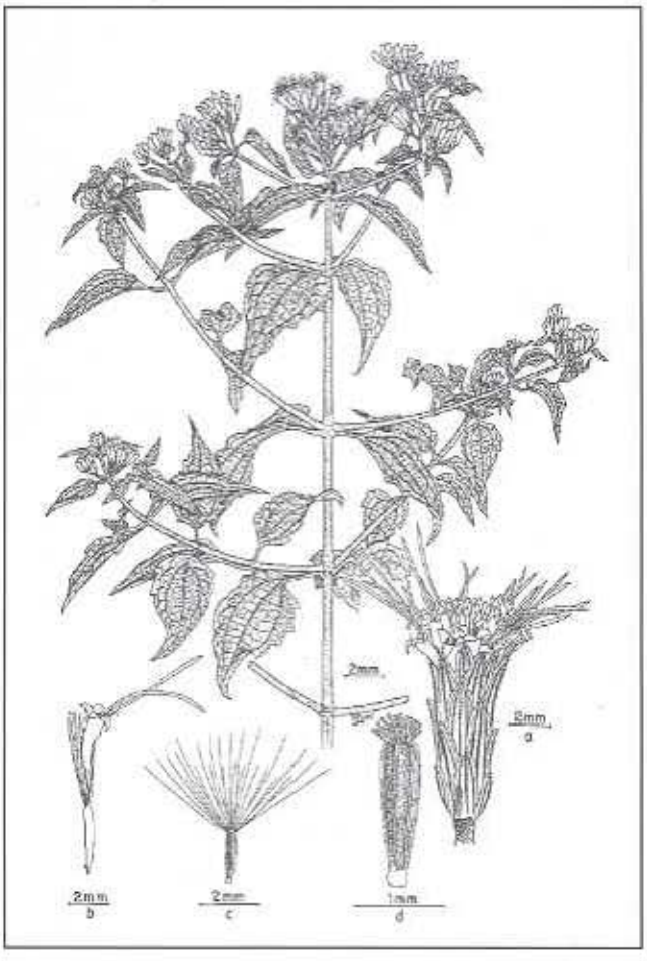
WEED ALERT

SIAM WEED – COMING HOME WITH THE TROOPS?

by Barbara Waterhouse

SIAM WEED (*Chromolaena odorata*) is one of the most serious tropical weeds one can expect to encounter. Originally from South America, it has been introduced and become aggressively invasive in West Africa, South Africa, the Indian subcontinent, southeast Asia and the Pacific. A small infestation which was noted near Tully in far north Queensland in 1994 is more or less under control – at a cost (so far) of nearly $1 million.



The plant is a perennial shrub which forms tangled masses to 3m tall in open areas, but can scramble up to 5-10m along forest margins. It produces fluffy pinkish-white flowers between June and September, which result in millions of seeds attached to a parachute that floats them away on the wind. It can form impenetrable thickets and smother ground layer and shrub vegetation. It is a serious weed of riverbanks and disturbed sites, and will smother plantations, tree seedlings regenerating after logging, crops and pastures, as well as natural areas. In sites with wet and dry seasons, such as the Kimberley, it dries off after flowering, burns readily at this stage, then resprouts from the rootstock. It is unpalatable to stock, but toxic if inadvertently eaten – perhaps if included in fodder in feedlots.

The risk from Timor

Siam weed is widespread across Indonesia, including Timor and Irian Jaya and is spreading rapidly through PNG. The next time you see news footage from East Timor, pay attention to the roadside weeds and background "greenery" – much of it is Siam weed, which is widespread within Dili as well as in more rural areas.

Siam weed is notorious for spreading in association with military personnel and equipment. It hitched rides across the Pacific on military vehicles during WWII. The Australian Quarantine and Inspection Servive (AQIS) realised that it was the biggest risk of the possible threats that could return with the troops from Timor. The detection of Siam weed seeds in the footwell of a UN vehicle brought to Darwin for repairs in October provided convincing evidence that this was not just a "perceived" risk, but the real thing.

A team of AQIS officers worked in Dili, cleaning vehicles before they were shipped back to Australia (this sometimes involved dismantling vehicles and/or engines), while a second team in Darwin checked personnel. In all of this, the Defence Department has been wonderfully helpful and co-operatiive.

But the probability is that, despite all the care, some seeds will slip through.

Where you come in

There will be ongoing surveillance near military bases, but it is actually more likely that concealed seed will be "bounced off" during excercises in rough terrain.

Siam weed could grow in coastal regions of Australia from the Kimberley across to the eastern seaboard, possibly down as far as north-eastern Victoria. If you live in the north of WA, or if you go north for your holidays, collect a pressed specimen of any plant you are suspicious of, and check it with a Community Herbarium, or the Weed Science section of AgWEST.

Remember, this latest incursion by Siam weed hasn't happened (quite) yet, but it (probably) will happen, and it is (probably) coming to a site near you!

Barbara Waterhouse is a botanist with AQIS's Northern Australia Quarantine Strategy based in Mareeba, Qld. For more information, contact the following website: http://www.agric.wa.gov.au/progserv/plants/weeds/clero/siam.htm

PRACTICALITIES

Regenerating Woodlands - Similar to Growing a Crop!

by Avril Baxter

SO, you've got a nice patch of woodland on your place, but there doesn't seem to be many young trees or shrubs. If you think back to last season, you will realise that regenerating your patch of woodland is similar to growing a crop.

To get a good crop you kept the sheep out of the paddock, controlled weeds, created a seed bed and planted seeds, manipulated fertility and pest species, you may even have introduced pollinators and finally prayed for perfect winter rains.

Treat yourself for a walk through your bushland. Have a look around and see if any of the following elements are missing. Changing them could be the start of this year's bushland management programme.

- Grazing control

  Fence to exclude stock, control rabbits. Monitor and, if necessary, control kangaroos.

- Weed control

  Prevent weeds and excess nutrients from entering the site. If necessary, control weeds within the site and replace immediately with seedlings or by direct seeding.

- Seed source

  Are there enough parent plants to reseed the area? Hard seeded wattles and peas can remain in the soil for up to 50 years – others have a short life. Has soil erosion on slopes removed most of the soil seed bank? Can the seeds reach the area you want to regenerate eg. do prevailing winds blow them the wrong way? Do the plants need fire to open the fruits and release seeds?

- Seed germination

  Many native plant seeds need a specific trigger to stimulate germination, this may be heat, or smoke. If direct seeding, make sure the seeds have been treated before you sow.

- Seed bed

  Compacted surface, or niche for seed to fall into? Consider raking, or cultivation. Do not disturb the surface near the edges as this will create a seedbed for weeds blown from the paddock. Do not seed under the canopy of existing trees – it will have little effect.

- Good rains

  Do not treat the whole area at once. Water erosion could occur or there may be inadequate follow-up rains.

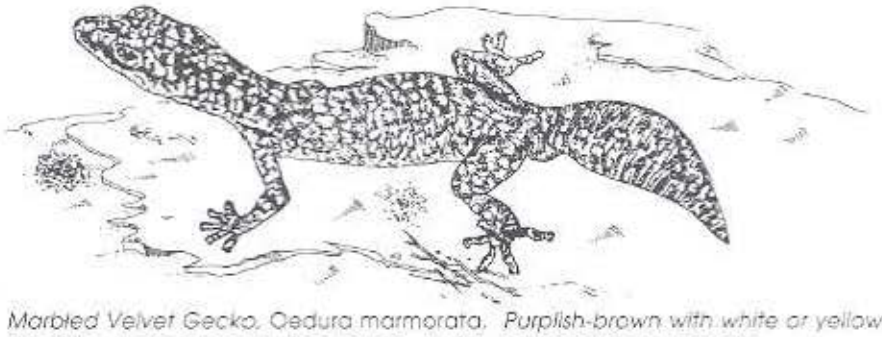
- Pollination and pest control

  Maximise plant diversity to encourage insect and bird populations. Control foxes.

Finally, give it time. New plants will continue to appear several years after you started the regeneration process.

Create fauna habitat on rock outcrops using paving slabs

LOOSE rocks have been removed from many granite outcrops, either by the water authority to build walls to channel water, or, around urban centres, by householders for use in landscaping. The crevices under these rocks are a most important fauna habitat. Two researchers in NSW decided to see if they could recreate habitat on degraded sandstone outcrops by putting out concrete paving slabs.



Marbled Velvet Gecko, Oedura marmorata. Purplish-brown with white or yellow speckles, in cross-bands when young. In WA, mulga region and north.

They were interested in the endangered broad-headed snake (*Hoplocephalus bungaroides*) and its major prey, the velvet gecko (*Oedura lesueurii*). The gecko uses rock crevices for shelter, so declines in numbers when the rocks are removed. Then the snake numbers decline also. The researchers put out pavers, propped up to give a variety of crevice widths. Some were in shady areas, some more exposed.

The results showed that the geckos used these crevices. This demonstrates that habitat restoration with appropriate-sized concrete pavers may be a feasible conservation technique for degraded rock outcrops.

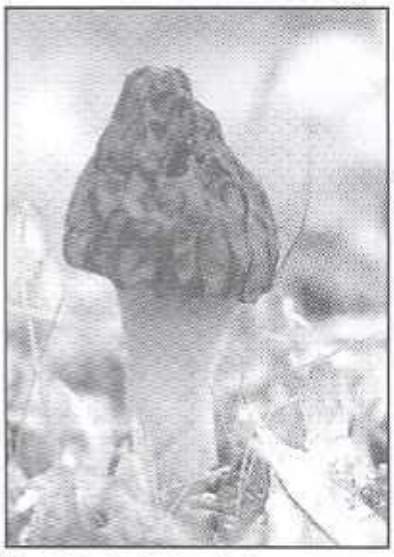
They recommend the use of large pavers (30-45 cm wide, 5-10 cm thick) with a variety of crevice sizes up to 10mm, to maximise the diversity of retreat sites.

Has anyone here had success with a similar technique?

Reference: Webb, J.K. & Shine, R. 2000. "Paving the way for habitat restoration: can artificial rocks restore degraded habitats of engangered reptiles?" *Biological Conservation* **92,** *pp 93-99.*

FUNGI

Morel



Morel, York. Photo: P. Hussey

The fruiting body of the Morel, *Morchella elata*, has a stout yellowish-white stalk topped by a conical, wrinkled brown cap, overall height 10 - 15 cm. The whole thing is hollow. In WA they occur in forests and woodlands of the south-west.

In Europe and America, Morels are highly regarded as edible fungi, but they are not used much in Australia. There doesn't even seem to be any records of use by Aboriginal people. This lack of interest might be because they are not often noticed, as fruiting bodies seem to be produced in abundance only after bushfires.

After a fire, Morels fruit and release spores which germinate in the soil to form mycelia (feeding threads) and then form sclerotia. Sclerotia are fungal 'resting bodies' up to 5 cm in diameter, composed of large thick-walled cells which enable the fungus to survive adverse conditions. Many south-west fungi form sclerotia, and it has been suggested that it could be a feature that is an adaptation to cope with frequent fires. In spring the sclerotium will either germinate to form a new mycelium or produce a fruiting body. Generally, however, the Morel will not produce a fruiting body until after the next fire.

Morels have a light flavour, and there is nothing much else they could be confused with. If anyone wanted to try them. However, note that some reports from other continents say that, if alcohol is taken at the same meal, severe vomiting and diarrhoea will result!

FLORA

Cord Rush

Ecdeiocolea monostachya

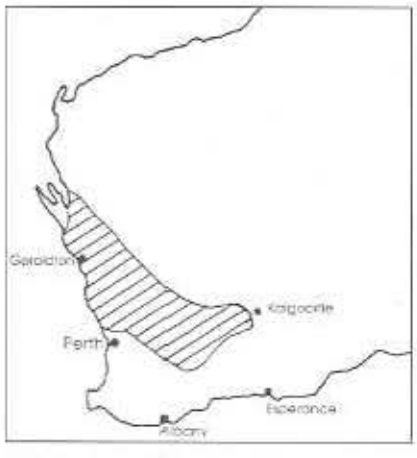
ECDEIOCOLEACEAE

Cord rush is a tufted perennial which forms large clumps, with culms (upright stems) up to 1m tall, each with a single cone-shaped inflorescence. The plants are either male or female. The flowers are produced in spring. It grows in sand under heath or woodland, often in association with granite. After fire it resprouts, or may grow from seed. It is common and widespread from Kalbarri throughout the northern and central wheatbelt.

Female head

Male head

Illustration by Ellen Hickman from "Australian Rushes" - see New Books section



Distribution of Ecdeiocolea monostachya

FAUNA

Native Snails

Following the article in 'Western Wildlife' a native snail shell was found on the Australian Bush Heritage's block at Kojonup. Mal Graham, of CALM Kojonup, sent it to the Museum, and Dr Slack-Smith was very interested. She replied, in part:

"Prior to receiving your specimen we have had only a single shell of a *Bothriembryon* species from anywhere near Kojonup. It is a mystery as to why there should be so few records of specimens of this group of native snails from the huge area inland of the Escarpment and north of the Stirlings until one reaches the Goldfields-Esperance road. It is possible that it could be a paucity of collectors, but I don't think that is the only reason. The snails are really sparse.

"In addition, their shells are generally fragile, perhaps because of a low calcium content of the soil and so of the vegetation. As a result, the shells seem to disintegrate soon after the death of the snails, unlike those nearer to the coasts or in other calcium-rich localities. Species with well-calcified shells leave behind plenty of evidence of their existence, even when the populations aren't large.

