STATE NRM PROGRAM: FINAL REPORT

PROJECT TITLE:	Critically endangered flora recovery
STATE ID NUMBER:	12030

PROJECT DETAILS

1. Were the final outcomes, activities and/or location(s) of your project significantly different to your original project schedule?

( ) Yes (**X**) No

1.1 Project summary *(only complete if your project varied significantly to that described in the original project schedule)*

This new summary will be used on our website to promote your project.

Summary

1.2 Project location *(only complete if your project varied significantly to that described in the original project schedule)*

If the location of your project changed from the original schedule please update these details.

- **General location - street address, lot numbers, reserve names.**
- **GPS coordinates**
- **Local Government Areas covered by the project**
- **Natural Resource Management Region(s) covered by the project**

  [ ] Rangelands [ ] Northern Agricultural [ ] Wheatbelt (Avon) [ ] Perth (Swan)
  [ ] Peel-Harvey [ ] South West [ ] South Coast

2. Assets

2.1 List any assets worth more than $5000 that were purchased with this funding. These assets remain the property of the State Government until new ownership arrangements are established.

Asset Do not include fencing and trees	**Purchase date**	**Cost** $	**What do you recommend should happen to this asset at project completion?**

2.2 Please provide any supporting documents that show how the asset may be managed after this project ends. Evidence may include MoUs or planning documents.

3. Intellectual Property

Intellectual property refers to creations of the mind for which exclusive rights are recognised, they enable people to earn recognition or financial benefit from what they invent or create. Intellectual property developed with grant funding remains the property of the State Government.

Please refer clause 17.1 of your Funding Agreement

Examples of intellectual property you may produce as part of your project include:

- digital media, such as applications, software and audio/video clips that can be downloaded online
- publications, such as books and journal articles
- methodology, such as a new way to bait feral animals.

3.1 Please describe any intellectual property that has been created through this project that has the potential for exploitation and/or commercialisation, and for which the intellectual property rights should be legally protected under statutory and/or common law.

3.2 Please name all publications/reports/data compiled with funding provided to this project in the table below. Please provide hard or electronic copies or a link

Document	Link
Erica Shedley^, Neil Burrows, Colin Yates and David Coates submitted to Biological Conservation. Using bioregional variations in fire history, fire responses and vital attributes as a basis for managing threatened flora in a fire-prone Mediterranean climate biodiversity hotspot (attached) D. A. Rathbone, S. Barrett, D. Lehmann and E. Harper Unpublished report Vertebrate browsing impacts in a threatened montane ecosystem (attached). Translocation proposal for *Daviesia ovata* Translocation proposal for *Eucalyptus cuprea* Translocation proposal for *Schoenia filifolia subulifolia* Translocation proposal for *Andersonia annelsii* Translocation proposal for *Synaphea stenoloba* Translocation proposal for *Eremophila rostrate* ssp *trifida* Translocation proposal for *Grevillea maxwellii*	

3.3 How will this information be maintained for future use by other interested parties?

All information, in published and unpublished papers and reports will be retained as copies in the Department of Parks and Wildlife library. Data will be maintained on Departmental databases such as the Threatened and Priority Flora Database and Naturemap .

4. KEY ACHIEVEMENTS

The points you provide here will be used on our website to promote the achievements of your project.

4.1 Please list the key achievements of your project.

In total 105 Critically Endangered plant species across the southwest of the State were provided with increased protection and their conservation status has improved through a range of actions targeting natural populations, and through ex situ conservation measures such as re-introductions. The populations of these species have been shown to be in poor condition, in significant decline, small and in many cases isolated due to habitat fragmentation. Most of these Critically Endangered species have had a range decline of at least 50% over the last 10 years and/or at least an estimated 20% decline in population size over the last 5 years. They are all estimated to have a 50% probability of extinction in the next 10 years. The actions outlined below, reported against five project milestones, have resulted in significant improvement in the conservation trajectory of these species.

- Viable populations of 28 Critically Endangered species were established in threat free areas.
- Fire management protocols were developed and fire management procedures implemented for 42 Critically Endangered species. This includes the development of electronic data reporting fields for fire response monitoring of threatened flora throughout the State.
- Fencing and grazing control was completed for 29 Critically Endangered species with 11.9 km of fencing erected to protect 1,009 ha from grazing by feral animals and 17,070 ha of land baited for control of rabbits.
- Weed control and habitat restoration was completed for 34 Critically Endangered species covering 507.1 ha
- Successful control of Phytophthora dieback disease was implemented in 22 highly susceptible Critically Endangered species covering 329 ha.

5. Lessons and unexpected outcomes

5.1 Did your project proceed as anticipated?

(**X**) Yes ( ) No – please explain

5.2 Did anything happen throughout the life of your project that impacted (positively or negatively) on the final outcomes?

( ) Yes – please explain (**X**) No

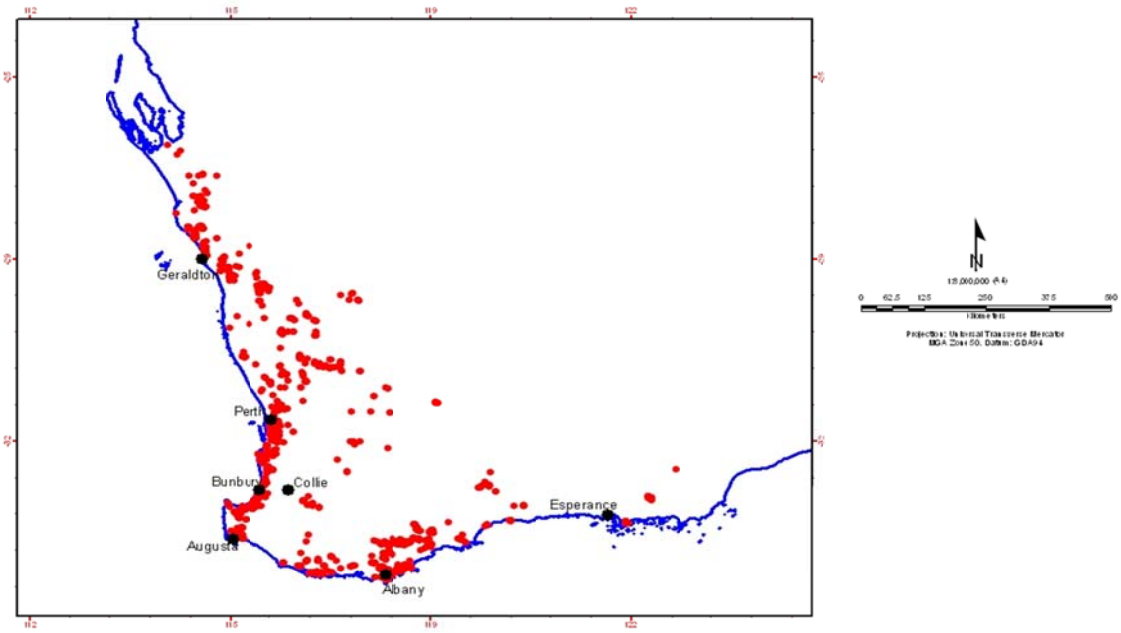
5.3 Please identify any lessons you have learnt as a result of the project.

Significant progress can be made in addressing the decline and potential extinction of Critically Endangered Flora where a strategic and targeted approach dealing with key threatening processes is implemented. Actions such as those targeted in this project which covered managing and controlling the major threats of invasive weeds, grazing and trampling by feral animals, and Phytophthora dieback, can lead to significant progress in reducing the impact of these threats and reversing decline in the populations of the target species. The assessment and development of fire management protocols, and monitoring procedures for fire response of threatened flora can not only result in a direct management benefit for the 42 target species but can also be applied across all 423 threatened plant species in the State. While all these activities have resulted in the refinement of approaches for managing threats and fire, the establishment of new viable populations has posed some of the greatest challenges and the progress made through this NRM project, in this particular activity, has been found to provide a solid background for further success in this area.

6. Use of Project Results

6.1 Where have your results been used and/or where do you anticipate them being used in the future?

The project focussed on stabilising populations from threats and reversing the decline of 105 Critically Endangered plants in the south west of the State. Activity sites cover south west region roughly from Shark Bay in the north west to north east of Esperance in the south east as shown in the map below



The activities applied across the south west of the State involved controlling the key threats: invasive weeds, grazing and trampling by feral animals, and Phytophthora dieback, and the development of fire management protocols. These activities were aimed at preventing any further loss of individuals from populations of each of the targeted threatened species and providing conditions that will favour recruitment. The use of targeted fire management in some areas has already resulted in significant recruitment events. Recent assessment of the other major management activity, the establishment of new populations on secure sites, also indicates a potential improvement in the conservation status of the 28 species.

The results from these activities are already being applied across other areas of the southwest, targeting additional threatened plant species particularly those ranked as critically endangered, and can also be applied to management of threatened flora in other parts of the State.

6.2 List any benefits this project has provided to other groups.

Activities carried out in this project (under 4.1) and the methodologies developed will be of benefit to Regional NRM groups throughout the State, a range of NGO groups (i.e Australian Wildlife Conservancy, Bush Heritage, Greening Australia) and local community groups where they are involved with the conservation management of threatened plants.

6.3 Describe any future actions that are planned or are likely to arise as a result of this project.

All activities carried out as part of this project are likely to be implemented elsewhere, particularly in the southwest, and a number are already planned for other species of threatened flora although these will be reviewed and prioritised depending upon the availability of resources and suitable funding.

6.4 How is your organisation planning to maintain the project after funding has ceased?

The Department of Parks and Wildlife in conjunction with Departmental regional Flora Recovery Teams, will continue to target the highest priority threatened species (Critically Endangered and Endangered) for various recovery actions as carried out in this project and this work will continue through core organisation funding. However, given the number of species and limited resources actions will always be restricted for at least some species and careful prioritisation will be needed to ensure that available resources are appropriately allocated where the best outcome can be achieved in terms of minimising extinction of populations and species.

6.5 Who is responsible for ongoing maintenance and operations?

The Department of Parks and Wildlife

7. PARTICIPATION

7.1 How many people were involved in your project?

Please include everyone that contributed to the planning, implementation, administration and financial aspects of the project including your own group.

Category	Full-time equivalents
Volunteers	82
Consultants or contractors providing in-kind assistance	14.7
Paid staff, contractors, consultants	5.7

8. Value of co-contributions

Please provide an updated figure for the total value of co-contributions towards the project using the 'co-contributions (cash and in-kind)' details from your work plan.

Final value of co-contributions	**$**
Department Parks and Wildlife	$708,800
Albany District Threatened Flora Recovery Team	$8,500
UWA students	$2,400
Main Roads Western Australia	$1,500
Pindiddy Aboriginal Corporation	$2,100
Geraldton Regional Herbarium Group	$28,100
Geraldton District Threatened Flora Recovery Team	$9,400
Northern Agricultural Catchments Council	$22,100
Australian Wildlife Conservancy	$8,100
Shire of Kellerberrin	$3,000
20 Million Trees Program grant 'Yanget Station	
– Protecting Threatened Flora'	$39,600
Durack TAFE (in-kind on-ground assistance)	$11,750
Geraldton Regional Prison (in-kind on-ground assistance through Durack TAFE)	$12,500
Shire of Northampton – ripping of small area for rehab around Pterostylis sinuata population on Yerina Springs Road (in-kind contribution of machine and operator for approx. 3hrs)	$600
Green Army	$750
Total	**$859,200**

9. Project statistics

9.1 What did you protect?

This is a summary in numbers of what your project has helped to protect.

Please select the categories that apply to your project

[ ] Wetland or lake

[ ] Waterway

[ ] Coastal or estuarine area

[ ] Marine environment

[**X**] Plant species

[ ] Animal species

[ ] Bushland

Wetlands and lakes

If your project has helped to protect a wetland or lake we would like to know:

Name of wetland or lake

Waterways

If your project has helped to protect a ***waterway*** we would like to know:

Name of the waterway	Kilometres of waterway protected

Bushland

If your project has helped to protect ***bushland*** we would like to know:

Name of bushland area	Hectares of bushland protected

Coastal and estuarine areas

If your project has helped to protect a coastal or estuarine area we would like to know:

Name of the coastal or estuarine area	Hectares of coastal area protected	Kilometres of coastline protected

Marine environments

If your project has helped to protect a *marine environment* we would like to know:

Name of the marine environment	Square kilometres protected

Plant species

If your project has helped to protect a *plant species* we would like to know:

Name of species protected (with common name in brackets)
Viable populations established in threat free areas *Acacia unguicula* (A Shurb)

Name of species protected (with common name in brackets)
Acacia awestoniana (Stirling Range Wattle) *Acacia cochlocarpa* (Spiral-Fruited Wattle) *Acacia imitans* (Gibson Wattle) *Acacia volubilis* (Tangle Wattle) *Andersonia annelsii* (NA) *Banksia anatona* (Cactus Banksia) *Banksia brownii* (Feather-leaved Banksia) *Banksia ionthocarpa* (Kamballup Dryandra) *Banksia montana* (Stirling Range Dryandra) *Daviesia cunderdin* (Cunderdin Daviesia) *Daviesia euphorbioides* (Wongan Cactus) *Daviesia glossosema* (Maroon-flowered Daviesia) *Daviesia ovata ovata* (Broad-leaf Daviesia) *Daviesia pseudaphylla* (Stirling Range Daviesia) *Eremophila rostrata subsp. Trifida* (NA) *Eucalyptus cuprea* (Mallee box) *Gastrolobium luteifolium* (Yellow-leafed Gastrolobium) *Grevillea calliantha* (Foote's Grevillea) *Grevillea maxwellii* (Maxwell's Grevillea) *Lambertia fairallii* (Fairall's Honeysuckle) *Lambertia orbifolia* (Round-leafed Honeysuckle) *Leucopogon gnaphalioides* (Stirling Range Beard Heath) *Lysiosepalum abollatum* (Woolly Lysiosepalum) *Persoonia micrantha* (NA) *Schoenia filifolia* (Showy everlasting) *Synaphea stenoloba* (Dwellingup Synaphea) *Verticordia albida* (White Feather-flower) NB Two species were removed from the original list (*Hybanthus cymulosum, Stylidium semaphorum*) due to technical difficulties and two species were added (*Eremophila rostrata subsp. trifida, Synaphea stenoloba)* Fire management protocols developed and fire management procedures implemented *Acacia imitans* (Gibson Wattle) *Acacia pharangites* (Wongan Gully Wattle) *Acacia rhamphophylla* (Kundip Wattle) *Acacia vassalli* (NA) *Acacia unguicula* (A Shurb) *Andersonia annelsii* (NA) *Banksia ionthocarpa* (Kamballup Dryandra) *Beyeria lepidopetala* (Short-petalled Beyeria) *Boronia clavata* (Bremer Boronia) *Caladenia elegans* (Elegant Spider Orchid) *Caladenia huegelii* (Grand Spider Orchid) *Caladenia winfieldii* (Majestic Spider Orchid) *Commersonia sp. Mt Groper* (NA) *Conostylis dielsii subsp. Teres* (Irwin Conostylis) *Conostylis micrantha* (Small-flowered Conostylis) *Dasymalla axillaris* (Native Foxglove) *Daviesia euphorbioides* (Wongan Cactus) *Drakaea confluens* (Late Hammer Orchid) *Drakaea elastic* (Glossy-leafed Hammer Orchid) *Eucalyptus beardiana* (Beard's mallee) *Eucalyptus cuprea* (Mallee Box) *Gastrolobium hamulosum* (Hook-point poison) *Gastrolobium glaucum* (Spike Poison) *Gastrolobium vestitum* (Stirling Range Poison) *Gastrolobium graniticum* (Granite Poison)

Name of species protected (with common name in brackets)
Goodenia arthrotricha (NA) *Grevillea maxwellii* (Maxwell's Grevillea) *Gyrostemon reticulatus* (Net-veined Gyrostemon) *Hibbertia abyssa* (NA) *Hibbertia priceana* (NA) *Hybanthus cymulosus* (Ninghan Violet) *Lasiopetalum pterocarpum* (Wing-fruited Lasiopetalum) *Leucopogon marginatus* (Thick-margined Leucopogon) *Lysiosepalum abollatum* (Woolly Lysiosepalum) *Macarthuria keigheryi* (Keighery's Macarthuria) *Pityrodia axillaris* (Native Foxglove) *Pterostylis sinuate* (Northampton midget greenhood) *Stylidium amabile* (NA) *Synaphea sp. Fairbridge Farm* (Selena's Synaphea) *Synaphea sp. Pinjarra* (Club-leafed Synaphea) *Verticordia spicata subsp. squamosal* (Scaly-leafed feather-flower) *Verticordia staminosa subsp. staminosa* (Granite feather-flower) Fencing and grazing control completed *Acacia awestoniana* (Stirling Range Wattle)_ *Acacia imitans* (Gibson Wattle) *Acacia unguicula* (A Shurb) *Banksia anatona* (Cactus Banksia) *Banksia montana* (Stirling Range Dryandra) *Caladenia huegelii* (Grand Spider Orchid) *Caladenia hoffmanii* (Hoffman's Spider Orchid) *Caladenia wanosa* (Kalbarri Spider Orchid) *Calectasia cyanea* (Star of Bethlehem)or(Blue Tinsel Lily) *Darwinia collina* (Yellow mountain bell) *Daviesia obovata* (Paddle-leafed Daviesia) *Daviesia ovata* (Broad-leaf Daviesia) *Diuris purdiei* (Purdie's Donkey orchid) *Drakaea elastica* (Glossy-leafed Hammer Orchid) *Drakaea micrantha* (Dwarf Hammer Orchid*)* *Drummondita ericoides* (Morseby Range drummondita) *Eucalyptus cuprea* (Mallee Box) *Grevillea bracteosa subsp. Howatharra* (Howatharra grevillea) *Grevillea christineae* (Christine's Grevillea) *Hybanthus cymulosus* (Ninghan violet) *Drummondita ericoides* (Morseby Range drummondita) *Eucalyptus cuprea* (Mallee Box*)* *Latrobea colophona* (NA) *Leucopogon gnaphalioides* (Stirling Range Beard Heath) *Myoporum turbinatum* (Salt Myoporum) *Persoonia micranthera* (Small flowered snottygobble) *Reedia spathacea* (Reedia) *Synaphea sp. Fairbridge Farm* (Selena's Synaphea) *Synaphea stenoloba* (Dwellingup Synaphea) *The following species have been added:* *Acacia imitans* (Gibson Wattle) *Acacia unguicula* (A Shurb) *Caladenia hoffmanii* (Hoffman's Spider Orchid) *Caladenia wanosa* (Kalbarri Spider Orchid) *Drummondita ericoides* (Morseby Range drummondita) *Eucalyptus cuprea* (Mallee Box)

Name of species protected (with common name in brackets)
Grevillea bracteosa subsp. Howatharra (Howatharra grevillea) *Hybanthus cymulosus* (Ninghan violet) Weed control and habitat restoration completed *Andersonia axilliflora* (Giant Andersonia) *Banksia montana* (Stirling Range Dryandra) *Banksia nivea subsp. uliginosa* (Swamp Honeypot) *Banksia oligantha* (Wagin Banksia) *Banksia squarrosa subsp. argillacea* (Whicher Range Dryandra) *Calactesia cyanea* (Star of Bethlehem)or(Blue Tinsel Lily) *Caladenia elegans* (Elegant Spider Orchid) *Calytrix sp. Tutunup* (NA) *Conostylis misera* (Grass Conostylis) *Chamelaucium sp. C Coastal Plain* (NA) *Darwinia collina* (Yellow mountain bell) *Darwinia whicherensis* (Abba Bell) *Dasymalla axillaris* (Native Foxglove) *Daviesia glossosema* (Maroon-flowered Daviesia) *Daviesia pseudaphylla* (Stirling Range Daviesia) *Eremophila denticulata ssp denticulate* (Fitzgerald Eremophila) *Eucalyptus cuprea* (Mallee Box) *Gastrolobium papilio* (Butterfly-leaved Gastrolobium) *Grevillea althoferorum subsp. fragilis* (NA) *Grevillea bracteosa subsp. Howatharra* (Howatharra grevillea) *Grevillea elongate* (Ironstone grevillea) *Grevillea maccutcheonii* (McCutcheon's Grevillea) *Gyrostemon reticulatus* (Net-veined Gyrostemon) *Lambertia echinata subsp. occidentalis* (Western Prickly Honeysuckle) *Lambertia orbifolia ssp orbifolia* (Round-leafed Honeysuckle) *Lasiopetalum pterocarpum* (Wing-fruited Lasiopetalum) *Latrobea colophona* (NA) *Leucopogon gnaphalioides* (Stirling Range Beard Heath) *Persoonia micranthera* (NA) *Petrophile latericola* (Laterite Petrophile) *Pterostylis sinuate* (NA) *Schoenia filifolia* (Showy everlasting) *Stylidium amabile* (NA) *Tetratheca deltoidea* (Granite Tetratheca) *Verticordia plumosa.var. pleiobotrya* (Mundijong Feather-flower) *Verticordia spicata subsp. Squamosa* (Scaly-leafed Feather-flower) *Species added:* *Calactesia cyanea* (Star of Bethlehem)or(Blue Tinsel Lily) *Conostylis misera* (Grass Conostylis) *Grevillea bracteosa subsp. Howatharra* (Howatharra grevillea) *Schoenia filifolia* (Showy everlasting) Species moved to Fencing and grazing control: *Acacia imitans* (Gibson Wattle) *Acacia unguicula* (A Shurb) *Hybanthus cymulosus* (Ninghan violet) These species were original targeted for weed control but that has not proved to be necessary and they will now be fenced for goat control Successful control of disease in highly susceptible species.

Name of species protected (with common name in brackets)
Andersonia axilliflora (Giant Anersonia) *Andersonia pinaster* (Two People's bay Andersonia) *Banksia anatona* (Cactus Banksia) *Banksia brownii* (feather-leaved banksia) *Banksia montana* (Stirling Range Dryandra) *Banksia rufa subsp. pumila* (NA) *Darwinia nubigena* (Success Bell) *Darwinia oxylepis* (Gillhams bell) *Darwinia wittwerorum* (Wittwer's Mountain Bell) *Daviesia glossosema* (Maroon-flowered Daviesia) *Daviesia obovata* (Paddle-leafed Daviesia) *Daviesia ovata* (Broad-leaf Daviesia) *Daviesia pseudaphylla* (Stirling Range Daviesia) *Gastrolobium luteifolium* (Yellow-leafed Gastrolobium) *Isopogon uncinatus* (Albany Cone bush) *Lambertia echinata subsp. echinata* (Prickly Honey Suckle) *Lambertia fairallii* (Fairall's Honeysuckle) *Lambertia orbifolia* (Round-leafed Honeysuckle) *Latrobea colophona* (NA) *Leucopogon gnaphalioides* (Stirling Range Beard Heath) *Persoonia micranthera* (NA) *Sphenotoma drummondii* (Mountain Paper-heath) NB Most of these species are extremely rare and a number do not have common names

Animal species

If your project has helped to protect an *animal species* we would like to know:

Name of species protected (with common name in brackets)

9.2 Project activities

This is a summary in numbers of what your project has achieved. These numbers are commonly known as 'project outputs'.

Please select the categories that apply to your project

Did you do?

[**X**] Fencing

[ ] Revegetation

[**X**] Weed control

[**X**] Disease control

[**X**] Feral animal control

[ ] Surveying (e.g. weed, dieback, plant or animal)

[ ] Resource monitoring activities (e.g. water quality, radio tracking)

[ ] Demonstration of sustainable land management practices

[ ] Stabilisation works (e.g. erosion control structures)

Did you produce?

[**X**] Management plans (Translocation Prposals)

[**X**] Reports

[ ] Information products (e.g. pamphlets, websites, apps, guides)

Did you hold?

[ ] Training
[ ] Events (e.g. field days, displays, planting days)

Did you install?

[ ] Infrastructure (e.g. a bird hide, walk trail, sign, nest box, artificial wetland, riffle in waterway)

Fencing

If you installed *fencing* we would like to know:

What it was for?	What type of fencing was installed?	Kilometres installed	Hectares protected by fencing
Protection against grazing	A range of different kinds of fencing were installed over different sites	11.9 km	1009ha

Revegetation

If you undertook *revegetation* activities we would like to know:

Type of area revegetated e.g. farmland, coastal, waterway, wetland, bushland	Hectares planted	Number of plants planted

Weed control

If you undertook *weed control* we would like to know:

Name of weed controlled Common names are fine	**Method of control** e.g. hand, chemical, biological	Hectares of weed control
Broad range of weed species on different sites	Chemical control and hand weeding	507.1ha

Disease control

If you undertook *disease control* we would like to know:

Name of disease	Hectares protected
Phytophthora dieback	329ha

Feral animal control

If you undertook f*eral animal control* we would like to know:

Type of animal controlled e.g. fox, cat, rabbit, goat, pig, camel	Hectares of control	Estimated number removed (if possible)
Baiting for rabbits	17,070ha	

Surveys

If you conducted *surveys* we would like to know:

What you surveyed e.g. weeds, dieback, plants, animals	Hectares surveyed

Resource monitoring

If you undertook *resource monitoring* activities we would like to know:

Type of resource monitoring	Hectares monitored	Kilometres monitored

Sustainable land management practices

If you project demonstrated *sustainable land management practices* we would like to know:

Type of practice demonstrated	Hectares of activity

Stabilisation works

If your project undertook *stabilisation works* we would like to know:

Type of work	Hectares stabilised	Kilometres stabilised

Management plans

If you have produced *management plans* we would like to know:

Name of plan developed	Hectares covered by plan
Translocation proposal for *Daviesia ovata* Translocation proposal for *Eucalyptus cuprea* Translocation proposal for *Schoenia filifolia subulifolia* Translocation proposal for *Andersonia annelsii* Translocation proposal for *Synaphea stenoloba* Translocation proposal for *Eremophila rostrate* ssp *trifida* Translocation proposal for *Grevillea maxwellii*	

Reports

If you have produced *reports* we would like to know:

Name of Reports	Hectares covered by the report (if applicable)
Erica Shedley, Neil Burrows, Colin Yates and David Coates submitted to Biological Conservation. Using bioregional variations in fire history, fire responses and vital attributes as a basis for managing threatened flora in a fire-prone Mediterranean climate biodiversity hotspot (attached)	N/A
D. A. Rathbone, S. Barrett, D. Lehmann and E. Harper Unpublished report Vertebrate browsing impacts in a threatened montane ecosystem (attached).	N/A

Information products

If you have produced *information products* (e.g. pamphlets, websites, apps, tools) we would like to know:

Name of product produced

Training

If you delivered *training* we would like to know:

Name of training	Number of participants

Name of training	Number of participants

Events

If you held an *event* (e.g. field day, display, planting day) we would like to know:

Name of event	Number of events	Number of attendees

Infrastructure

If you have *installed infrastructure* (e.g. bird hide, walk trail, bollards, sign, nest box, artificial wetland, artificial wetland) we would like to know:

Type of infrastructure	Number built or installed

10. PROJECT MONITORING

10.1 Photo point monitoring

Please attach at least two photos from each of your photo point monitoring sites that clearly show the site(s) prior-to and after completion of works.

Photo	Date photo was taken	Photo point description (identifier)

10.2 Other monitoring

If you used methods other than photo points to monitor your project please describe your findings below.

All sites for the following activities have been monitored:

- Establishment of viable populations of 28 Critically Endangered species
- Fencing and grazing control for 29 Critically Endangered species.
- Weed control and habitat restoration c for 34 Critically Endangered species
- Control of Phytophthora dieback disease for 22 highly susceptible Critically Endangered flora

Monitoring by the Department of Parks and Wildlife will continue at all sites, based on available resources, as part of a standard monitoring program for threatened flora

11. Promotional photos

Please provide us with at least two high quality* photos that highlight your project activities, the area you are working in or what you are working on/protecting.

Close up images and action shots are best.

*Specifications: JPG, RAW or TIFF format and where possible at least 300 dpi at 21 x 10 cm

Photos will be used to promote your project on our website and may be used in our annual report and publicity materials.

Photo	**Caption** Must be no more than 50 words	**Acknowledgement** Must be no more than 50 words
Fencing on Bluff Knoll	Fencing erected on Bluff Knoll in the Stirling Range to protect threatened *Darwinia collina*, *Latrobea colophona* and *Leucopogon gnaphalioides* from grazing by native and feral herbivores	Sarah Barrett and Damien Rathbone
Daviesia euphorbioides seedlings	Critically Endangered *Daviesia euphorbioides* seedlings following a prescribed fire near Wongan Hills	Brett Beecham
Seedling of *Daviesia ovata*	Seedling of Critically Endangered *Daviesia ovata* following the establishment of a reintroduction at Mt Manypeaks	Leonie Monks
Grevillea calliantha a species translocated near Dandaragan	A new population of the Critically Endangered *Grevillea calliantha* has been established near Dandaragan	David Coates
Acacia unguicula reintroduction	Janet Newell, Department of Parks and Wildlife, plants a seedling of *Acacia unguicula* as part of the establishment of a new population south west of Paynes Find	Leonie Monks
Lambertia fairallii	Critically Endangered *Lambertia fairallii,* a highly susceptible species targeted for the control of Phytophthora dieback	Anne Cochrane

Permission to use photos

We will assume that you have sought permission of any adults pictured in your photos and will not seek further permission before using the images.

If your images contain people under the age of 18 **we need to see a copy of the signed photo release form**. See Appendix 1 for an example photo release form.

12. Declaration

In order to maximise the benefits of this funding, information relating to all projects funded by the State NRM Program is regarded as in the public domain and will be made available to the public on request except for information which needs to be kept confidential. Under privacy legislation, personal information cannot be divulged without the consent of those involved.

Do you consent to the inclusion of your name and contact details in response to public information requests concerning this project?

(**X**) Yes ( ) No

Project manager's declaration

I, the undersigned, declare under the Oaths, Affidavits and Statutory Declarations Act 2005 *that:*

1. *I am authorised by my organisation to make this declaration.*
2. *Information given on this form is complete and correct and in accordance with relevant documents and information held by the organisation.*
3. *The entire sum of the grant has been spent in line with the proposed outcomes of the Project Schedule (in particular the project plan).*
4. *I know that it is an offence to make a declaration knowing that it is false in a material particular.*

I have read and agree to the above

(**X**) Yes ( ) No

Project manager's name: **Dr David Coates**..

Organisation: **Department of Parks and Wildlife** ....

Day time phone number: **0439 969 404**..................................

Email: **dave.coates@dpaw.wa.gov.au**...

Date: **10 March 2016** ....

13. Acquittal of Grant

Please provide details of how you spent your State NRM Program grant on this project using the template provided.

Please attach your completed and signed grant acquittal to this report.

Contact us

P: 9368 3168

E: snrmo@agric.wa.gov.au

W: nrm.wa.gov.au

Funding Acquittal – *See attached PDF*

Project Title:

Project ID:

PLEASE PROVIDE DETAILS OF **STATE NRM PROGRAM GRANT SPENDING ONLY** FOR THE DURATION OF THE PROJECT.

Statement of Income and Expenditure

Income *(State NRM Program grant)*	$ GST incl/excl#	**Expenditure** *(State NRM Program grant)*	$ GST incl/excl#
Grant received **Interest earned**		**Employment** *Salaries and/or wages* **Operating expenses** • *Contractors* • *Consultants* • *Materials (fencing, trees etc.)* • *Monitoring* • *Financial audit* • *Other (please provide detail)* **Capital expenses** *Detail items worth $5000 or more*	
		Unspent funds ##	
TOTAL ###	$	**TOTAL ###**	$

 # Cross out as applicable

An invoice for these funds will be sent once the final report is approved

Totals on both sides should be equal

I certify that this statement is a fair presentation of the project's income and expenditure and is in accordance with the relevant books/source project documentation and is free from material mis-statement.

I declare that I am independent of this project, have had no material involvement in this project and have not benefitted materially from this project.

A *Must be used if grant is more than $55,000 but may be used for any grant size.*	or	**B** *Must be used if grant is more than $25,000 but less than $55,000. May be used if grant is less than $25,000.*	or	**C** *Can only be used if grant is less than $25,000.*
Signature		Signature		Signature
Full name		Full name		Full name
Phone/Mobile		Phone/Mobile		Phone/Mobile
Occupation #		Occupation ##		Occupation ###
Registration/Membership Number				

Must be a registered auditor or a current member of a relevant professional body (e.g. CPA, ICAA, IPA)

Must have accounting/book keeping skills and experience
Accounting/book keeping skills or experience preferred but not required

FUNDING RECIPIENT DECLARATION – *SEE ATTACHED PDF*

This report must be signed by the funding recipient's delegated officer.

In order to maximise the benefits of this funding, information relating to all projects funded by the State NRM Program is regarded as in the public domain and will be made available to the public on request except for information which needs to be kept confidential. Under privacy legislation, personal information cannot be divulged without the consent of those involved.

Do you consent to the inclusion of contact name and contact details in response to public information requests concerning this project?	**Yes**	**X**	**No**	

I, the undersigned, declare under the *Oaths, Affidavits and Statutory Declarations Act 2005* **that:**

1. **I am authorised by my organisation to make this declaration.**
2. **the information given on this form is complete and correct and in accordance with relevant documents and information held by the organisation.**
3. **the entire sum of the grant has been spent in line with the proposed outcomes of the Project Schedule (in particular the project plan).**
4. **I know that it is an offence to make a declaration knowing that it is false in a material particular.**

Signature of authorised officer			
Full name			
Position in organisation			
Contact			

This declaration is made at .... on ....

{*place*} {*date*}

in the presence of:

....

{*Signature of witness*}

....

{*Printed name of witness*}

....

{*Qualification as such a witness*} #

Please refer to Appendix 2

APPENDIX 1: Photographic Release Form

This form is used by the State Natural Resource Management (NRM) Program
to obtain your permission to publish a photograph that you appear in.

Replace shaded parts with your organisations details

Brief description of the photographs

Conditions of Use

The State NRM Program may:

- Use the photographs in any way it chooses. This includes distorting, blurring or altering images as needed.
- Produce the photographs in either colour or black and white.
- Use and reuse the photographs for an unlimited time at no further cost.
- Transfer or supply the images to another State Government agency without further permission.

Copyright© of the photographs will be held by the State of Western Australia and managed by the State NRM Program.

The State NRM Program undertakes not to use the photographs in a derogatory or otherwise inappropriate way.

If you are prepared to have your name used in association with the photographs, please tick the box below.

☑ I give my consent to the use of my name in association with the photographs.

☐ No, I do not give consent to the use of my name in association with the photographs.

Agreement

I have read and understood this release form and agree to the terms as shown. (The form must be signed by a parent or guardian when the person concerned in this clearance is under the age of 18 years.)