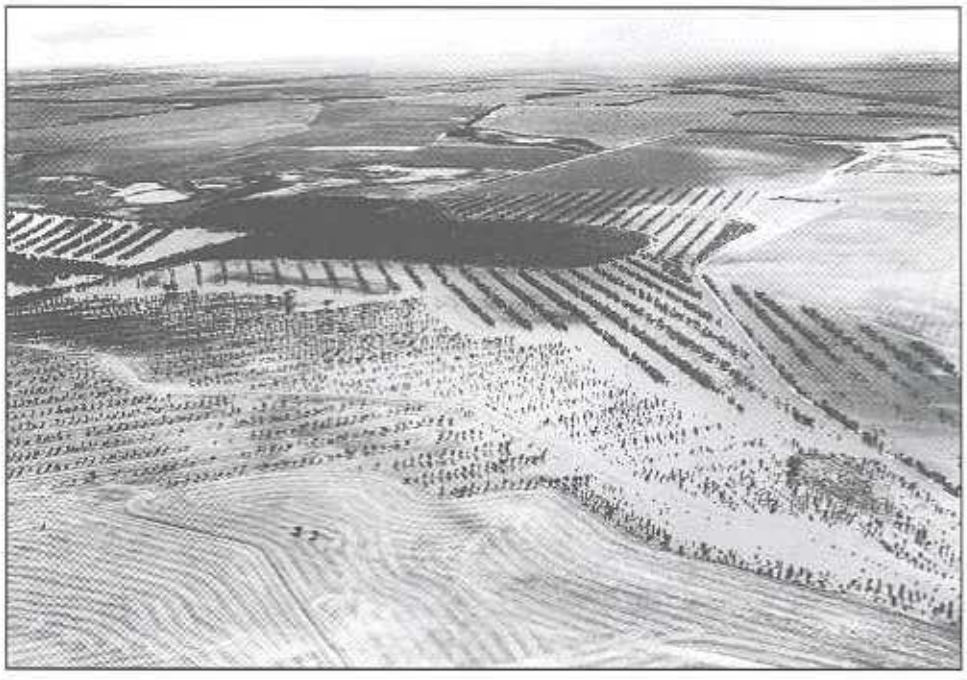
"An interesting point is that wandoo woodlands seem to be more often inhabited by native snails of various groups than are surrounding jarrah or marri woodlands. Wandoo is often associated with outcrops of dolerite which, I understand, contains more calcium than does granite.

"I would be really keen to receive any information or, better still, any specimens of *Bothriembryon* species from the general area. If the specimens are alive then they could be packed into a dry container with air holes, such as a matchbox, and sent to me. I could have the live animal photographed, and could then narcotise and preserve it in such a way that it would be suitable for anatomical and genetics studies - should we ever have the good fortune to have a researcher willing and able to work on the group."

So how about it, *Land for Wildlifers* in the Great Southern? **Early this winter, have a Great Snail Hunt!** You never know, you might find a new species, and then it might be named after you! (Incidentally, the Kojonup species might be *Bothriembryon bradshawi*, originally found at Tambellup.)

MEMBERS PAGE

Should we be farming kelp?!



Kerry and Wayne Smart's revegetation in the South Lake Bryde catchment after 6.5 inches of rain, Jan 2000. Photo: Anne Rick.

Natural Vermin Control

by Monica Strauss

WE are very lucky to have our own Vermin Controller living in our house at Toodyay. It is a small *Varanus tristis*, who moved inside our roof some 10 weeks ago. Our leathery-looking black friend enters via a gap between the external brick fireplace wall and the roof. He appears to have taken up permanent residence, and is doing the most wonderful job exterminating any mice or rats that are wishing to move into the roof space. So much better than having to set traps!

We used to sometimes hear the pitter and patter of tiny feet, now we hear thump, thud and squeak, and on occasions, a little later, see a smug looking black monitor reclining on the outside rafters. He (or she?) also wanders daily about the garden, mostly looking very furtive, the curled tail held high a giveaway. Only once have I seen it with the tail flat on the ground, looking more gloomy and depressed than ever, and that was after it got watered by accident.

V. tristis also hunts in our feed shed, which is some 40 m away from

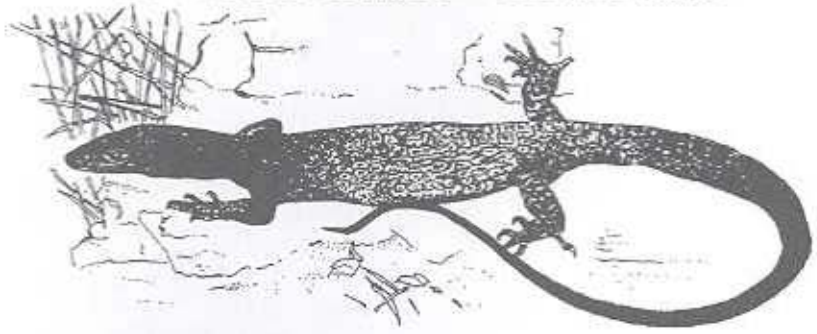
the house. I saw it with a freshly-caught rat, which was so big it didn't seem possible that he could eat it, but eat it he did. When next I looked, only the rat's tail was hanging out of his mouth. Some time later he came home, slowly made his way up the brick wall, stomach bulging, and went inside the roof. Vermin control without traps or poison!

The only disturbance that his presence causes is to the people-friendly birds, wren and robin, who are not frequenting our small garden as much as they normally would. His presence does not upset resident bobtails, nor the carpet python that has been spending the last few days in a wandoo next to the house. However, absent is a mulga snake that we have seen around the area for a number of years and I wonder if it is keeping away because of *tristis*.

Another thing perhaps worth mentioning is the fact that this summer is the best for bungarra [*V. gouldii – Ed.*] that we have seen since buying the property in 1990. There are always quite a good number about, but this year there are bungarra, in all sizes, just everywhere. I wonder if others have noticed this also?

MEMBERS PAGE

Black Tailed Monitor – *Varanus tristis*



BLACK TAILED MONITORS (black goannas) are widespread over most of northern WA, Perth is at the southern limit of their extent. Most southern forms are very dark, although the juveniles are more colourful with yellowish speckles, while inland forms often retain the indistinct yellowish markings into adulthood. They can grow up to 80 cm long.

They are excellent climbers, resting in a hollow or basking on a limb high up. Look for scratch marks on smooth-barked trees such as wandoo (or verandah posts). They specialise in hunting for birds' nests and eggs, but will also take frogs, mice, lizards and various insects. Within a hollow tree, the animals move around to find hotter or cooler places, and so help to regulate their body temperature. Ceiling spaces are ideal on all counts. In winter they sleep near the chimney!

Young animals would have numerous predators, including cats and birds such as kookaburras, but the adults are killed by dogs or carpet snakes. They are often road casualties, as they bask on the tarmac to raise their body temperature. If they are noticed, small birds often mob them, so, when emerging from a den site, the black goanna looks around very carefully before moving out. Sometimes this nearly gives a heart attack to people when they look out of their window and see a long snaky neck peering at them from the rafters!

If they are disturbed when on the ground, they run up things to escape, usually trees. If you note one running away, try sneaking up on a likely tree, you can catch him sidling around to keep the tree between you and him! There are several stories of the animals running up people, and I once observed the effect on a horse ... I clearly saw the startled goanna hurl itself sideways off the horse's shoulder as Brandis (the horse) tried to go vertical himself. After that, things got a little hectic for a while!

Around human dwellings, black goannas (or chuditch) may take mice or rats that have been poisoned. If the rat-poison is used according to the label instructions it is unlikely that the predators would eat enough of the dead rodents to cause them any problems. Use a bait station, and never overdose, as if you do that the rat may die before the poison has decomposed inside it – that would be fatal to a predator. Better still, of course, is not to use poison at all and try to persuade your neighbours not to do so either. – *Ed.*

Congratulations!

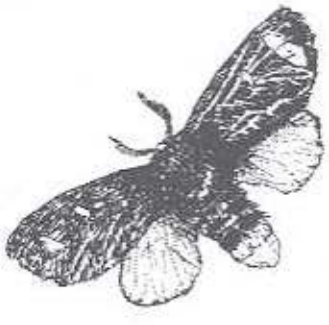
to Margaret and Colin Tonkin of Collie for winning the NHT National Rivercare Award.
Well done!

BUSH DETECTIVE ANSWER

It is made by caterpillars of the bag-shelter moth (*Ochrogaster lunifer*) which construct communal bag-shelters of silk and frass. They are found hanging on branches of Acacia species throughout southern Australia.

The adult moths emerge in November and December and the females lay their eggs on branches of jam wattle (*Acacia acuminata*). There are six larval stages occurring from January to June. The densely-hairy caterpillars emerge in late December or early January and live together in a bag-shelter made out of silk, frass and dried larval skins hanging on tree branches. The bags range in size from about 20mm in January to 225mm in June. The caterpillars feed from January to June and emerge from the bag-shelter at night to feed on the host tree, leaving trails of silk to their foraging sites. This is known as 'central-place foraging'. They move in a single line or procession giving rise to another common name 'processionary caterpillar'. In late May or early June the caterpillars move down to the ground to pupate.

The caterpillars are well protected by their dense hairs which can be irritating to humans and animals. The Aborigines avoided the bag-shelters filled with discarded hairs and wriggling caterpillars as a bag could cause severe irritation if it fell on a sleeping person. Cattle may die from stomach irritation if they ingest a fallen bag of caterpillars while feeding. It is possible that the caterpillars could be predated by several insectivorous bird species common in woodlands, in particular cuckoos, who have a special stomach lining to deal with the hairs. The bag-shelter could be an anti-predation advice and it could reduce water loss when the caterpillars rest inside it during the day.



Bag-shelter moth
(Ochrogaster lunifer)

NEW BOOKS

AUSTRALIAN RUSHES: BIOLOGY, IDENTIFICATION AND CONSERVATION OF RESTIONACEAE AND ALLIED FAMILIES.

Ed. Kathy A. Meney & John S. Pate.
University of Western Australia Press, Perth. 1999.
$95.00

Any person who has ever taken part in a bushland survey will be aware of those 'reedy things' that are always present but no-one knows the name of. Like Admiral Nelson, we often turn a blind eye and pretend we didn't see them! But in fact they are an important part of native vegetation communities, and deserve more attention. Now, a new book has thrown light on one family of reedy things, the 'southern rushes' from the family Restionaceae.

Each of the 144 Australian species has a page of description, including photomicrographs of culm (aerial stem), rhizome and root, as well as a page of drawings, done by Ellen Hickman. These are a feature of the book, being both detailed and delicately beautiful. There are also chapters on morphology, anatomy, biology, diseases, propagation and conservation.

This is not a book for the faint-hearted! Even dedicated volunteers at Community Herbaria are likely to still have trouble with exact naming of individual specimens. But it is a beautiful book, full of fascinating detail about this important but little understood/neglected group of plants.

MANAGING OUR RIVERS: A GUIDE TO THE NATURE AND MANAGEMENT OF THE STREAMS OF SOUTH-WEST WESTERN AUSTRALIA.

Luke J. Pen
Water and Rivers Commission, Perth. 1999.
$19.95 + $6 p&h.

This book is a must for anyone who loves our south-west rivers. It contains a wealth of detail on how rivers work - landform and topography, vegetation on banks and bed, fauna and human use. How and why rivers degrade is also discussed, followed by chapters on management and the future.

Not just a text but a work of love, this book is easy to read and very informative. It will provide a huge amount of background to assist in the understanding and management of any size and type of stream likely to be encountered. By taking a broad view, the author shows how all the processes interact with one another, so that maintenance of the beauty, fertility and productivity of our south-western rivers is the responsibility of all of land users.

Very reasonably priced, this book should be in the collection of all truly concerned land carers.

THE LAND IS IN YOUR HANDS: A PRACTICAL GUIDE FOR OWNERS OF SMALL RURAL LANDHOLDINGS IN WESTERN AUSTRALIA.

AgWEST, Perth. 1999.
Free

This comprehensive guide has been developed to promote good management practices to the State's growing number of small landholders. It contains practical, user-friendly information on a wide range of topics including land management, water supply, stocking levels, chemical use, weed and pest management, property design and many others. It will be a valuable resource regardless of the size of the property.

Obtain your copy by contacting your local AgWEST office.

FUNDING

Threatened Species Network Community Grants

Round 3 opens in April, closes June.
If you think you have a small project that would help threatened species, contact Sandra McKenzie for more information ph: 9387 6444 fax: 9387 6180
email smckenzie@wwf.org.au

COMING EVENTS

"Eucalypt Tree Decline in the Great Southern"

Workshop planned for late August. Kojonup area.
Focussing on Wandoo, Flooded Gum, Flat-topped Yate and Marri.
Organised by *Land for Wildlife* and Bushcare Support.
For more info, or to register interest,
ring Avril Baxter: 9881 9218.

▶ LFW Officers will be attending the following Shows - put the date in your diary!

Dowerin Field Days - 24- 26 August
Dalwallinu Show - 25 August
York Show - 2 September
Newdegate Field Days - 6-7 September
Mingenew Expo - 16-17 September
Moora Show - 22-23 September
Narrogin Show - 7 October
Bindoon Show - 21 October
Gidgegannup Show - 28 October
Busselton Show - 3-4 November
Blackwood Show - 7 November
Margaret River Show - 10 November
Bridgetown Show - 25 November

This Newsletter is a compendium of articles written by many different people. The views expressed are those of the authors, not necessarily those of the Department of Conservation and Land Management.
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DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

Western Wildlife

LAND FOR WILDLIFE

NEWSLETTER OF THE *LAND FOR WILDLIFE* SCHEME

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THE NOISY SCRUB-BIRD IN THE DARLING RANGE

by Alan Danks

THE NOISY SCRUB-BIRD is one of the most intriguing birds you are likely to come across in Western Australia. It isn't large or spectacular and it doesn't dominate the skies in large raucous flocks. But this small, semi-flightless inhabitant of dense scrub draws attention with its loud song and tantalises with its easy command of a tangled and impenetrable habitat. Those with the patience to wait quietly may be rewarded with a few glimpses of a bright-eyed, cocky bird dressed in subtle colours but with a voice that makes your ears ring. After a Cheshire Cat history of discovery, disappearance and rediscovery, the successful management of this threatened species in recent decades has ensured that the bird is well established in coastal areas east of Albany. One of Western Australia's conservation icons, the Noisy Scrub-bird has recently been reintroduced to its old haunts in the Darling Range.

John Gilbert discovered the Noisy Scrub-bird in November 1842 while exploring and collecting in Western Australia for John Gould. With the botanist James Drummond he travelled from Perth to Augusta along the coastal plain. From Pinjarra they made a detour to explore Mt William in the Darling Range. They made their way from the Murray River rapids up into the hills, crossing several westward flowing streams before reaching their goal.