Your name	
Your address	
Signature	
Date	

APPENDIX 2

The Declaration must be made before one of the following persons:

Academic (post-secondary institution)
Accountant
Architect
Australian Consular Officer
Australian Diplomatic Officer
Bailiff
Bank Manager
Chartered secretary
Chemist
Chiropractor
Company auditor or liquidator
Court officer (magistrate, registrar or clerk)
Defence Force officer
Dentist
Doctor
Electorate Officer (State – WA only)
Engineer
Industrial organisation secretary
Insurance broker
Justice of the Peace (any State)
Lawyer
Local government CEO or deputy CEO
Local government councillor
Loss adjuster
Marriage Celebrant
Member of Parliament
Minister of religion
Nurse
Optometrist
Patent Attorney
Physiotherapist
Podiatrist
Police officer
Post Office manager
Psychologist
Public Notary,
Public Servant (State or Commonwealth)
Real Estate agent
Settlement agent
Sheriff or deputy Sheriff
Surveyor
Teacher
Tribunal officer
Veterinary surgeon

Further information on witnessing documents is available at www.dotag.wa.gov.au

TRANSLOCATION PROPOSAL
Andersonia annelsii Lemson
ERICACEAE
March 2015

1. SUMMARY

Andersonia annelsii is a Critically Endangered species which is confined to a small area east of Manjimup in Western Australia. The species was declared as Rare Flora and ranked as Critically Endangered in June 2006 due to the species being known from a single population, its limited area of occupancy and the low number and continuing decline of mature individuals. The major threats to the species persistence are; its limited distribution, *Phytophthora cinnamomi*, grazing, vehicle traffic and inappropriate fire regimes (DEC 2012).

Andersonia annelsii was first collected in 1982 by Tony Annels from the only known location. Extensive surveys in areas of suitable habitat have failed to locate any new plants.

A. annelsii is currently known from one population containing 2,500 mature plants. The population occupies less than 0.4 ha.

Currently there are 71,254 seeds in storage at the Department's Threatened Flora Seed Centre. One collection has been tested for its germinabilty and yielded a germination rate of 88%.

The aim of this translocation proposal is to assist the long term persistence of the species by establishing new, viable, secure populations of A. annelsii*.*

This translocation proposal outlines the need for translocation of the Critically Endangered *A. annelsii*, the site selection process, the design of the translocation sites and the provisions for monitoring. In addition, it outlines the criteria for success or failure of this proposed translocation.

2. PROPONENTS

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3. BACKGROUND

3.1 Taxonomy, History and Status

A member of the Ericaceae family, *Andersonia annelsii* is a low, wiry shrub reaching up to 25 cm in height. The rhomboid to ovate leaves are 1-3 mm in length and 1-2mm wide, with bases sheathing the stem. The flowers are white and held terminally in spikes containing 3-8 flowers (DEC 2012). Flowering occurs in October with ripe fruits collected in November (A. Crawford pers com.). The species is similar in appearance to *A. aristata*, but differs in some leaf and flower characteristics (Lemson 2007).

Andersonia annelsii was first collected in 1982 by Tony Annels. It was formally described by K. L. Lemson in 2007 (Lemson 2007). Extensive survey of the Perup area has failed to locate any additional populations and the species is only known from the original site (DEC 2012). Currently *A. annelsii* is known from one population containing approximately 2,500 plants.

Andersonia annelsii was declared as Rare Flora and ranked as Critically Endangered in June 2006 due to the species being known from a single population, its limited area of occupancy and the low number and continuing decline of mature individuals. The major threats to the species persistence are its limited distribution, grazing, *Phytophthora cinnamomi*, vehicle traffic and inappropriate fire regimes (DEC 2012).

Table 1. Population details for *Andersonia annelsii*.

Population number	Location	Number of individuals	Land tenure
1	Perup	2,500 (Sept 2012)	Nature Reserve

3.2 Distribution and Habitat

Andersonia annelsii is known only from a single population located in the Tone-Perup Nature Reserve, 37km east of Manjimup, W.A. The species is found growing in shallow grey sandy loam over a low, exposed granite/quartzite ridge. The associated vegetation is low open heath dominated by *Pericalymma ellipticum* and *Babingtonia camphorosmae*. Other associated species include; *Corymbia calophylla, Eucalyptus marginata, Xanthorrhoea preissii, Hakea undulata, Allocasuarina huegelii, Cryptandra* sp*., Leptospermum ellipticum, Gastrolobium ovalifolium, Isopogon teretifolius, Kunzea micrantha* subsp*. micrantha, Bossiaea aquifolium, Verticordia habrantha* and *Darwinia vestita.* The population encompasses three separate sites within approximately 300 m of each other (DEC 2012).

3.3 Germplasm collection and Ecology

Currently there are 71,254 seeds of *Andersonia annelsii* from four collections in storage at the Department's Threatened Flora Seed Centre (TFSC). The collection made in 2001 contains 8,215 seeds however most were found to be empty and it is suspected that this collection may have been made when the seeds were too immature. The 2013 collections are better quality and a germination trial on one of the collections has yielded germination rate of 88% (A. Crawford, unpublished data).

Table 2. Details of *Andersonia annelsii* collections and seed in storage in the Threatened Flora Seed Centre*

Population	Year collected	Number of collections	Number of seed
1	**2001**	**1**	**8215 (contains mostly empty seed)**
1	**2013**	**3**	**63,039**

*Additional seed collection planned for 2015.

Little is known of the species ecology and biology. *A. annelsii* flowers in October and ripe seed have been collected in November (A. Crawford pers com.). Pollinators have not been observed to date, but could include insects such as butterflies and moths (Keighery 1996).

A. annelsii appears to be killed by fire and regenerate from seed (Hearn *et al.* 2006), although it is not clear if the species is also capable of resprouting after fire. Routine monitoring has shown that seed germination does not appear to be an annual event. Good germination was recorded in 2006, the reason for which is unknown, but possibly may be attributable to the smoke effects of a prescribed burn adjacent to the population. A small wildfire in spring 2014 burnt some plants on the edge of the population. Follow up monitoring during 2015 will determine if this fire promotes germination and recruitment or resprouting of adult plants. The susceptibility of *A. annelsii* to dieback disease (caused by *Phytophthora* spp.) has not been tested in trials to date, but field observations suggest the species is susceptible to the disease (DEC 2012). The persistence of the soil seed bank is unknown.

4. THE TRANSLOCATION

4.1 The Need to Translocate

A. annelsii is listed as Critically Endangered due to the species being known from a single population (with an area of occupancy less than 0.4ha) and the low number of mature individuals (DEC 2012).

The major threats to the species include limited distribution, inappropriate fire regimes, grazing, *Phytophthora cinnamomi* and vehicle traffic.

As the species is only known from one population with a total of 2,500 plants, the vulnerability of this single population to disturbance events, and consequently extinction, is of concern. Translocating this species to a new site will buffer the taxon against random loss of a population due to catastrophic or other unpredictable environmental events (Guerrant 1996).

The long term viability of the *A. annelsii* population may be affected by inappropriate fire regimes. It is not known exactly what the fire response of the species is, however frequent fire is likely to destroy the populations if it occurs before regenerating or juvenile plants have reached maturity, produced seed and replenished the soil seed bank. Alternatively, infrequent fires may be required for the species to regenerate from soil stored seed and root stock.

During routine monitoring of the population, the heavy grazing/mortality of seedlings has been recorded (DEC 2012). This targeting of seedlings by herbivores has the capacity to limit population stability through recruitment.

As mentioned previously *A. annelsii* has not been tested for susceptibility to *Phytophthora cinnamomi* in glass house trials, but a large decline of individuals occurring in coincidence with *Phytophthora* infestation has been recorded.

Vehicle traffic has also posed a threat to *A. annelsii.* Plants occurred along the edges of an access track where they were vulnerable to damage from passing vehicles and road maintenance. Recently the Department of Parks and Wildlife has created an alternative access track, allowing the track passing through the population to be closed and rehabilitated.

Given the very limited distribution of the species, small population size and current threats, translocation of the species to a secure site is critical in order to assist its survival.

The current status of A. annelsii *leads us to believe that translocation is now crucial to the recovery of this species.*

4.2 Translocation Site Selection

A search was made of conservation reserves in the vicinity of the known population of *A. annelsii* to locate two suitable translocation sites. The search focused on areas with similar soil characteristics and associated vegetation to the natural population, land with secure tenure, and location in relation to the known population of *A. annelsii*. An additional factor in site selection was the risk of a major disturbance event affecting both the translocated and natural population at the same time. Consideration was also given to whether measures could be put in place to ensure the risk of a major disturbance event affecting the translocated populations and the natural population at the same time, were low.

Translocation Site 1 – Lunchbox site, Walton road – Greater Kingston National Park
The first proposed translocation site is in Greater Kingston National Park and located on Walton road, off Kingston road. The site is situated approximately 22km north-northwest of the natural population of *A. annelsii* (Appendix 1).

The suitability of the proposed site was assessed in May 2013 by Jo Smith (Flora Conservation Officer, DPaW Donnelly District), Susanne Schreck (Technical Officer, DPaW Science Division) and Rebecca Dillon (Research Scientist, DPaW Science Division). The site was assessed on the basis of disease status, hygiene issues, access, soil type, risk of secondary salinity, drainage, windbreaks, the presence of potential pollinators and the presence of other *Andersonia* species that could pose a risk of potential hybridisation with *A. annelsii*.

The site was assessed for the presence of *Phytophthora cinnamomi* and was determined to be *Phytophthora*-free based on the presence of healthy indicator species.

The site contains some exposed granite and occupies a gentle slope with a northerly aspect. The soils are shallow grey sandy loam over granite, which are similar to the soils on which *A. annelsii* naturally occurs. Soil depth increases with distance from the granite. There is no evidence of current or potential salinisation at the site or its surrounds.

At the site, adjacent vegetation provides protection from wind damage and habitat for potential vertebrate or invertebrate pollinators. The vegetation occurring on the shallow soils is low open heath and the surrounding vegetation is open woodland with an understorey dominated by shrub and heath species. The main plant species are outlined in Table 2, a number of which occur naturally with *A. annelsii.* No *Andersonia* species were present that pose a risk of hybridisation.

This site has no weed competition and good vehicle access for maintenance and monitoring the translocated plants. The site occupies an area adjacent to an existing fire break/access track, and as such will be readily defendable in the event of wildfire. Furthermore Walton and Kingston roads completely surround the small block of forest in which the site occurs, aiding in its protection from wildfire (Appendix 2).

Potential threats at the site include grazing by vertebrates including rabbits and kangaroos. This threat will be managed by fencing the site to exclude vertebrate herbivores. Introduction of *Phytophthora cinnamomi* to the site will be avoided through use of strict hygiene procedures.

Translocation Site 2 – Winnejup
The second proposed translocation site is also in Greater Kingston National Park and located on North Boundary Road, off Kingston Road. The site is situated approximately 25km north-west of the natural population of *A. annelsii* (Appendix 1).

The suitability of the proposed site was assessed in November 2014 by Jo Smith (Flora Conservation Officer, DPaW Donnelly District). The site was assessed on the basis of disease status, hygiene issues, access, soil type, risk of secondary salinity, drainage, windbreaks, the presence of potential pollinators and the presence of other *Andersonia* species that could pose a risk of potential hybridisation with *A. annelsii*.

The site was assessed for the presence of *Phytophthora cinnamomi* and was determined to be *Phytophthora*-free based on the presence of healthy indicator species.

The site contains some exposed granite and occupies a gentle slope with a north-west aspect. The soils are similar to site one, with shallow grey sandy loam over granite. Soil depth increases with distance from the granite. There is no evidence of current or potential salinisation at the site or its surrounds.

At the site, adjacent vegetation provides protection from wind damage and habitat for potential vertebrate or invertebrate pollinators. The vegetation is also similar to site one, with open low heath occurring on the shallow soils and surrounding vegetation comprised of open woodland with an understorey dominated by shrub and heath species. The main plant species are outlined in Table 2, a number of which occur naturally with *A. annelsii.* No *Andersonia* species were present that pose a risk of hybridisation.

This site has no weed competition and good vehicle access for maintenance and monitoring the translocated plants. The site occupies an area adjacent to an existing fire break/access track, and as such will be readily defendable in the event of wildfire. Furthermore, North Boundary and Access roads provide some protection to the site from wildfire. (Appendix 2).

Potential threats at the site include grazing by vertebrates including rabbits and kangaroos. This threat will be managed by fencing the site to exclude vertebrate herbivores. Introduction of *Phytophthora cinnamomi* to the site will be avoided through use of strict hygiene procedures.

Table 2. Associated vegetation at proposed translocation sites for *Andersonia annelsii*.

Site 1	**Site 2**
*Eucalyptus marginata**	*Allocasuarina huegliana**
*Corymbia calophylla**	*Corymbia calophylla**
Trymalium ledifolium	*Trymalium ledifolium*
Hakea lissocarpha	*Hakea lissocarpha*
*Tetraria sp.**	*Leucopogon propinquus*
Hibbertia commutata	*Hibbertia commutata*
	Hibbertia notibractea
	Hibbertia furfuraceae
	Darwinia citriodora
	Acacia pulchella
*Macrozamia riedlei**	*Astroloma pallidum*
*Xanthorrhoea preissii**	*Xanthorrhoea preissii**
*Pericalymma ellipticum**	
*Drosera sp**	

* - denotes species also present at natural population of *Andersonia annelsii.*

The plants and seeds are proposed to be established at the translocation sites in winter 2015. As *A. annelsii* has not previously been recorded from these sites, the translocations can be considered ‘introductions’ under the definitions provided by the Guidelines for Translocation of Threatened Plants in Australia (Vallee *et al.* 2004) and the definitions in DPaW Policy Statement 29. A map of the proposed translocation sites in relation to the known population is shown in Appendix 1.

Endorsement for the use of these sites has been sought from the DPaW Warren Region and the translocations will not go ahead unless the project is approved by the region.

4.3 Translocation Design

Seed for the translocation will be sourced from existing collections held in the Threatened Flora Seed Centre (TFSC). One-hundred seed will be germinated at the TFSC after which the Botanic Gardens and Parks Authority (BGPA) will grow on the plants in their accredited nursery at Kings

Park. Each plant will be permanently tagged so each plant will be identifiable for monitoring purposes. Up to 50 seedlings will be planted at each of the translocation sites in winter 2015.
Seed for the plants will be sourced from approximately 20 parents collected in 2013 from population 1. While it is not clear at present what animals pollinate *A. annelsii*, other species are present at the site which will provide cover and food sources for potential pollinators. In the interim, efforts will be made to determine what pollinates the species.

Plants will be planted approximately 1m apart (to replicate the *in-situ* population) within small cleared areas amongst the existing vegetation. Seedlings will be irrigated over the first two summers and protected from grazing by fencing to maximise survival. Community involvement in the project through the Warren Region Threatened Flora Recovery Team will be sought to promote awareness of, and interest in, the species.

All equipment used during planting will be maintained under strict disease hygiene.

Monitoring of the translocated populations will commence at planting out of the seedlings and then every six months, for the first year and then annually thereafter. Monitoring will include counting the number of surviving seedlings, height of the surviving seedlings, width of the crown of the surviving seedlings in two directions, reproductive state, number of flowers, number of fruits and general health of the plants.

Monitoring of the original population will also occur in conjunction with monitoring of the translocated populations. This will provide essential baseline data for assessing the performance of the translocated population. Monitoring will include counting the number of individuals, height and crown width of the individuals, reproductive state, number of flowers, number of fruits and general health of the plants.

4.4 Site management

As these plants will be established for the purpose of conservation, they will be regarded as Declared Rare Flora and will have the same legal protection.

The land managers (DPaW) currently implement *Phytophthora* hygiene procedures for the whole of theGreater Kingston National Park, where both translocation sites are located.

DPaW is also responsible for fire management within the Greater Kingston National Park. Currently the area each site occupies is subject to a prescribed burn approximately every 7 years. However, the length of the fire-free period that *A. annelsii* requires in order to reach maturity and set seed is unknown. It is possible that a fire frequency 7 years is too frequent for population persistence. Consequently, a cautious approach will be utilised and fire will be excluded from the site until further knowledge of the species response to fire is obtained.

4.5 Source of Plants

Seedlings for the first years' planting will be derived from seed stored at the TFSC, based on three collections from population 1 of *A. annelsii*.

Further material will be sourced from population 1 in 2015 to replace that used from the TFSC collections. Current seed collection guidelines (up to 20% of available seed on one plant at time of collection) will be followed to ensure sufficient soil seed storage to replace the present population in the event of fire.

Seedlings will be raised at BGPA's accredited nursery at Kings Park, which has hygiene procedures in place to ensure seedlings are free from diseases, pests and weeds.

4.6 Criteria for Success or Failure

Success criteria for each translocation site

The aim of the translocation is to achieve a viable self-sustaining population. This will be achieved by planting over successive years as plants are propagated until a population of at least 250 plants has been established. The time frames required to achieve this aim may need to be adjusted to take into account the number of plants available for planting, seasonal influences on maturation times, survival and availability of funding.

Success

Initial success of each planting (approx 1 year)

- Survival of at least 50% of each years plants past their first summer.

Medium term success of all plantings (2-10 years)

- Survival of at least 40% of all plants planted beyond first year.
- At least 80% of surviving plants producing viable seed at a rate similar to that at the natural population.
- Recruitment of a second generation – seedling recruitment equivalent to or greater than that observed at the natural population (bearing in mind this may be nil if seedling recruitment is linked to disturbance and this does not occur in this timeframe).

Long term success of all plantings (greater than 10 years)

Establishment of a viable self-sustaining population of at least 250 mature plants (natural recruitment of second and subsequent generations without additional plantings).

Failure

Initial failure of each planting (approx 1 year)

Less than 50% of each years plants surviving beyond the first summer

Medium term failure of all plantings (2-10 years)

- Less than 40% of all plants planted surviving beyond first year
- Less than 80% of surviving plants producing viable seed at a rate similar to that of the natural population.
- Seedling recruitment significantly less than that observed at the natural populations

Long term failure of all plantings (greater than 10 years)

Population fails to become viable and self-sustaining.

5. TIMETABLE

Time	Action
May 2013	Translocation sites selected
March 2015	Translocation proposal submitted for review.
January 2015	Seed germination at TFSC
January-June 2015	Cultivation at BGPA.
May 2015	Site preparation
June 2015	Planting at site
June 2015 – ongoing	Monitoring and maintenance of translocation site.

6. FUNDING

This project is fully funded under the Western Australian Governments' State Natural Resource Management "Fast Track Critically Endangered Flora Recovery" project until the end of June 2015. The position of the Flora Conservation Officer based at Pemberton (currently filled by Jo Smith) is internally funded by DPaW. Therefore, the Flora Conservation Officer will monitor the translocation beyond the availability of the State NRM funding.

7. ACKNOWLEDGMENTS

Andrew Crawford – DPaW, Threatened Flora Seed Centre

8. REFERENCES

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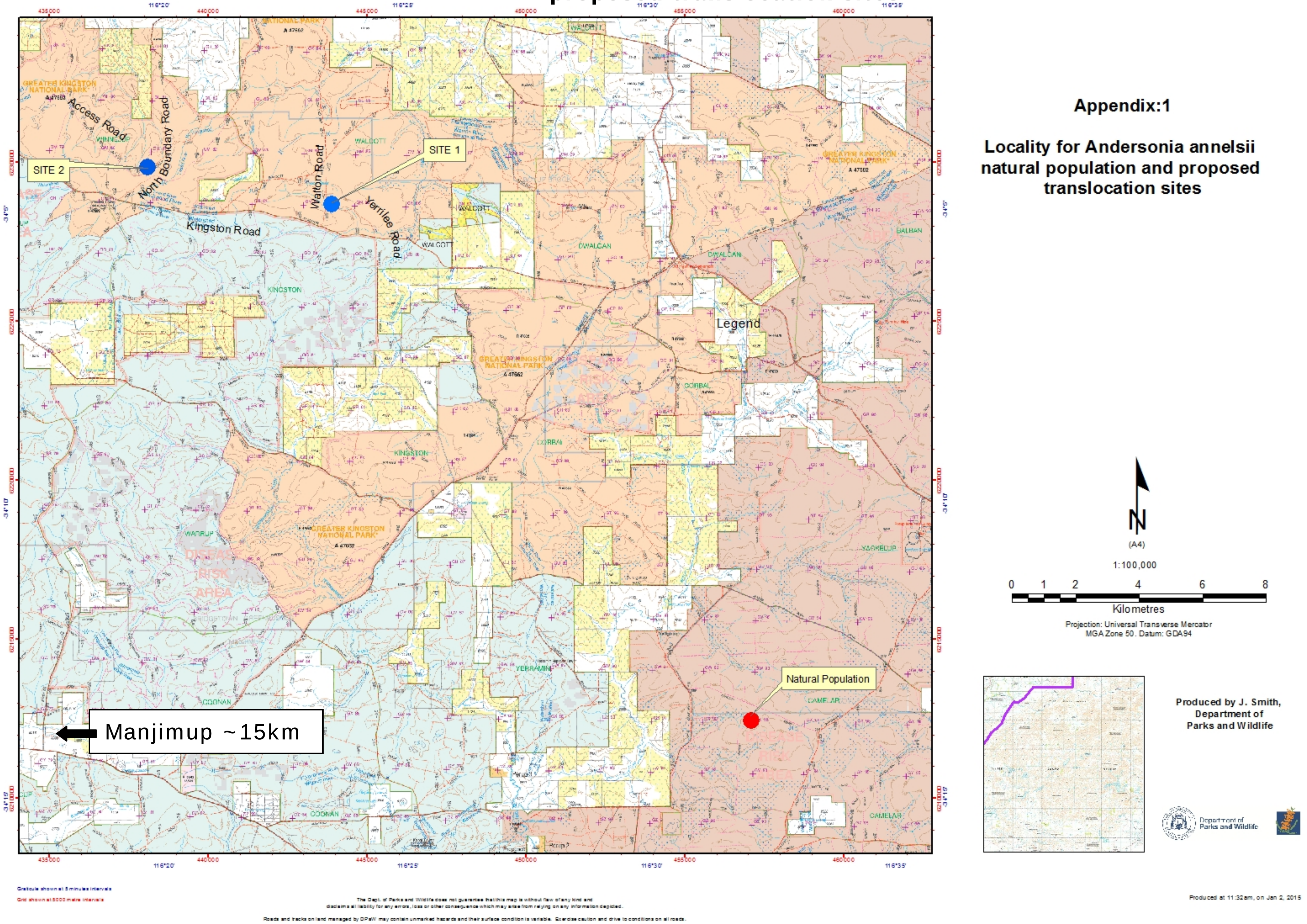
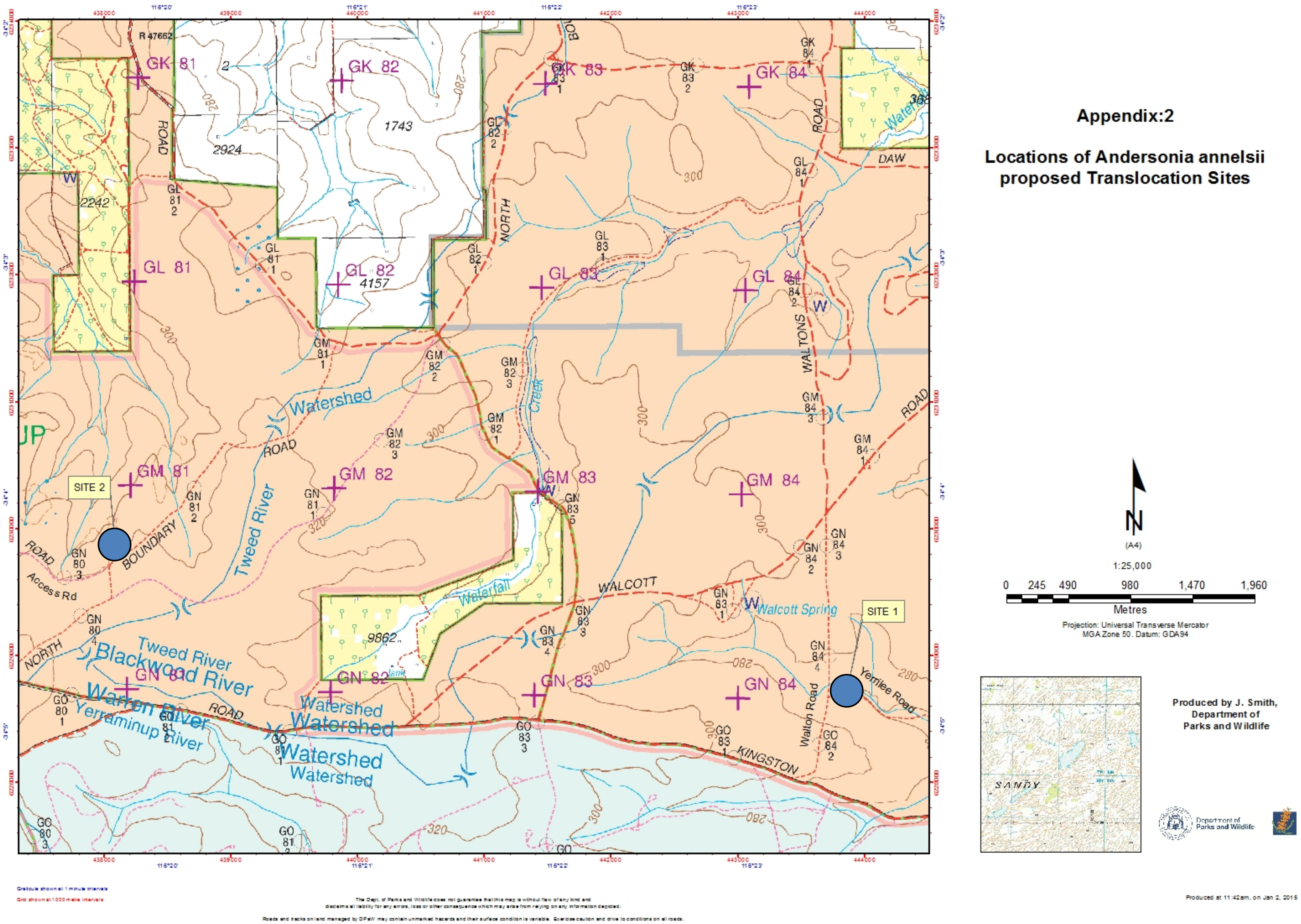
Appendix 1: Locality for *Andersonia annelsii* natural population and proposed translocation sites



Appendix 2: Location of *Andersonia annelsii* proposed translocation sites



TRANSLOCATION PROPOSAL

DAVIESIA OVATA
BROAD-LEAVED DAVIESIA
(FABACEAE)

1. SUMMARY

Daviesia ovata Benth. is a Critically Endangered taxon, endemic to Mount Manypeaks, located on the south coast of Western Australia. *Daviesia ovata* was declared as Rare Flora in 2008 and ranked as Critically Endangered due to its restricted area of occupancy, the low number of mature plants and continuing decline in the number of individuals.

Daviesia ovata is an erect shrub 2m tall and up to 2m wide. Branches are hairless, long and angular. The leaves are approximately 5cm in length, ovate to elliptical in shape with a small thickened tip. The pea-like flowers are approximately 8mm long and orange and purple in colour. Flowering occurs between September and November. The fruit is a triangular pod, approximately 13mm in length (Leigh *et al.* 1984; DEC 2010).

The species was first collected prior to 1846 by James Drummond from an unknown location. The species was later collected by C. Gardner in 1935 from Mount Manypeaks and not seen again until 1982 when one plant was found at the same location. Surveys by DEC (now Department of Parks and Wildlife) staff in 2007 and 2008 located a total of two populations comprised of six subpopulations. No other populations have been discovered despite extensive survey.

Daviesia ovata is currently known from two populations containing 50 mature plants and 72 juvenile/non-reproductive plants. The two populations occupy approximately 1.7ha in area.

Daviesia ovata is threatened by grazing, inappropriate fire regimes and fire break maintenance.

Currently there are 462 seeds from four collections in storage in the Department's Threatened Flora Seed Centre (TFSC), from population 1. Four additional collections from populations 1 and 2 are yet to be quantified. Seed is readily germinable with 67% germination following seed coat scarification.

The aim of this translocation proposal is to assist the long term persistence of this species by increasing the number of individuals within a natural population (population 1) of D. ovata, *which currently consists of 70 adult (and five juvenile) plants. This will be achieved by restocking population 1 with seedlings to produce a viable, secure population of* D. ovata *within the Mount Manypeaks Nature Reserve.*

This proposal outlines the need for translocation of the Critically Endangered *D. ovata,* the site selection process, the design of the translocation and the provisions for monitoring. In addition it outlines the criteria for success or failure of this proposed translocation.

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3. BACKGROUND

3.1 Taxonomy, History and Status

A member of the family Fabaceae, *Daviesia ovata* Benth. is an erect shrub; 2m tall and up to 2m wide. Branches are hairless, long and angular. The leaves are approximately 5cm in length, ovate to elliptical in shape with a small thickened tip. The leaves are stiff and leathery with conspicuous net-like veins. Flowers are pea-like, borne singly in leaf axils; commonly held in leafy bunches towards the ends of the branches. The flowers are approximately 8mm long and orange and purple in colour. The fruit is a triangular pod approximately 13mm in length (Leigh *et al.* 1984; DEC 2010).

Table 1. Population details for *Daviesia ovata*.

Population number	**Location**	**Land status**	**Date of most recent survey**	**Number of individuals at location** () = juveniles	**Area of occupancy at location**	**Condition of site**
1a	Mount Manypeaks	Nature Reserve	19/10/2011	6 (1)	0.01ha	Good. Grazing of *D. ovata* by quokka.
1b	Mount Manypeaks	Nature Reserve	19/12/2011	0 (2)	0.5ha	Good. Grazing of *D. ovata* by quokka.
1c	Mount Manypeaks	Nature Reserve	19/12/2011	0 (2)	0.5ha	Good. Grazing of *D. ovata* by quokka.
1d	Mount Manypeaks	Nature Reserve	19/10/2011	40 (24)	0.4ha	Good. Grazing of *D. ovata* by quokka.
2a	Mount Manypeaks	Water Reserve	19/12/2011	0 (3)	0.04ha	Good. Grazing of *D. ovata* by quokka.
2b	Mount Manypeaks	Water Reserve	19/10/2011	4 (40)	0.25ha	Good. Grazing of *D. ovata* by quokka.

Daviesia ovata was first collected by J. Drummond prior to 1864 from an unknown location in Western Australia. The second collection for the species was made by C.A. Gardner in 1935 from Mount Manypeaks. The species was not relocated until 1982, when D. Davidson and B. Swainson collected it from the same hill as Gardner (DEC 2010). Further collections were made by Davidson in 1983, Taylor and Ollerenshaw in 1983 and Keighery in 1986 from similar locations that differ in altitude. It is assumed that these collections were most likely made from what now constitutes the sub populations of population one.

The next collection occurred in 2007 (from population one) when DEC (now Department of Parks and Wildlife) staff located the species on the lower slopes of Mount Manypeaks in Mount Manypeaks Nature Reserve. An additional population (population two) was found in 2008, approximately 1.8km north of the known population in a Shire Water Reserve. Despite extensive survey over a large area of Mount Manypeaks, no additional new populations have been located.

Daviesia ovata is currently known from two populations of approximately 50 adult plants and 72 juvenile/non-reproductive plants (Table 1).

The species was declared as Rare Flora in 2008 and ranked as Critically Endangered due to its restricted area of occupancy, the low number of mature plants and continuing decline in the number of individuals. The major threats to the species are grazing and inappropriate fire regimes.

3.2 Distribution and Habitat
Daviesia ovata is endemic to Mount Manypeaks, located on the south coast of Western Australia east of Albany. The species grows on the lower foothills and slopes of Mount Manypeaks. The two populations occur within 1.8km of each other and their total area of occupancy is approximately 1.7ha.

Soils are typically sandy brown loam over granite. The species grows among open mallee shrub over heath. Associated species include *Allocasuarina humilis*, *Eucalyptus marginata*, *Daviesia alternifolia*, *Hakea elliptica*, *Hakea ceratophylla*, *Gastrolobium coriaceum*, *Taxandria angustifolia*, *Banksia sphaerocarpa* and *Banksia plumosa*.

3.3 Ecology and germplasm collection
Little is known of the biology and ecology of *Daviesia ovata.* A fire burnt through both populations in 2005 and regeneration from both seed and resprouting adults was observed. The age to first flowering is unclear due to the consistent heavy grazing of regenerating plants following fire. The persistence of the soil seed bank is unknown.

Daviesia ovata flowers during September to November. Insects are the major pollinators of *Daviesia* species, although pollinators of *D. ovata* have not been observed to date. Pods mature in December to February and generally contain 1 or 2 seeds (A. Cochrane *pers. com*.). Most seed collected to date has been from plants that resprouted after fire.

Daviesia ovata is highly palatable to quokka. Consistent heavy grazing of plants (by quokka and possibly rabbits) has been observed since 2007 and plastic tree guards were employed to protect plants from herbivory. The use of tree guards greatly encouraged plant growth and reproduction; however plants once again became susceptible to damage upon outgrowing the tree guard. This led to the use of wire cages and ultimately the fencing of most subpopulations.

Currently there are eight collections of *D. ovata* seed in storage in the Department's Threatened Flora Seed Centre (TFSC) (Table 2). Four of these collections (all from population 1) have been processed and are reported to contain 462 seeds in total. Four collections await processing and quantification. Germination trials indicate successful germinability, with 67% germination. In these trials seeds were nicked prior to plating on agar at 15°C (A. Crawford, unpublished data).

Table 2. Number of *Daviesia ovata* seed in storage in the Threatened Flora Seed Centre

Population	Number of collections	Number of seed
1	6	462 (not including 2 collections not quantified)
2	2	Not quantified

4. THE TRANSLOCATION

4.1 The Need to Translocate
The rarity of *Daviesia ovata* is due to its geographically restricted distribution, the low number of plants and the effects of heavy grazing. There are presently only two known natural populations with a total of approximately 122 individuals, 72 of which are juvenile/non-reproductive plants

(Table 1). The majority of mature plants (40) are in subpopulation 1d. Only two other subpopulations have any surviving mature plants.

A substantial threat to all subpopulations is consistent heavy grazing by quokka. Grazing of this level has been observed since regular population monitoring began in 2007 and is likely to have been operating since the fire in 2005, if not before at a lower level. Quokka numbers have been observed to increase following fire. Regenerating vegetation is favoured feeding habitat for quokka and encourages population growth (S. Barrett, S. Comer *pers. obs*.). The openness of vegetation following fire exposes seedlings to easier detection by herbivores and the mass germination of some species in response to fire may lead to a significant concentration of herbivores in the area. Grazing can not only kill regenerating seedlings and plants, but also severely limit growth and reproduction. Very little flowering and fruit production in plants regenerating after the 2005 fire was observed until herbivores were excluded from plants with the use of plastic tree guards, cages or fencing (S. Barrett *pers. obs*.).