This was Gilbert's second trip to WA and he was reasonably familiar with the bird life of the colony. But at the Murray he was tantalised by a bird whose resonant song told him it was something new. Gilbert wrote to Gould in England: "... its loud but pleasing note fairly made my ears ring, and yet I could not see the creature". At the first stream past the Murray (now known as Drakesbrook) after "waiting around in the rain for days" he at last got a glimpse of it and was able to shoot one. Gilbert sent several specimens to Gould who officially described the new species. Gould was also intrigued by the bird and wrote: "Few of the novelties received from Australia are more interesting than (this) species". He also predicted gloomily that it was "destined to rarely meet the gaze of civilised man".

Gilbert considered scrub-birds were locally common but after his report, no other naturalist reported them in the Darling Range. But Gould's publication and interest aroused curiosity and ornithologists were keen to find out more about the life history and breeding biology of the Noisy Scrub-bird. They were intrigued by its anatomical peculiarities - it has no wishbone for instance - and puzzled about its relationships to other birds. The bird's elusive habits and impenetrable habitat however, made it extremely difficult to study in the wild or even to obtain specimens. Frustratingly, as scientific curiosity about the scrub-bird grew stronger in Australia and Europe, the scrub-bird was dwindling as its habitat was ravaged by wildfire and clearing for agriculture. By the end of the nineteenth century the Noisy Scrub-bird was referred to as "rara avis", by the 1920s it was widely considered to be extinct. In 1948, a memorial to the "sweet-voiced bird of the bush" was placed at Drakesbrook, near the site of John Gilbert's discovery.

Fortunately however, the Noisy Scrub-bird was not actually extinct. One tiny population remained, hidden in the deep gullies of the Mt Gardner peninsula at Two Peoples Bay. Here, less than 50 individuals clung precariously to existence and, in 1961, after more than 70 years without an official record, the Noisy Scrub-bird made a dramatic reappearance. This "rediscovery" brought international conservation attention to Albany and Two Peoples Bay in the early 1960s. The Noisy Scrub-bird was literally on the brink,

continued on page 3

EDITORIAL

Greetings everyone!

In March this year the State Government released an update of the Salinity Strategy. This is a very important document for everyone whose property could be affected by salinity – indeed for all Western Australians. You can obtain a copy of the information package from AgWEST. It comes with a booklet which summarises the resources available to landholders: "Salinity: a guide for land managers". I would urge every interested person – especially anyone on an LCDC or CG Committee – to read these, note the current state of play and what has – and has not - been suggested for the future. Reports on native vegetation management and drainage are also available from AgWEST.

There is some great information in this issue of 'Western Wildlife'! Among others, Steve Hopper takes up the issue of the effect of climate change on dryandras (raised by Odile Pouliquen-Young last issue) to explain just why WA plants are unlikely to 'move to track the climate'. John Pate gives some interesting detail about nitrogen-fixing plants in the bush, Alan Danks talks about translocating noisy scrub-birds, while Ian Common introduces us to a little known group of moths.

Personally, I was fascinated by the 'scat moths' who undergo their entire larval development within the droppings of marsupials. Dr Common is interested in looking for more of these moths from WA, especially from possums, quendas or tammars, but to do that he needs poo samples. If you can locate some scats which you can confidently attribute to a particular native mammal (NOT roos) you might like to contact Dr Common and ask if he would like you to send him some samples. The droppings must not be too fresh, since adult moths have to have time to find them and lay an egg. Well – it's a different sort of quest!

Penny Hussey

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Sylvia Leighton	Albany	(08) 9842 4500
Anne Rick	Newdegate	(08) 9871 1791

Review of "Managing Your Bushland"

As part of the *Land for Wildlife* package, many members will have received a copy of the book "Managing Your Bushland". This was published in 1993 as a text outlining the principles on which bushland management and revegetation for nature conservation are based. Its now out of print, and the authors, Ken Wallace and Penny Hussey, are interested in whether you have found it useful, as a guide to whether it should be reprinted.

Sometime before the end of the year, a researcher will telephone a random sample of *LFWers* to ask about your reaction to "Managing Your Bushland". If you get such a call, we would be grateful if you would take time to answer the questions as fully as you can.

Many thanks in advance!

Did you know .....??

.....why spiders don't get stuck to their own webs?

They walk between the sticky bits! When spiders construct the web, they lay down sticky patches and bare patches at just the right interval for their stride. As the spider grows, so the spacing changes. Small spiders with small webs use very small sticky patches to avoid catching large insects that would either damage their web or even injure the spider.

From Peter Mawson, CALM

continued from page 1

however, and strong measures were needed if it were to be saved from extinction.

Conservation

The first priority was to protect the bird's habitat. This was begun by the creation of Two Peoples Bay Nature Reserve. On-site management made it possible to exclude fire within the reserve and this seems to have been particularly important. Scrub-bird numbers began to increase from 1972. Such a small population however, is at risk from many factors – fire, habitat disturbance, predation. The solution is to build the numbers quickly and spread the population out in the landscape. But the bird needed access to more habitat if the population was to grow enough to provide security from wildfires in the longer term. For a bird with very limited powers of dispersal, this meant that new populations would have to be created by translocation from the rediscovered population. Fortunately, by the early 1980s scrub-bird numbers had grown enough to allow some removals and a translocation program began to be developed.

Once the essential methods of capture, transport and monitoring were developed, the birds were taken to new homes in a number of places along the south coast between 1983 and 1995. Populations developed successfully in the area east of Albany but, interestingly, not to the west where there were several failures. Overall however, the program was successful and resulted in a five-fold increase in numbers in the Albany area.

By 1995, however, scrub-birds in the Albany area were already occupying most of the suitable habitat. Numbers would continue to rise as these populations developed, but it was clear that there were no other areas suitable for establishing large populations. There was a need to look further afield. To the east and north, lower rainfall meant little suitable habitat. To the west of Albany, the unsuccessful attempts at settling Noisy scrub-birds and the lack of any historic evidence that they had occurred there, indicated little likelihood of success in that direction.

FAUNA

On the other hand, it was known from John Gilbert's records that scrub-birds had definitely existed in parts of the Darling Range last century. Perhaps some habitat still existed which would allow the reintroduction of the Noisy Scrub-bird to these former haunts?

During 1996 extensive surveys were carried out from the Murray River, where it flows out of the hills to the coastal plain, south to the Wellington Dam. It soon became clear that the riparian vegetation along the streams originating in the uplands around Mt William contained habitat which looked suitable for Noisy Scrub-birds. This was precisely the area where John Gilbert had recorded the scrub-bird in 1842. The habitat in this area - a distinct association within the surrounding jarrah/marri forest - is characterised by a fringing forest of Bullich (*Eucalyptus megacarpa*) and Blackbutt (*E. patens*) with *Agonis linearifolia* in the stream zone. Dense tangles of *Gahnia* and *Hypocalymma* along the swampy banks provide an equivalent for the low scrub and sedges at Two Peoples Bay.

First releases in the Darling Range

Department of Conservation and Land Management staff, with the support of Alcoa Australia, released the first batch of Noisy Scrub-birds from Two Peoples Bay in two sites in this area during June and July in 1997. The initial pioneer group consisted of males only. This was a deliberate strategy developed during the previous ten years of translocation work on the south coast. Males, although difficult to capture, are more easily caught than females and are usually in surplus. Importantly, because they sing when they establish territories, they allow survival in the new area to be monitored. This provides a way of confirming the new habitat without the possibility of wasting precious females in unsuitable areas.

In one of the release areas, the males were fitted with tiny radio-transmitters before release allowing their movements in the thick vegetation to be followed without needing to see the birds themselves. For the few weeks in which the transmitters remained attached, the scrub-birds led the scientists up and down the stream system as they foraged and explored their new home. Many "song battles" between competing males were witnessed and it was clear that territory ownership changed hands, often several times. Territory ownership was seen to be more dynamic than previously thought. This was a new observation about scrub-bird behaviour, only detectable by the use of radio-transmitters with individually identifiable signals.

But most importantly, the birds continued to sing in the release area indicating the habitat could support them. A year later, at the beginning of the next breeding season, some scrub-birds were still singing. If they had survived through the summer, and it was a particularly dry one, then the chances of longer-term survival were reasonably good. It was time to introduce the surviving males to some females. In 1998, the first females and some more males were added to the initial release areas and a third site was used as well. More males and females were released in 1999.

A small number of male Noisy Scrub-birds can now be heard singing regularly in the Darling Range for the first time in over 150 years and only a few kilometres from where John Gilbert heard them in 1842. If the scrub-birds now present and surviving can be nurtured into establishing a breeding population, their off-spring may be better able to colonise the available habitat. Indeed, for the reintroduction to be considered a success, we need to be able to demonstrate that breeding is occurring and young are being recruited into the adult population. This will take several years yet. But, the success so far is encouraging and, with luck the Darling Range could become a permanent home for a new population of Noisy Scrub-birds.

Alan Danks is Regional Leader Nature Conservation at CALM, Albany. He can be contacted on 9842 4514.

FLORA

CLIMATE CHANGE, DISPERSAL MECHANISMS AND REVEGETATION WITH WA PLANTS

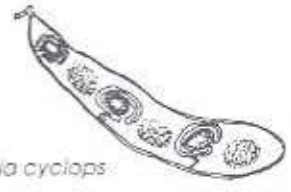
by Stephen Hopper

ODILE Pouliquen-Young's recent article (Western Wildlife 4/2 pp 8-9) highlighted the vulnerability of species of *Dryandra* in south-western Australia to minor climate change of up to 2°C. I would like to expand on two aspects of this important issue – is it likely that south-western plants might disperse across the landscape to track the climate? And, secondly, what does the answer mean in terms of best practice approaches to natural revegetation and restoration in the south-west?

Dispersal capabilities

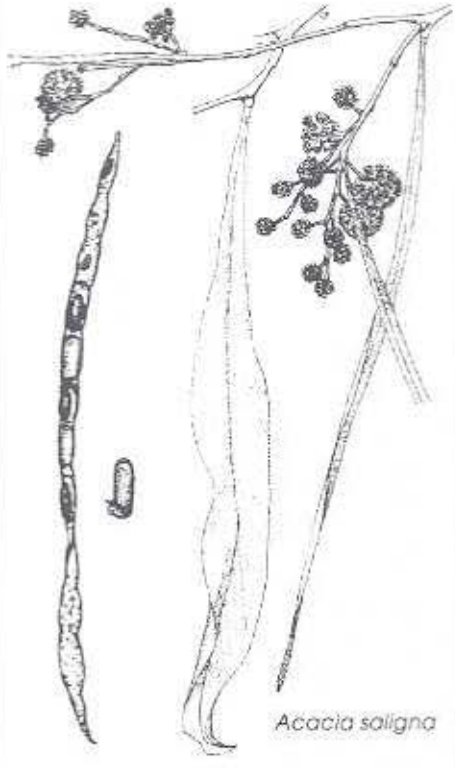
Effective dispersal involves transport of seeds or vegetation propagules some distance from the mother plant, followed by germination and successful establishment to form a breeding population at a new site.

One striking aspect of the majority of the south-west's 8000 native plant species is the absence of obvious means of seed dispersal. Very few species have large wings or light-weight seeds for wind dispersal – orchids, daisies, some native grasses and sheoaks come immediately to mind as exceptions. But look at the seeds of eucalypts, kangaroo paws or most shrubs and perennial herbs that dominate south-western plant communities and you will see that they are unlikely to move away from the maternal plant more than a few metres unless picked up by cyclonic winds, firestorms, sheet flooding or animals.



Acacia cyclops

Another significant deficiency in the flora are berries, drupes and other fleshy fruits encasing seeds as an enticement for birds and mammals to consume and disperse seeds in their droppings. Exceptions are quandongs, mistletoes and many southern heaths (Epacridaceae). Legumes, including wattles, may carry a fleshy structure attached to



Acacia saligna

individual seeds called an aril or elaiosome. These seeds are usually gathered by ants and dispersed short distances, often to underground caches. In a few species, such as the coastal wattle *Acacia cyclops*, the aril is big and bright red, attracting mobile birds as dispersal agents. But, again, the vast majority of south-western plants lack such enticements.

Indeed, it is predominantly in relatively new or open habitats that obvious adaptations for seed dispersal are found – aquatic environments, coastal dunes, margins of rivers and salt lakes, recent dunes or granite outcrops are places to look. The habitats that dominate the south-west display the converse – plants of woodlands, forests, kwongan heaths and mallee country for example usually lack any obvious means of dispersal other then gravity.

This situation contrasts strikingly with that seen in most places elsewhere. Rainforests, for example, are replete with fleshy-fruited species that attract animals as dispersers. The woodlands and forests of eastern Australia have far more such species than do those of the south-west. The vast conifer forests of the northern hemisphere are dominated by widespread fast-growing species with seeds readily dispersed by the wind or by fruit-eating animals. Even the fynbos heathland vegetation of South Africa, so similar to the south-west kwongan in many ways, has a predominance of berry fruits and seeds adapted for wind dispersal.

Why is the dominant south-western flora so different? The explanation is likely to be found in the great antiquity and continuous presence of land in the south-west above sea level and without major disturbance from mountain-building or massive glaciers for more than 200 million years. Such conditions are almost unique on earth. They explain why so much of the south-west is so flat, why soils are so highly leached of nutrients, why such a complicated mosaic of different soil types sits on the gently undulating terrain of the wheatbelt, and why so much salt sits in the landscape.

The native flora, during its evolution over vast periods, has faced quite different selection pressures to that of places where massive glaciers covered vast areas during the ice ages of the past two million years, or where mountain building has rejuvenated soils through accelerated erosional processes (e.g. eastern Australia down the Great Dividing Range). In the south-west, staying close to the maternal plant has been the safest bet for seeds and propagules for tens of millions of years. In many landscape positions, moving even tens of metres away increases the likelihood of striking a different

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soil type and therefore being at a competitive disadvantage to species of the alternative soil preference.

Contrast this with being a plant in a coniferous forest on the edge of a retreating ice-age glacier in North America or Eurasia. Vast areas of rejuvenated bare fertile soil beckoned to those species able to disperse their seeds long distances. Little wonder that adaptations such as prominent wings on seeds or berry fruits are so prevalent in these habitats.

Implications for climate change

An appreciation of the limited seed dispersal capabilities of most south-western plants suggest that tracking climate change is an unlikely option. Perhaps along coastal dunes, riverlines and salt lake systems some movement might occur. For plants of most other habitats, however, much more likely under a drying climate scenario is that populations would die out in marginal habitat and persist in the landscape only in refugial wetter habitat.

Evidence for this is all around us in the south-west. Many rare relictual species are found in locally wet habitat such as on granite outcrops, on the southern slopes of breakaways, on seeps and in ephemeral swamps. This becomes clear in a cursory read of habitats covered in CALM's book on WA's threatened flora (see ref.). Conservation of such seasonally wet habitats will be a key strategy as the climate warms.

I would venture to suggest that Dr. Pouliquen-Young's conservative models for species of *Dryandra* are overly optimistic as they assume that species are capable of colonising most patches of preferred soil within a given climatic envelope. Years of searching for

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rare and poorly known plant species in the south-west has impressed upon me that occupation of all or even half the available preferred soil patches occurs rarely indeed. It is far more common for species to occur sporadically in localised patches even if their preferred soil is quite abundant and continuous over many kilometres.

One only has to reflect upon the recent death of many plants on shallow soils adjacent to granite outcrops in the jarrah forest, wheatbelt and goldfields during summer heatwaves of the 1990s to appreciate that persistent global warming will have immediate and dramatic impact locally. Moreover, given the severe limitations on seed dispersal of most native plants, and relatively high proportion of weeds now in the south-western flora, such deaths associated with global warming may well exacerbate weed invasion.

Implications for revegetation

The extraordinary limitations on seed dispersal for most south-western plant species indicate that using local seed and planting to soil type for revegetation are critical – far more so than anywhere else on earth. This will ensure the conservation of the full range of biodiversity, including all the local animals that track differences over short distances in the flora.

Naturally, there will be differences in what constitutes local seed depending upon the species of concern. Research is currently under way to help put some figures for local gene pools on a range of plant species of different biology and life-form. Already we know that forest and major woodland trees in the south-west having continuous large populations are more genetically uniform across their geographical range than understorey plants such as triggerplants, lilies or kangaroo paws, or mallee species distributed on isolated granite outcrops. Until such research is well advanced, however, the precautionary approach is to stay as local as possible in seed collecting within the soil type being revegetated.

Ref: Western Australia's Threatened Flora 1998. Ed: A. Brown, C. Thompson-Dans & N. Marchant. CALM

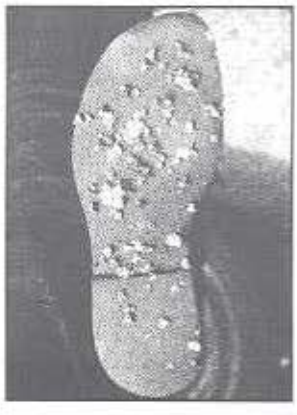
Dr Steve Hopper is Director of the Botanic Gardens and Parks Authority (formerly Kings Park and Botanic Gardens). He is a botanist and ecologist with special interest in specific plant groups, such as eucalypts and kangaroo paws, and in granite rock habitats. He can be contacted on 9480 3600.

BUSH DETECTIVE

Where do the prickles come from?

This thong has picked up a load of hard, sharp, prickly fruits. What plant do they come from? (Hint: It's not native to WA!)

Answer - page 19



FAUNA

MALLEE MOTHS

by Ian Common

MOTHS and butterflies constitute the large insect order Lepidoptera (insects with scaled wings) which, next to the beetles (Coleoptera), is the largest order in Australia. With about 400 species Australia has a poor butterfly fauna, whereas the moth fauna is richly diverse, with more than 10,000 named species and an estimated fauna of some 22,000 species. As in other insects adult moths have a tough external frame or exoskeleton enclosing the softer internal organs of the body, which are bathed in haemolymph (blood), They have six jointed legs and two pairs of wings. The body, wings and legs are covered with minute overlapping scales, which contain the pigments responsible for their patterns and colours. The head is equipped with two antennae and compound eyes, paired mouthparts bearing complex sensory organs and, usually, a coiled proboscis for sucking up water or other fluids.

The mallee moths of the family Oecophoridae number more than 3000 known species and represent about a quarter of the Australian moth fauna; a total of some 5000 species is estimated. Most are fairly small, with cryptic colours and markings, but many are among the most beautiful moths. Their larvae have very diverse, often complex behaviour patterns, but for food most depend on the live or dead foliage of the hard-fruit genera of Myrtaceae. Nearly all of the known species feed on dead *Eucalyptus* leaves, which are tough and leathery and very resistant to breakdown, especially in a dry climate. They are rich in phenolic compounds and tannins that normally act as feeding deterrents for most organisms. Thus mallee moths have a significant role in breaking down dead eucalypt leaves to humus, thus returning nitrogen and other nutrients to the poor soils characteristic of Australian forests. Except for clear-felling or large-scale wild fire, I believe that extensive control burning at short intervals poses the greatest threat to the survival of these insects and the long-term health of our native forests. The relationship between control burning and mallee moth diversity deserves scientific study.

It is thought that the Australian mallee moths evolved from Gondwanan stock and, after the Australian continent split off from Antarctica, their extensive radiation probably parallelled that of the large

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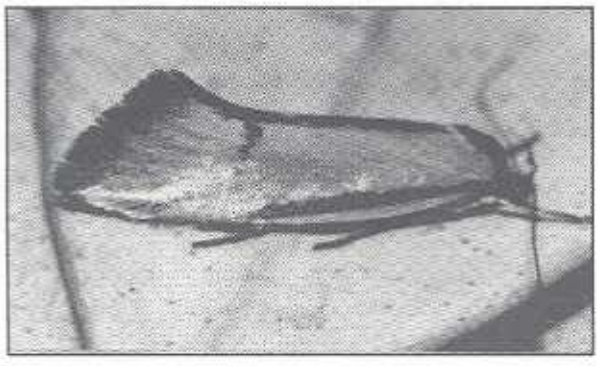

Fig. 1. Philobota sp., wingspan 20 mm, forewings orange, outer one-third and leading edge dark brown, hindwings dark brown.

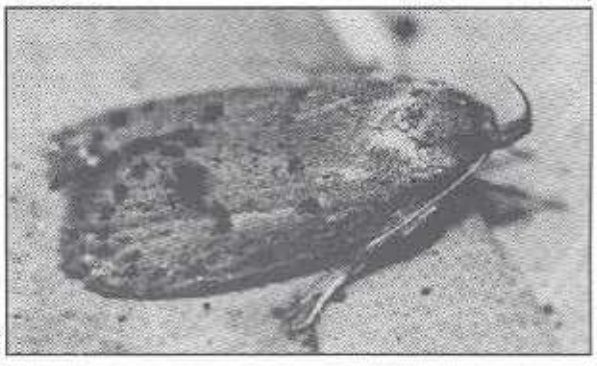

Fig. 2. Eulechria atmospila (Turner), wingspan 18 mm, forewings light grey, spots blackish, hindwings light grey.

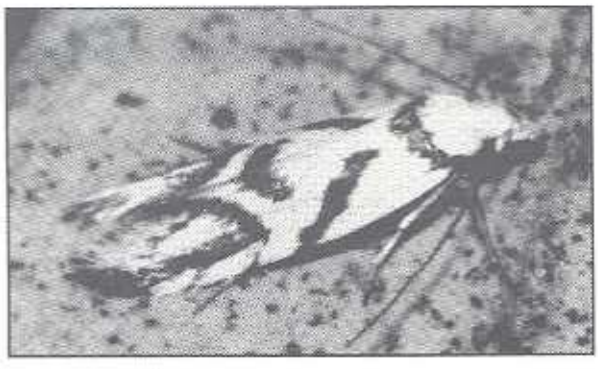

Fig. 3. Oxythecta acceptella (Walker), wingspan 15 mm, forewings white, markings orange, hindwings grey, fringe yellowish.

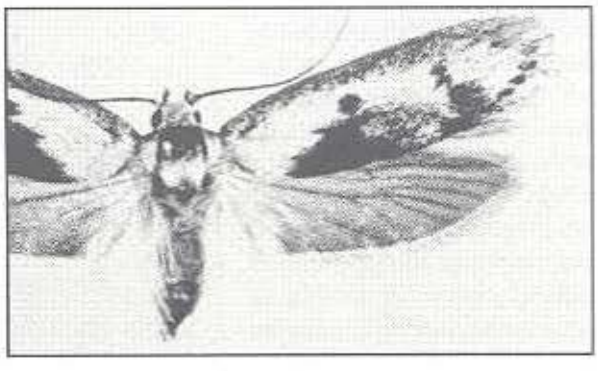

Fig. 4. Conobrosis acervata (Meyrick), wingspan 18 mm, forewings whitish, leading edge grey, markings dark brown, hindwings grey-brown, fringe pale yellow.

continued from page 6

genus *Eucalyptus* and other hard-fruited Myrtaceae. Nearly all of the 271 named genera are endemic to Australia, and several are endemic to the south-west. The greatest concentration of both genera and species occurs in New South Wales and south-east Queensland, where more than 1000 species are known in nearly 200 genera. Only 356 named species in 98 genera are known from southern Western Australia. However, the relatively low number of species recorded from the south-west may simply reflect the absence of resident collectors with an interest in small moths.

Myrascia larvae feed on live foliage of *Melaleuca*, *Leptospermum* and *Kunzea*. *Myrascia megalocentra* larvae, from the Geraldton area, live in portable cases on *Melaleuca uncinata*. The larvae are unique in having a diverticular sac of the foregut in which they secrete pure pungent oil from the foliage, gaining protection by regurging it on to any potential predator. The secreted oil is discarded when moulting occurs but, at pupation in the larval case, the whole sac is shed along with the lining of the foregut and other larval cuticle. The sac of oil thus provides a deterrent should a bird or other predator attempt to open the case.

Wingia has larvae using live eucalypt leaves as food, and includes some of the larger and most beautiful mallee moths. *W. lambertella*, which has a wingspan of about 4 cm, has rich pink fore wings and hind wings which are light yellow in Western Australia, but pink in south Queensland. The slightly smaller *W. aurata* has hook-tipped fore wings which vary in shade from yellow to orange-red.

It seems likely that the dead-leaf feeding behaviour of Australian mallee moths is more specialised than live-leaf feeding. This suggestion is based on the behaviour patterns of several unrelated genera of larvae that use live eucalypt foliage when young, but complete their development using dead eucalypt leaves. In *Heliocausta*, for example, the eggs are apparently laid in the eucalypt tree canopy and

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the young larvae feed on the live leaves. When about 1 cm in length they shelter between two undamaged leaves, join them lightly with silk and sever the two petioles. Having dropped to the ground the larva attaches the two leaves with silk to a stone or other object and feeds on the two wilting and finally dead leaves for the remainder of its development, leaving only an irregular oval shelter formed from the leaf remnants. This it attaches with silk to a tree or stone and pupates in a dense cocoon it spins within the shelter. At least ten species are known, two of which, *H. oecophorella* and *H. floridula* occur in the south-west.

Dead eucalypt leaves are used by most mallee moth larvae throughout their development. Most of the 200 named species in each of two genera *Philobota* (Fig. 1) and *Eulechria* (Fig. 2) are good examples. Each includes only about 20 named species in the south-west, but most of them, as well as several other genera, would have larvae using dead eucalypt leaves as food.

We have recently discovered that as many as 50 species in three genera of mallee moths, *Telanepsia*, *Oxythecta* (Fig. 3) and *Scatochresis*, have larvae which depend for the whole of their development on the faecal droppings (scats) of marsupials, including koalas, brushtail possums, wombats and rock and other wallabies. As the first of these were reared from koala scats, which consist of finely divided fragments of their eucalypt-leaf food, we suspected that the larvae were thus using eucalypt leaves indirectly. However, wombats and wallabies do not eat eucalypt leaves. Nearly all of our records come from eastern Australia, but one unnamed species of *Telanepsia*, two unnamed species of *Oxythecta* and one species, *Scatochresis perigrapta*, are from the south-west. Only one adult (?*Oxythecta* sp) has been reared so far from scats (rock wallaby) collected in Western Australia.

Dung-feeding (coprophagy) also occurs in the two large species of *Trisyntopa*. The larvae of *T. scatophaga*, from Cape York Peninsula, live in the nest hollows of the golden-shouldered parrot that are excavated in termite mounds. The larvae feed on the droppings produced by the nestlings and probably help to maintain a hygenic nest environment. Those of *T. euryspoda* have a similar role in the nests of the eastern rosella and mulga parrot farther south.

Although the larvae of most mallee moths depend on the foliage of Myrtaceae as food, there are some exceptions. Two species of *Conobrosis* utilise the dead male cones of *Macrozamia* cycads, apparently feeding on the pollen, sporangia and microsporophylls. Infested cones are covered by a dense webbing of silk, faecal pellets and sporangia. *C. acervata* (Fig. 4) is found on *M. riedlei* in south-west Western Australia.

Ian Common is an Honorary Research Fellow of CSIRO Entomology, having retired in 1982 after 34 years research, mainly on Microlepidoptera, especially mallee moths. He can be contacted on (07) 4638 4203.

Further Reading

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RESEARCH

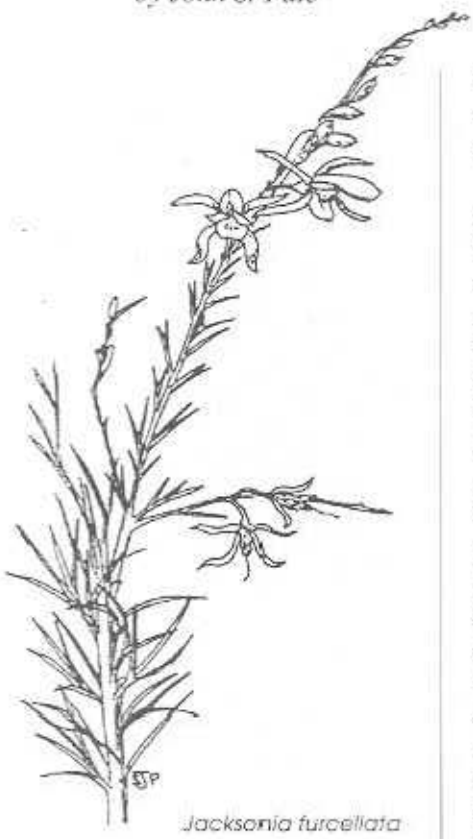
LEGUMES IN NATIVE BUSH AND AGRICULTURE: POTENTIAL ROLES IN FIXATION AND CYCLING OF NITROGEN?

by John S. Pate

WHENEVER one sees a prolific crop of lupins, peas, faba beans or chickpeas, or a pasture rich in clover or serradella, one immediately thinks of bacterial-induced root nodules and their capacity to supply legumes with fixed atmospheric nitrogen. Indeed, without inputs from such crop and pasture legumes, broadacre farming in most regions of Australia would be disastrously unprofitable, since it is uneconomical for most farmers to replace the free source of nitrogen from legumes with expensive nitrogen fertilisers.