Daviesia ovata is vulnerable to inappropriate fire intervals. If repeated fires occur at high frequency (at an interval less than the juvenile period of the species) the plants may be killed before reaching reproductive maturity and the soil seed bank, along with resprouting plants, could become depleted resulting in localised extinction. Conversely, too long an interval between fires may also threaten the long-term persistence of *D. ovata* as the species is thought to mainly regenerate through seed germination following fire (DEC 2010). If there is an absence of fire beyond the life span of the population and its soil stored seed bank, extinction may result.

It is possible that rarity and current small size of the *D. ovata* population may be a result of the combination of fire followed by heavy grazing.

These threats are exacerbated by the existence of only two small populations with a very small area of occupancy. As the population size decreases and isolation increases, populations may become more vulnerable to extinction for the following reasons: (i) the loss of genetic variation and increased inbreeding have been associated with a reduction in the ability of a population to adapt to short-term environmental change; (ii) small populations are more susceptible to chance events due to environmental or human impacts and (iii) the population size or density is such that the reproductive capacity drops below a threshold so that the organism can no longer replace itself (Hobbs & Yates 2003).

Several extensive surveys have been undertaken for this species since 2007, two years after an extensive wildfire, with only two populations found. It is unlikely that further new populations will be located or, if located, it is probable that their habitat would be subject to the same threatening processes as for the current populations. Thus at this present stage there are only two, small extant populations, both of which are extremely vulnerable to threatening processes. There is therefore, a high risk of extinction in the wild.

Given the very limited distribution of the species and decline in population size, restocking of the species natural populations is crucial in order to assist its survival. Restocking will increase population size and reduce the risk of population extinction.

The current status of D. ovata *leads us to believe that restocking is now crucial to the recovery of this species.*

The aim of this translocation is to assist the long term persistence of this species by increasing the size of a natural population (population 1) of *D. ovata*. This will be achieved by restocking this population with seedlings to produce a viable, secure population of *D. ovata*.

4.2 Translocation Site Selection

An assessment was made of the two *Daviesia ovata* populations for their suitability for restocking (translocation). Populations were assessed on characteristics such as security of tenure, number of existing plants, presence of threatening processes, habitat quality and access for implementation, maintenance and monitoring. Consideration was also given to whether measures could be put in place to ensure the risk of a major disturbance event affecting the translocated population was low.

Both natural populations are located on Mount Manypeaks, although only population 1 is located within Mount Manypeaks Nature Reserve. Population 1 has been selected for restocking. Population 2 is also considered a suitable restocking site, however, access for implementation of the translocation and its ongoing maintenance is difficult. If restocking of population 1 proves successful, restocking of population 2 may be considered at a later date.

Population 1 was selected for restocking (translocation) due to it being of secure tenure (nature reserve), having high quality habitat, ease of access, ease of fire management/exclusion (adjacent to an existing firebreak) and an absence of threats. Maps showing the proposed translocation site are shown in Appendices 1 and 2.

Translocation Site – Mount Manypeaks Nature Reserve.
The proposed translocation site is located immediately adjacent to population 1 within the Mount Manypeaks Nature Reserve. The site is located in the western part of the reserve, within approximately 100m of an existing firebreak (S 34^{o} 54' 25.7" E 118^{o} 14' 22.4") (Appendix 1). The suitability of the proposed site was assessed in 2012 by Sarah Barrett (Flora Conservation Officer, Department of Parks and Wildlife) and Rebecca Dillon (Research Scientist, Department of Parks and Wildlife). The site was assessed on the basis of security of tenure, hygiene issues, access, soil type, risk of secondary salinity, drainage, windbreaks, disease status, risk of potential hybridisation and the presence of potential pollinators.

This site is gently sloping, has no weed competition and good vehicle access for maintenance and monitoring the translocated plants. The site occupies an area approximately 50–100m east of a main firebreak and as such will be readily defendable in the event of wildfire.

At the site, the vegetation is in moderate condition (due to impact of *Phytophthora* dieback and grazing) and will provide protection from wind damage and habitat for potential invertebrate pollinators. The presence of naturally occurring *D. ovata* plants at the site should ensure the appropriate pollinators are available. The vegetation is open mallee shrub over heath species. The main plant species are outlined in Table 3. *Daviesia alternifolia* occurs at the site but there are no indications that existing *D. ovata* plants hybridise with this naturally co-occurring species, thus hybridisation is not considered an issue.

Glasshouse trials have indicated that *D. ovata* is not susceptible to *Phytophthora* dieback caused by *P. cinnamomi* (C. Crane, unpublished data). Introduction of other plant pathogens to the site will be avoided through use of strict hygiene procedures.

Potential threats at the site include grazing and trampling by rabbits, quokka and kangaroos. This threat will be managed by fencing the translocation for protection from damage by vertebrate browsers.

The plants are proposed to be established at this translocation site in winter 2014. As *D. ovata* is currently present at this site, this translocation can be considered as 'restocking' or 'augmentation' under the definitions provided by Policy Statement 29 and the Guidelines for Translocation of Threatened Plants in Australia (Vallee *et al.* 2004).

Endorsement for the use of this site has been sought and received from the Department of Parks and Wildlife South Coast Region (See Approvals page attached).

Table 3. Associated vegetation at proposed translocation site for *Daviesia ovata*

Anarthriaceae
Anarthria prolifera

Casuarinaceae
Allocasuarina humilis

Cyperaceae
Mesomelaena tetragona

Dasypogonaceae
Kingia australis

Dilleniaceae
Hibbertia microphylla

Ericaceae
Sphenotoma dracophylloides

Fabaceae
Gastrolobium coriaceum

Myrtaceae
Beaufortia decussata
Melaleuca striata
Taxandria angustifolia

Papilionaceae
Daviesia alternifolia

Proteaceae
Adenanthos apiculatus
Banksia sphaerocarpa
Banksia plumosa
Banksia formosa
Grevillea fasciculata
Hakea elliptica
Hakea cucullata
Hakea ceratophylla
Hakea trifurcata
Hakea lasiantha

Xanthorrhoeaceae
Xanthorrhoea platyphylla

4.3 Site management

As these plants will be established for the purpose of conservation, they will be regarded as Declared Rare Flora and will have the same legal protection. Any seed harvested from plants will be used for conservation purposes only.

The land managers (Department of Parks and Wildlife) maintain firebreaks and currently implement *Phytophthora* hygiene procedures for the nature reserve as a whole.

There are currently no prescription burns planned for the area containing the translocation site. If this area is required to be burnt in the future, a buffer area will be established around the site to ensure the translocated plants are excluded from fire, at least until a greater knowledge of the species' fire response is gained.

4.4 Translocation Design

Seed for translocation has been collected from populations 1 and 2. The Botanic Gardens and Parks Authority (BGPA) will grow on 50 plants from populations 1 and 2. Seedlings will be planted at the translocation site in winter 2014. Each plant will be permanently tagged so that each individual will be identifiable for monitoring purposes.

To avoid seedling losses due to summer drought, water will be provided during the summer months. A water tank will be located on site and will be filled with town water from Albany (in which the chlorine helps to any kill pathogens). The water will be carried in Departmental fire trucks (the tank of which is sterilised with a bleach solution, then rinsed, prior to filling with water).

All translocated seedlings will be protected from grazing by fencing to further maximise survival. Community involvement in the project through the Albany Threatened Flora Recovery Team will be used to promote awareness of, and interest in, the species. All equipment used during planting will be maintained under strict disease hygiene.

Monitoring of the translocated population will be undertaken after planting and then every six months for the first year and then annually thereafter. Monitoring will include counting the number of surviving plants, measuring their height and width of the crown in two directions, and recording the reproductive state, number of flowers, number of pods, whether second generation plants are present and general health of the plants.

Monitoring of the original populations will also occur in conjunction with monitoring of the translocated plants. This will provide essential baseline data for assessing the performance of the translocated plants. Monitoring will include counting the number of individuals, measuring their height and crown width, and recording reproductive state, number of flowers, number of pods, whether second generation plants are present and general health of the plants.

4.5 Source of Plants

Plants will be grown from seed collections stored at the TFSC, from the *Daviesia ovata* populations 1 and 2. The BGPA will grow on 40 plants from population 1 and 10 plants from population 2. Seed will be sourced from approximately 23 parents from two collections from population 1 and four parents from two collections from population 2.

Additional seeds will be sourced from populations 1 and 2 in 2014 and as more fenced plants become reproductive, more parent plants will become available for seed collection. Plants raised from these will be planted in successive years. Current seed collection guidelines (up to 20% of available seed on one plant at time of collection) will be followed to ensure sufficient soil seed storage to replace the present population in the event of another fire.

No known genetic studies have been undertaken for this species. In the absence of such data, we will use a conservative approach and aim to plan, implement and manage the translocation in such a way as to maximise its genetic diversity. Under both national and international guidelines (e.g. Guerrant 1994, Offord & Meagher 2009), when the breeding system of the species is unknown it is recommended that seed is collected from at least 50 plants to ensure 95% of the genetic variation within that population is represented in the collection. If the population consists of less than 50 individuals, then seed should be collected from all reproductive plants present. The seedlings for this translocation will be sourced from seed collected from all reproductive plants in the two populations.

Seedlings will be raised at BGPA's accredited nursery at Kings Park, which has hygiene procedures in place to ensure seedlings are free from diseases, pests and weeds.

4.6 Criteria for Success or Failure

Success criteria

The aim of the translocation is to achieve a viable and self-sustaining population of *Daviesia ovata*. This will be achieved by planting over successive years as plants are propagated until at least 250 plants have been successfully established. The time frames required to achieve this aim may need to be adjusted to take into account the number of plants available for planting, seasonal influences on maturation, survival and availability of funding.

Biological success or failure

<u>Success</u>

Initial success of each planting (approx. 1 year)

- Survival of at least 50% of each year's plants past their first summer.

Medium term success of all plantings (2-10 years)

- Survival of at least 40% of all plants planted beyond the first year.
- At least 80% of surviving plants producing viable seed at a rate similar to that at the natural population.
- Recruitment of a second generation – seedling recruitment equivalent to or greater than that observed at the natural population (bearing in mind this may be nil if seedling recruitment is linked to disturbance and this does not occur in this timeframe).

Long term success of all plantings (greater than 10 years)

- Establishment of a viable self-sustaining population of at least 250 mature plants (natural recruitment of second and subsequent generations without additional plantings).

<u>Failure</u>

Initial failure of each planting (approx. 1 year)

- Less than 50% of each years plants surviving beyond the first summer.

Medium term failure of all plantings (2-10 years)

- Less than 40% of all plants planted surviving beyond first year.
- Less than 80% of surviving plants producing viable seed at a rate similar to that of the natural population.
- Seedling recruitment significantly less than that observed at the natural populations.

Long term failure of all plantings (greater than 10 years)

- Population fails to become viable and self-sustaining.

5. TIMETABLE

Time	Action
July 2013	Translocation proposal submitted for review and approval.
November 2013	Germination of seed stored at TFSC and then growing on of these seedlings at BGPA.
December 2014/January 2015	Further seed collection from populations 1 and 2 for TFSC.
June 2014	Seedlings planted at translocation site.
October 2014	Progress report.
Annual review	Monitor, assess flower and fruit production.

6. FUNDING

This project is fully funded under the State NRM "Fast Track Critically Endangered Flora Recovery" project for a period of three years. One of the proponents, Sarah Barrett (Flora Conservation Officer based at Albany) is internally funded by the Department of Parks and Wildlife. The proponents are therefore willing to make a commitment to monitor the translocation beyond the availability of the State NRM funding.

7. ACKNOWLEDGMENTS

Andrew Crawford – Department of Parks and Wildlife, Threatened Flora Seed Centre
Anne Cochrane – Department of Parks and Wildlife, Threatened Flora Seed Centre

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APPENDIX 1

Natural populations of *Daviesia ovata* including proposed translocation site

D. ovata populations in Mount Manypeaks NR

Proposed translocation site (Pop #1)

APPENDIX 2

Proposed translocation site (population #1)
Mount Manypeaks NR

Proposed Translocation Site (Pop# 1)

TRANSLOCATION PROPOSAL

EREMOPHILA ROSTRATA SUBSP. *TRIFIDA*
BEAKED EREMOPHILA
(SCROPHULARIACEAE: MYOPOREAE)
AUGUST 2014

1. SUMMARY

Eremophila rostrata subsp. *trifida* Chinnock is a Critically Endangered taxon, endemic to the Mid West region of south west Western Australia. *Eremophila rostrata* was declared as Rare Flora in 2001 and ranked as Critically Endangered because it contains an extremely low total number of plants, has a very restricted distribution and area of occupancy, and is experiencing continuing decline. In 2007, *E. rostrata* was recognised as containing two distinct subspecies, *E. rostrata* subsp. *rostrata* and *E. rostrata* subsp. *trifida* based on differences in leaf and flower morphology (Chinnock, 2007). The two subspecies occur 280 km apart, are restricted to different soil types and are genetically very distinct (Llorens *et al.*, ms submitted).

Eremophila rostrata subsp. *trifida* is a dense rounded shrub to 3 m height (Chinnock, 2007). The narrow, terete, dark green glossy leaves are approximately 50-75 mm long and terminate in three small spines (Chinnock, 2007). The solitary deep pink flowers are 15-22 mm long and are produced between August and October (Brown and Buirchell, 2011). The fruit is laterally compressed and convex above, with dry papery wings, and is approximately 12-20 mm long and 5-9 mm wide (Chinnock, 2007). Extant populations occur on decomposed granite in hard sandy light brown loams under open mallee/Acacia woodland up to 6 m in height (Stack and English, 2003; Chinnock, 2007).

The first collection of *E. rostrata* subsp. *trifida* was made in 1981 near Perenjori by H. Demarz, a collector for Kings Park and Botanic Garden (KPBG). The habitat of *E. rostrata* subsp. *trifida* has been extensively cleared for agriculture and the taxon is now restricted to a small area near the town of Perenjori in the Avon Wheatbelt region. Only two extant populations remain, containing 30 and 12 mature plants, respectively (DEC, 2013). One population occurs on a Shire road reserve and the other on private property. Both populations are within isolated remnants, surrounded by cleared land and are approximately 2.5 km apart.

Both *E. rostrata* subsp. *trifida* populations are highly threatened with extinction. The main threats are: road maintenance, land clearing, lack of habitat, poor recruitment, grazing, weed invasion farming activities, inappropriate fire regimes, and lack of genetic diversity.

Currently there are 4,026 fruits from two populations in storage in the Department's Threatened Flora Seed Centre (TFSC), which are estimated to contain 4,443 seeds. Further collections are planned for summer 2014. Initial germination trials have shown a 65% germination success rate (A. Crawford, pers. comm.), with more trials currently underway.

The aim of this translocation proposal is to assist the long term persistence of the species by establishing a new, viable, secure population of E. rostrata *subsp.* trifida.

This proposal outlines the need for translocation of the critically endangered *E. rostrata* subsp. *trifida,* the site selection process, the design of the translocation and the provisions for monitoring. In addition it outlines the criteria for success or failure of this proposed translocation.

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BACKGROUND

3.1 Taxonomy, History and Status

A member of the Scrophulariaceae family (formerly in the Myoporaceae), *Eremophila rostrata* subsp. *trifida* Chinnock is a dense rounded shrub to 3 m in height (Chinnock, 2007). The narrow, terete, dark green glossy leaves are approximately 50-75 mm long and terminate in three small spines (Chinnock, 2007). The solitary deep pink flowers are 15-22 mm long and are produced between August and October (Brown and Buirchell 2011). The fruit is laterally compressed and convex above with dry papery wings, is approximately 12-20 mm long and 5-9 mm wide, and can contain up to four seeds (Chinnock, 2007). Seeds are ovoid and approximately 3 x 1 mm (Chinnock, 2007).

Eremophila rostrata was first collected by C.A. Gardner in 1927 from near Cue and originally known as *E. fitzgeraldii*. A second locality was collected in 1981 from near Perenjori by H. Demarz, a collector for Kings Park and Botanic Garden (KPBG). In 2007, *E. rostrata* was recognised as containing two distinct subspecies, *E. rostrata* subsp. *rostrata* (the Cue populations) and *E. rostrata* subsp. *trifida* (the Perenjori populations) based on differences in leaf and flower morphology (Chinnock, 2007). The type specimen for *E. rostrata* subsp. *trifida* was collected by R.J. Chinnock in 1981. The two subspecies occur 280 km apart, are restricted to different soil types and are genetically very distinct (Llorens *et al.*, ms submitted).

The habitat of *Eremophila rostrata* subsp. *trifida* has been extensively cleared for agriculture and only two extant populations remain, containing 30 and 12 mature plants, respectively (DEC, 2013). The two populations are located southeast of Perenjori and are 2.5 km apart, with one on a Shire road reserve and the other on private property (Table 1). Both populations are within isolated remnants surrounded by cleared farmland. Despite numerous surveys (both targeted and opportunistic) being undertaken in areas of suitable habitat, no additional new populations have been located.

Eremophila rostrata subsp. *trifida* was declared as Rare Flora in 2001 under the Western Australian *Wildlife Conservation Act 1950* and ranked as Critically Endangered because of the extremely low total number of plants, the very restricted distribution and area of occupancy, and the continuing decline of population size. The main threats to the taxon are: road maintenance, grazing, inappropriate fire regimes, poor recruitment, lack of supporting habitat, lack of genetic diversity, weed invasion and edge effects.

While the remaining *E. rostrata* subsp. *trifida* plants are in a healthy condition, in one population they occur in a highly degraded habitat, and neither population is on secure tenure to ensure their protection.

Table 1. Population details for ***Eremophila rostrata* subsp. *trifida*.**

Population #	Land status	Date of most recent survey	Number of individuals at location*	Area of occupancy at location	Condition of site
1. SE of Perenjori	Private property	June 2013	30	1.0 ha	Moderate site condition but plants healthy
3. SE of Perenjori	Shire road reserve	June 2013	12	0.02 ha	Highly disturbed habitat but plants healthy

*Please note there is no population 2, as this population is *Eremophila rostrata* subsp. *rostrata*.

3.2 Distribution and Habitat

Eremophila rostrata subsp. *trifida* is endemic to the Avon Wheatbelt region of south west Western Australia. It occurs in a restricted area to the southeast of Perenjori, where it is confined to two small populations 2.5 km apart. The taxon's extent of occurrence is 0.2 km^2 and the area of occupancy of the two extant populations is only 1.02 ha.

Eremophila rostrata subsp. *trifida* grows on decomposed granite in hard, sandy, light brown loams under open mallee/Acacia woodland up to 6 m in height (Stack and English, 2003; Chinnock, 2007). Associated species include mallee Eucalypts, such as *Eucalyptus loxophleba* and *Eucalyptus subangusta* subsp. *subangusta* and other species such as *Acacia acuminata, Acacia aneura, Acacia coolgardiensis, Melaleuca uncinata, Ptilotus exaltatus*, *Hibbertia* sp. and *Wurmbea* sp. (DEC 2013).

3.3 Ecology and germplasm collection

Eremophila rostrata subsp. *trifida* plants appear to be relatively long-lived. Although their response to fire is unknown, most eremophilas are thought to be disturbance opportunists, with plants regenerating through root suckering or mass seed germination from a long-lived soil-stored seedbank following fire or soil disturbance (Richmond and Ghisalberti, 1996; Chinnock, 2007). No regeneration of *E. rostrata* subsp. *trifida* via seedlings has been observed in the field. New plants that have been recorded during survey are thought to be plants that have recovered significantly following fencing. Most eremophilas are well-adapted to arid environments and may be able to survive extremely dry periods. There are reports of closely-related *E. rostrata* subsp. *rostrata* plants resprouting vigorously following a rain event, after previously being considered dead or in decline (JJ Tucker Environmental Solutions).

Mature fruits of *E. rostrata* subsp. *trifida* are dry with a papery exocarp and can contain up to four seeds (Chinnock, 2007). However, only 32% of fruits collected from Population 1 in 2000 contained seeds, and most of these contained only one seed (Stack and English, 2003; Cochrane *et al.* 2002). Fruits fall to the ground in the months following maturation, where they may remain dormant for many years (Chinnock, 2007). Fruit production is low in *E. rostrata* subsp. *trifida* (A. Crawford, pers. comm.) which may be caused by several factors including lack of suitable pollinators due to loss and isolation of habitat, and lack of suitable mates due to small population size and isolation from other populations.

Seed dispersal is expected to be limited, and any dispersal away from the maternal plant probably mostly results from water movement following heavy rainfall or from recently-fallen fruits being blown along the ground in windy conditions (Chinnock, 2007). Chinnock (2007) hypothesised that wind dispersal of *Eremophila* fruits in Western Australia is likely to be mostly in an easterly direction, as fruit maturation occurs in late spring to summer, when the wind blows predominantly from the west.

Eremophila rostrata subsp. *trifida* produces pink flowers from August to October (Brown and Buirchell, 2011) that are adapted for pollination by birds from the Meliphagidae (honeyeaters, miners and wattlebirds) (Chinnock, 2007). Insects such as moths and honeybees are also known to visit the flowers of some ornithophilous *Eremophila* species (Chinnock, 2007) but have not been recorded on *E. rostrata* subsp. *trifida*. The abundance and diversity of pollinating birds visiting *E. rostrata* subsp. *trifida* populations is likely to have declined significantly due to habitat loss and population isolation. The two extant populations occur in very small habitat patches that are isolated from the few other remaining patches of native vegetation in the area, and are therefore likely to support much lower levels of bird visitation than existed prior to land clearing.

A genetic study has confirmed that *E. rostrata* subsp. *trifida* is genetically very different from its sister subspecies, *E. rostrata* subsp. *rostrata* (Llorens *et al.*, ms submitted). The study also revealed there is some genetic differentiation between the two extant *E. rostrata* subsp. *trifida* populations, with approx. 50% intermixing among individuals from the two *E. rostrata* subsp. *trifida* populations on a Principal Coordinate Analysis. It is unknown whether this differentiation is a result of historical isolation-by-distance effects or the currently very small population sizes, or a combination of both. Genetic diversity within both *E. rostrata* subsp. *trifida* populations is quite low, and significantly lower than that found in several other *Eremophila* species, including the

Critically Endangered *E. rostrata* subsp. *rostrata* (Elliott, 2009; Llorens *et al.,* ms submitted). This indicates that as much genetic material as possible should be conserved from both extant populations in order to prevent further loss of diversity, which could have serious implications for reproductive success, the fitness of future generations and ability to adapt to changing environmental conditions.

Polyploidy is common in *Eremophila*, with approximately one-third of species studied by Barlow (1969, 1971) showing infraspecific polyploidy. Polyploids are thought to be recently-derived adaptive variants with less morphological variation, while diploids are thought to be relictual, representing the historical form and showing greater morphological variation to enable future adaptive responses to changing environmental conditions (Barlow, 1971; Stewart & Barlow, 1976). Root tip squashes have indicated that both *E. rostrata* subsp. *trifida* and *E. rostrata* ssp. *rostrata* are diploid ($2n = 36$) (Llorens *et al.,* ms submitted).

There is no information available on rates of selfed and outcrossed seed production in *E. rostrata* subsp. *trifida*. A genetic study on *E. glabra* subsp. *glabra* in fragmented remnants in NSW showed that most seeds produced were derived from inter-population pollination events, with 0-10% selfed (Elliott, 2009). Selfed seeds produced seedlings that were significantly smaller than outcrossed seedlings, but there was no difference in seedling growth among seeds derived from local and foreign pollen sources (Elliott, 2009). It is likely that due to the very small size of extant populations, low genetic diversity and probable reduced pollinator visitation, the two *E. rostrata* subsp. *trifida* populations will experience increased inbreeding expressed as increased selfing, correlation of paternity and bi-parental inbreeding, all of which would potentially reduce genetic diversity among the seeds.

Currently there are five collections of *E. rostrata* subsp. *trifida* seed in storage in the Department's Threatened Flora Seed Centre (TFSC) (Table 2). Two of these collections have been processed and yielded 4,443 seeds. Germination trials conducted on seeds collected from Population 1 showed a 65% germination success rate, with further germination trials currently underway (A. Crawford, pers. comm.). Additional seed collections are planned for summer 2014.

Table 2. Number of *Eremophila rostrata* subsp. *trifida* seed in storage in the Threatened Flora Seed Centre

Population	Number of collections	Year collected	Number of fruits/seeds
1	3	2000 2004 2013	70 fruits, estimated 36 seeds 7 fruits, seeds not yet quantified 3553 fruits, estimated seed 4407
3	2	2007 2013	8 fruits, seeds not quantified 388 fruit, seeds not yet quantified

4. THE TRANSLOCATION

4.1 The Need to Translocate

The rarity of *E. rostrata* subsp. *trifida* is due to the large scale clearing of its habitat, its restricted distribution and area of occupancy and the low number of plants remaining. Its original distribution is unknown. There are presently two known natural populations with a total of approximately 42 individuals (Table 1). None of these individuals occur on secure tenure: one population is in a fenced remnant on private farmland and the other is on a Shire road reserve. While the remaining *E. rostrata* subsp. *trifida* plants are in a healthy condition, in one population they occur in a highly degraded habitat, and neither population is on secure tenure to ensure their protection.

Severe loss of the species' habitat due to clearing for agriculture has resulted in populations having very little or no surrounding natural vegetation to provide a buffer from the impacts of farming or other activities, or to mitigate against exposure to biotic or abiotic edge effects such as weed and feral animal invasion and exposure to increased wind, radiation and soil erosion.

A lack of supporting habitat is likely to compromise the abundance and diversity of pollinating birds visiting *E. rostrata* subsp. *trifida* populations, with implications for seed set and seed quality. It is also likely to have disrupted other important ecosystem processes such as soil disturbance by animals, the opportunity for seed dispersal, and exposure to natural fire regimes.

Potential unauthorised clearing is a threat to Population 1, which occurs in a small remnant on private farmland and is therefore vulnerable to accidental or deliberate damage or removal by farm machinery. Both populations are threatened by other farming activities including fertiliser and chemical drift.

Eremophila rostrata subsp. *trifida* is palatable to herbivores, which can cause damage to adult plants and remove seedlings, as well as exacerbate weed problems through soil disturbance and the vectoring of weed seeds. Sheep were grazed in the paddock containing Population 1 until it was fenced to exclude stock in 2004. The condition of plants improved significantly following fencing.

Population 3 occurs on a Shire road reserve adjacent to farmland, so plants are vulnerable to damage or death during maintenance of the road and road shoulder, include grading, chemical spraying, construction of drainage channels and the mowing or slashing of roadside vegetation. These activities also encourage weed invasion.

Weeds are common at Population 3, and may suppress *E. rostrata* subsp. *trifida* seedlings and juvenile plants by competing for light, nutrients and soil moisture. The seeds of many weed species germinate profusely following fire, coinciding with what is likely to be the major flush of germination for seeds. Weeds also increase fuel loads and therefore the risk of too frequent fires.

Eremophila rostrata subsp. *trifida* is vulnerable to decline due to inappropriate fire regimes. The passage of fire is likely to prompt the species' seeds to germinate, so frequent burning may deplete the soil seed store and may kill young plants before they reach reproductive maturity. Too long an interval between fires may threaten the long term persistence of *E. rostrata* subsp. *trifida* if mature plants have senesced and the soil seed bank decays before fire occurs to stimulate germination.

Poor seed production and recruitment threatens the persistence of *E. rostrata* subsp. *trifida* populations, which is magnified by the lack of available habitat for seedlings to recruit into.

A decline in genetic diversity could detrimentally affect the species' viability through reduced seed production, seed viability and offspring fitness, as well as reducing its capacity to adapt to altered selective conditions. Genetic diversity is already very low and is likely to continue declining.

The above threats are exacerbated by the existence of only two small populations with a very small area of occupancy. As population sizes decrease and isolation increases following fragmentation, populations may become more vulnerable to extinction due to: (i) the loss of genetic variation and increased inbreeding have been associated with a reduction in the ability of a population to adapt to environmental change; (ii) small populations are more susceptible to chance events due to environmental or human impacts; and (iii) the population size or density is so low that the plant's reproductive capacity drops below the threshold required for population viability (Hobbs & Yates, 2003).

Several extensive surveys have been undertaken for this species, with no new populations found. However, given the lack of remnant vegetation in the area, it is unlikely that further new populations will be located or, if located, it is probable that their habitat would be subject to the same threatening processes as for the currently known populations.

The current status of *E. rostrata* subsp. *trifida* indicates that translocation is now crucial to the recovery of the species, and that the establishment of new, secure populations is required to increase the viability of the species and reduce the chances of extinction. Translocating *E. rostrata* subsp. *trifida* to a new site will increase the number of secure populations and buffer the species against random loss of populations due to unpredictable environmental events (Guerrant, 1996) or human activities.

The aim of this translocation is to assist the long term persistence of this species by establishing a new, viable population of *E. rostrata* subsp. *trifida* secured on a conservation reserve.

4.2 Translocation Site Selection

The availability of suitable translocation sites within the known distribution of *E. rostrata* subsp. *trifida* is extremely limited due to the lack of suitable, native vegetation in the area where threats are absent or controllable. Another alternative considered was to restock the known populations; however, new individuals would be subject to same threatening processes. Therefore it is not considered possible to locate a translocation site within areas of suitable habitat within the species' known range. A new site outside the known range of *E. rostrata* subsp. *trifida* is proposed for the translocation. The site selected for the translocation is located within West Perenjori Nature Reserve.

The suitability of the proposed site was assessed in November 2013 by Alana Chant and Janet Newell (Flora Conservation Officers, Geraldton District, Dept. Parks and Wildlife), and Leonie Monks and Tanya Llorens (Research Scientists, Science and Conservation Division, Dept. Parks and Wildlife). The site was assessed on the basis of disease status, hygiene issues, access, soil and vegetation type, risk of secondary salinity, drainage, windbreaks, the presence of potential pollinators and the presence of other *Eremophila* species that could pose a risk of potential hybridisation with *E. rostrata* subsp. *trifida*.

Translocation site, West Perenjori Nature Reserve.

The proposed site is located west of Perenjori, approximately 26 km NW of the nearest known natural population of *E. rostrata* subsp. *trifida*. This site is situated in the eastern part of the nature reserve (29° 28' 03.1"S, 116° 12' 39.5"E).

Soils are brown clayey loam. Due to the site's position relatively high in the landscape, there is minimal risk of salinisation. The site occupies an area approximately 100 m west of a main firebreak and as such will be readily defendable in the event of wildfire.

Adjacent vegetation provides protection from wind damage and habitat for potential vertebrate or invertebrate pollinators. The vegetation is open *Eucalyptus loxophleba* woodland, with the main understorey species including *Ptilotus divaricatus, Ptilotus obovatus, Enchylaena tomentosa, Rhagodia drummondii, Sclerolaena diacantha* and *Waitzia acuminata*. The translocated plants will be established amongst the existing vegetation.

The site has no weed competition and good vehicle access for maintenance and monitoring the translocated plants.

Phytophthora dieback disease is not considered a threat at this proposed translocation site as this pathogen is unlikely to occur in areas where the average annual rainfall is below 400mm (www.dieback.orgau accessed August 2014). Average annual rainfall for Perenjori is 329mm (www.bom.wa.gov.au, accessed August 2014).

The translocation site for the critically endangered *Eremophila nivea* is also located in West Perenjori Nature Reserve, approximately 1.3 km to the south of the proposed site for *Eremophila rostrata* subsp. *trifida*. These two taxa are unlikely to hybridise as they are fairly dissimilar (Andrew Brown pers comm 2014). However, as a precaution the translocation sites are located more than several hundred metres apart, as recommended by Andrew Brown.

Potential threats at the site include grazing by rabbits and kangaroos. This threat will be managed by fencing the translocation site for protection from herbivory. The establishment of any weeds will be closely monitored and actions undertaken to eradicate them.

It is proposed to establish the *E. rostrata* subsp. *trifida* plants from populations 1 and 3 at the translocation site in winter 2015. As *E. rostrata* subsp. *trifida* has not previously been recorded from the site, the translocation can be considered a 'conservation introduction' under the definitions provided by the Guidelines for Translocation of Threatened Plants in Australia (Vallee *et al.* 2004) and an 'introduction' under the definitions in DPAW Policy Statement 29 (Anon. 1995). A map of the proposed translocation site in relation to the known populations is shown in Appendix 1.

Endorsement for the use of this site has been sought from the Dept. Parks and Wildlife Midwest Region (See attached approvals page).

4.3 Site management

As these plants will be established for the purpose of conservation, they will be regarded as Declared Rare Flora and will have the same legal protection.

The land managers (DPAW) maintain firebreaks for the Nature Reserve as a whole. There are currently no prescription burns planned for the area containing the translocation site. If this area is required to be burnt in the future, a buffer area will be established around the site to ensure the translocated plants are excluded from fire, at least until a greater knowledge of the species fire response is gained.

4.4 Translocation Design

Seed for translocation collected from populations 1 and 3 will be germinated under laboratory conditions at the TFSC. The Botanic Gardens and Parks Authority (BGPA) will grow on 250 plants from populations 1 and 3. Seedlings will be planted at the translocation site in autumn/winter 2015. Seed will be sourced from approximately 27 parents from population 1 and 11 parents from population 3. Each plant will be permanently tagged so that the parent plant and source population will be identifiable for monitoring purposes. Planting will occur in such a way that those from the same parent will be separated in order to maximise the production of outcrossed seed.

To avoid seedling losses due to summer drought, water will be provided during the summer months. A water tank will be located on site and will be filled with town water from Perenjori (in which the chlorine helps to kill any pathogens). All translocated seedlings will be protected from grazing by fencing to further maximise survival. Community involvement in the project through the Geraldton Threatened Flora Recovery Team will be used to promote awareness of, and interest in, the species.

All equipment used during planting will be maintained under strict disease hygiene. Each plant will be permanently tagged to enable population monitoring at the individual level.

Monitoring of the translocated population will be undertaken after planting and then every six months for the first year and then annually thereafter. Monitoring will include counting the number of surviving plants, measuring their height, width of the crown in two directions, recording the reproductive state, number of flowers, number of fruit, whether second generation plants are present and general health of the plants.

Monitoring of the natural populations will also occur in conjunction with monitoring of the translocated plants. This will provide essential baseline data for assessing the performance of the translocated plants. Monitoring will include counting the number of individuals, height and crown width of the individuals, reproductive state, number of flowers, number of fruit, whether second generation plants are present and general health of the plants.