Nevertheless, it must be remembered that our agricultural systems operate successfully only through continued application of superphosphate and, in certain circumstances, any of a number of other potentially limiting nutrients such as potassium, sulphur, copper, zinc, manganese, molybdenum and cobalt. By correcting such deficiencies, a situation is created in which legumes flourish and compete successfully with non-fixing species in low nitrogen soils. Additionally, where a cereal follows a previous legume crop or pasture, the yield of the cereal is noticeably benefited by nitrogen released in decomposition of residues of the legumes concerned.

But what about nitrogen fixation in the original bushlands from which our artificial agrosystems have been created? In virtually all cases legumes are present in significant amount in terms of numbers of species and the collective biomass which they represent. In fact in some cases, such as mulga and certain heathland systems, legumes such as wattles (*Acacia* spp) may comprise major components of vegetation. Yet, is there evidence



Jacksonia furcellata

that such legumes are nodulated and, if so, do they fix nitrogen as effectively as in our ameliorated agricultural systems?

As a further issue, are there other classes of plant in native vegetation which are able to engage in symbiotic nitrogen fixation in a manner akin to legumes? The remainder of this short article will attempt to answer these and other questions, mostly using information which the author and his colleagues have gathered from a range of ecosystems in south west WA over the past years.

Is it correct to assume that all legumes are capable of forming nodules and therefore fixing nitrogen? Legumes comprise three groups, the pea family (Fabaceae), the acacias and their allies (Mimosaceae) and the cassias and their allies (Caesalpiniaceae). Members of the first two groups can form nodules in the presence of appropriate bacteria, while members of the third group cannot.

Even then, inspection of roots of native members of Fabaceae and Mimosaceae (peas and wattles) will often fail to show presence of nodules, especially when dealing with relatively old plants. However, stands of seedlings of short-lived legumes (eg *Bossiaea, Acacia, Gompholobium, Sesbania*) recruiting after recent fires would be expected to be well nodulated and can be shown by various chemically-based assays to be currently fixing appreciable amounts of nitrogen. However, as these stands age, nodulation becomes much less prolific or even totally absent. Our interpretation of this phenomenon is that the element phosphorous, normally the principal limiting nutrient in our ecosystems, becomes transiently available after a fire in the form of deposited ash or released from plants killed in the fire. On the other hand, most nitrogen of above-ground biomass is lost to the atmosphere as gaseous ammonia and oxides of nitrogen during the fire, and so under the ensuing nitrogen-limited: phosphorous-sufficient conditions well-nodulated legumes will flourish and compete particularly effectively with non-legumes. The predominance of shrub legumes in many post fire understoreys in our forest and woodland ecosystems attest to this.

Eventually, however, once phosphorous availability declines, both legumes and non-legumes have to invest increasingly in specialised feeding roots and symbiotic associations with mycorrhizal fungi to access insoluble forms of phosphorous. Ability to fix nitrogen

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is then no longer an issue. Indeed, legumes might well be disadvantaged if devoting part of their resource of photosynthetic product to formation of nodules while also supporting energy-demanding mechanisms for acquiring phosphate. Nevertheless, despite their declining activity in fixing nitrogen in later years, it is generally agreed that understorey legumes of the above kind play an important role in replenishing nitrogen resources lost in fire. In some cases populations of such shrub legumes die off more or less synchronously, say 6-10 years after the fire event which prompted their establishment. In such cases transfer of nitrogen to non-leguminous sibling species over the following seasons may be very noticeable.

It is well known that cycads such as our zamia (*Macrozamia riedlei*) fix nitrogen through the agency of specialised coralloid roots harbouring nitrogen-fixing blue green algae (*Cyanophyta*), and sheoaks (*Casuarina, Allocasuarina*) behave similarly using root tubercles containing the actinomycete *Frankia*. Studies suggest these long-lived species carry perennial symbiotic organs providing the host plant more or less continuously with nitrogen. However, at least in zamia, nitrogen fixation becomes particularly active after fire, coinciding with the plant producing a flush of new leaves and engaging in fire-induced reproduction. In the case of the above non-legume species and equivalently long-lived legumes one would expect significant and continuous inputs of fixed N to be made, thus contributing towards maintenance of nitrogen capital within the parent ecosystem between successive fires.

One has to be careful before condemning a legume as non-functional in nitrogen-fixation simply on the basis of not finding nodules in its roots. Nodules on most shallow-rooted legumes are typically short lived and, as far as south west WA conditions are concerned, are typically present and active only for a short winter/spring period when soils are moist and temperatures are not excessively high. So excavations in summer would provide misleading information on nodulating capacity. As a general rule of thumb a legume found to be carrying during the growing season a population of nodules collectively amounting to 3-10% of the mass of the plant would be expected to be providing itself with sufficient fixed nitrogen to support growth. But the nodules concerned would have to be healthy and this is best indicated by presence of red or pink pigmentation in their central bacteria-containing tissues. This indicates presence of haemoglobin-type pigment essential to proper functioning of the nodule in nitrogen fixation.

Gastrolobium bilobum

Unfortunately we still know very little regarding the nodulation status and nitrogen fixing capacities of many of our native legumes, nor indeed of the strains of bacteria which they require to nodulate successfully. Research continues to bring up surprises. For instance, we have recently encountered clusters of large elongated and apparently perennial nodules at 1-4m depth encircling the deeply penetrating tap roots of certain native legumes (eg *Acacia saligna, Jacksonia* spp) and the fodder tree legume tagasaste (*Chamaecytisus proliferus*). Being located in deep, continuously moist parts of the soil profile these nodules are protected from the seasonal drought and high temperature stresses experienced by ephemeral counterparts in near surface layers of the soil.

A further example in which unexpected results have been obtained, concerns our recent studies of nitrogen cycling in mulga vegetation of Western and eastern Australia. Here we have failed to find nodules on any of the half dozen or so acacias which dominate this class of vegetation. Using a specialised stable isotope technique to assay the sources of nitrogen which these legumes and cohabiting non-legumes are using, we have confirmed that symbiotic inputs of nitrogen by the acacias are insignificant and that they and other non-fixing species appear to be relying mostly on the large resources of nitrate typically encountered in soil and groundwaters of the ecosystem. It is well known that nodulation and nitrogen fixation of agricultural legumes are strongly inhibited by nitrate and possibly this is what is happening in acacias at our mulga sites. Supporting this contention we have encountered interesting legume populations inhabiting ridges of leached wind-blown sand around a lake in one of the mulga habitats. In this unusual situation the legumes turned out to be well nodulated and were shown by our isotope assay technique to be heavily dependant on fixed nitrogen. Incidentally, despite the general absence of nitrogen fixation by legumes in the major plant components of mulga, fixation inputs were indicated as being made by certain lichen crusts, and possibly more importantly by termite colonies. Worker termites have been shown to have colonies of cellulose-decomposing and nitrogen-fixing bacteria in their guts, with the former micro-organisms providing the latter with energy-yielding sugars to implement nitrogen fixation. Furthermore, one can detect high concentrations of nitrate in the soil below certain termite colonies suggesting that they may have been

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MAKING CONNECTIONS

MOST of us tend to be focused on our own patch of bush and as a consequence manage it as an isolated entity. It may be worthwhile taking a step back and considering the important role 'our patch' plays, or could play, in the broader vegetation landscape.

By connecting bush remnants, we establish a living network, which is more diverse than the individual elements. We then become part of a more robust system, that has the capacity to buffer and protect our patch from permanent loss of biodiversity caused by a localised disturbance or catastrophe. With time and good management wildlife activity in our patch should increase as a result of being part of a larger system.

A project currently underway in Bridgetown is looking to identify opportunities where these broad landscape connections can be made.

The BiG.liNCS Project

In March 1999 the Blackwood Environment Society received funding from the Natural Heritage Trust to undertake the "Bridgetown-Greenbushes Nature Conservation Strategic Plan", now known by its acronym as the **BiG.liNCS** project. The project is using a blend of geographic information systems, on-ground vegetation surveys, ecological expertise and local land manager groups to identify and target priority areas for future conservation management and on-ground works within the Shire of Bridgetown-Greenbushes. Ultimately the implementation of the strategic plan should lead to an effective integrated nature conservation network across the Shire.

Bridgetown's Vegetation Mosaic

The landscape mosaic in the Shire is composed of a series of distinct and typically unconnected elements. The largest of these are the big areas of State Forest to the south, west and north, which extend well out beyond the Shire boundary. These blocks comprise about 75% of the native vegetation cover in the Shire. Nestled inside these large forest areas are 12 unconnected smaller forest blocks, some of which are State Forest and others various categories of reserve, which make up another 18%.

Privately owned bush remnants are then scattered between these other vegetation elements, and account for less than 7% of the vegetation cover in the Shire. Of these 1500 private remnants most are only several hectares, with only around 150 being 20 hectares or greater, and a third of these modified to some extent (heavily grazed, regularly burnt or partially cleared).

The other significant element in the mosaic is the Blackwood River, which splits the Shire roughly in two. The river can be both a connecting element between vegetation remnants for some species and a barrier for others.

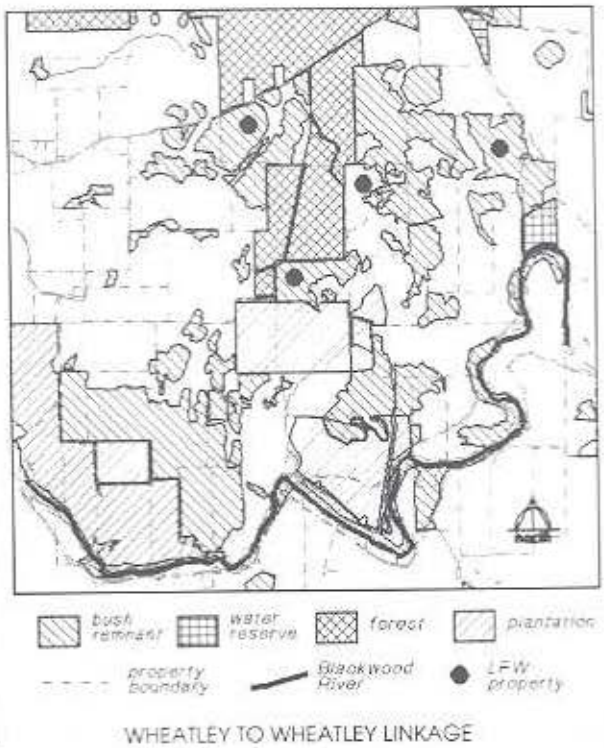
Under the guidance of consultant ecologists, the project team has been able to study the Shire's vegetation mosaic. The most logical routes for connecting all of the forest and reserve blocks and the private remnants greater than 40 hectares have been identified. To avoid dead ends in this proposed network, at least two connections were made to each element. The route of each connection typically optimises the use of smaller remnants along its path to act as stepping-stones. It also takes into account location in the landscape (ridge, creekline), the vegetation types which it moves through, and a social consideration where known (does the affected landmanager have an enlightened attitude to nature conservation).

While the process has focused on the connections between the larger public and private bush remnants at a whole of Shire scale, it can be used at a much smaller scale, right down to individual properties if the base data is accurate enough.

The BiG.liNCS project has also confirmed the importance of several potential connections, which had previously been recognised during *Land for Wildlife* property visits. BiG.liNCS team member and local *Land for Wildlife* Officer Jenny Dewing has been working with landholders along one of these connections for 6 months.

Wheatley to Wheatley Linkage

During a *Land for Wildlife* property visit in December 1998, Jenny Dewing and members of the Wheatley family identified a potential landscape connection through the property. Commencing on the Blackwood River, the connection passes through their remnant bush up to one of the Hester Forest blocks and back down across a number of large private remnants to the Blackwood River, about 10 kilometres downstream. It has become known as the 'Wheatley-to-Wheatley' linkage after the two distantly related families that live at either end of the link. The Blackwood Basin Group's



WHEATLEY TO WHEATLEY LINKAGE

LINKING BUSH REMNANTS

By Jenny Dewing & David Singe

continued from page 10

Biodiversity Program has also recently ranked this chain of remnants as a high priority complex.

Landholders in the linkage reflect the changing demographic and landuse profile of the Shire, where larger farms are being broken up into lifestyle bush blocks, hobby farms or tree farms. The seventeen properties include three large farms, four small farms, two timber plantations, a tourist enterprise, a berry farm, three bush blocks, a property owned by the Shire, a DOLA Reserve and part of the Hester Conservation Zone. Seven of the property owners are absentee owners.

Ten of the "greater than twenty-hectare" remnants in the Shire occur in the Wheatley-to-Wheatley linkage. Vegetation types include jarrah–marri forest, jarrah-wandoo woodlands, banksia–tea tree thicket wetlands, rock outcrops, the flooded gum woodland of the Blackwood River foreshore and "bull and ti tree" gullies. The linkage includes some large wandoo remnants, a less common vegetation type within the Shire.

Landholders have reported sightings of the common western grey kangaroo and small mammals such as chuditch, phascogales, brush-tailed wallabies and possums, bandicoots and water rats. Indeed, Eric and Gillian Wheatley at the downstream end of the linkage have an ongoing encounter with a young male chuditch. Responsible for taking their poultry, the chuditch was trapped on a number of occasions, dutifully taken back to the bush only to have it return for more of the same several days later. The chook pen is now chuditch-proofed. The area also provides nesting sites for red–tailed black cockatoos, wedge–tailed eagles and a number of owl species.

Landholder Groups

In October 1999 landholders with properties in the Wheatley-to-Wheatley linkage were invited to a meeting to learn about the BiG.liNCS project, and to consider opportunities for managing their remnant bush together, with nature conservation as a common goal. An important outcome of the meeting was this new way of seeing the landscape as an integrated system, rather than isolated patches of bush. There was general agreement on the value of working together,

Learning about the forest floor with John Dell.

particularly for weed and feral animal control and when applying for fencing and revegetation grants.

Resources available to the group include fencing subsidies from the Blackwood Biodiversity Program, advice on providing habitats for wildlife for landholders who register with the *Land for Wildlife* scheme, and vegetation surveys and management advice through the BiGliNCS project. From this initial meeting two more landholders within the group joined *Land for Wildlife*, and two other landholders decided to covenant the bush on their property. Covenants are voluntary agreements to provide long-term protection for conservation values on private land.

From October to December 1999 Jenny Dewing (as Shire Landcare Co-ordinator) and Landcare Trainee Anthea Paino carried out vegetation community and condition assessments on most properties within the linkage. Specific management issues were discussed with each landholder on a property- by- property basis.

With landholders keen to learn more about the bush in their linkage, John Dell, Senior Technical Officer for the WA Museum was invited down in March this year. Twenty-five people spent the whole day in the field with John, walking and talking as representative sites on four properties and in the Hester Conservation Zone were explored. Landholders learnt first hand about habitats and how to manage them for wildlife, with particular emphasis upon reducing disturbance and encouraging natural regeneration.

The key lessons from John's visit were the importance of the invertebrate communities that live on the forest floor and the unique management issues for fragmented landscapes. As with all situations where remnant bush and farmland adjoin, the balance between fire prevention and wildlife habitat maintenance was raised as a major concern. The day was capped off by evening spotlighting in the Hester Conservation Zone which revealed a pair of brush-tailed possums, a barn owl, and many spiders. Following this a fourth property registered for *Land for Wildlife* and two others are considering covenants.

Landholders followed up the March activity with a group fox baiting effort in April. Twelve dozen 1080 baited eggs were laid across the linkage during the same week.

Future Directions

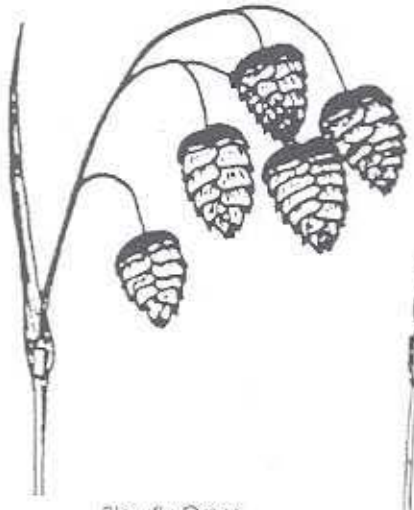
At the big end of the scale the process developing through the BiG.liNCS project may be extended beyond its current Shire limits, or could be taken elsewhere and adapted to a quite different vegetation landscape. At the other end of the scale the process has only just begun. Landholders are thinking "whole of landscape" and "long term". **What we do now will have impacts in two to three hundred years and longer**. Learning to work together in a landscape sense takes time and involves negotiation and compromise. There is an opportunity to develop working partnerships with the Bridgetown–Greenbushes Shire and CALM. A workshop on fire management is planned. Several small gaps in the linkage need revegetating, and some remnants still need to be fenced. Importantly a start has been made and this same process will extend to other connections identified by the BiG.liNCS project.

Jenny Dewing is the Land for Wildlife Officer in Bridgetown, and David Singe the Project Manager for the BiG.liNCS Project. They both have properties on the Blackwood River, where they are connecting their remnant vegetation back to the river. Both work out of the Old Railway Station in Bridgetown. David's Boyup Brook property is registered with Land For Wildlife. Jenny can be contacted on 9761 2318, and David on 9761 2450.

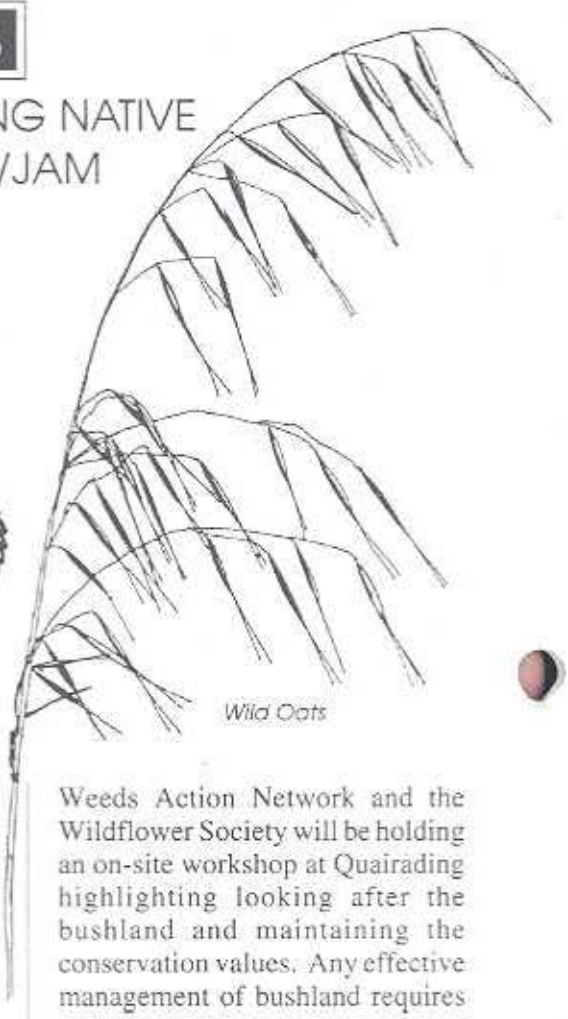
PRACTICALITIES

MANAGING WILD OATS AMONG NATIVE GRASSES IN A YORK GUM/JAM WOODLAND

by Kate Brown



Blowfly Grass



Wild Oats

THE Quairading Nature Reserve, 600 hectares of bushland just west of Quairading, contains a diverse range of soils, landforms and associated plant communities. Salmon gum and wandoo woodlands occur on the heavier soils, *Banksia prionotes* woodlands on the yellow sandy rises and heathlands on grey sand plains. York gum/jam woodlands grade into rock oak woodlands around the granites and tamma shrublands cover a range of soils including sandy loams and gravelly sands. Much of the bushland is relatively undisturbed, however a past history of grazing in the York gum/jam woodlands has left a legacy of weed invasion. These woodlands have historically been favoured sites for grazing, and wild oats (*Avena barbata*) and blowfly grass (*Briza maxima*) are now common components of the understorey, smothering and out-competing many of the flowering native herbs and native perennial grasses.

Previous studies both in Western Australia and in native grasslands in eastern Australia have indicated that very low rates of grass selective herbicides sprayed early in the winter season can effectively control annual exotic grasses without seriously impacting on other plants including perennial native grasses. Preliminary results of our work among the native grasses in the York gum/jam woodland at Quairading are supporting these earlier studies

In early August 1999 when the wild oats were around 10cm high, plots of 20m x 20m were sprayed with low rates of grass selective herbicide (for exact prescription, contact author). Within the sprayed plots the wild oats were very much reduced both in abundance and size. The blowfly grass was also much reduced. There was no loss of native grasses within these sprayed plots, however there did appear to be a reduction in flowering particularly in foxtail mulga grass (*Neurachne alopecuroidea*). It will be interesting to see what the next season brings in the way of recruitment of native species. Over the summer months seed from native everlastings including *Rhodanthe manglesii*, *R. citrina*, and *Waitzia acuminata*, also from perennial grasses such as foxtail mulga grass, *Austrostipa trichophylla* and *A. elegantissima* were collected. Hopefully sowing these into sprayed areas this autumn will encourage natives rather exotic invaders to move into the gaps. Wild oats' seed is short lived (around six months) in the soil and so it was not surprising that few germinants were observed in the sprayed plots following summer rains in January/ February 2000.

The management of wild oats is just one example of the sort of management actions that are required to effectively look after the conservation values of woodlands. In August 2000 the Environmental Weeds Action Network and the Wildflower Society will be holding an on-site workshop at Quairading highlighting looking after the bushland and maintaining the conservation values. Any effective management of bushland requires an understanding and knowledge of plants (both native and introduced) and their patterns of distribution in a particular bushland patch. The workshop will look at how the information gathered from the September 1998 bushland plant survey, carried out by the Wildflower Society with help from members of the Quairading community, can be used to help manage the conservation values of this diverse patch of remnant vegetation. It will include site inspections and a visit to the wild oats trials.

Ref: Hitchmough J.D., Kilgour R.A., Morgan J.W. and Shears I.G. (1994). Efficacy of some grass specific herbicides in controlling exotic grass seedlings in native grassy vegetation. Plant Protection Quarterly, 9: pp 28-34.

Kate Brown is Project Officer for the Environmental Weeds Action Network. She can be contacted at the Swan Catchment Centre on 9220 5300.

DO YOU LIKE TO WATCH BIRDS?

If you like to watch birds, if you can identify the local birds, and if you live in or visit the wheatbelt, then you can enjoy watching birds for a new project. The Wheatbelt Birds Monitoring Project links the New Atlas of Australian Birds and the Biological Resources Survey work being done for the Salinity Action Plan by CALM.

News of a Community Conservation Grant for this project came to hand just before this newsletter went to press, so we can't print more details here.

If you're interested, contact Cheryl Gole, Birds Australia WA, Tel/Fax 9293 4958.

TRIAZINE RESISTANT WILD RADISH

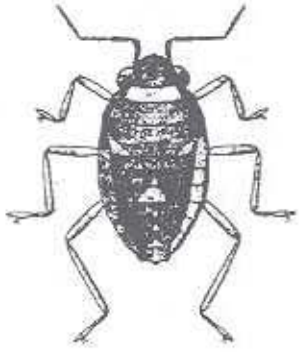
Wild radish in WA has evolved resistance to triazine herbicides such as simazine and atrazine. A patch was first discovered in 1998 in a paddock at Mingenew. When seed was collected and tested in the laboratory, 10-30% of seedlings survived up to 18.0L atrazine (normal paddock dosage is 6.0L – 2.0L pre- and 4.0L post-emergence spray). Evolution of resistance to triazines by wild radish poses a great risk to the oilseed, lupin and pulse industries in WA and has the potential to become very widespread.

Abul Hasheem, the scientist working on this problem, urges all farmers to be aware of the risk triazine resistant wild radish could pose, and to adopt integrated weed management including non-chemical methods to control it. His trials have shown that autumn tickling, crop topping and blanket wiping are effective in depleting the soil seed bank and preventing seed-setting in wild radish.

In bushland, hand pulling or wiping with a knockdown herbicide are the best options.

For more information, contact Dr. Abul Hasheem, AgWEST, 9368 3333.

IN BRIEF



MEET THE MILLENNIUM BUG!

It had to happen, a bug has been discovered which will be named the 'Millennium Bug'! It is a small (2 mm long) water strider, living in mountain streams in Qld and northeast NSW. The bug will be used as a biological indicator to monitor the health of the streams.

For further information, contact: Ebbe Nielson, CSIRO, on (02) 6246 4258.

HITCH-HIKING TIGER SNAKE!

New Zealand is snake-free, and their quarantine authorities keep a close watch on cargoes arriving in the country to try and ensure that it remains so. Recently a tiger snake (*Notechis ater*) was spotted by a crane operator unloading containers from Fremantle. He solved any possible problems by dropping a container on it! But it makes one wonder how such an animal could get on board a ship - presumably in an open-sided machinery-carrying container, or hidden deep within one of the hollow struts that are used when the container is being moved by a fork-lift.

The most interesting question though - is the Fremantle container wharf a haven for tiger snakes??

From Dick Veitch, Papakura, New Zealand.

CARNABY'S COCKATOO DECLINING - AND TOO GOOD TO LOSE!

Carnaby's Cockatoo is a white-tailed black cockatoo living nowhere else but the south-west of WA. This big, visible and wonderfully rowdy cockatoo is specially protected as threatened fauna. Most people know the Carnaby's wailing 'wee-ooo' call. But if we don't do something to save it, people in the future may never hear that wonderful sound.

This great cockatoo needs your help. The first part of the recovery plan for the Carnaby's will identify some of its important breeding areas in the wheatbelt so that they can be protected for the future. Birds Australia WA, CALM and other community organisations and individuals are working together. You too can work with us.

Carnaby's Cockatoo breeds in the wheatbelt between July and December. If you see Carnaby's in this area at this time of the year, we'd like to hear from you. What can you do? Tell us you're interested. We'll add you to our mailing list and send you reply-paid postcards on which to record information on where the birds are, how many there are, and what they are doing.

Carnaby's needs you!

Contact: Cheryl Gole, BA WA, 71 Oceanic Dr, FLOREAT 6014. Tel/fax: 9293 4958. Email: gole@starwon.com.au

MEMBERS PAGE

WHAT KIND OF FROG?

We live on a small bush block, close to Lake Powell on the west side of Albany. The property itself is divided by a drainage channel conveying storm water to the lake. Being close to water, we share the environment with a host of frogs; the quacking frog, moaning frog, banjo frog, slender tree frog, spotted thigh frog, motorbike frog and various froglets that we still have to identify. We have noticed that with this year, being so wet, there are many more adult frogs than there have been over the past four to five years. Our snake numbers also seem to be fewer. The king skinks still seem to be out in force and we have noticed that they hunt frogs, grabbing them by their hind legs and flaying them backwards and forwards as does a crocodile with its prey, then devouring them when they are pacified.

One particular frog has roused our curiosity because of its dramatic defence behaviour, and not being experts we have yet to identify it. Its first reaction to disturbance is a very loud screeching. This is piercing and sustained. If escape seems impossible, its next ploy is to appear aggressive. When approached (by a hand) it raises itself on its toes so that it appears somewhat larger and it jumps straight at its aggressor with its mouth open. It has a large gape, even for a frog, and will actually grab a finger tip (quite painless!!!) Finally, if these two behaviours do not work to its advantage, it enacts the most amazing ploy of all - it feigns dying!! It stretches out its fore and hind limbs stiffly and at the same time pushes itself on to its back. In this position it quivers and jerks spasmodically, gradually becoming rigid and changing colour! The drab grey and white colouration combined with the extended body (which appears dry and shrunken) has the appearance of something dead - long dead - it fooled us! Heart failure maybe? We were sure it had expired. However, after a fairly protracted time the changes reversed and it eventually hopped away. Obviously this last behaviour cost a lot of effort because the frog seemed a bit slower and maybe even exhausted.