4.5 Source of Plants

Plants will be grown from seed sources at the TFSC, based on material sourced from populations 1 and 3. Current seed collection guidelines (up to 20% of available seed on one plant at time of collection) will be followed to ensure sufficient seed remains to replace the present population in the event of a fire.

The translocation will be planned, implemented and managed in such a way as to maximise its genetic diversity. Under international guidelines (eg. Guerrant *et al.* 2004), when the breeding system of the species is unknown it is recommended that seed is collected from at least 50 plants to ensure 95% of the genetic variation within that population is represented in the collection. As both populations consist of less than 50 individuals, seed will be collected from all plants present that have sufficient fruits available. The seedlings for this translocation will be sourced from seed collected in 2013 from 27 parents from population 1 and up to 11 parents from population 3.

Seedlings will be raised at BGPA's accredited nursery at Kings Park, which has hygiene procedures in place to ensure seedlings are free from diseases, pests and weeds.

4.6 Criteria for Success or Failure

Success criteria
The aim of the translocation is to achieve a viable and self-sustaining population of *E. rostrata* subsp. *trifida*. This will be achieved by planting over successive years as plants are propagated until at least 250 plants have been successfully established. The time frames required to achieve this aim may need to be adjusted to take into account the number of plants available for planting, seasonal influences on maturation, survival and availability of funding.

Biological success or failure

<u>Success</u>
Initial success of each planting (approx 1 year)
- Survival of at least 50% of each year's plants past their first summer.

Medium term success of all plantings (2-10 years)
- Survival of at least 40% of all plants planted beyond first year.
- At least 80% of surviving plants producing viable seed at a rate similar to that at the natural populations.
- Recruitment of a second generation – seedling recruitment equivalent to or greater than that observed within natural populations (unless seedling recruitment is linked to disturbance, as appears to be the case, and appropriate disturbance does not occur in this timeframe).

Long term success of all plantings (greater than 10 years)
Establishment of a viable self-sustaining population of at least 250 mature plants (natural recruitment of second and subsequent generations without additional plantings).

<u>Failure</u>
Initial failure of each planting (approx 1 year)

Less than 50% of each year's plants surviving beyond the first summer.

Medium term failure of all plantings (2-10 years)

- Less than 40% of all plants planted surviving beyond first year.
- Less than 80% of surviving plants producing viable seed at a rate similar to that of the natural populations.
- Seedling recruitment significantly less than that observed at the natural populations.

Long term failure of all plantings (greater than 10 years)
Population fails to become viable and self-sustaining.

5. TIMETABLE

Time	Action
August 2014	Translocation proposal submitted for review and approval
November 2014	Propagation of seedlings at BGPA
January 2014	Further seed collection from populations 1 and 3 for TFSC
June 2015	Seedlings planted at translocation site
September 2015	Progress report
Annual review	Monitor, assess flower and fruit production

6. FUNDING

This project is fully funded under the State NRM 'Fast Track Critically Endangered Flora Recovery' project for a period of three years. One of the proponents, Alanna Chant (Flora Conservation Officer) based at Geraldton is internally funded by the Department of Parks and Wildlife. The proponents are therefore willing to make a commitment to monitor the translocation beyond the availability of the State NRM funding.

7. ACKNOWLEDGMENTS

Andrew Crawford – DPAW, Threatened Flora Seed Centre

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TRANSLOCATION PROPOSAL

EUCALYPTUS CUPREA
MALLEE BOX
(MYRTACEAE)
AUGUST 2014

1. SUMMARY

Eucalyptus cuprea Brooker & Hopper is a Critically Endangered taxon, endemic to the Midwest region of south-west Western Australia. It was declared as Rare Flora in 1987 and ranked as Critically Endangered due to it occurring in small, fragmented populations, its restricted area of occupancy and continuing decline.

Eucalyptus cuprea is an erect mallee to 6 m tall with narrow, glossy green adult leaves. The trunk has smooth grey or coppery bark above and a flaky, fibrous stocking at the base. Small white flowers are produced between August and November. The fruit capsules are obconical-shaped and occur in groups of seven. *Eucalyptus cuprea* grows amongst low heath or tall shrubland. It mainly grows in sandy brown loam over sandstone or granite, but has also been found in red-brown clay loam over laterite.

Eucalyptus cuprea was first collected in 1952 by G.E. Brockway from between Northampton and Lynton. The species is currently known from 12 extant populations located between the Murchison River, Hutt River and Nanson, containing a total of 359 mature plants/clumps. The populations occupy approximately 13.65 ha in area and all but two are located either in paddocks on private properties or on road reserves.

All *E. cuprea* populations are highly threatened. The main threats are: habitat loss, clearing, farming activities, poor recruitment, weed invasion, inappropriate fire regimes, insect infestation, grazing, lack of genetic diversity, road, track and firebreak maintenance and feral pigs.

There are 5,151 seeds from four populations (1, 2, 5, 7 and 12) in storage in the Department's Threatened Flora Seed Centre (TFSC). The seeds are readily germinable, with up to 100% germination.

The aim of this translocation proposal is to assist the long term persistence of the species by establishing a new, viable, secure population of E. cuprea *and by increasing the number of individuals within a secure, natural population in Chilimony Nature Reserve that currently consists of only nine individuals.*

This proposal outlines the need for translocation of the critically endangered *E. cuprea,* the site selection process, the design of the translocation and the provisions for monitoring. In addition it outlines the criteria for success or failure of this proposed translocation.

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3. BACKGROUND

3.1 Taxonomy, History and Status

A member of the Myrtaceae family, *Eucalyptus cuprea* is an erect mallee reaching 4-6 m in height. The trunk has smooth grey or coppery bark above and a flaky, fibrous stocking at the base. The glossy dark green adult leaves are narrow, approximately 11 cm long and 2.3 cm wide, while the oval-shaped juvenile leaves are light green. Small white flowers are produced between August and November and the lack of anthers on the outer stamens distinguishes *E. cuprea* from other similar species. The buds are clavate with a hemishperical operculum and occur in groups of seven. The fruit capsules are obconical in shape. Seeds are dark greyish brown and ovoid.

Eucalyptus cuprea was originally known as *Eucalyptus sp*. Northampton, and was officially described by Brooker & Hopper (1993). It was first collected in 1952 by G.E. Brockway from between Northampton and Lynton, and subsequently in 1959 by C.A. Gardner from near Hutt River. Neither of these populations have been relocated since. The type specimen was collected by Ian Brooker alongside the North West Coastal Highway in 1984. By 1989, five populations had been located. Population 3 was destroyed and a plant was removed from population 1 in the early nineties. Seven additional populations were found between 2000 and 2008. In 2010/11 most of population 6 and 7a were cleared by a property owner removing paddock trees from cropping paddocks. Some, but not all, of these trees have since resprouted. The likelihood of additional populations being located is very low due to most potential sites having already been surveyed.

Eucalyptus cuprea is currently known from 12 populations of approximately 359 adult plants/clumps. While 12 plants occur in Nature Reserves, the remainder are located on private property or road reserves (Table 1).

Eucalyptus cuprea was declared as Rare Flora in 1987 under the Western Australian *Wildlife Conservation Act 1950* and was ranked as Critically Endangered in 1998 due to it occurring only in small, fragmented populations, its restricted area of occupancy and continuing decline. The major threats to the species are habitat loss, clearing, farming activities, poor recruitment, weed invasion, inappropriate fire regimes, insect infestation, grazing, lack of genetic diversity, road, track and firebreak maintenance and feral pigs.

While *E. cuprea* plants in most populations are in a healthy condition, they occur in very degraded habitat.

Table 1. Population details for *Eucalyptus cuprea*.

Population #	Land status	Date of most recent survey	Number of individuals at location*	Area of occupancy at location	Condition of site
#1a Mary Springs	Road reserve	2011	8	0.3 ha	Very good (woodland/ shrubland)
#1b and 1c Mary Springs	Private property	2011	48	1 ha	1b - Very good (shrubland) 1c – Completely degraded (cleared paddock)
# 2a-2c W and NW of Ogilvie	Private property	2014	25	0.35 ha	2a&c – Completely degraded (cleared paddock) 2b – (Degraded shrubland)
# 3	Private property	1990 (all plants had been destroyed)	0	0	Completely cleared
#4 Nanson Howatharra Rd	Private property	2013	3	0.04 ha	Degraded (shrubland)
#5 W of Ogilvie	Private property	2014	9	0.03 ha	Completely degraded (cleared paddock)
#6 W of Ogilvie	Private property	2014	0	0.02 ha	Completely degraded (cleared & burnt paddock)
#7a-7i SW of Ogilvie	Private property	2011	90	1 ha	Range from good to completely degraded
#8 Chilimony NR	Nature reserve	2011	9	0.2 ha	Very good (shrubland)
#9 Bella Vista NR	Nature reserve	2013	3	0.15 ha	Excellent (shrubland)
#10 Yarder Gully	Private property	2011	17	0.02 ha	Excellent (shrubland)
#11a E of Ogilvie	Road reserve	2011	2	0.01 ha	Degraded (open shrubland)
#11b E of Ogilvie	Private property	2011	100	9 ha	Good to very good
#12a-12b E of Ogilvie	Private property	2011	41	1.5 ha	Good to very good
#12c-12d E of Ogilvie	Road reserve	2008	4	0.01 ha	Degraded
#13a E of Ogilvie	Road reserve	2008	2	0.01 ha	Degraded
#13b E of Ogilvie	Private property	2008	3	0.01 ha	Degraded

* Number of stem clumps

3.2 Distribution and Habitat

Eucalyptus cuprea is endemic to the Midwest region of south-west Western Australia. It occurs in an area from north of Ajana to east of Howatharra, approximately 25 km north of Geraldton (Appendix 1). The species is confined to four main areas spanning approx. 80 km. Although the species' extent of occurrence is 818.6 km^2, the area of occupancy of all 12 extant populations is only 13.65 ha.

Eucalyptus cuprea is mainly found growing in sandy brown loam over sandstone or granite, but has also been found growing in red-brown clay loam over laterite. The species grows amongst low heath or tall shrubland. Associated species include *Acacia acuminata, Acacia andrewsii, Acacia tetragonophylla, Acacia rostellifera, Allocasuarina acutivalvis, Allocasuarina campestris, Allocasuarina obesa, Atriplex* sp., *Austrostipa elegantissima, Calothamnus homalophyllus, Calytrix* sp., *Clematicissus angustissima, Daviesia* sp., *Dioscorea* sp., *Dodonaea inaequifolia, Dodonaea viscosa, Enchylaena tomentosa, Eremophila* sp., *Eucalyptus loxophleba, Gastrolobium oxylobioides, Gastrolobium spinosum, Grevillea pinaster, Hakea orthorrhyncha, Hakea preisii, Hakea recurva, Hibbertia hypericoides, Maireana* sp., *Marianthus bicolor, Melaleuca megacephala, Melaleuca radula, Melaleuca scabra, Nuytsia floribunda, Petrophile* sp., *Pimelea microcephala, Ptilotus polystachyus*, *Rhagodia drummondii, Solanum* sp. and *Waitzia acuminata*.

3.3 Ecology and Germplasm Collection

Eucalyptus cuprea plants develop a persistent lignotuber, suggesting that they typically resprout following fire and are probably long-lived. Plants in several populations have been observed to resprout following fire (*e.g.* population 2b) and other disturbances such as mechanical 'stumping' (CALM, 1999). This regeneration strategy has resulted in many plants developing the typical mallee growth form, with numerous stems occurring in a clump.

A genetic study has confirmed that *E. cuprea* reproduces clonally (Sampson & Byrne, 2009). With few exceptions, each clump of stems represents a single genetic individual. Clones can be extensive, and in some cases extend up to 25 m in diameter. It is likely that some large clones become fragmented over time, and form two or more clumps of stems that are unconnected but genetically identical. This appears to have occurred at each of the two Nature Reserves, where every clump tested was genetically identical. Nevertheless, genetic diversity within populations (among non-clonal plants) was moderate to high, with observed heterozygosity ranging from 0.488 to 0.792 and expected heterozygosity ranging from 0.250 to 0.660 (Sampson & Byrne, 2009).

There is significant genetic differentiation among the extant populations (diversity = 0.256), with 27% of overall variation found between geographically discrete groups of populations (Sampson & Byrne, 2009). Population 1 (an isolated northern population) was genetically distinct from the other populations tested. A lower degree of differentiation was found between populations 2, 7 and 11/12. The other populations sampled by Sampson and Byrne (2009) were Populations 4, 8 and 9; additional genetic variation is likely to occur within populations that were not sampled for the study. Conservation of plants from each population, including unsampled populations, would be necessary to ensure the maintenance of existing genetic diversity within the species.

Eucalyptus cuprea flowers from August to February (DPaW, 1998-2013; DPaW, 2014), producing abundant small white flowers. Although the pollinating species are not known, they are likely to include ants, native beetles, bees and honeyeaters, all of which have been observed foraging on the flowers of the closely related *E. absita* (CALM, 2006). However, the abundance and diversity of pollinators visiting *E. cuprea* populations is likely to have declined significantly due to habitat loss and population isolation. Fruit and viable seed production of *E. cuprea* plants is very low (Sampson & Byrne, 2009; DPaW, in prep) and no regeneration via seedlings has been observed in the field (DPaW, in prep). Low fruit production is likely to be caused by several factors including lack of suitable pollinators due to loss and isolation of habitat, and lack of suitable mates due to small population size and isolation from other populations.

Outcrossing rates measured in seeds collected from four populations (Populations 1, 2, 7 and 11/12) ranged from quite low for eucalypts (46.2%) to high (90.9%), and were unrelated to population size (Sampson & Byrne, 2009). Significant pollen-based gene flow occurred into two small populations (Populations 2 and 7) from other populations up to 5 km distant, but there was no obvious gene flow into two more isolated populations (Populations 1 and 11/12). In the more isolated populations, very few plants contributed pollen to outcrossed seeds, thus producing a form of inbreeding known as correlation of paternity. In conjunction with self-fertilisation, this would significantly reduce genetic diversity among the seeds, which has implications for the diversity of future generations and for conservation-based seed collections.

Currently there are eight viable collections of *Eucalyptus cuprea* seed in storage in the Department's Threatened Flora Seed Centre (TFSC) (Table 2). All collections have been processed and contain a total of 5151 seeds. Further collections are planned for late 2014. Germination trials indicate excellent germinability, with 100% germination (A. Crawford, unpublished data).

Table 2. Number of *Eucalyptus cuprea* seed in storage in the Threatened Flora Seed Centre.

Population	Number of collections	Number of seed
1	1	780
2A	1	288
2B	2	2767
4	1	0
5	2	594
7	1	608
12	1	114

4. THE TRANSLOCATION

4.1 The Need to Translocate

The rarity of *Eucalyptus cuprea* is due to the large scale clearing of its habitat, its restricted area of occupancy and the low number of plants remaining. There are presently 12 known extant natural populations with a total of approximately 359 individuals (Table 1). Only 12 individuals (most of which are probably clones) in two populations occur on secure tenure, with the remainder on private property or road reserves.

Severe loss of the species' habitat due to clearing for agriculture has resulted in populations having very little or no surrounding natural vegetation to provide a buffer from the impacts of farming or other activities.

Potential clearing is a threat to the majority of populations on private property. Most of these populations are solitary stands on the edge of or surrounded by cleared paddocks, and are vulnerable to damage or removal by farm machinery. This is an increasing risk as farming practices are encouraging larger paddocks and there is greater pressure to remove paddock trees in the way of the larger machinery. These populations are also threatened by other farming activities including fertiliser and chemical drift, damage to roots during cropping and weed encroachment.

Lack of recruitment (no seedlings of *E. cuprea* have been recorded) threatens the persistence of *E. cuprea* populations. This is magnified by the lack of available habitat in many populations for seedlings to recruit into and low seed production.

All *E. cuprea* populations are threatened by habitat degradation caused by weed invasion. The Nature Reserve containing Population 8 was grazed in the past, and consequently has weed issues. Weeds may suppress *E. cuprea* seedlings and juvenile plants by competing for light, nutrients and soil moisture. The seeds of many weed species germinate profusely following fire, coinciding with what is likely to be the major flush of germination for *E. cuprea* seeds. Weeds also increase fuel loads and therefore the risk of too frequent fires.

Eucalyptus cuprea is vulnerable to inappropriate fire regimes. Most populations on private property have been burnt in "stubble fires" in the past (DPaW, in prep). The passage of fire is likely to prompt mature plants to resprout from their lignotubers, with too frequent burning of crops, weeds or native vegetation possibly depleting lignotuber reserves.

The majority of populations have been affected by insect infestation, thought to be caused by the plants being weakened by farming activities. In particular, caterpillar nests of the bag-shelter moth/processionary caterpillar (*Ochrogaster lunifer*) have been observed at many of the *E. cuprea* populations. These usually appear to have limited or no impact on the plants, for example some of the nests cause minor defoliation around the nest. However in 1997 a large number of nests and significant foliage loss was noted at populations 1, 2 and 8. In 2008 the caterpillar nests were removed from the trees at population 2, although the on-going impact of this is unknown. In the early 1990's, an unidentified leaf mite was present in high numbers at subpopulations 1a and 1b (covering up to 70 per cent of the leaf surface on up to 80 per cent of mature trees) but did not appear to have any significant detrimental impact on the plants (DPaW, in prep). In 2004 termites were observed in the base of one clump of *E. cuprea* at population 8, which may have since caused the death of some of the plant's limbs (DPaW, in prep).

Several populations of *E. cuprea* occur on farming land where sheep have been grazed, and the plants can be the only shelter available to the sheep. Sheep droppings cause an elevation of soil nutrients, while the animals damage plants through soil compaction and grazing on roots and branches as well as complete removal of seedlings. However, most properties are not carrying sheep at present.

A decline in genetic diversity could detrimentally affect the species' viability through reduced seed production, seed viability and offspring fitness, as well as reducing its capacity to adapt to environmental change and altered selective conditions. Genetic diversity is already low due to clonal reproduction and extensive loss of populations, and is likely to continue declining due to reduced abundance and diversity of pollinators, increased isolation among populations and low rates of outcrossing.

Maintenance of roads, tracks and firebreaks may damage or kill *E. cuprea* plants and encourage weed invasion. Maintenance activities can include grading, chemical spraying, construction of drainage channels and the mowing or slashing of roadside vegetation.

Feral pigs occur in the areas of *E. cuprea* distribution and may threaten populations directly by damaging habitat while digging for food, as well as indirectly by introducing weed seeds and additional nutrients and encouraging the establishment of weeds through soil disturbance.

A soil pathogen, thought to be *Armillaria*, was observed in the Nature Reserve containing Population 9 in 2010. Other eucalypts are known to be highly susceptible to this fungus, which kills trees several years after infection.

Mineral extraction leases are held over many *E. cuprea* sites. The species' habitat and the plants themselves could be severely impacted or destroyed by future exploration or mining operations, although the likelihood of these activities occurring is unknown.

The above threats are exacerbated by the existence of only 12 small populations with a very small area of occupancy. As population sizes decrease and isolation increases following fragmentation, populations may become more vulnerable to extinction due to: (i) the loss of genetic variation and increased inbreeding, which have been associated with a reduction in the ability of a population to adapt to environmental change; (ii) small populations are more susceptible to chance events due to environmental or human impacts; and (iii) the population size or density being so low that the plant's reproductive capacity drops below the threshold required for population viability (Hobbs & Yates, 2003).

Several extensive and opportunistic surveys have been undertaken for this species in areas of suitable habitat since 1996, with several new populations found. It is unlikely that further new populations will be located, and if any are located, it is probable that their habitat would be subject to the same threatening processes as the currently known populations.

The current status of E. cuprea *indicates that translocation is now crucial to the recovery of the species.* The establishment of new, secure populations and the augmentation of existing secure populations is required to increase the viability of the species and reduce the chances of extinction. Translocating *E. cuprea* to a new site will increase the number of secure populations and buffer the species against random loss of populations due to unpredictable environmental events (Guerrant, 1996) or human activities. Translocating *E. cuprea* individuals into an existing secure population will increase the size of the population, thus buffering it against the loss of plants and genetic diversity, and potentially increasing the genetic diversity and fitness of seeds produced.

The aim of this translocation is to assist the long term persistence of this species by (1) establishing a new, viable population of *E. cuprea* secured on a conservation reserve, and (2) restocking with seedlings to increase the size of a secure natural population (Population 8) which currently consists of only nine individuals, at least some of which are genetically identical.

4.2 Translocation Site Selection

A search of conservation reserves in the vicinity of the known populations of *E. cuprea* was conducted to locate suitable translocation sites. The search focused on land with secure tenure that had similar soil characteristics and associated vegetation to the natural populations. Additional factors in site selection were: weeds, ease of access, risk of disturbance by members of the public, and ease of delivery of water for irrigation of the translocation sites. The suitability of the proposed sites was assessed in November 2013 by Janet Newell, Alanna Chant (Flora conservation officers, DPaW), Leonie Monks and Tanya Llorens (Research Scientists, DPaW).

Moresby Range Conservation Park - new population

One site located on secure conservation estate within Moresby Range Conservation Park was selected for the establishment of a new population of *E. cuprea*. Moresby Range Conservation Park is located between Geraldton and Northampton, and is approximately 7 km south of the southernmost distribution of *E. cuprea* (Populations 4 and 9). The translocation site is in the centre of the Conservation Park and is part of a large, open, cleared area that was formerly used as pasture (Appendix 2). A 1.8 ha section of the cleared area will be rehabilitated in 2014/2015 by replanting with local native plants as part of a State NRM project. The *E. cuprea* translocation will form part of this habitat restoration.

The translocation site is at the top of a narrow cleared valley that slopes down towards the south-west. The hills surrounding the other sides of the translocation site are vegetated with Moresby Range PEC shrubland in excellent condition, which should provide habitat for potential pollinators of *E. cuprea* (Table 3). The open shrubland and heath are dominated by *Banksia fraseri, Banksia sessilis, Melaleuca megacephala, Allocasuarina campestris* and *Hakea pycnoneura*. The translocation site has red-brown sandy loam soil with a small amount of gravel, and is currently vegetated with grassy weeds and lupins. DPaW vehicles can access the translocation site via an existing track around the edge of the cleared area. Members of the public do not currently have access to the site due to a locked gate at the entrance of the Conservation Park, and the translocated *E. cuprea* will be entirely within the fenced restoration area.

Potential threats to the translocation at this site include grazing by kangaroos and rabbits, trampling by kangaroos and pigs, and weeds. Grazing and trampling will be managed by erecting a 625 m long fence which will enclose the entire 1.8 ha area to be rehabilitated. The fence will be approx. 1.8 m in height, and be designed to exclude rabbits, kangaroos and pigs. If necessary, the enclosure will be baited with 1080 baits for an extended period after fence construction to eliminate any rabbits within the enclosure. Weeds will be controlled using herbicide spray beginning in winter 2014, and weed matting will be placed around each translocated seedling for ongoing weed suppression.

As *E. cuprea* has not previously been recorded from this site, this translocation can be considered a ‘conservation introduction’ under the definitions provided by the Guidelines for Translocation of Threatened Plants in Australia (Vallee *et al.*, 2004) and an ‘introduction’ under the definitions in

Policy Statement 29. A map of the proposed translocation site in relation to the known populations is shown in Appendix 1.

Table 3. Associated vegetation at proposed translocation sites for *Eucalyptus cuprea*.

Associated species at the proposed translocation sites	
Moresby Range Conservation Park	Chilimony Nature Reserve
Asteraceae	**Chenopodiaceae**
Olearia sp.	*Chenopodium gaudichaudianum*
Casuarinaceae	**Fabaceae**
Allocasuarina campestris	*Acacia acuminata* *Acacia tetragonophylla*
Dilleniaceae	**Myrtaceae**
Hibbertia hypericoides	*Eucalyptus cuprea*
Fabaceae	**Proteaceae**
Acacia rostellifera *Gastrolobium spinosum*	*Hakea preissii* *Hakea recurva*
Mytraceae	**Sapindaceae**
Calothamnus quadrifidus subsp. *homalophyllus* *Melaleuca megacephala* *Melaleuca radula* *Verticordia monadelpha*	*Dodonaea inaequifolia*
Proteaceae	
Banksia fraseri *Banksia sessilis* *Grevillea* sp. *Grevillea levis* *Hakea lissocarpha* *Hakea pycnoneura*	

Chilimony Nature Reserve - restocking existing population

The two *E. cuprea* populations that occur on secure tenure (Populations 8 and 9 occur within Nature Reserves) were assessed for suitability for population augmentation. Assessment was based on characteristics such as number of existing plants, presence of threatening processes, habitat quality and access for maintenance and monitoring. Population 8, within Chilimony Nature Reserve (Appendix 3), was selected for restocking because of far greater ease of access, and because of the presence of an open area suitable for establishment of *E. cuprea* plants with minimal disturbance to existing vegetation. There are currently nine *E. cuprea* plants within Population 8, at least some of which are clones (Sampson & Byrne, 2009).

Chilimony Nature Reserve is 146 ha in area, and has soil consisting of red-brown sandy loam with some surface granite rocks. The vegetation consists of *E. cuprea* open woodland and *Acacia tetragonophylla*/*Hakea recurva* tall shrubland (Table 3), which should provide habitat for potential pollinators of *E. cuprea*. The site has some weed issues, notably grassy weeds (wild oats) and lupins. The proposed translocation site is a gently sloping open area with scattered shrubs, and is located in an area surrounding the existing *E. cuprea* plants. Access to the translocation site is on foot, approximately 100 - 300 m through open woodland/shrubland from an adjacent track.

Potential threats to the translocation at this site include grazing and trampling by kangaroos and rabbits. The impact of mammals will be minimised by individually caging each *E. cuprea* seedling with wire cages. Weeds will be controlled by hand weeding around the translocated plants and by the placement of weed matting around each translocated seedling for ongoing weed suppression. There is a low likelihood that members of the public will access the proposed translocation site, as it cannot be seen from any road, the closest road is a very minor local access road, and there will be minimal infrastructure at the site.

As *E. cuprea* is currently present at this site, this translocation can be considered as 'restocking' or 'augmentation' under the definitions provided by Policy Statement 29 and 'an enhancement' under the Guidelines for Translocation of Threatened Plants in Australia (Vallee *et al.*, 2004).

Endorsement for the use of these sites has been sought from the Midwest Region and the translocation will not go ahead unless the project is approved by the Region (See Approvals page attached).

4.3 Site Management

As these plants will be established for the purpose of conservation, they will be regarded as Declared Rare Flora and will have the same legal protection. Any seeds harvested from plants will be used for conservation purposes only.

Chilimony Nature Reserve and Moresby Range Conservation Park both have secure conservation tenure for the protection of the translocation sites, and are both managed by the Department of Parks and Wildlife. Chilimony Nature Reserve is managed for the sole purpose of nature conservation, while Moresby Range Conservation Park is managed to conserve the area's natural values as well as provide for future forms of nature-based recreation and tourism that do not adversely affect the values of the Park. Moresby Range Conservation Park is currently closed to visitor vehicle access but it has been proposed by the Department to be developed in the future for visitors, including improved vehicle tracks, a lookout, camping area and day walks. Planning for this future development will take into account the location of the *E. cuprea* translocation to minimise the likelihood of visitors accessing the translocation site. The habitat restoration at Moresby Range, of which the translocation is a part, will be monitored and managed by DPaW staff.

The land managers (Department of Parks and Wildlife) maintain firebreaks for both sites. If a prescribed burn is planned for either Chilimony Nature Reserve or Moresby Range Conservation Park in future, the District Flora Conservation Officer will recommend that the translocation sites are excluded and protected during the burn. There are currently no prescription burns planned for these areas. Strict soil hygiene management will be implemented at both translocation sites during set-up and monitoring.

At Moresby Range Conservation Park, the soil within the area for habitat restoration will be deep ripped in mid-2014 to combat any soil compaction and assist with plant establishment. Weed control via chemical spraying will be undertaken at the translocation site in Moresby Range Conservation Park in mid-2014. Spraying will occur on a minimum of two occasions, firstly following the first flush of autumn/winter germination, and later in winter after further germination has occurred. Further chemical weed control will occur in 2015. At Chilimony Nature Reserve, weeds will be controlled by hand weeding around the translocated plants. At both sites, weed matting will be placed around each translocated seedling for ongoing weed suppression.

4.4 Translocation Design

Seed for translocation has been collected from populations 2, 5, 7 and 12. Seed will be germinated under laboratory conditions at the TFSC, and plants will be grown on to seedling stage by the Botanic Gardens and Parks Authority (BGPA) at King's Park. Seedlings (tubestock) will be planted at the translocation sites in autumn/winter 2015. Each plant will be permanently tagged with a unique number so that information regarding the maternal parent plant and source population can be recorded in a database against this number and to enable population monitoring at the individual level. To maximise the production of outcrossed seed, seedlings from the same parent, and ideally the same population, will not be planted adjacent to each other.

All equipment used during planting will be maintained under strict disease hygiene.

Moresby Range Conservation Park – new population

At Moresby Range Conservation Park, approximately 250 seedlings will be planted in the fenced habitat restoration area. Seedlings will be planted approximately 5 m apart, to allow for the spreading growth habit of *E. cuprea* adults. Seedlings grown from seeds collected from existing native plants within the Conservation Park will be used in the habitat restoration, and will be planted amongst the *E. cuprea* plants in a separate project.

A water tank will be located on site and used to water seedlings at planting and through the summer months. The tank will be filled with town water from Geraldton and delivered in a DPaW fire truck. Prior to filling with water, the tanks of departmental fire trucks are sterilised with a bleach solution to kill pathogens, and then rinsed. The water tank will be located uphill from the translocation, so water delivery will be gravity-assisted.

A new method of water delivery will be trialled for a small proportion (approx. 10%) of *E. cuprea* seedlings. For these seedlings, a moisture-holding gel 'sausage' (*e.g.* Watergrower or Driwater) will be buried at the root zone at planting, and will slowly release moisture to the soil over a period of up to 90 days. The sausages will be inserted within a plastic tube that remains in place, so that sausages can be replaced every couple of months, before their water content has fully depleted. These seedlings will be supplied with irrigation piping, and will be given initial watering at the time of planting. If the seedlings appear to be suffering greater stress or mortality than the irrigated seedlings, they will be supplied with supplemental water. If the trial is successful, and this method is able to successfully sustain plants through summer at a similar or greater rate to seedlings being watered normally, it could potentially be a much less resource-intensive method of watering other translocated species.

Chilimony Nature Reserve – restocking existing population

Approximately 250 seedlings will be planted within an open area at Chilimony Nature Reserve, near the existing *E. cuprea* plants. Seedlings will be planted approximately 5 m apart.

Due to resource constraints, planting will be spread across a number of years, beginning with a trial of 10 seedlings to be planted in winter 2015. All seedlings will be thoroughly watered in at planting. The initial 10 seedlings will be supplied with moisture-holding gel 'sausages' (see above), that will be replaced as needed.

Monitoring

Monitoring of the translocated populations will be undertaken after planting, every six months for the first year and then annually thereafter. Monitoring will include recording the number of surviving plants, measuring their height and the width of the crown in two directions, recording the reproductive state, number of flowers, number of capsules, whether second generation plants are present and general health of the plants.

Monitoring of several of the original populations (likely to be Populations 8 and 9) will also occur in conjunction with monitoring of the translocated plants. This will provide essential baseline data for assessing the performance of the translocated plants. Plants in these populations will be tagged with a unique number. Monitoring will include recording the number of clumps, height and crown width of the individuals, reproductive state, number of flowers, number of capsules, whether seedlings are present and general health of the plants.

4.5 Source of Plants

Plants will be grown from seed sources stored at the TFSC. Seeds will be taken from existing collections from the *E. cuprea* populations 2, 5, 7 and 12. Further material will be sourced from populations 8, 9 and 11 (if available) in 2014 and subsequent years, and seedlings from these populations will be added to both translocation sites when available. Current seed collection guidelines (up to 20% of available seed on one plant at time of collection) will be followed to ensure sufficient canopy seed storage to replace the present population in the event of a fire.

The translocation will be planned, implemented and managed in such a way as to maximise its genetic diversity. As it is not always possible to identify clones, seeds to be used in the translocation will be sourced from as many individual plants as possible, and from as many populations as possible in the species' central and southern distribution. However, seeds will not be used from Population 1, the most northern population, which is remote from the translocation sites and differs genetically from the other sites (Sampson & Byrne, 2009).

Seedlings will be planted in a manner that ensures different genotypes are mixed throughout the site; as far as is possible, seedlings will be interspersed with other seedlings from different populations of origin, and far from seedlings of the same maternal origin. As *E. cuprea* plants are predominantly outcrossing (Sampson & Byrne, 2009), this should help increase the genetic diversity of seeds produced by translocated plants.

Seedlings will be raised at BGPA's accredited nursery at Kings Park, which has hygiene procedures in place to ensure seedlings are free from diseases, pests and weeds.

4.6 Criteria for Success or Failure

Success criteria
The aim of the translocation is to achieve two viable and self-sustaining populations of *Eucalyptus cuprea*. This will be achieved by planting over successive years as plants are propagated until at least 250 plants have been successfully established at each translocation site. The time frames required to achieve this aim may need to be adjusted to take into account the number of plants available for planting, seasonal influences on maturation, survival and availability of funding.

Biological success or failure for each translocation site

<u>Success</u>

Initial success of each planting (approx 1 year)
- Survival of at least 50% of each year's plants past their first summer.

Medium term success of all plantings (2-10 years)
- Survival of at least 40% of all plants planted beyond first year.
- At least 80% of surviving plants producing viable seed at a rate similar to that at the natural population.

Long term success of all plantings (greater than 10 years)
Establishment of a viable self-sustaining population of at least 200 mature plants (natural recruitment of second and subsequent generations without additional plantings).

<u>Failure</u>

Initial failure of each planting (approx 1 year)
Less than 50% of each year's plants surviving beyond the first summer.

Medium term failure of all plantings (2-10 years)
- Less than 40% of all plants planted surviving beyond first year.
- Less than 80% of surviving plants producing viable seed at a rate similar to that of the natural population.

Long term failure of all plantings (greater than 10 years)
Population fails to become viable and self-sustaining.

5. TIMETABLE

Time	Action
August 2014	Translocation proposal submitted for review and approval
October 2014	Seed collection from populations 8, 9 and 11 by TFSC
October 2014	Germination of seed from populations 2, 5, 7 and 12 at TFSC
November 2014	Propagation of seedlings at BGPA
June 2015	Seedlings planted at translocation site
September 2015	Progress report
Annual review	Monitor, assess flower and fruit production

6. FUNDING

This project is fully funded under the State NRM "Fast Track Critically Endangered Flora Recovery" project, finishing in October 2015. Two of the proponents, Alanna Chant, Flora Conservation Officer based at Geraldton, and Leonie Monks, Research Scientist, are internally funded by DPaW on an ongoing basis. The proponents are therefore willing to make a commitment to monitor the translocation beyond the availability of the State NRM funding.

7. ACKNOWLEDGMENTS

Andrew Crawford – DPaW, Threatened Flora Seed Centre
Amanda Shade - BGPA

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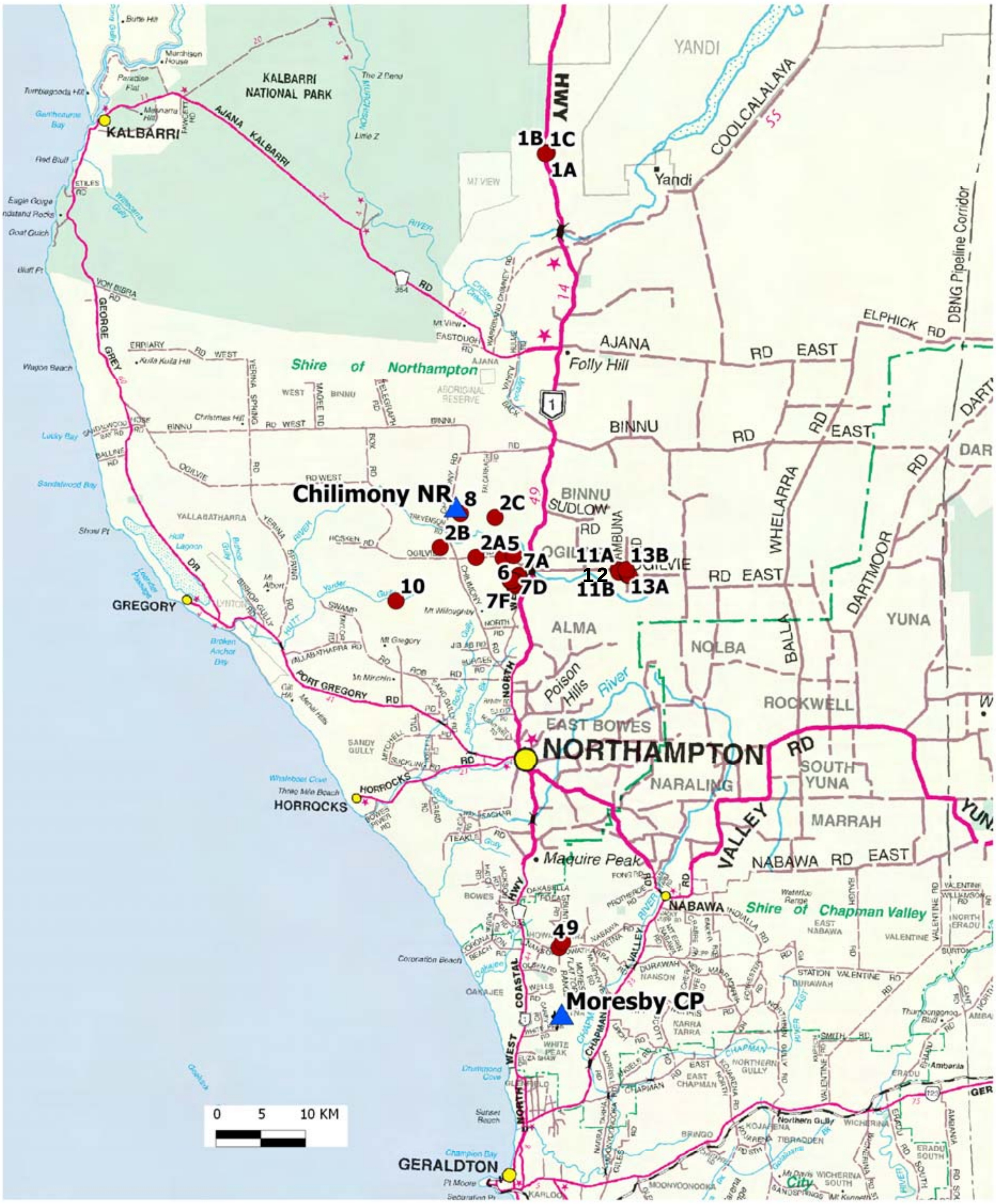
APPENDIX 1

Natural populations of *Eucalyptus cuprea* including proposed translocation site



Eucalyptus cuprea natural populations

Proposed translocation sites

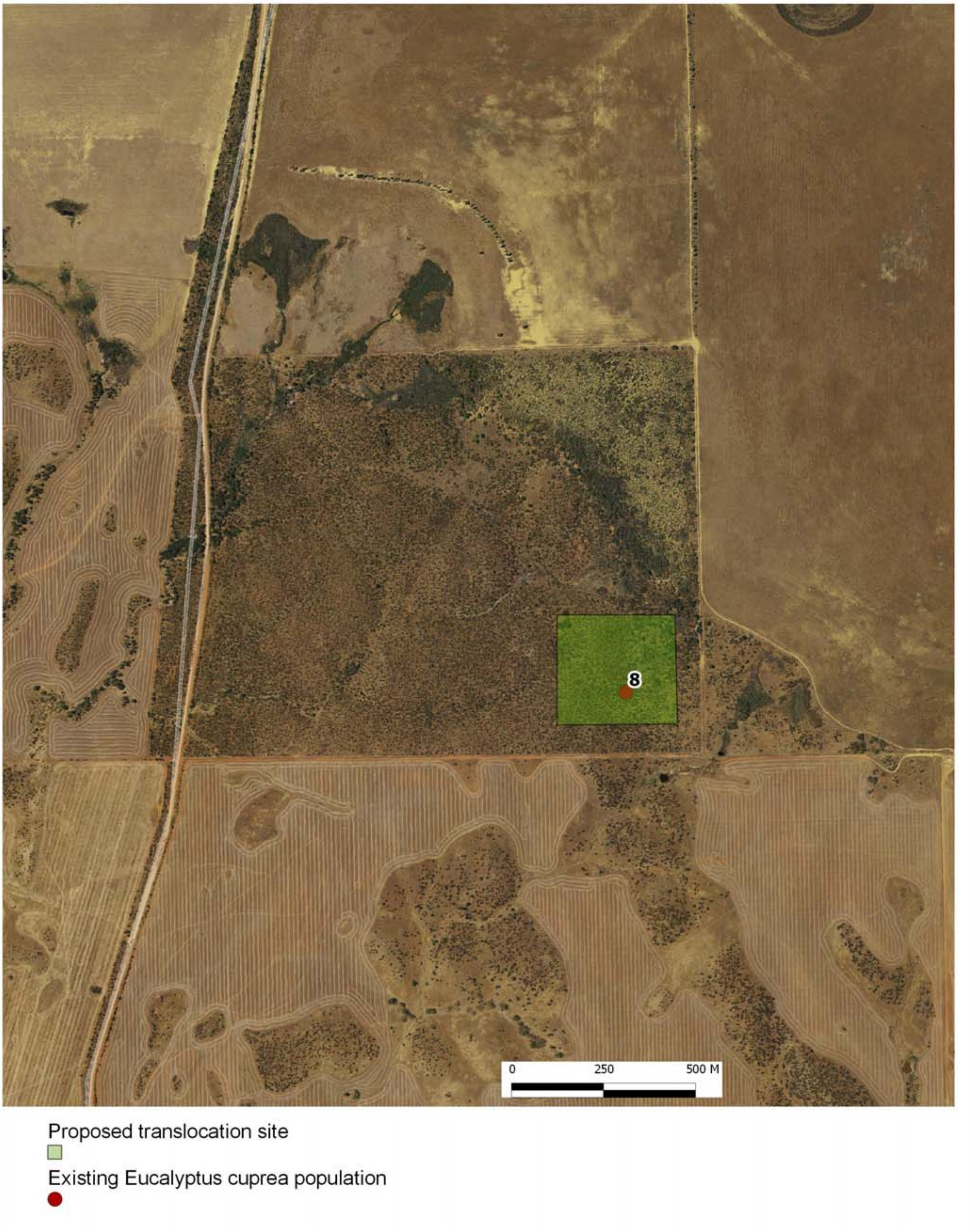
APPENDIX 2

Proposed translocation site within Moresby Conservation Park

Area to be fenced for habitat restoration, including Eucalyptus cuprea translocation

APPENDIX 3

Proposed translocation site within Chilimony Nature Reserve



Using bioregional variations in fire history, fire responses and vital attributes as a basis for managing threatened flora in a fire-prone Mediterranean climate biodiversity hotspot

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Abstract

Inappropriate fire regimes brought about by patterns of human settlement and land-use are a major threat for plant diversity in Mediterranean Type Climate (MTC) regions. In highly diverse MTC regions, such as south west Western Australia (SWWA) where there are a large number of threatened species distributed across a range of human modified and fire-prone landscapes, approaches are needed to identify where the threat is greatest. Information on recent fire regimes, their variability and effects on populations of threatened flora is lacking for many threatened species and this limits the strategic fire-management of these species. In this study we compile fire-response and vital attribute information (*sensu* Noble and Slatyer 1980) for SWWA's threatened plant species and undertake a bioregional assessment of recent fire regimes across SWWA including information on the fire history of threatened flora populations. Most threatened species are obligate-seeders that require fire for seed release or germination, but a high proportion of populations had no record of being burnt in the last 40 years. Survival of many populations of threatened flora in this biodiversity hotspot will depend on developing appropriate fire regimes that match the regeneration requirements of each species, and this depends on collation of quality population monitoring and fire history data.

Keywords: threatened flora, fire response, vital attribute, obligate seeder, fire history, fire management

1. Introduction

The world's five Mediterranean-type climate (MTC) regions collectively comprise about 2% of the world's land area, but are home to more than 15% of the world's total vascular plant flora (Cowling et al. 1996; Rundel 2004). Because of their equable climates the five regions have been the focus of substantial development and have the unfortunate status of global biodiversity hotspots, those places on Earth richest in endemic species, but under the most threat (Myers et al. 2000). Land clearing for agriculture and urbanization have been the primary causes of declines in biodiversity, and are responsible for the current status of most threatened plant species (Coates and Atkins 2001; Raimondo et al. 2009; Underwood et al. 2009; Rebelo et al. 2011). Land clearing remains an issue, but new threats are emerging with many species at risk from demographic factors associated with small populations and fragmented habitats, and landscape factors such as disease, invasive species, altered hydrology and modification of historical disturbance regimes (Burgman et al. 2007; Raimondo et al. 2009; Rebelo et al. 2011).

Like other seasonally dry biomes fire is a primary agent of recurrent disturbance in MTC landscapes, consuming biomass and interacting with climate and geology to influence plant population dynamics and community assembly (Keeley et al. 2012). The presence of people in MTC landscapes strongly affects the frequency of fires, and in contemporary MTC landscapes this relationship is complex and non-linear (Syphard et al. 2009). Generally as population density increases, human ignitions and fire frequency also increase, but beyond a density threshold, the relationship becomes negative as fuels become sparser and fire suppression resources become concentrated (Syphard et al. 2009). However, land-use and land cover may also be important determinants of fire patterns in MTC regions due to their effects on fuel types, flammability and human use of fire (Parsons and Gosper 2011; Boer et al. 2009; Viedma et al. 2009).

As is the case for other fire prone regions in the world, plants in MTC regions possess specialized traits which provide resilience to periodic burning (Bond and van Wilgen 1996; Keeley et al. 2012). Variation in traits relating to survival, reproduction, dispersal and establishment contributes to a diversity of responses and makes some species more vulnerable to decline under particular fire regimes (Keeley et al. 2011). As a consequence, changes in fire-regime relative to historical variability, brought about by patterns of human settlement and land-use can result in species declines. Those species that are killed by fire and rely on seed germination after fire for population persistence are most at risk (Bond and van Wilgen 1996). These obligate-seeding species face two threats in relation to fire-interval: immaturity-risk, where intervals are shorter than the time needed to establish a seed bank and senescence-risk where intervals are longer than the life span of plants or the seed bank (Keeley et al. 2012). Inappropriate fire season, intensity and other fire-event dependant effects can also influence recruitment success in MTC vegetation due to direct and indirect impacts on seed dormancy, release of seed from woody capsules, seed predation and seasonal variations in soil moisture (Cowling and Lamont, 1987; Auld and Scott 1997).

Obligate-seeding species which store their seeds within woody capsules in the plant canopy are most susceptible to immaturity-risk than species which form a soil seed bank. This is because serotinous species usually release all their seeds following a fire. As a consequence there is no residual seed bank if post-fire germination fails or fire occurs before the canopy seed bank is replenished. In contrast, obligate-seeders which store seeds in the soil usually have a residual seed bank remaining following post-fire germination which provides greater resilience (Bond & van Wilgen 1996).

In Australia’s MTC landscapes inappropriate fire regimes are identified as a major threat of growing importance for Nationally and State listed threatened plant species (Coates and Atkins 2001; Burgman et al. 2007). The nature of this threat is likely to vary across the landscape because of the influence that population density and patterns of land-use have on ignition and factors which affect flammability such as landscape fuel continuity. For example in peri-urban landscapes with moderate population densities, increases in ignitions and the frequency of fire at the wildland-urban interface, may expose threatened plant species to immaturity-risk (e.g. Forsyth and van Wilgen 2008). In contrast, in heavily cleared agricultural landscapes with relatively low population densities, many fragments of native vegetation have a considerably lower probability of burning than analogous continuously vegetated landscapes because of low fuel continuity, reduced likelihood of ignitions and fire suppression (e.g. Parsons and Gosper, 2011), potentially exposing threatened plant species to increased senescence-risk.

In highly diverse MTC regions, such as south west Western Australia (SWWA) where there are a large number of threatened species distributed across a range of more or less human modified fire-prone landscapes, approaches are needed to identify where the threat is greatest. This requires knowledge of contemporary fire regimes, how they vary across landscapes, and the sensitivity of threatened species to these regimes. Currently, this information is lacking for many threatened species and this limits the strategic fire-management of threatened species.

In this study we compile fire-response and vital attribute information for SWWA’s threatened plant species and undertake a bioregional assessment of recent fire regimes across SWWA including information on the fire history of threatened flora populations. Our purpose is to identify at a bioregional level where threatened plant species in SWWA are potentially at risk either from excessively frequent burning or from protracted fire-free intervals. The threat posed by recent historical fire regimes can be determined by the sensitivity of species to elements of the fire regime. We also discuss what additional information is needed to conserve threatened flora species in a fire-prone environment.

2. Materials and Methods

2.1 Study area

The focus of our study is the MTC region of SWWA (Fig. 1). The region encompasses seven Australian bioregions and has strong biogeographic affinities with two adjacent bioregions which are transitional with the Australian arid zone. The bioregions are based on common climate, geology, landform and native vegetation characteristics and provide a framework for national and regional conservation planning (Department of Sustainability, Environment, Water, Population and Communities, 2012). Plant species and vegetation formation distributions in SWWA are correlated with landforms and soils at local scales and climate gradients at macro-ecological scales. Average annual rainfall declines and temperature increases in northwards and eastwards directions with a corresponding increase in the length of the of the hot summer dry season.

Native vegetation varies from tall eucalypt forests in the Warren bioregion (WAR), eucalypt forests and woodlands and banksia woodlands in the Jarrah Forest (JAF) and Swan (SWA) bioregions, and mosaics of eucalypt woodlands, eucalypt mallee shrublands, acacia dominated shrublands and proteaceous heathlands in the Geraldton Sandplain (GES), Avon Wheatbelt (AVW), Esperance (ESP), Yalgoo (YAL) and Coolgardie (COO) bioregions.

Massive land clearing and habitat fragmentation has occurred with some 75% of native vegetation cleared for intensive agriculture and human settlements. The most impacted bioregions are AVW, which has been extensively cleared for broad-acre intensive agriculture with remnants of native vegetation existing in small isolated patches, roadsides and a few larger conservation reserves, and SWA with extensive urbanization and smaller-scale intensive agriculture. Other bioregions have also experienced considerable amounts of land clearing but are less fragmented and contain large tracts of uncleared vegetation and conservation reserves, while the remote bioregions COO and YAL have almost continuous native vegetation with major land uses being pastoral grazing leases, mining activities, conservation reserves and unallocated crown land (Fig.1; Table 1).

2.2 Threatened flora fire responses, vital attributes and habitats

There are 401 extant rare and threatened flora taxa (including species, sub-species, varieties and phrase names and hereafter referred to as ‘species’) listed under the State of Western Australia Wildlife Conservation Act (1950) within the nine bioregions with another 12 species found in more remote regions of the state (Smith, 2013). The location of species and other information are recorded in the Western Australian Department of Parks and Wildlife (DPaW) Threatened and Priority Flora Database (TPFL) as separate populations and sub-populations (hereafter called ‘populations’). The conservation status and ranking for each species is assessed at state level using the International Union for Conservation of Nature criteria prior to listing and is reviewed annually. Across all nine bioregions in 2013 there were 151 critically endangered, 115 endangered and 135 vulnerable species.

A threatened flora shapefile with 5370 populations was intersected with bioregional boundaries. Fire response strategies and vital attributes were recorded for threatened species from a variety of sources including, TPFL data base (accessed during 2010), the Western Australian Herbarium database (Western Australian Herbarium 1998 –;), post-fire monitoring records, DPaW reports and published literature. Most of the records were population-based so variations in fire responses due to population age and condition, fire regime and habitat factors were captured. Each species was assigned to one of four basic fire response categories (obligate seeder – S; facultative seeder/resprouter – SR; resprouter – R; and geophyte – G). Where there was no evidence of a fire response, species were assigned to the Unknown – U category.

Other information on vital attributes was collated where possible, including age to first flowering or juvenile period (JP = short <3 yrs; medium 3 – 5 yrs; long >5 yrs) and seed storage mode (seeds held in the canopy for >12 months – SC; seeds stored in the soil – SS; seeds not stored in canopy and do not remain viable for >12 months in the soil – SO).

The typical habitat for each threatened species with known fire response was recorded from herbarium specimen information in (Western Australian Herbarium 1998 –;) Brown et al. (1998) and from TPFL population monitoring records and assigned to one of four broad categories reflecting local exposure to fire. Three categories; montane peaks (M), wetlands and drainage lines (W), granite and other rocky outcrops (G), which generally experience a lower fire frequency than surrounding slopes and plains (S), and as a consequence may contain species that are more prone to changes in fire regimes.

2.3 Bioregion and threatened flora fire history

Fire history data for threatened flora was obtained from two separate sources; the DPaW fire history database (FHD) and the TPFL. Spatial fire data from the FHD was intersected with bioregional boundaries using ArcMap10.1 spatial analysis tools (http://www.esri.com/software/arcgis/arcgis10/) to generate bioregional fire spatial layers and statistics, such as the total area burnt, fire frequency (number of fires per bioregion) and largest fire area per bioregion. The fire history data was sorted into two 20–year time periods (1973–1992, 1993–2012) to assess changes in fire regimes over this period for each bioregion.

The fire history of threatened flora populations is stored in the TPFL and was considered to be a more accurate record of when populations were actually burnt than the fire history data from the FHD. TPFL population records were intersected with bioregional boundaries using ArcMap 10.1 and sorted into the two time periods (as above) based on year last burnt (YLB) recorded for each population. However, the number of populations with fire history data is constrained by the period over which the populations have been monitored and the resources available for monitoring.

2.4 Data analysis

Fire history data for each bioregion was used to determine the total areas burnt, the total number of fires, the mean area burnt per fire, season and fire type (wildfire or prescribed fire). Differences in these fire history metrics between the bioregions, time periods and seasons (spring, summer and autumn) were compared using analysis of variance (one-way and two-way ANOVAs). Comparisons of mean areas burnt used all data records for each time period, while other statistics were generated using the summary data for each bioregion (n=9), time period (n=2) or season (n=3). Relationships between variables (number of species and populations, area of remnant vegetation, number of fire records) were examined using scatter graphs and tested using multiple regression statistics (R^2) in Excel 2010 (http://office.microsoft.com/en-us/).

3. Results

3.1 Bioregional variation in fire responses, vital attributes and habitats of threatened flora

The greatest numbers of threatened species and populations occur in the AVW and JAF bioregions, which together make up 41.5% of the total number of threatened flora populations in this study area, followed by SWA (15.8%), GES (14.9%) and ESP (11.3%) (Table 1). There was a strong negative relationship between the proportion of remnant vegetation in each bioregion and the number of threatened species (r^2 = 0.74; p<0.005) and populations (r^2 = 0.83; p<0.001).

Fire responses were able to be determined for 242 (c. 60%) of the 401 threatened species in the nine bioregions. There was insufficient data to determine the fire response category of the remaining 159 species. Across all bioregions, there were 128 obligate seeder species (53%), 63 seeder/resprouter species (26%), 27 resprouter species (11%) and 24 geophyte species (10%). The obligate seeder fire response was more common than other fire responses within each bioregion, except for SWA and COO, which had more seeder/resprouter species (Fig. 2). AVW had more than twice the number of species (70) with unknown fire response than other bioregions (Fig. 2).

Mode of seed storage mode could be assigned to 208 of the 242 species for which fire responses were determined. Of these, 36 species (17%) have canopy stored seed, including species of *Allocasuarina, Banksia*, *Eucalyptus, Hakea, Lambertia* and *Petrophile*. Fifteen species with canopy stored seed are obligate-seeders, and these mostly occur in the ESP and JAF bioregions. The majority of species (71%) have soil-stored seed while some (12%), mostly orchids, have no seed storage mechanism. Among the 147 threatened species with soil-stored seed, 90 are obligate-seeders including species of *Acacia, Darwinia, Daviesia, Eremophila, Grevillea, Jacksonia* and *Verticordia.*

Juvenile periods (JP), could be determined for 159 of the 242 species with known fire responses. Fifty nine species (37%) had short JPs (<3 yrs), 66 species (42%) had moderate JPs (3–5 yrs), while 34 species (21%) had long JPs (>5 yrs), including 15 species with JPs >7 yrs. ESP had the greatest number of species with moderate and long JPs, while JAF had the greatest number of species with short JPs (Fig. 3). Twenty one of the 34 species with long JPs were obligate-seeders, including seven with canopy stored seed.

For the 242 species for which fire responses were determined, there were 97 species (40%) that occurred on slopes and plains (S), 21 species (9%) on montane peaks (M), 71 species (29%) on granite outcrops, stony ridges and breakaways (G), and another 53 species (22%) that occurred near drainage lines or wetlands (W). The greatest number of S species occurred in AVW, ESP had the greatest number of M species, JAF had the greatest number of G species, while JAF and SWA had the greater number of W species (Fig. 4).

3.2 Bioregion and threatened flora fire history

Fire history statistics from all records in the FHD from 1973–2012 varied considerably among bioregions (Table 2), with a significant difference between nine bioregions in the total areas burnt (F = 5.5054, P<0.01) and in the total number of fires (F = 37.1197, P<0.001) using the two 20–year time periods as replicates. This difference is partly due to the higher levels of prescribed burning in the JAF, WAR and SWA bioregions, whereas in the other bioregions most of the area burnt was due to wildfires, which are infrequent but are usually large and intense, particularly in the COO, ESP and MAL bioregions. The remaining bioregions of AVW, GES and YAL have experienced relatively few fires resulting in a low total area burnt (Table 2; Fig. 5).

Fire frequency increased in all bioregions from 1973–1992 to 1993–2012 except for JAF and WAR (data not presented). Greatest increases (more than two-fold) in fire frequency were evident in GES, ESP, MAL and SWA. The total area burnt decreased markedly in JAF (5.5 to 2.6 Mha) and WAR (1.2 to 0.7 Mha) from 1973–1993 to 1993–2012 and increased in all the other bioregions, especially in COO (0.3 to 3.2 Mha), MAL (0.4 to 1.7 Mha) and ESP (0.03 to 0.8 Mha), but there was no significant difference in the total areas burnt, or fire frequency, between the two time periods across all bioregions.

Summer fires increased in JAF over the last 40 years from 8% (1973–1992) to 14% (1993–2012), while spring fires decreased from 78% to 53% (a decrease of nearly 2 Mha) and autumn fires increased from 10% to 24% over the same time periods. In COO, summer fires increased from 21% to 64% (an increase of over 1.8 Mha) while autumn fires decreased from 11% to <1%. Summer fires also increased in ESP from 61% to 73% and in all other bioregions except SWA over this time period.

Overall, there were 232 species in the TPFL database (58%) with at least one record of year last burnt, but only 22% of all populations had a record being of burnt, including 15% that were burnt in the last 20 years. Records of species and populations being burnt is limited to the period for which they are known and monitored. The number of populations with no fire record was positively related to the total number of populations per bioregion ($R^2 = 0.9207$, $P<0.001$) (Fig. 6).

4. Discussion

We were able to determine the fire responses for c. 60% of the region's 402 threatened plant taxa. Over half of 242 species with known fire responses are obligate-seeders, and as a consequence will have population dynamics particularly sensitive to fire interval and season. Numerous population ecology studies of obligate seeding threatened species across MTC regions have shown the critical role fire regimes play in seed regeneration and population dynamics (Boucher 1981; Burgman and Lamont 1992; Yates et al. 2003; Yates and Ladd 2010; van Wilgen 2013).

At the bioregional level we found the number and proportion of threatened species that were obligate-seeders was substantially higher for ESP, AVW and JAF than other bioregions. In ESP, the substantial majority of threatened species have moderate to long juvenile periods and many of these species have canopy stored seed. In contrast, in AVW and JAF, the majority of species have short or moderate juvenile periods and there are fewer serotinous species. These trends indicate that the potential risk of population decline from fire intervals being too short to establish a seed bank (immaturity-risk) is highest in ESP and to a lesser extent AVW and JAF, but the actual risk will depend on fire regimes in these bioregions.

Our analysis of fire history shows considerable variation in fire regimes among the nine bioregions. This is to be expected because of underlying climate gradients, differences in weather patterns and the continuity and flammability (structure and biomass) of the natural vegetation (McCaw and Hanstrum, 2003; O'Donnell et al., 2011). However, patterns of human settlement and land-use also have an influence. Land clearing and landscape fragmentation since European settlement have dramatically reduced the continuity of native vegetation in some bioregions, while differing policies and practices of prescribed burning and suppression of wildfires have affected the incidence, intensity and extent of fires in all bioregions (McCaw and Hanstrum 2003; Boer et al. 2009; Parsons and Gosper 2011).

The differences are most striking for the heavily cleared and fragmented AVW compared to the more continuously vegetated JAF and WAR bioregions. Only 3.1% of all remnant vegetation in AVW was burnt over the last 10 years compared with 34% in ESP, and nearly 50% in the JAF and WAR bioregions, where prescribed burning is routinely practiced to reduce the scale and intensity of wildfires (McCaw et al., 2003; Boer et al. 2009).

Parsons and Gosper (2011) investigated the impacts of landscape fragmentation on fire intervals in AVW and estimated that intervals in small native vegetation fragments were much longer (mean = 339 years) than equivalent vegetation types in large remnants (mean = 69 years) or in continuous vegetation (mean = 40 years). Western Australia's wheatbelt also extends into GES, JAF, ESP and MAL and increases in mean fire interval are likely to have occurred in parts of those bioregions that are extensively fragmented.

While broad area fire history data provides information about when each population may have been exposed to fire, it cannot be used to determine whether the population actually burnt due to the often patchy nature of fire. We sought information about time since fire specifically for threatened species populations from the TPFL database. We found 85% of threatened flora populations have no record of being burnt, despite the relatively high fire frequency and proportion of area burnt in JAF, SWA and WAR. The large number of populations which have no record of being burnt may be a true reflection of the fire-history for many threatened species populations, especially in AVW and parts of other bioregions where there has been extensive habitat fragmentation. Moreover, in JAF, SWA and WAR threatened species may have been deliberately excluded from prescribed burning. This trend may also account for why we were unable to determine the fire response for 40% of threatened flora (159 species) of which 70 species occurred in AVW. However, our interpretation warrants some caution because the number of populations with a record of being burnt is constrained by the period over which the populations have been monitored and the resources available for monitoring. As a consequence it is possible that some threatened flora populations have burnt in recent history but data were not captured.

Despite the limitations in the data, some important bioregional trends emerge from our analysis. Immaturity-risk is highest for obligate-seeders in ESP where the majority of threatened flora populations have burnt in recent history and juvenile periods for most species are moderate to long. Indeed consecutive wildfires in 1991 and 2000 swept across montane heath vegetation in the ESP bioregion and impacted on 21 threatened species, of which eight are critically endangered taxa and obligate-seeders with long juvenile periods, resulting in poor regeneration (Barrett et al. 2009). Fire frequencies that are too high are commonly reported as a major threat in MTC landscapes and declines in obligate seeder species are commonly described (Zedler et al. 1983; van Wilgen et al. 2010; van Wilgen 2013). Significantly, some studies in fire-prone shrublands have observed that more frequent fires were associated with a reduction in both obligate-seeders with canopy stored seed and non-leguminous species with a soil seed bank indicating that the "storage" effect for some species may be overestimated (Carey and Morrison 1995; Morrison *et al*. 1996).

Our study found immaturity-risk is likely to be lowest for obligate-seeders in AVW and parts of GES, JAF and MAL where extensive land clearing and fragmentation of native vegetation has occurred. This is because the majority of threatened flora populations have not burnt in recent history, juvenile periods are mainly short to moderate and estimated fire intervals in vegetation fragments are relatively long in relation to these. In AVW, there is cause for concern that threatened flora populations are at risk from senescence. In contrast to the threat posed by too frequent fires for obligate-seeders, there is less evidence for MTC regions that excessively long fire intervals and senescence risk are a major threat. Nevertheless, investigations of landscape structure on fire behaviour in MTC regions show that fuel discontinuities at forest and shubland boundaries with agricultural land reduces the propagation of fires (Viedma et al. 2009), and that isolated fragments of native vegetation are far less likely to burn than continuous native vegetation (Parsons and Gosper 2011). Furthermore, evidence is emerging that fire intervals in very long unburnt fragments may be exceeding an upper threshold where the resilience of serotinous obligate-seeders is considerably diminished (Gosper et al. 2013).

Our finding that senescence-risk is a major threat is consistent with observed impacts of land-use on fire regimes (Syphard et al. 2009; Viedma et al. 2009; Parsons and Gosper 2011). Compared to most other MTC regions SWWA has the lowest population density and proportionally the largest area of agriculture factors which are consistent with a low frequency of fire. The Western Australian wheatbelt encompasses some 70% of the region (230,000 km^2) and is extensively fragmented with 74% of the native vegetation cleared with as little as 2% of native vegetation remaining across extensive areas (Gibson et al. 2004).

Population viability analysis (PVA) of threatened species in AVW indicate that senescence risk is high for obligate-seeders with canopy stored seed (Burgman and Lamont 1992), but for species with soil seed banks the risk is hard to quantify because there is still much to be learnt about seed longevity in the soil. Available data indicate that, for some species soil seed reserves may be relatively transient (Meney et al. 1994; Auld and Scott 1997; Yates and Ladd 2005). For example in species of *Darwinia* and *Verticordia* (Myrtaceae), the majority of dormant seed released in an annual seed-crop becomes non-dormant and has germinated or lost viability by two years after release (Auld and Scott 1997; Yates and Ladd 2005). The low level of seed-longevity in the soil in these species indicates that both adult survival and the level of adult fecundity are the critical factors that govern the persistence of the soil seed bank (Auld and Scott 1997). In *V. fimbrilepis* subsp. *fimbrilepis, a* relatively short-lived shrub, PVA indicates that current fire-intervals in the AVW are likely to be too long for populations to persist (Yates and Ladd 2010).

In contrast, some hard-seeded legume species in Fabaceae may have soil seed reserves that are long-lived with seeds surviving in excess of 50 years (Auld 1986). For many of these species it is well documented that the passage of a fire results in mass germination and that plants which are relatively short-lived decline in abundance with time (Auld and O'Connell 1991; Thomas et al. 2007). In these species seed-longevity in the soil is the critical factor affecting senescence-risk, and while it is reasonable to assume that hard-seeded leguminous species can persist in the soil seed bank for long periods, knowledge for a large number of non-leguminous species is lacking.

Granite outcrops and ironstone ranges are important fire refugial habitats for threatened flora in the south-west of Western Australia, as elsewhere (Yates et al. 2003a). These protected habitats are generally less prone to fire and often contain a higher proportion of obligate seeder species with long juvenile periods (Burrows 2013). Such species regenerate after occasional intense wildfires that extend up into rock crevices but are susceptible to local extinctions where repeated hot fires occur before the seed banks have been replenished (Yates et al. 2003a; Burrows 2013). Patchy*,* low intensity prescribed fires in the surrounding vegetation is recommended to limit the intensity and spread of landscape-scale wildfires and reduce the frequency of fire in refugial habitats to ensure that species with long juvenile periods can reach maturity (Burrows 2013).

To improve fire management and regeneration of threatened species, the minimum vital attribute and fire response information required for each species includes the fire response type, juvenile period (and hence minimum fire interval), seed storage type, life span of the mature plant and longevity of the seeds (and hence maximum fire interval). Most of these attributes are readily observed in the field but development of practical methodology for assessing the quantity and viability of soil-stored seed is clearly an area that needs further research. Historical records of juvenile period may not be relevant in an era of a drying climate in the south-west. There is evidence that a 16-20% reduction in winter rainfall in the first year post-fire can almost double the juvenile period of some serotinous species (Enright et al. 2014). Of equal importance is information about the fire intensity and when each population is burnt (season and year). Responses to fire often vary between populations, sites and for different fire regimes (frequency, season and intensity) and these variations need to be recorded and understood to determine appropriate regeneration and conservation strategies (Vivian et al. 2010).

This study highlights large differences in fire history across nine bioregions in the south-west of Western Australia and identifies areas where current fire regimes may be detrimental to threatened flora that have particular life attributes and responses to fire. The greatest risk appears to be in the highly fragmented agricultural bioregions (AVW, MAL, GES, ESP and parts of JAF) where the absence of fire is limiting opportunities for regeneration of obligate seeder species. In contrast, some areas of continuous vegetation in ESP and JAF, fires may be too frequent for serotinous seeders with long juvenile periods and increasing the risk of local extinctions. New approaches based on life attributes and fire responses are needed to manage fire specifically to conserve and regenerate threatened flora in these degraded but highly diverse, species-rich landscapes.

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Table 1. The proportion of remnant vegetation mapped in 2012, the total pre-European area of native vegetation (mHa) and the numbers of threatened species and populations, listed in order of increasing pre-European area. An approximate value for the mean annual rainfall across each bioregion is also provided for comparative purposes.