Cliff and Margaret White with one of the frogs more commonly found on their property - a motorbike frog (Litoria moorei)

Margaret and I have witnessed this drama on only two occasions, which coincide with the number of times that we have seen this particular type of frog. We hope to see it again, although we may have to wait a while. We will have a camera ready next time.

Cliff and Margaret White, Albany

Dale Roberts, Dept of Zoology, UWA, says: "The behaviour sounds like *Neobatrachus pelobatoides* which screams when agitated, blows itself up and stands on all fours. I haven't seen the next bit where it feigns death but that does not surprise me. Colours could be this species but the grey is more suggestive of *N. albipes*. They may both behave the same way, and both are likely to occur in your area. A good clear photograph would be useful. Incidentally, a lot of frogs scream when threatened. *Helioporus* species as well as *Litoria moorei* and *L. cyclorhynchus* often do so."

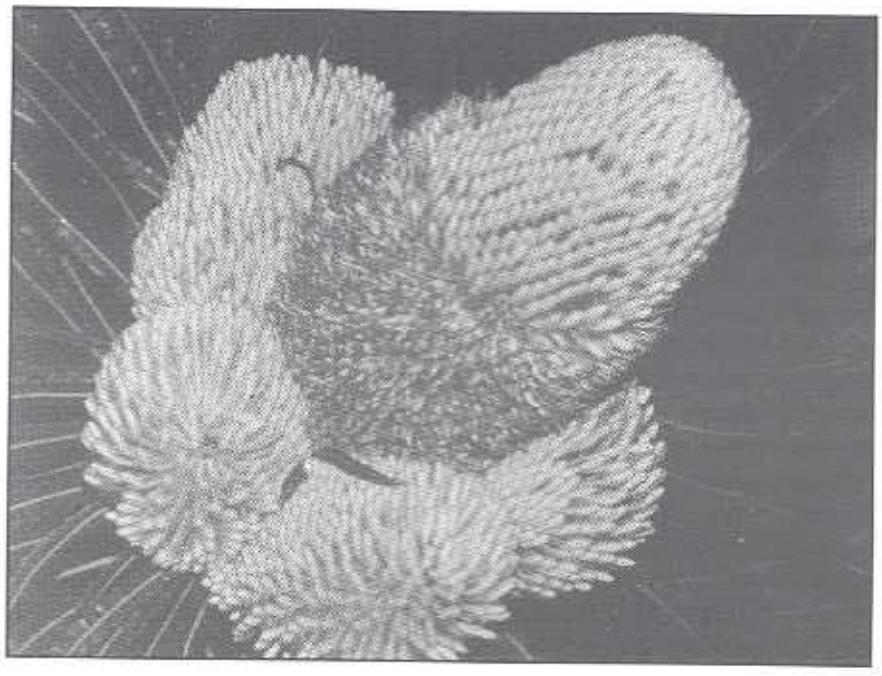
IN BRIEF

WATER UNDER THE DESERT?

Recently there was a story in the media about a 'massive', 'new' find of groundwater from the Officer Basin under the Great Victoria Desert. It was going to supply Perth for 4000 years! Philip Commander, a hydrogeologist with the Water and Rivers Commission, cautions everyone to be very careful about media hype ... The find is not new, the quality is variable and, due to very low rates of recharge, the proposals for use will need extremely careful evaluation if they are to be sustainable.

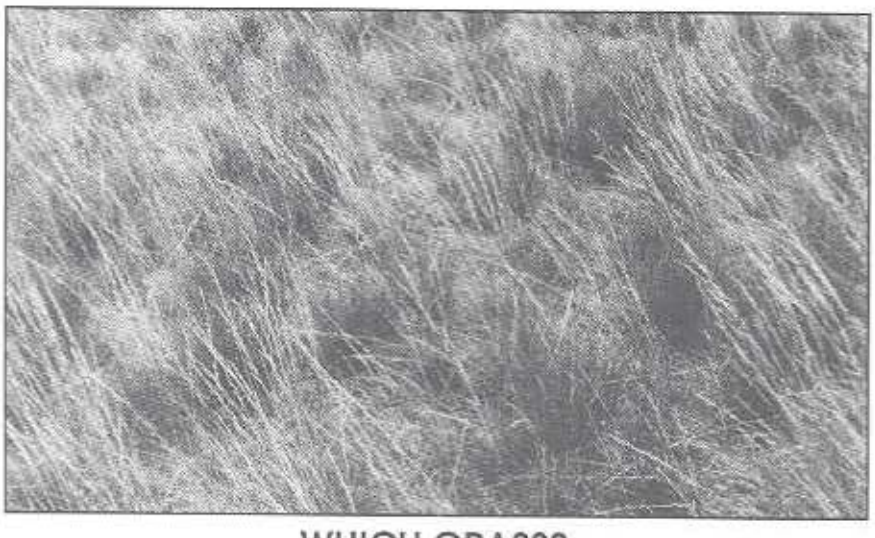
For copies of Dr Commander's two papers relating to this, ring 9334 0530.

MEMBERS PAGE



THIS photo was taken in March, and sent to us by Wally Jones of Mandurah. It shows a *Banksia prionotes* with lots of small flowerheads around the main one. Wally asks if we can explain why this happens.

It's probably caused by insects damaging the growing bud. If the damage is too great, the stem dies and new shoots grow out, but sometimes the effect is merely to segment the flower-producing cells, so that you get multiple heads, like this. The most likely culprit is a shiny green weevil about 1.5cm long which particularly likes eating *B. prionotes*.



WHICH GRASS?

Following the recent interest in native grasses, I observed this native grass in our sandplain paddocks, sometimes sparsely, but after 6.5 inches of rain in January it grew well and supported 14 bulls in one paddock for several months. The photo was taken around the farm yard, where it has grown for 30 years with no super and very light grazing. Can you tell me which grass it is?

Bev Hall, Quairading

Terry McFarlane, CALMScience, Manjimup, says: "It is an *Austrostipa* (spear grass), but you will need to collect the flowering heads next October before it can be identified to species."

MORE CROW TALK – A SHORT STORY

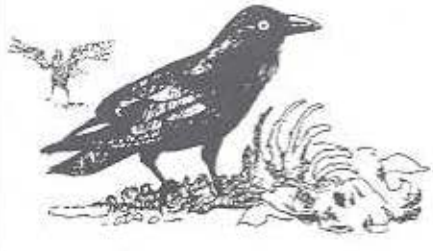
A pair of ravens built a nest in a tall marri tree, just below the canopy. The nest, although distant, is in full view from my kitchen window where I frequently sit for my cup of tea, particularly before breakfast.

I have watched these two bring out young ravens over several years, mostly only one at a time. There is no proof that it was the same birds every year, but I thought so. Last spring I noticed that the tree was looking poorly but the ravens were able to rear their usual nestling. Summer has passed and the tree has died.

The other morning as I sat by the window sipping tea, the ravens arrived one by one. What occurred then was almost beyond belief. They discovered the old nest tree was dead and bare and started to shout and fly into the air, flapping wildly. In and out and up they went, in and around where the nest was, all the time calling continuously in what seemed like grief and fury. Incredibly, this went on for a considerable time, then they flew away one by one. They could not have gone far, because in no time they were back and repeated the performance again and again, until finally they left and have not returned.

I am not one for imputing feelings to birds, but in this case??? I am now watching for which tree they will choose for a new nest this year – if they can find one.

Joanna Seabrook,
Helena Valley.



RUSHES AND SEDGES WORKSHOPS

During March, four very sucessful workshops were held at Ongerup, Mount Barker, Tambellup and Denmark, with the theme of rushes and sedges in rehabilitation work. The presenter was Linda Taman, a consultant with huge experience in growing and using plants from these families and great skill in presenting the topic. All told, 93 people attended the four workshops and were unanimous in their praise for the day, and in calling for more similar events.

The overall programme was organised by Dorothy Redreau of Greenskills, in collaboration with *Land for Wildlife*, Greening Australia and Water and Rivers Commission. Each of the four organisations took responsibility for being host at one of the venues, as well as contributing to the cost, which was also supported by grants from the Gordon Reid Foundation for Conservation and NHT. This wide collaboration worked very well, and led to more being achieved than each group could have managed on its own. This model could well be followed with other topics in future.

Sylvia Leighton

LFW NEWS

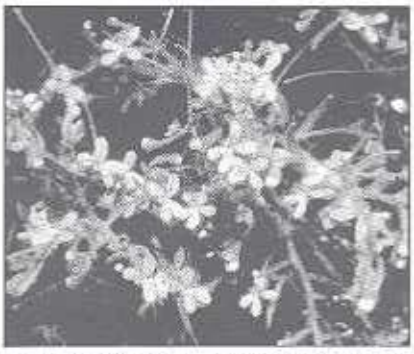
Congratulations

To Avril Baxter (*LFW* Narrogin) for winning "Runner up" in the Indoor Display at Wagin Woolorama. Visitors were enthralled by the fauna!
Photo: D. Lamont

LFW STAFF WORKSHOP - THREE YEARS' ON

On 18th 19th May, LFW staff gathered at CALM, Kensington, for a workshop to consider the operation of *Land for Wildlife*, and what future directions we might take. Shown here are, L-R back row: Penny Hussey, Sylvia Leighton, Bob Huston, Avril Baxter, Fiona Falconer, Claire Hall; front row: Jenny Dewing, Heather Adamson, Cherie Kemp. (Anne Rick had to leave early, her littlies had developed a virus.)

TRIGGERPLANT TREASURES



Stylidium merrallii. *Photo: K. Kenneally*

Once presumed extinct for more than 100 years, *Stylidium merrallii* (Merrall's Triggerplant) was rediscovered in 1976 in the Wongan Hills area but wasn't officially identified until 1992. Early this March a healthy new population was discovered near a granite outcrop on a *LFWer*'s property in the Doodlakine area.

Triggerplants have a sensitive trigger action that is used as a unique method of pollination. Insects sipping nectar from the throats of young flowers disturb a 'trigger' which releases a strap-like column that carries anthers loaded with pollen. Previously hidden beneath the petals, its sudden release causes a swinging blow which showers pollen over the insect's back. It takes about 20 mins for the trigger to reset for the next visitor. Anthers on older flowers develop a hairy cushion or brush between them, this brushes up pollen from any insects that had previously visited younger flowers, thus completing the pollination cycle.

The shape of triggerplant flowers throughout the wheatbelt usually resemble a small butterfly and are of various colours, the most common being bright pink with white throats. Each also has a secretive minute petal called a labellum, which is an added fascination and aid to identification.

To date there are 16 different triggerplants in the Shire of Merredin and it is a great pleasure to add *Stylidium merrallii* (Declared Rare Flora - status: Vulnerable), to that list.

Heather Adamson

FUNGI

The Ghoul Fungus

Fungi are as varied in their requirements as other organisms. One group, called the 'ammonia fungi' require nitrogen in the form of ammonia in order to grow and fruit. An example from the south-west forests and woodlands is *Hebeloma aminophilum*, the Ghoul Fungus.

This is a fairly large toadstool (cap about 14 cm across), all-over beige-brown with rusty spores. It is always found growing alongside the carcasses of kangaroos, sheep, snakes or other sizable animals. It fruits in winter and early spring. Since dead bodies can occur anywhere, it makes one wonder how many million fungal-spores are floating in the atmosphere, just waiting for the appropriate circumstances to occur so that they can develop and grow.

There are no known edible species of hebelomas, they are all more or less poisonous, though proably not deadly.

Illustration by K. Griffiths from "A Field Guide to the Larger Fungi of the Darling Scarp and the South West of Western Australia".

FLORA

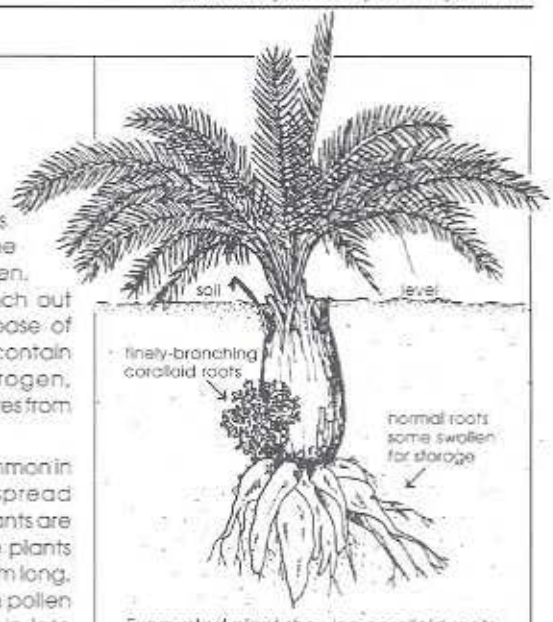
Zamia

Zamias grow well in WA's impoverished soil, as they have the ability to fix atmospheric nitrogen. Masses of "coralloid roots" branch out from the swollen underground base of the stem. These specialised roots contain cyanobacteria which fix nitrogen, themselves receiving carbohydrates from their host.

Zamia (*Macrozamia reidlei*) is common in the Jarrah forest, and widespread throughout the southwest. The plants are either male or female. The male plants develop several cones, up to 30 cm long, which are made up of scales with pollen sacs underneath. Pollen is shed in late spring. Female plants seldom develop more than two cones, and they are very large, weighing up to 14 kg. Each scale in the female cone develops two seeds, originally bright red in colour, which are released when the cone rots away. Emus, and possibly other animals, help to disperse the seed.

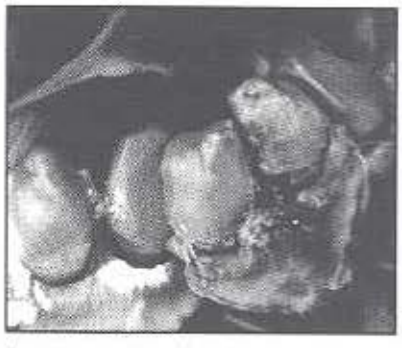
These huge cones are an enormous drain on a plant's stored food reserves. A male plant uses 10% of its stored energy in order to produce a cone. It takes 25% of a female plant's store to produce even one cone. If, due to burning off, Zamias are forced to use stored reserves to produce whole sets of new leaves every few years, there will be little energy left for reproduction, so cone production may be reduced. By the time the store has been built up, the fire comes again. This may account for the apparent preponderance of male plants in forest areas.