Bioregion	WAR	SWA	ESP	GES	JAF	YAL	MAL	AVW	COO
Remnant vegetation (%)	79.7	39.2	52.0	44.9	54.6	97.4	55.6	18.7	98.0
Area of pre-European native vegetation (mHa)	0.84	1.50	2.90	3.14	4.51	5.06	7.40	9.72	12.91
No. threatened species	25	62	76	77	107	11	44	128	25
No. threatened populations	267	851	606	799	1 002	98	378	1 222	147
Approximate mean annual rainfall (mm)	1 250	850	500	500	750	275	350	350	275

Table 2. Fire history statistics for each bioregion, based on existing fire records in the Fire History Database (FHD) from 1973 to 2012. The total area burnt is the sum of all areas burnt over the 40 years; fire frequency is the total number of fires divided by 40 years; prescribed burn (PB) is the proportion of fires that were prescribed burns rather than wildfires. The highest and lowest values in each column are highlighted.

Bioregion	Total area burnt (mHa)	Proportion of Pre-European area burnt/year (%)	Fire frequency (No./yr)	PB (%)	Largest single fire (Ha)	Mean area burnt/fire (Ha)
WAR	3.16	**6.3**	151	76.2	33 656	356
SWA	0.77	0.9	110	54.8	**22 718**	**148**
ESP	1.52	0.9	21	8.8	135 342	1 581
GES	**0.14**	0.1	3	10.9	25 960	472
JAF	**12.49**	4.6	**479**	**85.6**	80 913	456
YAL	0.26	0.1	**1**	**0.2**	61 932	3 557
MAL	3.23	0.7	8	2.5	191 923	**9 609**
AVW	0.30	**<0.1**	4	0.9	30 094	1 259
COO	4.47	0.6	10	1.2	**341 683**	6 324

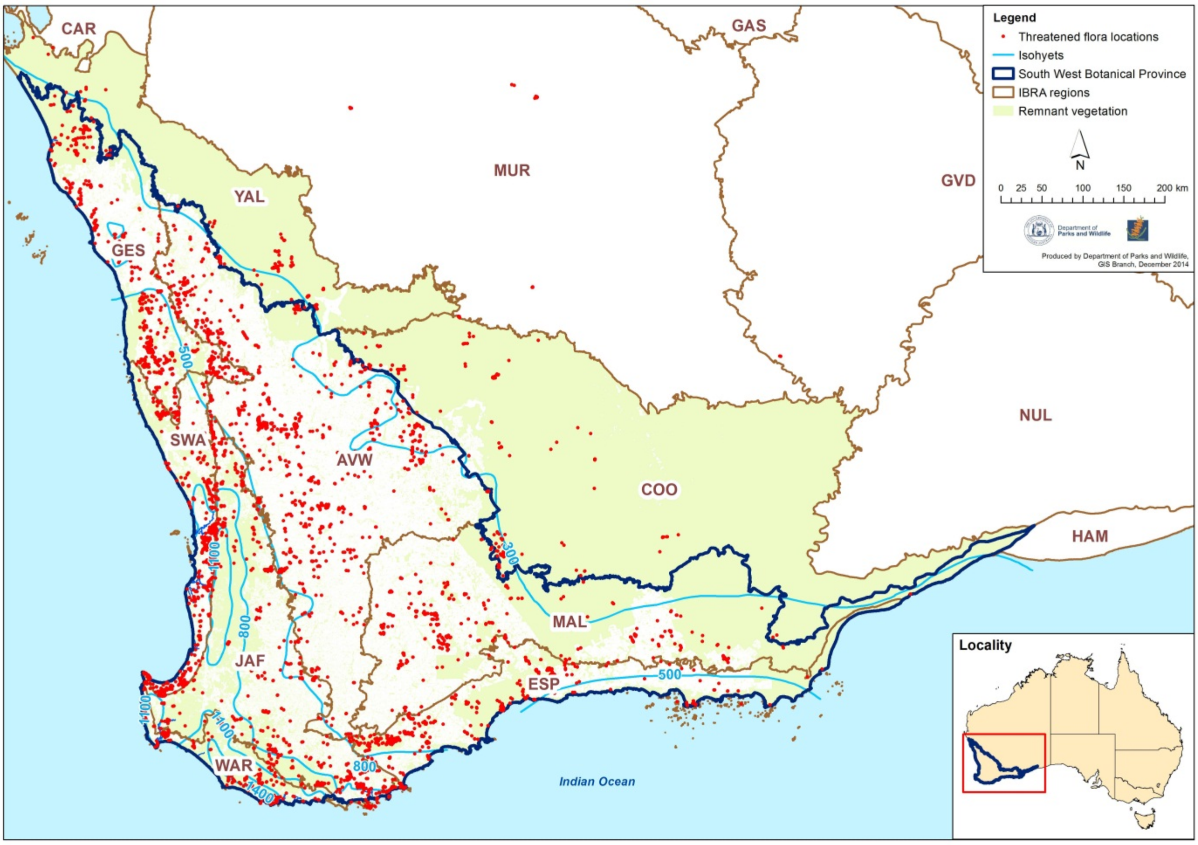

Figure 1. Map of the study area of the south-west of Western Australia showing the nine bioregions, the South-West Botanical Province in bold line, remnant vegetation in green, populations of threatened flora as red dots and selected rainfall isohyets (300, 500, 800, 1 100 and 1 400 mm mean annual rainfall).

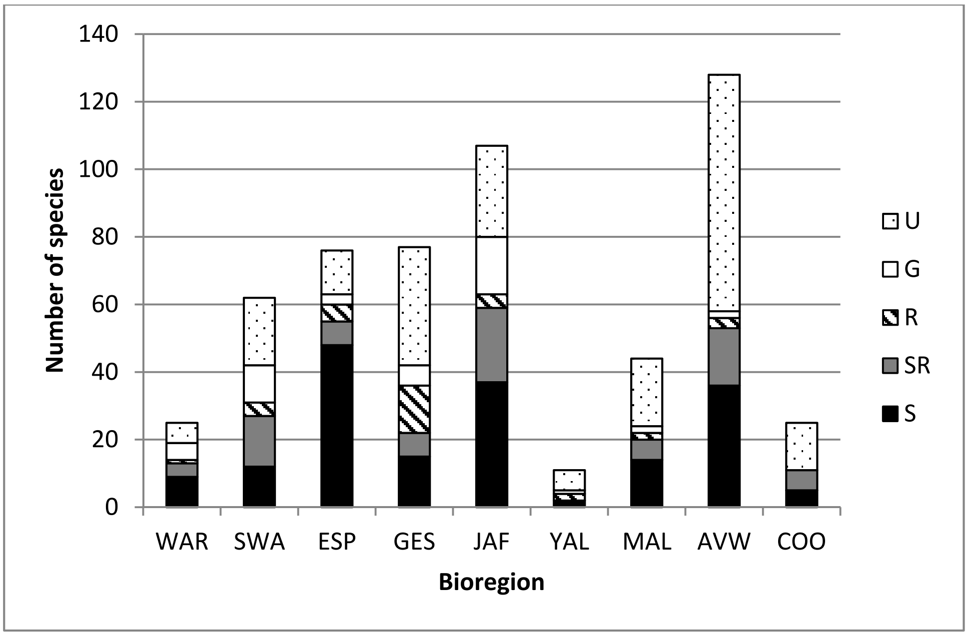

Figure 2. Distribution of threatened species in each bioregion and fire response category: S – seeders, SR – seeder/resprouters, R – resprouters, G – geophytes, U – unknown.

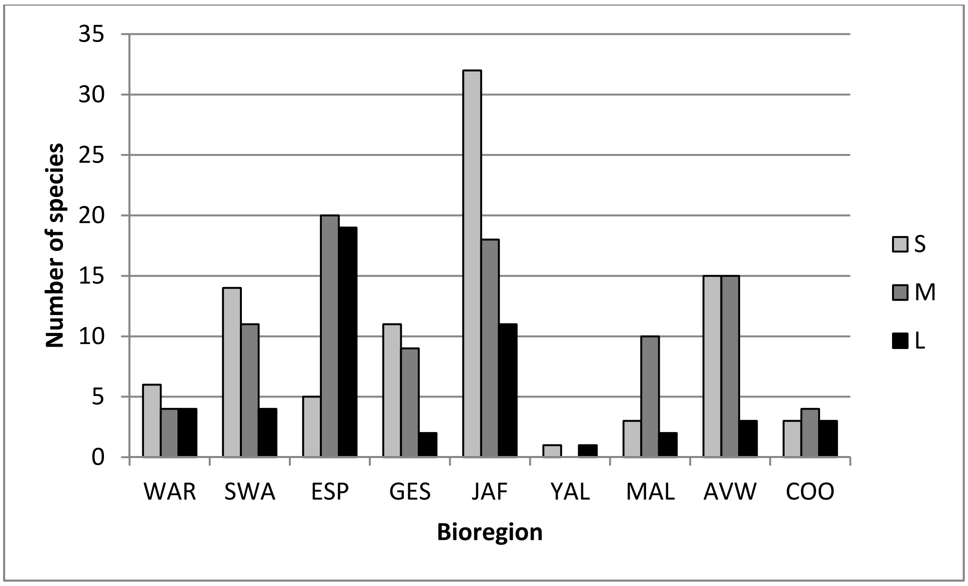

Figure 3. The number of threatened species in each bioregion that have short (S, <3 yrs), moderate (M, 3–5 yrs) or long (L, >5yrs) juvenile periods for all fire response categories.

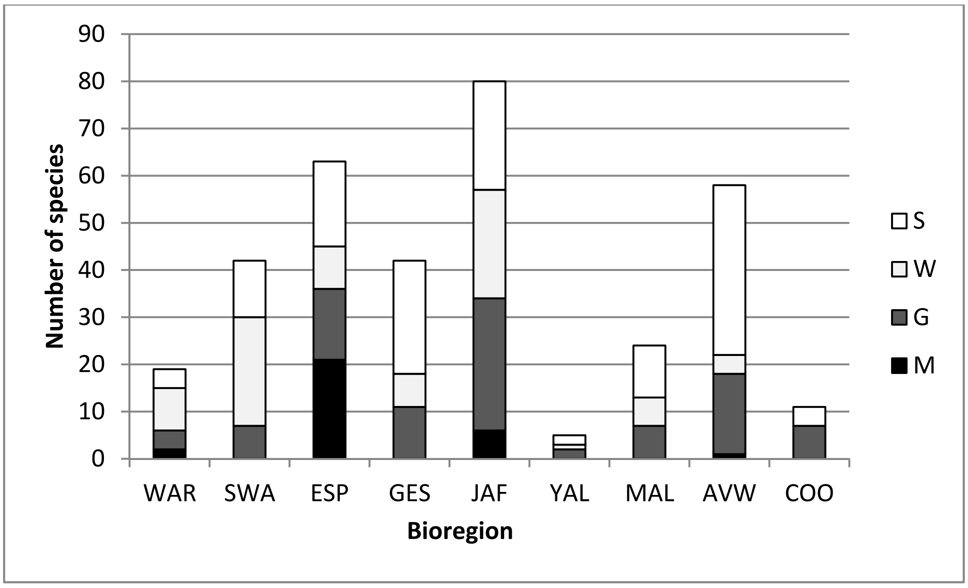

Figure 4. The number of threatened species in each bioregion with known fire response, grouped into four broad habitat types (S – slopes and plains; W – wetlands and drainage lines; G – outcrops, stony ridges and breakaways; and M – montane peaks).

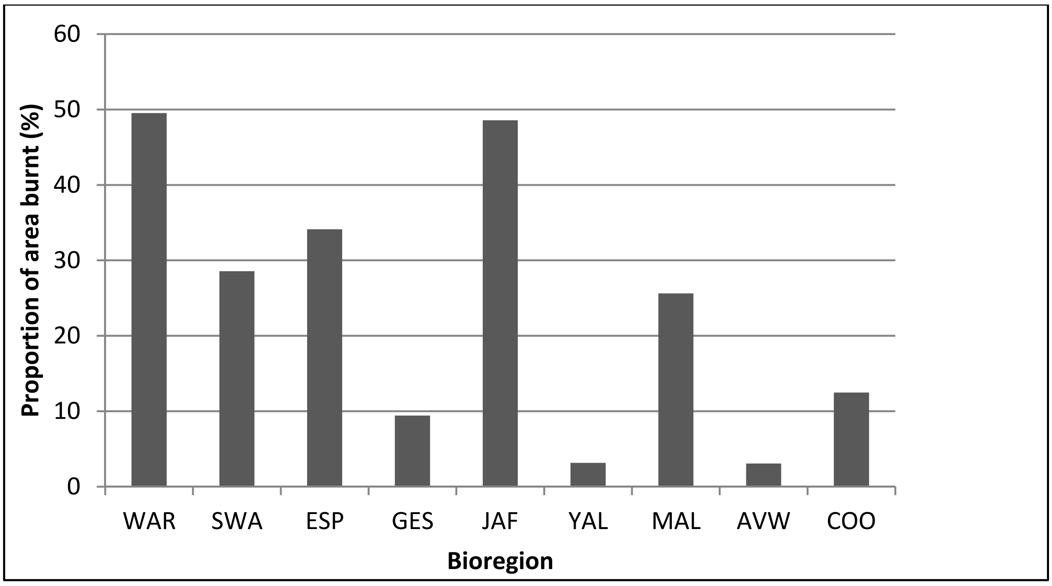

Figure 5. The proportion of remnant vegetation area present in 2012 that was burnt during the previous ten year period (2003–2012).

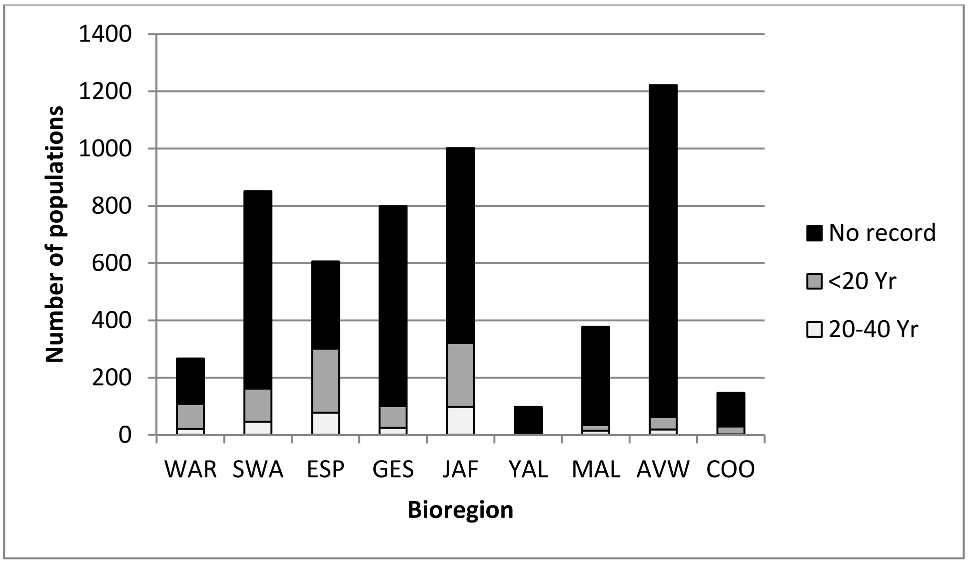

Figure 6. The number of populations with records of year last burnt for each bioregion, separated into two 20-year time periods, and the number of populations with no record of having been burnt.

TRANSLOCATION PROPOSAL
Maxwell's Grevillea
Grevillea maxwellii McGill (Proteaceae)

1. SUMMARY

Grevillea maxwellii is a Critically Endangered taxon endemic to the Pallinup River area, east of the Stirling Range in south west Western Australia. It was declared as Rare Flora in September 1994 and ranked as Critically Endangered in September 1995 due to populations being severely fragmented, deteriorating habitat quality and a decline in population numbers. *G. maxwellii* is currently known from eight remaining populations consisting of approximately 815 mature individuals.

G. maxwellii is a spreading shrub growing up to 1m high and 1.5m wide. The leaves are up to 7.5cm long and divided into 3-6 lobes. Large, red inflorescences are produced from July to September. The species occurs in low open heath in shallow soils over granite on rocky hilltops and slopes adjacent to the Pallinup River (Phillimore *et al*. 2001).

The species was first collected in 1840 by James Drummond from the Pallinup area. It was later collected by K. Newby in 1966 and not seen again until 1986 when a population was found on the southern side of the Pallinup River. Further surveys located an additional 9 populations in the vicinity of the river, bringing the total of known populations to 10. No new populations have been discovered since 2000.

Grevillea maxwellii is threatened by drought. The shallow soils on which the species occurs renders it susceptible to moisture stress with increases in mortality of both adults and seedlings during periods of drought.

G. maxwellii is also threatened by inappropriate fire regimes. It is killed by fire and its persistence is reliant upon the germination of soil stored seed with plants growing to reproductive maturity before the next fire. Fires in short succession are therefore capable of killing off live plants and rapidly depleting the soil seed bank. Conversely, an extensive period between fires may result in population senescence and soil seed bank expiration, and therefore rapid decline.

Other threats to the *G. maxwellii* populations include weed invasion, grazing and granivory.

There are currently 3565 seeds stored at the Department's Threatened Flora Seed Centre, with the majority from populations 1 and 2. *G. maxwellii* seed has germinated successfully in trials, with 62 to 95% germination.

The aim of this translocation proposal is to assist the long term persistence of the species by establishing a new, viable, secure population of *G. maxwellii*.

This translocation proposal outlines the need for translocation of the Critically Endangered *G. maxwellii*, the site selection process, the design of the translocation site and the provisions for monitoring. In addition, it outlines the criteria for success or failure of this proposed translocation.

2. Proponents

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3. BACKGROUND

3.1 Taxonomy History, and Status

Grevillea maxwellii, a member of the Proteaceae family, is a spreading shrub growing up to 1m high and 2m wide. The leaves are up to 7.5cm long and divided into 3-6 lobes, with each of these divided further into three smaller lobes. Leaves have two prominent edge veins, a pungent tip and revolute margins which enclose the hairy undersurface. Large, red inflorescences are produced from August to September. The brown ovoid pods are covered in glandular hairs and measure approximately 10mm long (Olde and Marriot 2005).

G. maxwellii was first collected in 1840 by James Drummond from the Pallinup area. The species was later collected by Ken Newby in 1966 and not seen again until 1986 when a population (population #3) of over 40 plants was located by Greg Keighery on the southern side of the Pallinup River. Further surveys conducted by Department of Environment and Conservation staff in between 1994 and 2000 located an additional 9 populations in the vicinity of the river, bringing the total of known populations to 10. No new populations have been discovered since 2000. Population 3 has not been relocated since its original discovery in 1986. It is possible that the location details recorded were incorrect as these lead to a site with markedly different habitat characteristics compared to other populations. Populations 5 and 9 currently have no living plants.

G. maxwellii was declared as Rare Flora in September 1994 and ranked as Critically Endangered in 1995. It met criteria for listing due to populations being severely fragmented, deteriorating habitat quality and a decline in population numbers (Phillimore *et al.* 2001).

3.2 Distribution and Habitat

G. maxwellii is endemic to the Pallinup River area located east of the Stirling Range in south-west Western Australia. The species is known from eight extant and one presumed extinct populations with the total population estimated to be 815 mature plants (Table 1). Populations occur over a distance of approximately 10km and occupy a total area of approximately 95 ha. Seven populations occur in small patches of remnant vegetation on private property, one population on unallocated crown land, one on a degraded road verge (presumed extinct) and one on a water reserve (incorrect record or presumed extinct)(Table 1).

G. maxwellii grows on shallow brown loamy soil over granite on hills and slopes leading to the Pallinup River. Plants decease in frequency as soil depth increases. Average annual rainfall is approximately 400mm. The associated vegetation community is low open heath with an emergent layer of *Allocasuarina* species. Associated species include *Allocasuarina huegeliana*, *Acacia sulcata*, *Calothamnus quadrifidus*, *Calytrix tetragona*, *Melaleuca villiosepala*, *Banksia armata*, *Taxandria spathulata*, *Petrophile crispata*, *Hakea marginata*, *Hypocalymma angustifolium*, *Leucopogon denticulatus*, *Gastrolobium spinosum*, *Borya sphaerocephala*, *Calectasia grandiflora*, *Phyllanthus calycinus*, *Xanthorrhoea platyphylla*, *Gahnia ancistrophylla*, *Anarthria polyphylla*, *Opercularia spermacocea* and *Stypandra glauca* (Phillimore *et al.* 2001, S Barrett, personal observation).

Table 1. Population information of *Grevillea maxwellii*

Population number/ location	Tenure	Number of individuals
1. S Pallinup River	Private Property	1999 55 2011 28 2013 28
2. S Pallinup River	Unallocated crown land	1999 40(30) 2011 145 2013 268
3. N&S Pallinup River	Water Reserve (UCL)	1999 0 2012 0
4. S Pallinup River	Private Property	2000 150 2011 2
5. S Pallinup River	Shire road reserve	1999 1 2011 0 2013 0
6. S Pallinup River	Private Property and UCL	1999 33(9) 2004 57 2011 82 2013 137
7. S Pallinup River	Private Property	1999 27 2011 15 2013 19
8. N Pallinup River	Private Property	1999 300 2011 150 (10) 2013 358
9. N Pallinup River	Private Property	2000 100 2011 0
10. N Pallinup River	Private Property	1999 180 2011 150

Numbers in brackets = number of seedlings.

3.3 Germplasm collection and ecology

Currently there are 3,565 *G. maxwellii* seeds in storage at the Department's Threatened Flora Seed Centre (TFSC). The seed has been collected from Populations 1, 2, 4 and 8 (Table 2). *G. maxwellii* germinated successfully in recent trials, with 62 to 95% germination. The seeds are relatively large (~35mm) and require treatment to break dormancy (Cochrane *et al.* 2002). The best method for germination of the species was to soak seeds in 10% *Regen® 2000 Smokemaster*™ solution for 24 hours, rinse with dionised water, then nick seed coat before plating onto plain agar. Seeds are then germinated at 15◦C under a 12 hour light/dark photoperiod (A. Crawford *pers. com*.).

Table 2. Number of *Grevillea maxwellii* seed in storage in the Threatened Flora Seed Centre

Population	Number of Seed
1. S Pallinup	1250
2. S Pallinup	1406
4. S Pallinup	55
8. N Pallinup	854

G. maxwellii is killed by fire and persistence of the species is contingent on seeds stored in the soil germinating, seedlings establishing and plants growing to reproductive maturity before the next fire. Recruitment trials conducted by Department of Environment and Conservation (DEC) in

2002 resulted in significant germination of soil stored seed in burnt plots, with negligible germination within plots treated with mechanical disturbance (raking) and aqueous smoke solution (Cochrane and Barrett, 2003).

Significant recruitment in natural populations has been recorded in response to high rainfall events. Over 100 juveniles were found in population 2 in May 2002, which may have been in response to high summer rainfall during January 2001, in which 341mm was recorded (Shedley 2011). Seedling survival is dependent upon adequate follow up rains. Survival in population 6 was recorded at 53% following the first summer, but was reduced to 16% after the second summer with mortality mainly attributed to summer rainfall deficit (Cochrane and Barrett, 2003).

Recruitment has also been recorded in response to soil disturbance, with several seedlings emerging following construction of a fence line in population 2.

The primary juvenile period for *G. maxwellii* is four to six years with the minimum desirable fire interval estimated at approximately 15 years. The maximum fire interval has been suggested to be 30 years. However it is possible that recruitment from high rainfall events may be adequate to maintain populations in the absence of fire (Shedley 2011).

G. maxwellii is susceptible to grazing by kangaroos and stock. Heavy grazing by kangaroos was recorded following a small scale experimental burn (Cochrane and Barrett 2003). High levels of grazing can cause seedling mortality and reduce the growth and reproductive output of mature plants. Several populations were fenced to exclude stock between 1996 and 2002.

The pollination biology of *G. maxwellii* is largely unknown, but the species is likely to be pollinated by nectarivorous birds (Olde and Marriot 2005). Insect and bird predation of seeds is high (Cochrane *pers com*.).

4. THE TRANSLOCATION

4.1 The Need to Translocate

G. maxwellii qualifies as Critically Endangered with the main threats to the species being fragmentation, small population size and area of occupancy, drought and inappropriate fire regimes. The number of individuals in some populations is in decline with one population extinct and a second with no plants recorded in recent years. All populations are long unburnt as a result of the fragmented nature of the landscape. Population decline is likely to continue as habitat quality is reduced by these threats. The increase in numbers in populations 2,6 and 8 since 2011 is partly due to very intensive survey in 2013.

Large scale land clearing in the area encompassing *G. maxwellii* has led to the severe fragmentation of habitat. Populations are small and confined to isolated patches of remnant vegetation or road reserves. Currently no populations of *G. maxwellii* occur on land managed for the purposes of conservation. Therefore, the opportunity for populations to expand into surrounding habitat in the absence of threatening processes is limited. As the population size decreases and isolation increases, populations may become more vulnerable to extinction for the following reasons: (i) the loss of genetic variation and increased inbreeding have been associated with a reduction in the ability of a population to adapt to short-term environmental change; (ii) small populations are more susceptible to chance events due to environmental or human impacts and (iii) the population size or density is such that the reproductive capacity drops below a threshold so that the organism can no longer replace itself (Hobbs and Yates, 2003).

Poorly timed, intense or too frequent fire may be detrimental to *G. maxwellii* as the species needs to reach reproductive maturity (approximately 4-6 years) in order to build up a soil-stored seed bank. Furthermore, whilst fire can induce large recruitment events, the occurrence of follow up rains is likely to be crucial to successful seedling establishment. Fire without such rainfall events may exhaust the soil seed bank, leaving no surviving plants with which to replenish it.

Drought not only effects seedling establishment but also impacts on adult plants. Increases in adult mortality have been recorded following summers with below average rainfall (Shedley 2011). The shallow soils on which the species occurs renders them vulnerable to intense moisture deficit during dry periods. Average rainfall totals have been declining in south west Western Australia since the mid 1970's and the occurrence of extreme rainfall events that drive large recruitment episodes are also predicted to decrease (IOCI 2005).

Weed infestation also threatens *G. maxwellii*. Most populations are located in remnant vegetation on private property and exposure to fire or other disturbance may see an increase in weed density. Populations 4 (part) and 5 (extinct) currently have heavy weed infestations. The presence of weeds can impact on recruitment through competition and also exacerbate grazing and fire risk through increased fuel loads (Phillimore *et al*. 2001).

Given the limited distribution of the species, small population sizes, decline of several populations and current threats, the Interim Recovery Plan 2001-2004 recommends translocation to a secure, threat free site in order to assist the survival of the species.

The currents status of G. maxwellii *leads us to believe that translocation is now crucial to the recovery of this species and the establishment of translocated plants at safe, secure sites is a prerequisite to this.*

4.2 Translocation Site Selection

The selection of suitable translocation sites within the known distribution of *G. maxwellii* is extremely limited due to the lack of suitable, threat free native vegetation in the area. Another alternative is to restock known populations; however, new individuals would be subject to same threatening processes. Therefore it is not considered possible to locate a translocation site within areas of suitable habitat within the species known range. A new site outside the known range of *G. maxwellii* is proposed for the translocation. The sites selected for the translocation is the Outhwaite's property, Boxwood Hill.

The suitability of the proposed site was assessed in December 2012 by Sarah Barrett (Flora Conservation Officer, Albany District, DPAW) and Rebecca Dillon (Research Scientist, Science Division, DPAW). The site was assessed on the basis of disease status, hygiene issues, access, soil and vegetation type, risk of secondary salinity, drainage, windbreaks, the presence of potential pollinators and the presence of other *Grevillea* species that could pose a risk of potential hybridisation with *G. maxwellii*.

Outhwaite's property, Boxwood Hill.

The proposed site is located south east of Boxwood Hill, approximately 26 km SE of the nearest known natural population of *G. maxwellii*. There is, however a single Perth Herbarium record from the lower Pallinup (near the South Coast Highway bridge) nearby that has not been relocated. The site is located within a 308ha private property bordering the Pallinup River. The property is used for tree production (130 ha under a 70 year carbon contract with Forest Products Commission), occasional sheep grazing (108 ha parkland cleared pasture) and supports 70 ha of remnant vegetation. Average annual rainfall is 505mm, approximately 100mm higher than at the natural populations (BOM 2013).

This site is located in the southwestern part of the property (UTM 50H 662918mE, 6189678mN [WGS 84]), amongst remnant vegetation and is gently sloping with a south westerly aspect. The sites' higher rainfall and south westerly aspect should ensure sufficient moisture for population persistence. Soils are well brown sandy loam over granite. Due to the site's position high in the landscape, there is minimal risk of salinisation. Adjacent vegetation provides protection from wind damage and habitat for potential vertebrate or invertebrate pollinators. The vegetation is open *Allocasuarina* heath, with the main plant species outlined in Table 3. The translocated plants will be established amongst the existing vegetation.

The proposed translocation site has good vehicle access for maintenance and monitoring the translocated plants. The perimeters of the property is fenced and secured with locked gates, so access will be restricted to landowners and DPAW staff.

The site was assessed to be *Phytophthora*-free based on the presence of healthy indicator species. The absence of *P. cinnamomi* cannot be confirmed by soil sampling, as this is not an effective means of isolating the pathogen in this situation.

Potential threats at the site include grazing by rabbits, sheep and kangaroos. This threat will be managed by fencing translocation sites for protection from herbivory. Grazing by invertebrates (i.e. grasshoppers) may also be a threat in this area. The site will be monitored for grazing activity during summer and whilst small and vulnerable, plants will be protected by temporarily covering them in individual screen enclosures and further management actions undertaken if required.

Introduction of *Phytophthora cinnamomi* to the property will be avoided through use of strict hygiene procedures. Weeds also pose a potential threat at the site due to its proximity to pasture. The establishment of any weeds will be closely monitored and actions undertaken to eradicate them.

It is proposed to establish the *G. maxwellii* plants from populations 1, 2 and 8 at the translocation site in winter 2014. As *G. maxwellii* has not previously been recorded from the site, the translocation can be considered a 'conservation introduction' under the definitions provided by the Guidelines for Translocation of Threatened Plants in Australia (Vallee *et al.* 2004) and an 'introduction' under the definitions in DPAW Policy Statement 29 (Anon. 1995). A map of the proposed translocation site in relation to the known populations is shown in Appendix 1.

Endorsement for the use of this site has been sought from the South Coast Region and the translocation will not go ahead unless the project is approved by the Region (See attached approvals page).

Associated species at the proposed translocation site. *indicates species also present at natural populations.

Outhwaite's property
*Allocasuarina huegeliana**
*Gastrolobium spinosum**
*Leucopogon denticulatus**
*Acacia sulcata**
*Thryptomene australis**
Daviesia horrida
*Borya sphaerocephala**
*Phyllanthus calycinus**
Allocasuarina thuyoides
*Hakea lissocarpha**
*Calytrix tetragona**
Ptilotus sp
*Opercularia spermacocea**
*Neurachne alopecuroidea**
*Stypandra glauca**
Verticordia densiflora
Nuytsia floribunda
*Petrophile crispata**
Melaleuca rigidifolia
Comesperma scoparia
*Leucopogon denticulatus**

Leucopogon obtusatus *Taxandria spathulata** *Astroloma sp* *Lepidosperma sp* *Mesomelaena stygia** *Gahnia ancistrophylla**

4.3 Site management

As these plants will be established for the purpose of conservation, they will be regarded as Declared Rare Flora and will have the same legal protection. Any seed harvested from plants will be used for conservation purposes only.

The land managers maintain firebreaks and currently implement *Phytophthora* hygiene procedures for the properties as a whole. Hygiene procedures are also in place for the translocation site and will be maintained within the remnant vegetation where the translocations will be located. The site is also listed on the DPAW south coast region fire GIS database as high priority for protection in the case of wildfire. The sites will be monitored for presence of weed species. Any weeds will be eradicated.

4.4 Translocation Design

We propose to establish 100 *Grevillea maxwellii* seedlings sourced from seed collected at populations 1, 2 and 8 at the site in winter 2014. If plants establish successfully at the translocation site, further seedlings will be added to the site over subsequent years. Plants sourced from different populations will be mixed to maximise production of outcrossed seed. Plants sourced from the same parent will be separated. While it is not clear at present what animals pollinate *G. maxwellii*, other species are present at the site, which will provide cover and food sources for potential pollinators. In the interim, efforts will be made to determine what pollinates the species.

Plants will be planted approximately 3m apart. All plants will be permanently labeled so each can be identified in terms of its parent and population. All equipment used during planting will be maintained under strict disease hygiene. Plants will be irrigated over the first two summers. The water tank on site will be filled with town water from Albany (in which the chlorine helps to any kill pathogens) and carried in either departmental fire trucks or by commercial water carters (the tank and hoses of which is sterilised with a bleach solution then rinsed, prior to filling with water). The plants will be protected from grazing by herbivore exclusion fencing to further maximise survival. Community involvement in the project through the Albany Threatened Flora Recovery Team will be used to promote awareness of, and interest in, the species.

Monitoring of the translocated population will be undertaken within the first month after planting and then every six months for the first year and then annually thereafter. Monitoring will include counting the number of surviving plants, measuring their height, width of the crown in two directions, recording the reproductive state, number of flowers, number of fruits, whether second generation plants are present and general health of the plants.

Monitoring of the natural populations will also occur in conjunction with monitoring of the translocated populations. This will provide essential baseline data for assessing the performance of the translocated population. Monitoring will include counting the number of individuals, height and crown width of the individuals, reproductive state, number of flowers, number of fruits, whether second generation plants are present and general health of the plants.

4.5 Source of Plants

Plants will be grown from seed, based on collections from 28, 61, 62 parents in *G. maxwellii* populations 1, 2 and 8 respectively.

Translocations are planned, implemented and managed in such a way as to maximise their genetic diversity. For this translocation, seed was collected from 151 individuals that were distributed throughout three populations. Under both national and international guidelines (eg. Guerrant *et al*. 2004, Offord and Meagher 2009), when the breeding system of the species is unknown it is recommended that seed is collected from at least 50 plants to ensure 95% of the genetic variation within that population is represented in the collection. These guidelines will be followed to maximise the genetic diversity of the translocated population. Where populations contain fewer than 50 plants, seed will be collected from all individuals. Current seed collection guidelines (up to 20% of available seed on one plant at time of collection) will be followed to ensure sufficient soil seed storage to replace the present population in the event of a fire.

Plants will be raised at BGPA's accredited nursery at Kings Park and Botanic Gardens, which has hygiene procedures in place to ensure seedlings are free from diseases, pests and weeds.

4.6 Criteria for Success or Failure

Success criteria

The aim of the translocation is to achieve a viable, self-sustaining population of *Grevillea maxwellii*. This will be achieved by planting over successive years as plants are propagated until at least 250 plants (that adequately represent the genetic diversity of the species) have been successfully established. The time frames required to achieve this aim may need to be adjusted to take into account the number of plants available for planting, seasonal influences on maturation, survival and availability of funding.

Biological success or failure

<u>Success</u>

Initial success of each planting (approx 1 year)

- Survival of at least 50% of each year's plants past their first summer.

Medium term success of all plantings (2-10 years)

- Survival of at least 40% of all plants planted beyond first year.
- At least 80% of surviving plants producing viable seed at a rate similar to that at the natural population.
- Recruitment of a second generation – seedling recruitment equivalent to or greater than that observed at the natural population (bearing in mind this may be nil if seedling recruitment is linked to disturbance and this does not occur in this timeframe).

Long term success of all plantings (greater than 10 years)

Establishment of a viable self-sustaining population of at least 200 mature plants (natural recruitment of second and subsequent generations without additional plantings).

<u>Failure</u>

Initial failure of each planting (approx 1 year)

Less than 50% of each years plants surviving beyond the first summer

Medium term failure of all plantings (2-10 years)

- Less than 40% of all plants planted surviving beyond first year
- Less than 80% of surviving plants producing viable seed at a rate similar to that of the natural population.
- Seedling recruitment significantly less than that observed at the natural populations

Long term failure of all plantings (greater than 10 years)
Population fails to become viable and self-sustaining.

5. TIMETABLE

Time	Action
August 2013	Submission of Translocation Proposal
September 2013	Germination of seeds at the TFSC
October 2013 – June 2014	Cultivation of plants at Kings Park and Botanic Gardens
June 2014	Seedlings planted at translocation site.
September 2014	Progress report
December 2014	Monitor survival and growth
Annual review	Monitor survival and growth, assess flower and fruit production

6. FUNDING

This project is fully funded under the State NRM "Fast Track Critically Endangered Flora Recovery" project for 3 years. The Flora Conservation Officer (currently filled by S. Barrett) based at South Coast Region is a permanent position and the Region has committed to on-going monitoring of the translocation site. The proponents are therefore willing to make a commitment to monitor the translocation beyond the availability of the State NRM funding.

7. ACKNOWLEDGMENTS

Andrew Crawford – DPAW, Threatened Flora Seed Centre

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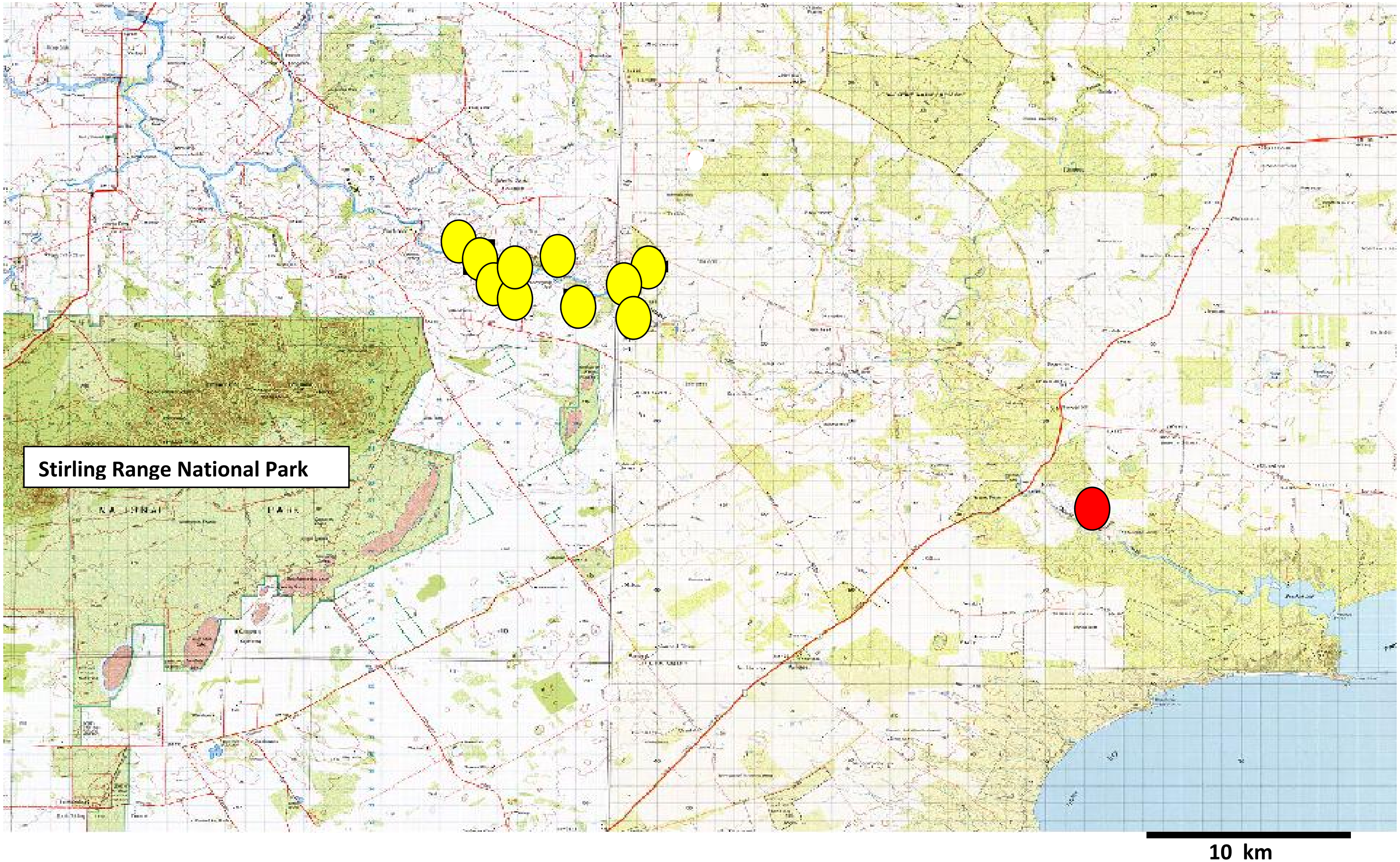
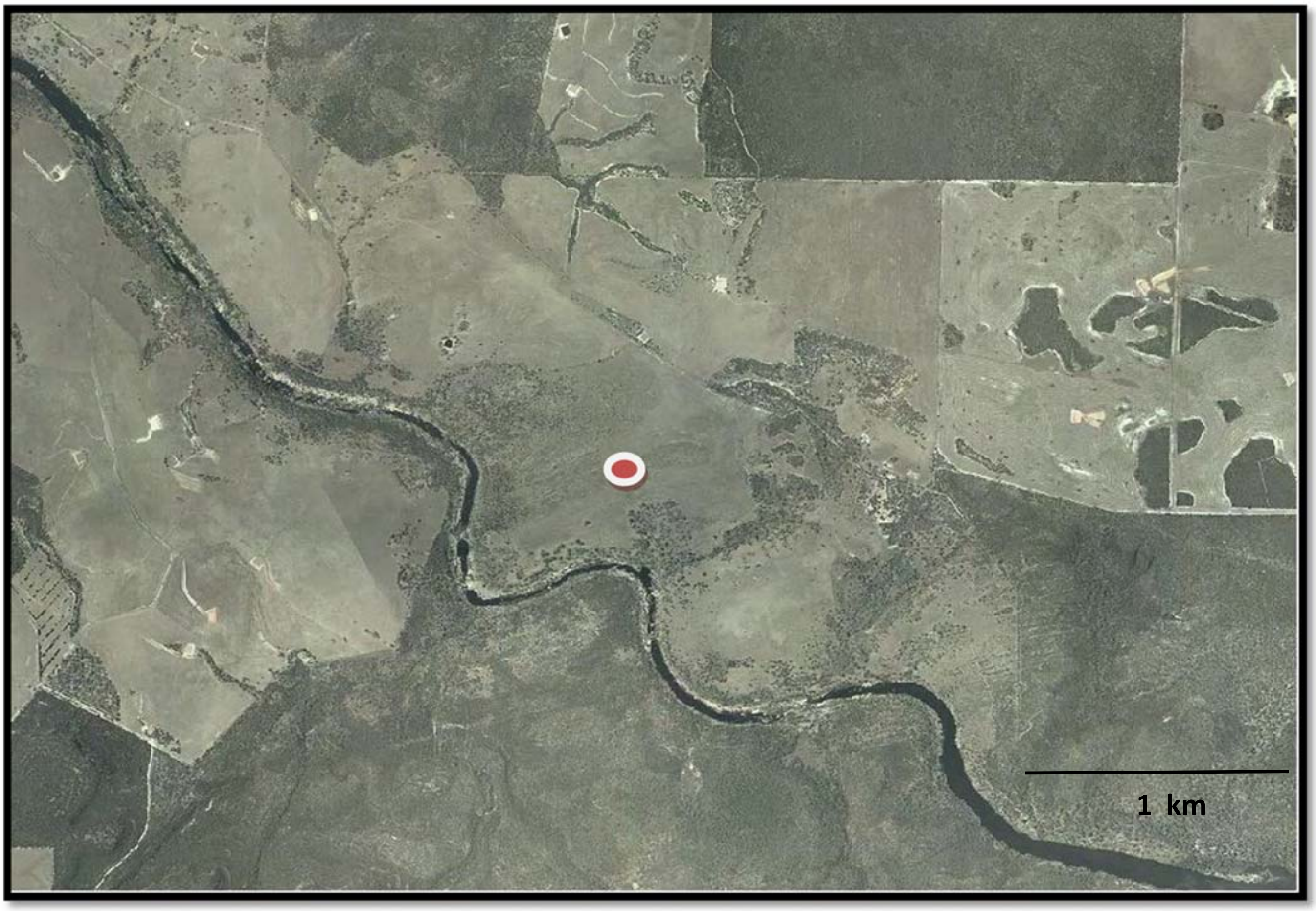
Appendix 1
Map of the proposed translocation site in relation to natural populations of *G. maxwellii*



Appendix 2



Proposed translocation site on Outhwaite's property.

Appendix 3

Management Agreement between the Department of Parks and Wildlife (DPAW) and Mr and Mrs Outhwaite for Proposed translocation site for *Grevillea maxwellii*, Outhwaite's property; 1895 South Coast Hwy, Boxwood Hill, Jerremungup shire.
August 2013

1. Translocated plants will be regarded as DPAW declared Rare Flora and will have the same protection under the Wildlife Conservation Act 1950. Seed or other material harvested from plants will be used for conservation purposes only and will require a permit to take arranged through DPAW Wildlife Conservation Section.

2. With approval from the landholders, DPAW staff will be allowed access to the site for establishment, monitoring and research purposes. The landholder will be contacted by DPAW staff prior to visiting the property.

3. Property firebreaks are to be maintained by the landholder. The location of the translocation site will be added to DPAW's fire information systems in case of wildfire in the area and DPAW will assist with fire suppression if requested by the Chief Bush Fire Controller.

5. Planting out of *Grevillea maxwellii* seedlings to be undertaken in June/July 2014 by DPAW staff. This will include:

- The translocation area will be fenced if necessary, by DPAW staff in consultation with the landholder to protect and clearly define the translocation area. Materials and labour to be provided by DPAW.

- Site preparation (i.e. weed control) to be undertaken by DPAW, if necessary, with the approval of the landholder prior to planting of *G. maxwellii*. Materials and labour to be provided by DPAW.

- An irrigation system will be installed in 2014 by DPAW staff, materials and maintenance (including filling of water tank) to be provided by DPAW.

6. Additional weed control on the site, if required, to be undertaken DPAW as necessary, materials and labour be provided by DPAW.

7. In the event of sale of the property the landholders will advise any prospective purchaser of the status of the plants, which will be protected as DRF, and the ongoing role DPAW will have in monitoring the site and collecting material.

Table 1. Summary of action items

Action	Materials provided by	Responsibility
Site preparation (i.e. weed control)	DPAW	DPAW
Site fencing	DPAW	DPAW
Fire-break maintenance		Landholder
Planting out	DPAW	DPAW
Plant labelling	DPAW	DPAW
Irrigation installation	DPAW	DPAW
Monitoring of irrigation		DPAW
Monitoring of plants		DPAW
Phytophthora hygiene		DPAW/Landholder
Fire suppression		DPAW/Landholder

DPAW Regional Endorsement of MOU (South Coast Region)

....

Date:...............................

Endorsement of the Landholder

....

Date: 13/8/13

TRANSLOCATION PROPOSAL

SCHOENIA FILIFOLIA SUBSP. *SUBULIFOLIA*
MINGENEW EVERLASTING
(ASTERACEAE)
APRIL 2014

1. SUMMARY

Schoenia filifolia subsp. *subulifolia* (F.Muell.) is a Critically Endangered taxon, endemic to the Mid West region of south west Western Australia. It was declared as Rare Flora in 2003 and ranked as Critically Endangered because of its very restricted distribution and area of occupancy and is experiencing continuing decline in the number of mature plants and habitat quality.

Schoenia filifolia subsp. *subulifolia* is an annual erect herb that can grow to 30 cm height and has terete leaves and yellow flowers. Plants flower from September to October (DPaW, 2014). The inflorescence consists of open corymbs with a hemispherical involucre and a ray approx. 7-10 mm long (Wilson, 1992). The innermost bracts have a yellow ovate lamina approx. 5 x 2.5 mm (Patrick, 2001). The fruit is a terete achene covered in dense hairs (Wilson, 1992). Extant populations occur in pale yellow/grey/brown clay, in swampy flats, tops of breakaways and crabholes (DPaW, 2014).

The first collection of *S. filifolia* subsp. *subulifolia* was made by J. Drummond in the 1800s. The habitat of *S. filifolia* subsp. *subulifolia* has been extensively cleared for agriculture and the taxon is now restricted to a small area between Yandanooka and Mingenew to the southeast of Geraldton. Only three extant populations remain, containing approx. 5200 mature plants. All populations occur on private property.

All *S. filifolia* subsp. *subulifolia* populations are highly threatened with extinction. The main threats are agricultural activities such as herbicide drift, land degradation by stock or machinery, weed invasion and secondary salinity.

Currently there are 168,619 achenes (fruits) from two populations in storage in the Department's Threatened Flora Seed Centre (TFSC), which are estimated to contain more than 155,000 seeds. Germination trials are currently being conducted.

The aim of this translocation proposal is to assist the long term persistence of the species by establishing a new, viable, secure population of S. filifolia *subsp*. subulifolia.

This proposal outlines the need for translocation of the critically endangered *S. filifolia* subsp. *subulifolia,* the site selection process, the design of the translocation and the provisions for monitoring. In addition it outlines the criteria for success or failure of this proposed translocation.

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3. BACKGROUND

3.1 Taxonomy, History and Status

Schoenia (family Asteraceae) is a small genus of five species, all of which are endemic to Australia. *Schoenia filifolia* subsp. *subulifolia* (F.Muell.) Paul G. Wilson is an annual erect herb that can grow to 30 cm height (DPaW, 2014), and has terete leaves and yellow flowers. Plants flower from September to October (DPaW, 2014). The inflorescence consists of open corymbs with a hemispherical involucre and a ray approx. 7-10 mm long (Wilson, 1992). The innermost bracts have a yellow ovate lamina approx. 5 x 2.5 mm (Patrick, 2001). The fruit is a terete achene covered in dense hairs (Wilson, 1992).

Schoenia filifolia subsp. *subulifolia* was first collected by J. Drummond in the 1800s (unknown date or location). Subsequent collections were made between Mingenew and Yandanooka in 1904, between Geraldton and Walkaway in 1962, near Mingenew (Population 1) in 1998, north-east of Mingenew (Population 2) in 1999 and north-east of Yandanooka in 1999 (Population 3) (DEC, 2011). The subspecies was formally named in 1992 by Paul G. Wilson from a collection made at Champion Bay (Geraldton) by P. Walcott (initially named in 1863 as *Helichrysum subulifolium*). *Schoenia filifolia* subsp. *subulifolia* differs from *S. filifolia* subsp. *filifolia* in its larger flower heads, hemispherical involucre, and larger achenes with longer, denser hairs (Wilson, 1992).

Schoenia filifolia subsp. *subulifolia* was reportedly much more widespread in the early 1900s and even up to the 1960s, but its habitat has since been extensively cleared for agriculture and invaded by weeds. Only three extant populations remain, containing approx. 5200 mature plants at last survey (Table 1). However, as the species is an annual, population sizes vary from year to year depending upon seasonal conditions. A fourth population (Population 3) has suffered severe weed encroachment in recent years from which it is unlikely to recover; no plants have been seen since 2007 and the population is considered to be effectively extinct (A. Chant, pers. comm.). All populations occur on private property (farmland). Despite numerous surveys being conducted by DPaW staff and volunteers from the Mingenew Regional Herbarium over the past 15+ years, no additional populations have been located.

Table 1. Population details for ***Schoenia filifolia* subsp. *subulifolia*.**

Population #	Land status	Survey date	Number of individuals at location*	Area of occupancy at location	Condition of site
1	Private property	Aug 2004	1000	20 x 40 m	Site in good condition, moderate number of weeds
		Sept 2013	200		
2	Private property	Oct 2004	200		Site in good condition, moderate number of weeds
		Sept 2013	0		
3 PROBABLY EXTINCT	Private property	Nov 2004	20		Site in poor condition - very weedy
		Oct 2008	0		
		Sept 2013	0		
4	Private property	Sept 2013	5000+	200 x 100 m	Site in moderate condition but plants healthy

Schoenia filifolia subsp. *subulifolia* was declared as Rare Flora in 2003 under the Western Australian *Wildlife Conservation Act 1950* and ranked as Critically Endangered because it has a very restricted distribution and area of occupancy and is experiencing continuing decline in the number of mature plants and habitat quality. The main threats to the taxon are agricultural activities such as herbicide drift, land degradation by stock or machinery, weed invasion and secondary salinity.

The remaining *S. filifolia* subsp. *subulifolia* populations occur in degraded habitat, and none are on secure tenure.

3.2 Distribution and Habitat

Schoenia filifolia subsp. *subulifolia* is endemic to the Dept. Parks and Wildlife Geraldton District of south west Western Australia. It occurs in a restricted area between Yandanooka and Mingenew to the southeast of Geraldton, where it is confined to three small populations covering a range of approximately 50 km. The taxon's extent of occurrence is estimated at 35 km^2 (DEC, 2011) and the area of occupancy is estimated at less than 0.03 km^2.

Schoenia filifolia subsp. *subulifolia* grows in pale yellow/grey/brown clay, in swampy flats, tops of breakaways and crabholes (DPaW, 2014). It may have once occurred on other soil types but is now restricted to small water-gaining areas unsuitable to agriculture (DEC, 2011).

Associated species include *Eucalyptus loxophleba* subsp. *supralaevis, Acacia acuminata, Acacia tetragonophylla, Hakea preissii, Waitzia acuminata, Waitzia nidita, Cephalipterum drummondii, Pimelea microcephala, Ptilotus* sp. and *Scaevola spinescens*.

3.3 Ecology

Schoenia filifolia subsp. *subulifolia* is an annual that germinates from soil-stored seed following late autumn rains. As with many other daisies from semi-arid areas of Western Australia, germination success in a given year is likely to depend upon the timing and volume of rainfall. Flowering occurs from September to October (DPaW, 2014) and seeds are set in late spring.

Schoenia filifolia subsp. *subulifolia* flowers are hermaphroditic and self-incompatible (Png, 2012). In self-pollinated flowers, pollen tube growth is inhibited and no seeds are set (Png, 2012). Pollination is probably predominantly by insects, although some wind pollination may occur over very short distances (Png, 2012).

Levels of viability among *S. filifolia* subsp. *subulifolia* seeds stored at ambient conditions have been found to be high at two to four months following harvest (96%: Choengsaat *et al.*, 1998; 78%: Peishi *et al.*, 1999) and at 32 weeks following harvest (>90%; Bunker, 1994). All seeds are dormant at maturity, with dormancy imposed by the embryo (Bunker, 1994). Temperature-dependent dormancy release occurs following a period of after-ripening; non-dormant seeds germinate readily (Bunker, 1994; Choengsaat *et al.*, 1998). Application of gibberellic acid can promote germination in dormant seeds (Bunker, 1994; Plummer & Bell, 1995).

The amount of rainfall occurring during the growing season is likely to significantly affect the size and branching pattern of *S. filifolia* subsp. *subulifolia* plants, as well as survival and seed production. Choengsaat *et al.* (1998) found that water deficits applied to plants in both glasshouse and field experiments greatly reduced the number of stems per plant and the number of seeds produced, although seed viability was unaffected.

Plants appear to form vesicular-arbuscular mycorrhizal associations but there was no evidence for endomycorrhizal associations (Warcup, 1990).

3.4 Germplasm Collection

Currently there are three collections of *S. filifolia* subsp. *subulifolia* seed in storage in the Department's Threatened Flora Seed Centre (TFSC) (Table 2). The collections (from Populations 1 and 4) have been processed and contain a total of 168619 fruit. A cut test performed on fruit from Population 4 indicated 100% seed fill, but fruits from Population 1 have not yet been tested

(A. Crawford, pers. comm.). Germination trials are currently being conducted. Further collections of seed will be carried out in late 2014 at Populations 1 and 4.

Table 2. Number of *Schoenia filifolia* subsp. *subulifolia* seed in storage in the Threatened Flora Seed Centre

Population #	Number of collections	Number of achenes (fruit)
1	2	9,592 4,017
4	1	155,010 (100% seed fill)

4. THE TRANSLOCATION

4.1 The Need to Translocate

The rarity of *S. filifolia* subsp. *subulifolia* is primarily due to the large-scale clearing of its habitat for agriculture. Old herbarium records and observations indicate that it was widespread in the Mingenew area in the early 1900s and occurred at Walkaway and Champion Bay (areas that it is now absent from) during the 1960s (DPaW, 2014). The plant is now found in only three natural populations, with an estimated 5200 plants at last survey, occupying an area less than 0.03 km^2.

All extant populations occur on degraded agricultural land, and none are on secure tenure. Access to private property is restricted in some cases (particularly Population 2), hindering routine monitoring and implementation of management actions.

Weeds invading from agricultural land are a threat to all populations, and may suppress plant growth and possibly germination by competing for light, nutrients and soil moisture. The seasonality of plant growth for many weed species coincides with that of *S. filifolia* subsp. *subulifolia*. Competition from weeds is probably the main cause of the recent extinction of *S. filifolia* subsp. *subulifolia* at Population 3.

A range of agricultural activities are ongoing threats to the persistence of populations. These include vegetation clearing and agricultural encroachment, soil disturbance, stock grazing, land degradation by stock or machinery, chemical drift and maintenance of fence lines/firebreaks.

Grading and herbicide use appear to have caused past population declines, and continue to be a major threat to populations.

Secondary salinity is a potential threat to Population 2, which occurs in a low-lying area.

Potential changes in surface hydrology (*e.g.* water flows) threaten populations, which occur in water-gaining areas.

Mining is a potential threat to Populations 1 and 3, which occur on a mining tenement.

Fires that occur either too frequently or at the wrong time of year could threaten populations. Fires may increase the abundance of weeds, while soil seed stores could be depleted by fires that occur prior to seed release. Climate change is likely to increase the risk of increased fire frequency and of fires occurring prior to summer/ late spring.

Recruitment and seed production are likely to decline due to land degradation, the drying climate and the lack of available habitat for seedlings to recruit into. The highly degraded site condition at Population 3 appears to have prevented recruitment and survival of *S. filifolia* subsp. *subulifolia* plants, leading to this population's probable extinction.

A decline in genetic diversity could detrimentally affect the species' viability through reduced seed production, seed viability and offspring fitness, as well as reducing its capacity to adapt to altered selective conditions. As *S. filifolia* subsp. *subulifolia* is an obligate outcrossing species, low genetic diversity in a population could reduce the likelihood that a given pollination event will occur between two sufficiently unrelated plants and result in successful seed production.

The above threats are exacerbated by the existence of only three populations with a small area of occupancy. As population sizes decrease and isolation increases following fragmentation, populations may become more vulnerable to extinction due to: (i) the loss of genetic variation and increased inbreeding have been associated with a reduction in the ability of a population to adapt to environmental change; (ii) small populations are more susceptible to chance events due to environmental or human impacts; and (iii) the population size or density is so low that the plant's reproductive capacity drops below the threshold required for population viability (Hobbs & Yates, 2003).

Despite numerous surveys being conducted by DPaW staff and volunteers from the Mingenew Regional Herbarium over the past 15+ years, no additional *S. filifolia* subsp. *subulifolia* populations have been located. However, it is possible that other small populations exist in isolated patches of remnant vegetation on private properties that are currently inaccessible. If such populations do exist, they are likely to be subject to the same threatening processes as the currently known populations.

The current status of *S. filifolia* subsp. *subulifolia* indicates that translocation is now crucial to the recovery of the species, and that the establishment of new, secure populations is required to increase the viability of the species and reduce the chances of extinction. Translocation to new sites will create secure populations and buffer the species against random loss of populations due to unpredictable environmental events (Guerrant, 1996) or human activities.

The aim of this translocation is to assist the long term persistence of this species by establishing new, viable populations of *S. filifolia* subsp. *subulifolia* secured on conservation reserves.

4.2 Translocation Site Selection

A search of conservation reserves in the vicinity of the known populations of *S. filifolia* subsp. *subulifolia* was conducted to locate suitable translocation sites. The search focused on land with secure tenure that had similar soil and drainage characteristics and associated vegetation to the natural populations, and did not have significant weed issues (in particular iceplant, *Mesembryanthemum nodiflorum*). Additional factors in site selection were: potential conflicts with the Coalseam Recreation Masterplan; the risk of disturbance by members of the public, as some potential sites were close to tourist facilities or attractions; and ease of delivery of water for irrigation of the translocation sites.

Three sites were selected for the translocations, all located within Coalseam Conservation Park, and therefore on secure conservation estate. The park contains areas with similar vegetation and soils to those found in natural populations of *S. filifolia* subsp. *subulifolia*. Numerous species of native annual daisy (see Table 3) are found within Coalseam Conservation Park, strongly suggesting the presence of healthy populations of insects that successfully pollinate annual daisies. It is considered unlikely that S. *filifolia* subsp. *subulifolia* will hybridise with the other annual daisy species present at the proposed translocation sites (P. Wilson pers. comm. Apr 2014)There are no known records of either *S. filifolia* subsp. *subulifolia* or its sister subspecies *S. filifolia* subsp. *filifolia* occurring within the park.

The Coalseam Rd site is located approximately 200 m east of Coalseam Rd, 1.5 km from the southern boundary of the Conservation Park. The translocation site consists of an open area approximately 100 m^2, surrounded by vegetation consisting of *Eucalyptus loxophleba* open woodland and a sparse understorey. The vegetation is in good condition, and there are very low numbers of iceplant present, although iceplant is very common in the surrounding area. The site is a relatively flat area just above a steep gully, with red/brown clay/loam soil. Access to the site is on foot through open woodland from Coalseam Rd. The likelihood that members of the public may access the site is minimal, due to the lack of either an access track or obvious features of interest.

The Najet site is located approximately 1.4 km south of Lookout Rd, 600 m from the eastern boundary of the Conservation Park, and 370 m SSE across the Irwin River South from the Miners picnic area and campground. The translocation site consists of two small open areas, each approximately 20x20 m, surrounded by vegetation consisting of *Eucalyptus loxophleba* open woodland and a sparse understorey including salt bush and several daisy species. The vegetation is in good condition and there are low numbers of iceplant present at the site, although iceplant is very common in the surrounding area. The site is relatively flat but water-gaining, and has red/brown clay/loam soil. Access to the site is on foot from the Miners carpark, crossing the bed of the Irwin River South and walking through open woodland for 300 m. This route passes close to the old mineshaft tourist site. The likelihood that members of the public may access the Najet site is low to medium, due to the proximity to the Miners campground and mineshaft.

The Miners site is located approximately 1.4 km south of Lookout Rd, 600 m from the eastern boundary of the Conservation Park, and 200 m south across the Irwin River South from the Miners picnic area and campground. The translocation site consists of an open area approximately 10x20 m, surrounded by vegetation consisting of *Eucalyptus loxophleba* open woodland and *Acacia acuminata* shrubland with a sparse understorey of low shrubs. The vegetation is in good condition with no iceplant present, although iceplant is present in the woodland to the east. The introduced grass *Pentameris airoides* occurs on the site, varying from sparse to thick. Several species of native annual daisy are present. The site is a relatively flat drainage line/flow on area, has red/brown clay/loam soil. Access to the site is on foot from the carpark, crossing the bed of the Irwin River South and walking through open woodland for 200 m. This route passes close to the old mineshaft tourist site. The likelihood that members of the public may access the Miners site is medium to high, due to the proximity to the Miners campground and mineshaft.

Table 3. Associated vegetation at proposed translocation sites for *Schoenia filifolia* subsp. *subulifolia*.

Associated species at the proposed translocation sites
Amaranthaceae
Ptilotus obovatus
Asteraceae
Waitzia acuminata
Chenopodiaceae
Enchylaena tomentosa
Rhagodia drummondii
Fabaceae
Acacia acuminata
Acacia tetragonaphylla
Myrtaceae
Eucalyptus loxophleba subsp. *supralaevis*
Solanaceae
Solanum lasophyllum

Potential threats at the sites include grazing and trampling by rabbits and kangaroos, which will be managed by erecting small fenced enclosures over and around each 1x1 m^2 plot. These will consist of 1x1x0.5 m mesh cages held in place using heavy duty tent pegs. Another potential threat is disturbance by members of the public, either through trampling or picking. These threats will be managed by siting two of the translocation sites in locations that are unlikely to be discovered by most visitors to the park, and by having minimal infrastructure at the site that should attract little attention.

Endorsement for the use of these sites has been sought from the Midwest Region and the translocation will not go ahead unless the project is approved by the Region (See Approvals page attached).

4.3 Site Management

As these plants will be established for the purpose of conservation, they will be regarded as Declared Rare Flora and will have the same legal protection. Any seed harvested from plants will be used for conservation purposes only.

As a Class A Conservation Park, Coalseam has secure conservation tenure for the protection of the translocation site. Coalseam is managed by the Department of Parks and Wildlife to conserve the area's biological, cultural and scenic values as well as provide for forms of recreation that do not adversely affect the values of the Park. Coalseam provides visitors with a basic camping area, picnic area, lookout and short walk trail, and receives an estimated 8000 to 36000 visitors a year, primarily during wildflower season (August and September) (DEC, 2013).

The land managers (Department of Parks and Wildlife) maintain firebreaks and manage visitors for the Conservation Park as a whole. Annual rainfall (less than 350 mm) is too low for dieback (*Phytophthora cinnamomi*) to affect vegetation at Coalseam Conservation Park.

If a prescribed burn is planned for Coalseam Conservation Park in future the District Flora Conservation officer will recommend that the translocation sites are excluded and protected during the burn until more is known about the fire response of this subspecies.

Weed control via chemical spraying will be undertaken at each translocation site and the area surrounding each site in 2014, primarily in order to control iceplant. Spraying will occur on a minimum of two occasions, firstly following the first flush of autumn/winter germination, and later in winter after further germination has occurred. Further weed control will occur in 2015 if necessary.

4.4 Translocation Design

Seeds for translocation have been collected from Populations 1 and 4. At each translocation site, the translocation will involve both direct seeding and the planting of seedlings, in order to perform a direct comparison between the effectiveness of direct seeding and the planting of seedlings. The majority of seeds used for the translocations will be from Population 4, due to the relatively small number of seeds in storage collected from Population 1.

Planting seedlings

Seeds will be germinated under laboratory conditions at the TFSC in late April 2015, (*i.e.* at the same time that seeds are sown in the field), before being transferred to the Botanic Gardens and Parks Authority (BGPA) nursery. The BGPA nursery will grow on germinants to seedling stage, and seedlings will be planted at the translocation sites in mid to late June.

At each translocation site, seedlings will be planted within five 1x1 m^2 plots that will be dispersed within the site in the most weed-free areas. Within each plot, 100 seedlings will be planted in a grid system, with seedlings at intervals of 10 cm. Seedlings will be hand watered following planting.

Direct seeding

Direct seeding will involve undertaking light soil disturbance, pressing seeds into small holes at a depth of 5 mm, and covering lightly with soil followed by hand watering. This will take place in late April 2015.

At each translocation site, seeds will be sown within five 1x1 m^2 plots that will be dispersed within the site in the most weed-free areas. Seeds will be sown in a grid system similar to that used for planting seedlings, with 100 holes containing seeds, and holes at intervals of 10 cm. The number of seeds sown per hole will depend upon the results of germination tests that are currently being conducted, but is expected to be between 1 and 3 seeds, based on data in the literature suggesting a very high germination rate for viable, non-dormant seeds of *S. filifolia* subsp. *subulifolia* (Bunker, 1994; Choengsaat *et al.*, 1998). We aim to sow sufficient seeds to enable approximately 100 seeds to germinate per plot, *i.e.* comparable to the number of seedlings planted in seedling plots.

At each site, sacrificial seeds will be buried in mesh bags to be retrieved later and tested for viability in case there was poor germination in the direct seeded plots.

Watering

To avoid seedling losses due to possible lack of rainfall through the winter, additional water will be provided if required. Hand watering will be conducted using watering cans. Depending upon the quantity of water required, it will either be carried in by hand or delivered via a hose from a Parks and Wildlife fire unit. Prior to filling with water, the tanks of departmental fire trucks are sterilised with a bleach solution to kill pathogens, and then rinsed. Watering will only occur in the year in which translocations are conducted at a particular site.

Monitoring

Monitoring of the translocated populations will be undertaken several weeks after planting and then at peak flowering time in spring.

During the first year, monitoring of translocated populations will include counting the number of surviving plants, and for each plant, noting its general health, measuring its height, and recording its reproductive state, number of flowers, and presence or absence of seed set. If seed set occurs, a sample of seeds will be collected to conduct laboratory viability tests.

During subsequent years, monitoring will continue twice a year: (1) after the first autumn/winter rains to record germination, and (2) in spring to record population health, recruitment, flowering and seed production. Plant height, number of flowers produced and seed set will be recorded for a random sample of plants.

Monitoring of the natural populations will also occur annually. This will provide essential baseline data for assessing the performance of the translocated plants. Monitoring will include estimating the number of individuals, and recording plant height, number of flowers produced and seed set for a random sample of plants.

4.5 Source of Plants

Plants will be grown from seed sources at the TFSC, based on material sourced from Population 1 in 2007 and 2013 and from Population 4 in 2013, and from additional collections planned from Populations 1 and 4 in late 2014. Current seed collection guidelines (up to 20% of available seed on one plant at time of collection) will be followed to ensure sufficient seed remains to replace the present populations in the event of a major disturbance such as a fire.

No known genetic studies have been undertaken for this species. In the absence of such data, we will use a conservative approach and aim to plan, implement and manage the translocation in such a way as to maximise its genetic diversity. Under international guidelines (*eg*. Guerrant *et al.,* 2004), when the breeding system of the species is unknown it is recommended that seed is collected from at least 50 plants to ensure 95% of the genetic variation within that population is represented in the collection.