Zamia leaves contain a substance toxic to stock. Grazing of regrowth leaves after fire or partial clearing of the country (ie probably the only time when these leaves are palatable to stock) causes "wobbles" in cattle. Zamia seeds contain a lot of starch, and the Aboriginal people leached out the poison before eating them. When Captain Fremantle explored the Swan River his party roasted and ate the seeds, and were extremely ill afterwards! Incidentally, Charles Fraser, the Colonial Botanist of NSW, explored the Swan with a party from Captain Stirling's H.M.S. *Success* in 1827. Near Claise Brook he reported Zamias 30 feet high! Zamias are slow growing, so these must have been extremely old. Few such large specimens still exist, although there are still some in Stockyard Gully National Park.

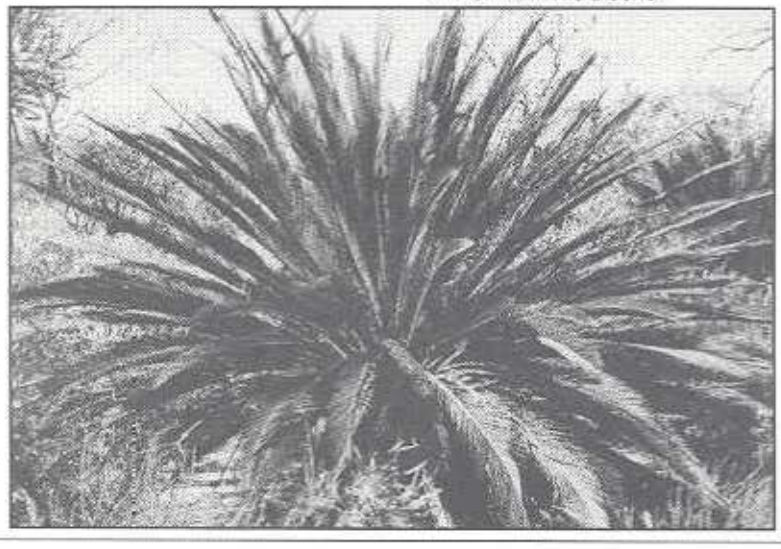


Excavated plant showing coralloid roots

Zamia "palm" is not a good name, as the Zamia is a cycad, a much more ancient group of plants than palms.



▲ *Ripe seeds on female cone*



▼ *Plant with male cone*

IN BRIEF

Frog WAtching

By Sue McLaughlin

Listening for banjos, motor bikes and humming - signs of some of the frogs found on site.....Alcoa's Simon Sandover at one of Pinjarra Refinery's permanent water holes.

MOTOR BIKES, banjos, humming and quacking .....what do these noises all have in common? Believe it or not they are all made by local frogs! The Alcoa FrogWAtch program involves collecting information on just such frogs.

Managed by Dr Ken Aplin, from the WA Museum, the Alcoa FrogWAtch program monitors what frogs are where. FrogWAtch members go out and listen to the frog calls to identify the types and numbers of frogs and also send dead frogs found back to the museum where they are checked for a fungal disease called Chytrid Frog Fungus which is killing frogs on a world wide basis.

If going out and listening to frogs in generally cold and wet conditions is not your cup of tea, frog watching team leader Simon Sandover, from Alcoa's Pinjarra Refinery, may have the answer.

Simon is a Senior Environmental Scientist. He has worked with Pinjarra Refinery's Environment and Industrial Hygiene Assistant, John Caldwell, and Lynton Storer of Herring Storer Acoustics, to come up with a system that allows a tape recorder and a computer to do all the hard work. An acoustics graph is produced from the recording, which identifies each frog call.

Since the system has been successfully trialed and tested on the squelching frog, another six species are currently being added, with the final aim to have the sounds of 16 different frog species included.

It is important to remember that this innovation will not replace people listening. We still need as many people as possible out there, listening and counting frogs as well as collecting dead ones for the museum.

Why is this program so important? Simon explains, "Lots of frogs equals a healthy environment. They are extremely sensitive to an environment that is out of balance. When this occurs the frogs will quickly die off".

Alcoa has developed a series of wetlands as part of Pinjarra Refinery's land management plan. These wetlands have involved the use of old 'borrow pits' that surround the Refinery's residue area and are now successful ecosystems and home to many frog species.

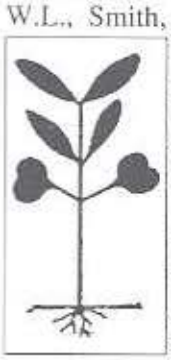
If you are interested in getting involved with the Alcoa FrogWAtch program, contact Dr Ken Aplin at the WA Museum on 94272826.

RECRUITMENT OF RED TINGLE AFTER FIRE

SUSTAINABLE management in tall timber country is just as problematical as in other ecosystems - there are so many unknowns. Red tingle (*Eucalyptus jacksonii*) forests are limited in extent, and so of particular concern. Recently, a team of CALMScience researchers, led by Lachlan McCaw, published data on the survival of red tingle and karri (*E. diversicolor*) seedlings after low-moderate intensity fuel reduction burns at two sites near Walpole. They noted that most seedlings emerged on burnt ground created where litter had been fully consumed, but some also emerged on the charred surface of fallen logs. Although initially seedlings were quite plentiful, they declined rapidly.

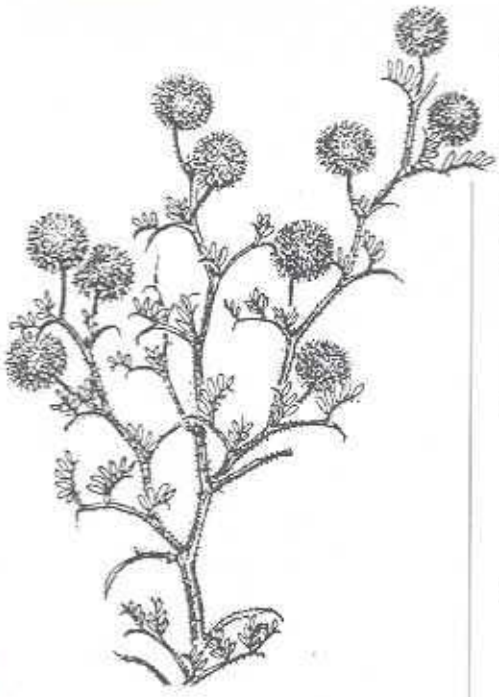
The authors concluded: "Few of the surviving seedlings exhibited dynamic growth or appeared likely to develop into saplings. Small gaps created by natural tree fall were no better stocked than areas beneath an intact forest canopy. The presence of red tingle and karri seedlings following low to moderate intensity fires used for fuel reduction may not therefore lead to even-aged sapling cohorts of these species. The scale and intensity of disturbance required for effective recruitment in red tingle-karri forest is a subject worthy of further investigation."

For the full story, read: McCaw, W.L., Smith, R.H. & Neal, J.E. 2000. Post-fire recruitment of red tingle and karri following low-moderate intensity prescribed fires near Walpole, south-west Western Australia. CALMScience **3**: 87-94.



A seven-month old red tingle seedling.

LEGUMES continued from page 9



Acacia drewiana

in the past and continue to be responsible for generating the large pools of nitrate now evident in the system.

So we still have much to learn about nitrogen fixation and nitrogen cycling in native and agricultural ecosystems. In view of the important role of nitrogen in plant growth and the dangers which can follow when the element pollutes the environment, research conducted in the future on this topic is clearly necessary and rewarding.

John Pate is Emeritus Professor at the University of Western Australia where he continues research on environmentally-related issues in the Botany Dept. and Centre for Legumes in Mediterranean Agriculture. He can be contacted on (08) 9380 1974 or 9380 2206.

Further Reading

Unkovich MJ, Pate JS, & Sanford P. (1997) Nitrogen fixation by annual legumes in Australian Mediterranean agriculture. *Aust J. of Agric. Res.* **48**: 267-293

Pate JS, Unkovich MJ, Erskine PD & Stewart GR. (1998) Australian mulga ecosystems – 13C and 15N natural abundance of biota components and their ecophysiological significance. *Plant, Cell and Environment* **21**, 1231-1242.

Pate JS & Unkovich MJ (1999) Measuring symbiotic nitrogen fixation: case studies of natural and agricultural ecosystems in a Western Australian setting. IN 'Physiological Plant Ecology' (Eds. MC Press, JD Scholes & MG Barker) pp. 153-173. Blackwell Science, Oxford.

Unkovich MJ, Pate JS, Lefroy EC & Arthur DJ. (in press) Inputs of fixed nitrogen by the fodder tree tagasaste at alley and plantation densities on deep sands in southwestern Australia. Aust. J. Plant Physiology.

ABOUT GROUPS

The community group Green Skills has asked that we include information about their employment arm, 'Ecojobs'.

ECOJOBS ENVIRONMENTAL PERSONNEL:
FOR ALL YOUR ENVIRONMENTAL PERSONNEL NEEDS

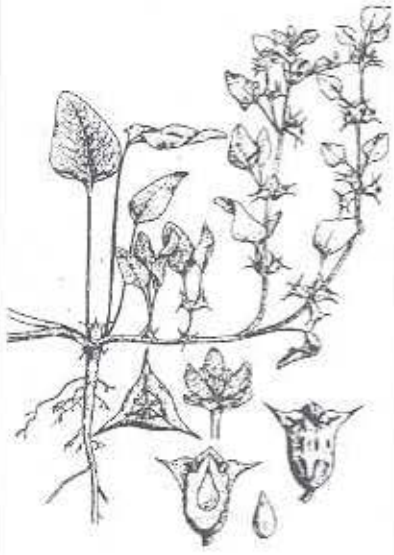
As we are in the middle of the tree planting season, I would like to remind everyone that Ecojobs offers a wide range of skilled environmental personnel at very affordable rates, starting from $17.50/hr (+ GST). Our rates are all inclusive and we can also provide project coordination and supervision of volunteers.

Ecojobs Environmental Personnel is a project of Green Skills inc. which has been successfully operating since 1995. Our clients include the Botanical Gardens and Parks Authority, the Water and Rivers Commission, various councils, private consultancies, as well as catchment and landcare groups.

We are looking forward to hearing from you soon.

Jean-Paul Orsini, Ecojobs Coordinator
Green Skills-Fremantle
30 Holdsworth Street
Fremantle WA 6160
Ph. (08) 9336 1033, Fax (08) 9336 3301.
email: grskills@upnaway.com
Website:
http://www.greenskills.green.net.au/

BUSH DETECTIVE ANSWER



They are Doublegee (*Emex australis*) fruits. Early settlers brought the plant from South Africa to use as a salad vegetable, and it is now widespread over the State. Red-tailed Black Cockatoos eat the seed, they are able to crack the fruit with their powerful bills. (Try to crack open the fruit yourself, to see how strong they must be.)

✦ ✦ ✦ ✦

A final comment, from a teenage *LFWer.*

Q: What do you get if you collect up a pile of Doublegee seeds, make holes in them, and thread them on twine to make two ropes?

Ans: A double G-string!

OUCH!!!

WEEKEND GETAWAY!

Many LFW members have facilities for visitors - if you are looking for somewhere to go where people care about bushland -you need the WA LFW Ecotourism Contact List! Ring 9334 0427 for your copy.

COMING EVENTS

FUNGIMAP WORKSHOPS

with **Katie Syme**
Learn about the importance of fungi and how to map their distribution
- Merredin Herbarium
- Sat-Sun 8th - 9th July

Contact: Heather Adamson 9041 2488;
email: heathera@calm.wa.gov.au

- Irabina Field Study Centre - Dryandra Woodland
- Friday 21st July 2000
- 9.00 am - 3.30 pm

cost $10.00
Contact Avril Baxter 9881 9218 oe
email: avrilb@calm.wa.gov.au

Organised by Land for Wildlife and Fungimap

YORK GUM AND ASSOCIATED UNDERSTOREY

With Malcolm French
- Sat 29th July
- 10.00am - 3.30 pm

Meet: Sandalwood yard, Avon Terrace, York
Organised by River Conservation Society

LOOKING AFTER OUR BUSHLAND: FIELD DAY IN THE QUAIRADING COMMUNITY NATURE RESERVE

- Quairading Community Centre
- Tuesday 15th August 2000
- 9.30 am – 4 pm

Cost: not yet decided
Maintaining the conservation values of bushland and management of weeds.
To register, ring Barbara Jones: 9220 5300.
Organised by Environmental Weeds Action Network and Wildflower Society of Western Australia.

GRASSTREES AND KINGIA

With Bill Loneragan
- Sat 26th Aug
- 10.00 am - 3.30 pm

Meet: Sandalwood yard, Avon Terrace, York
Organised by River Conservation Society

WEEDS IN BUSHLAND

With Neville Marchant
- Sat 3rd Sept
- 10.00 am 0 3.30 pm

Meet: Sandalwood yard, Avon Terrace, York
Organised by River Conservation Society

STOPPING TREE DECLINE IN THE GREAT SOUTHERN

A seminar and field day on how to stop tree loss

Do your trees look like this wandoo at York? Smallest crown branches dead, clumps of browned leaves show newly dead branches ... ?
And the process continuing remorselessly ...?
Attend the workshop:
- Thursday Sept 14th 2000
- 8.15 am - 4.30 pm
- Kojonup Memorial Hall

Contact: Avril Baxter: 9881 9218.
Organised by Land for Wildlife and Greening Western Australia

NEW BOOKS

HAKEAS OF WESTERN AUSTRALIA: BOTANICAL DISTRICTS OF IRWIN AND DARLING

By Jennifer Young
$20.00 + $5.00 postage

The second in a series of illustrated guides to hakeas, this one covers the northern sandplains and the southern forests, essentially from Shark Bay to Albany, including the Darling Range. As with the previous book (covering the wheatbelt), this has been written to assist with the identification of hakeas for revegetation projects and it details the use and provenance to which each plant belongs. Each species is illustrated with clear line drawings which will enable identification, and there are also many colour photographs.

Anyone interested in wildflowers, especially if your property is in the area covered, will find this an interesting and useful book.

To obtain a copy, contact: J. Young, PO Box 576, WEST PERTH, WA 6872. Ph: 9242 2207.

This Newsletter is a compendium of articles written by many different people. The views expressed are those of the authors, not necessarily those of the Department of Conservation and Land Management.
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