Seedlings will be raised at BGPA’s accredited nursery at Kings Park, which has hygiene procedures in place to ensure seedlings are free from diseases, pests and weeds.

4.6 Criteria for Success or Failure

The aim of the translocation is to achieve viable and self-sustaining populations of *S. filifolia* subsp. *subulifolia*. The time frames required to achieve this aim may need to be adjusted to take into account the number of plants available for planting, seasonal influences on germination and survival, and availability of funding.

Biological success or failure

<u>Success</u>

Initial success of each planting (approx 6 months)

- Translocated seedlings: Seedling survival, flowering and production of viable seeds to occur at a rate similar to that in natural populations.
- Direct seeding: Germination to occur at a rate similar to estimated seed viability; seedling survival, flowering and production of viable seeds to occur at a rate similar to that in natural populations.

Medium term success of all plantings (2-5 years)

- Natural recruitment of a second generation, with a similar number of plants recruiting to that in natural populations as a proportion of the previous year's population size.
- Natural recruitment of subsequent generations, with a similar number of plants recruiting to that in natural populations as a proportion of the previous year's population size.
- Area of occupancy either increases or remains stable.

Long term success of all plantings (greater than 5 years)

Establishment of a viable self-sustaining population.

<u>Failure</u>

Initial failure of each planting (approx 6 months)

- Translocated seedlings: Survival of seedlings to flowering and production of viable seeds occurs at a rate less than 50% of that in natural populations.
- Direct seeding: Germination, seedling survival, flowering and production of viable seeds occurs at a rate less than 50% of that in natural populations.

Medium term failure of all plantings (2-5 years)

- Recruitment of a second generation and subsequent generations occurs at a rate less than 50% that in natural populations.
- Area of occupancy decreases.

Long term failure of all plantings (greater than 10 years)

Population fails to become viable and self-sustaining.

5. TIMETABLE

Time	Action
April 2014	Translocation proposal submitted for review and approval
Late April 2015	Direct seeding at translocation site
Late April 2015	Seed germination at TFSC
May - June 2015	Propagation of seedlings at BGPA
Mid-late June 2015	Seedlings planted at translocation site
October 2014	Monitor, assess flower and fruit production
Annual review	Monitor, assess flower and fruit production

6. FUNDING

This project is fully funded under the State NRM "Fast Track Critically Endangered Flora Recovery" project, finishing in June 2015. Two of the proponents, Alanna Chant, Flora Conservation Officer based at Geraldton, and Leonie Monks, Research Scientist, are internally funded by Dept. Parks and Wildlife on an ongoing basis. The proponents are therefore willing to make a commitment to monitor the translocation beyond the availability of the State NRM funding.

7. ACKNOWLEDGMENTS

Andrew Crawford – Dept. Parks and Wildlife, Threatened Flora Seed Centre
Amanda Shade - BGPA

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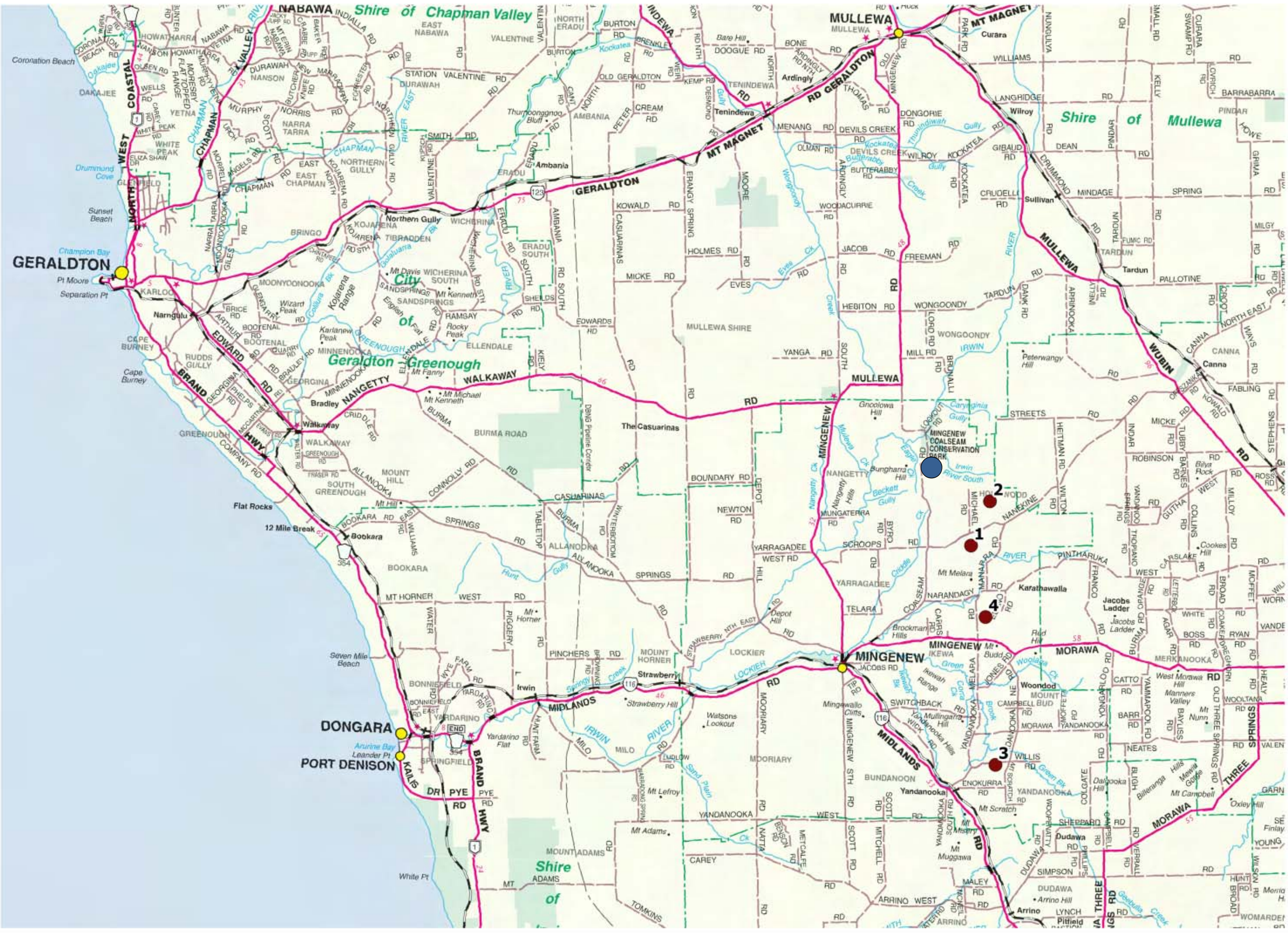
APPENDIX 1

Natural populations of *Schoenia filifolia* subsp. *subulifolia* including proposed translocation site

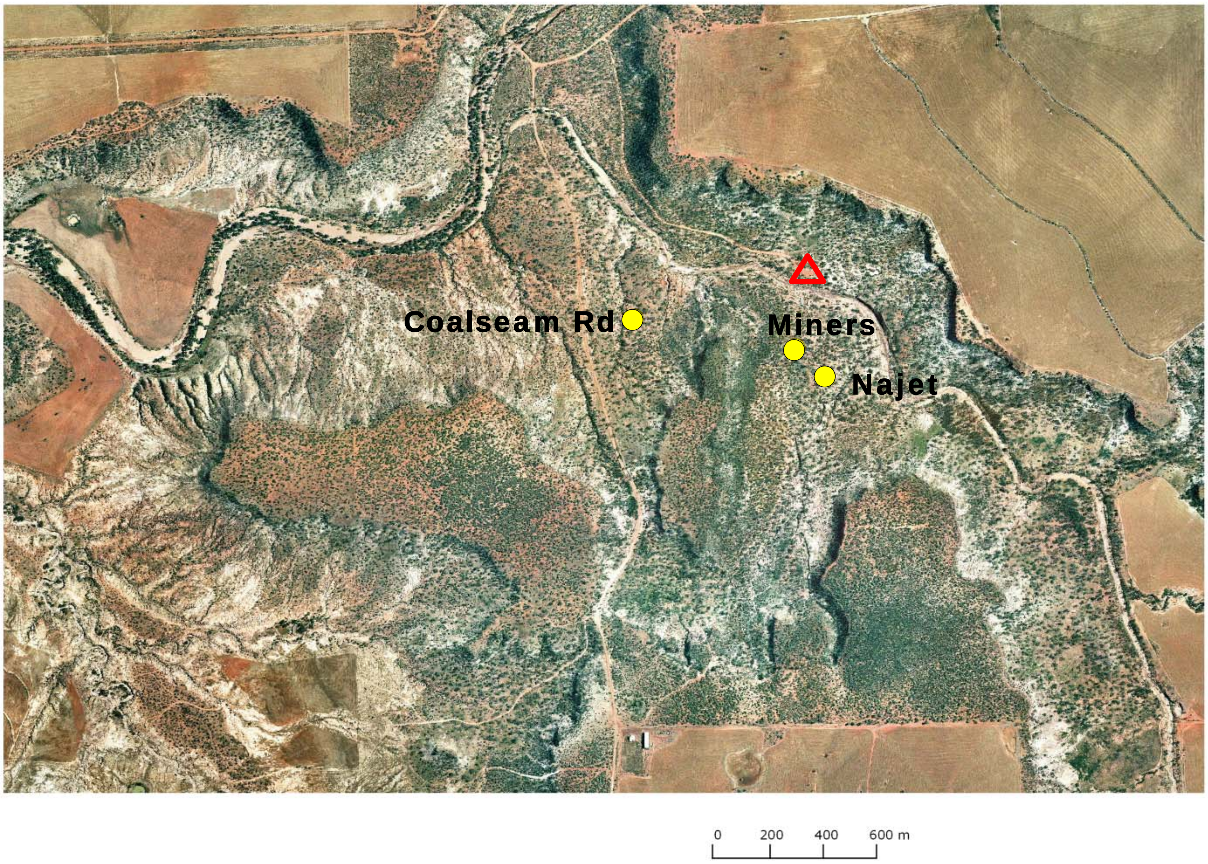


Schoenia filifolia subsp. subulifolia natural populations

Proposed translocation sites

APPENDIX 2

Proposed translocation sites within Coalseam Conservation Park



Proposed translocation sites

Miners picnic area and campsite

TRANSLOCATION PROPOSAL
Dwellingup Synaphea
Synaphea stenoloba A.S.George (Proteaceae)

1. SUMMARY

Synaphea stenoloba A.S.George is a Critically Endangered taxon endemic to the Pinjarra area, south of Perth in south west Western Australia. It was declared as Rare Flora in December 1999 and ranked as Critically Endangered at the same time. The ranking was due to populations being severely fragmented, deteriorating habitat quality and a decline in population numbers (Department of Environment and Conservation [DEC] 2013). *S. stenoloba* is currently known from 12 natural and one translocated population consisting of approximately 1425 mature individuals.

S. stenoloba is a compact, tufted shrub to 50cm high. Leaves are 10 to 45cm long and commonly divided three times (tripinnatipartite). Yellow inflorescences are held above the leaves to a height of 35cm. Flowers occur mainly from September to October (George 1995).

S. stenoloba grows on sandy or sandy clay soils, winter wet flats; commonly in swampy loam in depressions that are occasionally inundated. The majority of populations occur on privately owned land, or on road or rail verges. Just two small populations occur on land vested for the purpose of conservation. The species also occurs in association with two Threatened Ecological Communities: the Critically Endangered *"Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain (type SCP3a)" and the Vulnerable "Dense shrublands on dry clay flats (type SCP09)" (DEC 2013).

Synaphea stenoloba is threatened by weeds, road, rail and firebreak maintenance activities, hydrological changes, future mining operations, rabbits, habitat disturbance, inappropriate fire regimes, mealy bugs, clearing, dieback disease, insecure land tenure, poor recruitment and limited seed production.

The aim of this translocation proposal is to assist the long term persistence of the species by re-introducing an extinct population of *S. stenoloba*.

This translocation proposal outlines the need for translocation of the Critically Endangered *S. stenoloba*, the site selection process, the design of the translocation site and the provisions for monitoring. In addition, it outlines the criteria for success or failure of this proposed translocation.

2. Proponents

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David Willyams Propagation and Revegetation Research Officer Alcoa World Alumina, Australia Dwellingup WA (08) 9538 1578	Niall Sheehy Flora Conservation Officer Dept. Parks & Wildlife MUNDARING WA (08) 9290 6100
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3. BACKGROUND

3.1 Taxonomy, History and Status

Synaphea stenoloba A.S.George is a compact, tufted shrub to 50cm high. Leaves are 10 to 45cm long and commonly divided three times (tripinnatipartite). Yellow inflorescences are held above the leaves to a height of 35cm. Flowers occur mainly from September to October (George 1995).

Synaphea stenoloba has elongated, pinkish stems with long internodes, with the leaves arising at isolated points along the stem. The leaf lamina is either folded along the midline or has distinctly multiplanar ultimate lobes, the petioles are long and glabrous, and the margins of the sheathing bases of the petioles are usually pink to red. Inflorescences are long, terminal, somewhat undulate through the flowering region, with spikes arising at the tips of the branches. The sheaths surrounding the base of the spikes are few in number and are usually pink to red. The flowers are usually glabrous, moderately to widely opening, and with a broad, convex stigma which has short apical lobes (Butcher 2004; Butcher and Thiele 2014).

Many *Synaphea* species appear very similar to *S. stenoloba* and occur very close to known populations. These species include *S. gracillima*, *S. odocoileops*, *S. petiolaris*, *S*. sp. Fairbridge Farm, *S*. sp. Serpentine and a putative hybrid between *S. petiolaris* and either *S. gracillima* or *S.* sp. Serpentine (DEC 2013). The most difficult species to distinguish from *S. stenoloba* is *S. odocoileops*, although the strongly ascending, narrowly opening, glabrous flowers of that species are distinctive (Butcher and Thiele 2014).

Synaphea stenoloba was first collected from the Swan Coastal Plain as early as 1842 and 1900, but was not described until 1995 (in a review of the genus by A.S. George), following its relocation in 1993 north east of Pinjarra.

Synaphea stenoloba was declared as Rare Flora in December 1999 and given the ranking of Critically Endangered at the same time. The species meets the IUCN (2001) criteria for listing as Critically Endangered under criteria B1ab(iii)+2ab(iii) due to populations being severely fragmented, deteriorating habitat quality and a decline in population numbers (DEC 2013).

When *S. stenoloba* was first listed as Critically Endangered in 1999, it was known from four populations with a combined total of 332 individuals. Further surveys following the listing have located an addition six populations, bringing the total of known natural populations to 12 with a combined total of 1425 individuals. A translocation, developed and implemented by David Willyams from Alcoa World Alumina, Australia (hereafter Alcoa), was set up at a site south east of Pinjarra in 2007. The plants were propagated from tissue culture with material sourced from Population 1 in 2005. A total of 105 plants were planted at the translocation site on the 14th of July 2007. However, a combination of heavy grazing by kangaroos, drought, unsuitable soils and competition from grassy weeds are thought to have contributed to the loss of all plants by winter 2008.

3.2 Distribution and Habitat

Synaphea stenoloba is endemic to the Pinjarra Plain in Western Australia occurring mainly around the town of Pinjarra. An outlying population occurs near Yarloop.

The species is known from 12 natural and one translocated population with the total population estimated to be 1425 natural plants (Table 1). Two of the natural populations and the translocated population currently have no living plants. Populations occur over a range of approximately 44km however the species has an estimated area of occupancy of just 0.04km^2 (DEC 2013). The majority of populations occur on privately owned land or on road, or rail verges (Table 1). Just two small populations occur on land vested for the purpose of conservation (Populations 10 and 14).

Synaphea stenoloba grows on sandy or sandy clay soils and in winter wet flats, commonly in swampy loam in depressions that are occasionally inundated. Average annual rainfall is approximately 900mm for the Pinjarra area (BOM 2013), where the species occurs. The predominant associated vegetation community is wetland heath to 1m high with emergent *Nuytsia floribunda*. Common associated species are *Pericalymma ellipticum*, *Regelia ciliata* and *Corymbia calophylla* (DEC 2013). The species also occurs in association with two Threatened Ecological Communities (TECs): the Critically Endangered *"Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain (type SCP3a)" and the Vulnerable "Dense shrublands on dry clay flats (type SCP09)" (DEC 2013).

Table 1. Population information for *Synaphea stenoloba*

Population no. & location	DPaW district	Vesting	Manager	Number of individuals
1a. NE of Pinjarra*	Perth Hills	Main Roads Western Australia (MRWA)	MRWA	2003: 474 (a&b)
1b. NE of Pinjarra	Perth Hills	Private property	Alcoa	1993: 135 2003: 474 (a&b)
1c. NE of Pinjarra	Perth Hills	Private property	Alcoa	1993: 6 2002: 0 2003: 4
1d. NE of Pinjarra*	Perth Hills	Private property	Alcoa	1997: 25 2002: 28 2003: 2
2a. NE of Pinjarra	Perth Hills	Private property	Landowners	2002: 4 2003: 9
2b. NE of Pinjarra	Perth Hills	Private property	Landowners	2003: 34
2c. NE of Pinjarra	Perth Hills	Private property	Landowners	2003: 3
3a. SE of Pinjarra*	Perth Hills	Public Transport Authority (PTA)	Brookfield Rail	1997: 15 2003: 67
3b. SE of Pinjarra	Perth Hills	PTA	Brookfield Rail	1998: 40 2003: 154
3c. SE of Pinjarra	Perth Hills	PTA	Brookfield Rail	2003: 16
3d. SE of Pinjarra	Perth Hills	PTA	Brookfield Rail	2003: 127
4a. SE of Pinjarra	Perth Hills	Local Government Authority (LGA)	Shire of Murray	2002: 64 2003: 4 2009: 12
4b. SE of Pinjarra	Perth Hills	LGA	Shire of Murray	2003: 94 2009: 10
4c. S of Pinjarra	Swan Coastal	MRWA	MRWA	2003: 1
4d. S of Pinjarra	Perth Hills	MRWA	MRWA	2003: 1
5. N of Yarloop	Swan Coastal	PTA	Brookfield Rail	2001: ~50 2003: 70
6a + 6d. N of Pinjarra*	Swan Coastal	Private property	Landowners	2003: 7 2007: 100 2008: 346 2010: 143

Table 1 Continued. Population information for *Synaphea stenoloba*

Population no. & location	DPaW district	Vesting	Manager	Number of individuals
6b. N of Pinjarra*	Swan Coastal	LGA	Shire of Murray	2003: 218
6c. N of Pinjarra*	Swan Coastal	LGA	Shire of Murray	2003: 158 2008: 15
7. N of Pinjarra	Perth Hills	PTA	Brookfield Rail	2003: 9 2007: 0
8. ENE of Pinjarra*	Perth Hills	Private property	Alcoa	2005: 60 2014: 0
10. SW of Pinjarra	Swan Coastal	Conservation Commission of Western Australia (CCWA)	DPaW	2007: 12
12. SW of North Dandalup	Swan Coastal	PTA	Brookfield Rail	2003: 1
13. Fairbridge*	Perth Hills	Private Property	Landowners	2008: ~100 2009: 48
14. Austin Bay	Swan Coastal	CCWA	DPaW	2008: 4
Translocation Site SE of Pinjarra	Perth Hills	Private property	Alcoa	2013: 0

*= Occurrence of TECs *"Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain (type SCP3a)" or "Dense shrublands on dry clay flats (type SCP09)"

3.3 Ecology

The fire response of *S. stenoloba* is unknown (DEC 2013), as is the length of the juvenile period.

Pollination of *S. stenoloba* is likely through insect vectors (e.g. species of the native solitary bee *Leioproctus* (Colletidae); Houston 2000 & *pers. comm.* September 2013), although recent research suggests that the ballistic pollen ejection system that is characteristic of *Synaphea* enables pollen to disperse to neighbouring plants (Ye *et al.* 2012).

Testing for susceptibility of *S. stenoloba* to *Phytophthora cinnamomi* has shown the species has a high level of tolerance to the disease (C. Crane *pers. comm.* March 2015).

3.4 Germplasm Collection

Currently there are only a small number of collections of *S. stenoloba* fruit in storage at the Department's Threatened Flora Seed Centre (TFSC). Due to small sample sizes, these collections have not been quantified or germination tested (A. Crawford *pers. com*. March 2015). The seed has been collected from Populations 4 and 5 (Table 2). High levels of seed abortion and predation have been observed across the genus *Synaphea*, making seed collection for storage and propagation difficult (DEC 2013). The best method for propagation is through the use of tissue culture (Bunn *et al.* 2010). Alcoa currently have 20 clonal lines of *S. stenoloba* in culture. These are derived from plants collected in 2005 from Population 1a (Table 3). Plants from these clonal lines were used for the translocation planted by Alcoa in 2007.

Table 2. Collections of *Synaphea stenoloba* fruit in storage in the Threatened Flora Seed Centre

Population	TFSC accession number	Collection date	Collection details	Number of fruit	Status of collection
4. SE of Pinjarra (Fairbridge Farm)	00740	15/12/1999	Bulk of 30 plants	54	Not yet tested
5. N of Yarloop	02959	7/1/2009	8 individuals	Not yet processed	Not yet tested

4. THE TRANSLOCATION

4.1 The Need to Translocate

Synaphea stenoloba qualifies as Critically Endangered due to the extent of occurrence estimated to be less than $100km^2$; severe fragmentation; a continuing decline, in area, extent and/or quality of habitat; and the area of occupancy estimated to be less than $10km^2$. The threats to the species are weeds, road, rail and firebreak maintenance activities, hydrological changes, future mining operations, rabbits, habitat disturbance, inappropriate fire regimes, mealy bugs, clearing, dieback disease, insecure land tenure, poor recruitment and limited seed production (DEC 2013). Population decline is likely as habitat quality is reduced by these threats.

Large-scale land clearing in the area encompassing *S. stenoloba* has led to the severe fragmentation of habitat. Populations are small and confined to isolated patches of remnant vegetation or road reserves. The opportunity for populations to expand even in the absence of threatening processes is limited due to the fragmented nature of the habitat. Additionally, maintenance of these small road or rail reserves can also lead to damage or destruction of plants. As the population size decreases and isolation increases, populations may become more vulnerable to extinction for the following reasons: (i) the loss of genetic variation and increased inbreeding have been associated with a reduction in the ability of a population to adapt to short-term environmental change; (ii) small populations are more susceptible to chance events due to environmental or human impacts; (iii) the population size or density is such that the reproductive capacity drops below a threshold so that the organism can no longer replace itself (Hobbs and Yates 2003).

Weed infestation also threatens most populations of *S. stenoloba*. Many of the populations are located on road and rail verges and exposure to fire or other disturbance may see an increase in weed density. The presence of weeds can impact on recruitment and plant growth through competition for soil moisture, nutrients, space and light and also exacerbate grazing and fire risk through increased fuel loads (DEC 2013).

Given the limited distribution of the species, small population sizes, decline of several populations and current threats, the Interim Recovery Plan (DEC 2013) recommends translocation to a secure, threat-free site in order to assist the survival of the species.

The current status of S. stenoloba *leads us to believe that translocation is crucial to the recovery of this species.*

4.2 Translocation Site Selection

The suitability of several proposed sites was assessed in August 2013 by Anne Harris (Flora Conservation Officer, Swan Coastal District, Dept. Parks and Wildlife), Niall Sheehy (A/Flora Conservation Officer, Perth Hills District, Dept. Parks and Wildlife), Craig Olejnik (Program Leader Nature Conservation, Swan Coastal District Dept. Parks and Wildlife), Nicole Godfrey (Conservation Officer, Swan Coastal District, Dept. Parks and Wildlife), David Willyams (Alcoa), Leonie Monks, Ryonen Butcher and Tanya Llorens (Research Scientists, Science Division, Dept. Parks and Wildlife). The locations of Populations 6b and c, 13 and 14, as well as Meelon Nature Reserve and Burnside Nature Reserve, were visited. The sites were assessed on the basis of disease status, hygiene issues, access, soil and vegetation type, risk of accidental damage, presence of weeds, drainage, windbreaks, the presence of potential pollinators, presence of Threatened Ecological Community occurrences and the presence of other *Synaphea* species that could pose a risk of potential hybridisation with *S. stenoloba*. A further site visit by Leonie Monks and Mychelle Joyce (Environmental Officer, Fairbridge) to Populations 10 and 13 occurred in October 2013. This was followed by sites visits to the Alcoa bushland and Population 8, in November 2013 by Leonie Monks, Anne Harris, David Willyams and Suellen Davies (Alcoa) and in February 2014 by Leonie Monks, Anne Harris and Val English (Dept. Parks and Wildlife).

The selection of suitable translocation sites within the known distribution of *S. stenoloba* is extremely limited due to the lack of suitable, threat-free, native vegetation in the area. Another major factor limiting use of new sites is the presence of several other *Synaphea* species in the area, several of which are also listed as Threatened. Site selection is further limited by the occurrence of many populations of *S. stenoloba* within Threatened Ecological Communities. As such, it appears that the best option is to restock, or reintroduce a known population, in conjunction with measures to control the threatening processes that occur at these sites. The site selected for the translocation is: Alcoa bushland, location of Population 8. This site was chosen because of the absence of weeds, the low risk of accidental damage, the size of the remnant is sufficient to provide area for population expansion and habitat for pollinators and ease of access to site for maintenance and monitoring.

It is proposed to establish the *S. stenoloba* plants from Population 1A at the translocation site in winter 2016. A map of the proposed translocation site and the known populations is shown in Appendix 1. Endorsement for the use of this site has been sought from the DPaW Swan Region, and Perth Hills and Swan Coastal Districts and the translocation will not go ahead unless the project is approved by the Region and Districts (see attached approvals page). Permission to use this site has also been sought from the landowner, Alcoa of Australia (see Appendix 2).

The proposed site is located at Population 8 of *S. stenoloba*. There are currently no plants of *S. stenoloba* at the site and, as such, the translocation can be considered a 'reintroduction' under the definitions provided by the Guidelines for Translocation of Threatened Plants in Australia (Vallee *et al.* 2004) and DPaW Policy Statement 29 (Anon. 1995).

The two most likely causes of the extinction of *S. stenoloba* at this location have been hypothesized to be *Phytophthora cinnamomi* or grazing by kangaroos. The site was assessed by DPaW Dieback Interpreter Jake Cortis in July 2014 to be infected with *Phytophthora*; as indicated by the absence of key species that are highly susceptible to dieback infection. However, results from *P. cinnamomi* susceptibility testing have shown the taxon has a high level of tolerance to this disease (C. Crane *pers comm.* March 2015). Large numbers of kangaroos have been observed in the Alcoa bushland during site visits (L. Monks *pers. obs.*) and it is considered that grazing is most likely to have had the biggest impact on the species' decline at this site.

Soils at the proposed translocation site are white sandy clay with some lateritic gravel on the surface. The associated vegetation community at the site is open woodland with a shrub understorey. Associated vegetation includes *Eucalyptus calophylla, Eucalyptus wandoo, Nuytsia floribunda, Kingia australis*, *Pericalymma ellipticum*, *Stirlingia latifolia* and *Hakea lissocarpha*.

This site is also a listed occurrence of the TEC *"Corymbia calophylla* - *Kingia australis* woodlands on heavy soils, Swan Coastal Plain (type SCP3a)". Consultation and a site visit with Department of Parks and Wildlife (DPaW) Principal Ecologist, Val English, has occurred. It was agreed that, as the species formerly occurred at this location, the translocation could go ahead as long as damage to the associated vegetation is minimised.

The proposed translocation site has good vehicle access through Fairbridge Farm for maintenance and monitoring the translocated plants. Permission to access land from Alcoa and Fairbridge Farm School will be required before each site visit.

No weed invasion was evident during translocation site selection visits.

4.3 Site Management

As these plants will be established for the purpose of conservation, they will be regarded as Declared Rare Flora and will have the same legal protection.

No weeds were evident during translocation site selection visits; however, the establishment of weeds will be monitored during monitoring visits and actions undertaken to control any weeds if they are detected.

The site will be listed on the DPaW Swan Region fire GIS database as a priority for protection in the case of wildfire.

4.4 Translocation Design

We propose to establish the *S. stenoloba* plants in winter 2016. Plants sourced from different parents will be mixed to maximise production of outcrossed seed. Based on observations by T.F. Houston (WA Museum, *pers. comm.* September 2013) of *Leioproctus* spp. visitations to *S. spinulosa* and *S. grandis*, it is likely that solitary native bees (possibly also from the genus *Leioproctus*) are a pollinator of *S. stenoloba*. Research by Ye *et al.* (2012) suggests that plants may be able to utilize the explosive pollen ejection system characteristic of *Synaphea* to facilitate pollination in the absence of pollinators. Therefore, plants sourced from the same parent will be separated, to reduce the likelihood of crosses between the same clonal line (selfing).

Plants will be planted approximately 3m apart in natural gaps in the vegetation and care will be taken to minimize damage to the existing vegetation. All plants will be permanently labeled with a metal tag attached to a metal fence dropper next to each plant.

As grazing is likely to be the main threat to the plants at the proposed translocation site, each plant will be protected with a cage made from weld mesh and secured using at least two fence droppers.

Movement of *Phytophthora cinnamomi* around the site will be minimised through use of hygiene procedures (all equipment, boots and vehicles clean at entry and cleaned again prior to exiting the site).

Plants will be irrigated over the first two summers. A water tank will be located on site (and removed once irrigation ceases). The water tank on site will be filled with town water from Dwellingup or Jarrahdale (chlorine in this water helps to any kill pathogens) and carried in clean tankers (the tank and hoses of which are sterilised with a bleach solution then rinsed, prior to filling the tank with water). At least one of the proponents will visit the site every second week and use a hose fitted to the tank to water each plant with approximately 2 litres of water.

Monitoring of the translocated population will be undertaken immediately after planting and then annually thereafter. Monitoring will include counting the number of surviving plants, measuring their height, width of the crown in two directions, recording the reproductive state, whether second generation plants are present and general health of the plants.

Monitoring of a subset of the natural populations will also occur in conjunction with monitoring of the translocated populations. This will provide essential baseline data for assessing the performance of the translocated population. Monitoring will include counting the number of individuals, measuring height and crown width of the individuals, and recording reproductive state, whether second generation plants are present and general health of the plants.

4.5 Source of Plants

The plants for this translocation are clones generated by tissue culture. The propagation source material was collected from the Pinjarra Refinery access road population (Population 1a). The collection and tissue culture initiation was carried out by Ben Stone (UWA Plant Biology Honours Student) and Eric Bunn (Kings Park and Botanic Gardens) in 2005 (see clone origin details in Table 3).

The plants for this translocation were grown from the material collected in 2005. They were rooted *in vitro* in winter 2006, deflasked in October 2006 and placed in the greenhouses at Marrinup Nursery. In 2009 they were transferred to the Botanic Gardens and Parks Authority (BGPA) nursery at Kings Park. Plants are currently being raised at BGPA's accredited nursery, which has hygiene procedures in place to ensure seedlings are free from diseases, pests and weeds, until translocation planting (in winter 2016). There are currently 349 plants available for planting.

Table 3. *Synaphea stenoloba* clone identification information, and source location details.

Marrinup Nursery clone no.	Propagation material collection site	DPaW population no. of material collection site
$$ 0	Main population south of Alcoa Refinery entrance	1A
$$ 2		1A
$$ 3	Population north of Alcoa Refinery entrance	1A
$$ 34 (same material as $$3)	Population north of Alcoa Refinery entrance	1A
$$ 4		1A
$$ 5		1A
$$ 8	Main population south of Alcoa Refinery entrance	1A
$$ 9		1A
$$ 10		1A
$$ 12		1A
$$ 15		1A
$$ 17	Main population south of Alcoa Refinery entrance	1A
$$ 36 (same material as $$ 17)	Main population south of Alcoa Refinery entrance	1A
$$ 20	Main population south of Alcoa Refinery entrance	1A
$$ 22	Main population south of Alcoa Refinery entrance	1A
$$ 24	Main population south of Alcoa Refinery entrance	1A
$$ 26	Population north of Alcoa Refinery entrance	1A
$$ 28		1A
$$ 30		1A
$$ 32		1A
$$ 38		1A
$$ 40	Population north of Alcoa Refinery entrance	1A

4.6 Criteria for Success or Failure

Success criteria

The aim of the translocation is to achieve a viable, self-sustaining population of *S. stenoloba*. This will be achieved by planting over successive years until at least 250 plants (that adequately represent the genetic diversity of the source population) have been successfully established at the Alcoa bushland site. The time frames required to achieve this aim may need to be adjusted to take into account the number of plants available for planting, seasonal influences on maturation, survival, and availability of funding.

<u>**Success**</u>

Initial success of each planting (approx. 1 year)

- Survival of at least 50% of each year's plants past their first summer.

Medium term success of all plantings (2-15 years)

- Survival of at least 40% of all plants planted beyond first year.
- At least 50% of surviving plants producing viable seed at a rate similar to that in the natural population.
- Recruitment of a second generation – seedling recruitment equivalent to or greater than that observed in the natural population (bearing in mind this may be nil if seedling recruitment is linked to disturbance and this does not occur in this timeframe).

Long term success of all plantings (greater than 15 years)

Establishment of a viable self-sustaining population of at least 250 mature plants (natural recruitment of second and subsequent generations without additional plantings).

Failure

Initial failure of each planting (approx. 1 year)

Less than 50% of each year's plants surviving beyond the first summer.

Medium term failure of all plantings (2-15 years)

- Less than 40% of all plants planted surviving beyond first year.
- Less than 50% of surviving plants producing viable seed at a rate similar to that of the natural population.
- Seedling recruitment significantly less than that observed at the natural populations.

Long term failure of all plantings (greater than 15 years)

Population fails to become viable and self-sustaining.

5. TIMETABLE

Time	Action
2012 – June 2016	Propagation of plants at Alcoa's Marinup Nursery followed by growing-on at Kings Park and Botanic Gardens nursery
February 2016	Submission of Translocation Proposal
June 2016	Propagules planted at translocation sites and initial monitoring
November 2016 – March 2017	Water plants
November 2017 – March 2018	Water plants
Annual review	Monitor survival and growth, assess flower and fruit production for translocated and natural populations

6. FUNDING

Materials for this project (such as fencing wire, fence droppers, tags) were funded under the State NRM "Fast Track Critically Endangered Flora Recovery" project. Tissue cultured plants have been donated by Alcoa. Following the end of the State NRM funding in September 2015 the planting and on-going monitoring of this translocation site and a subset of the natural plants will be undertaken by Perth Hills and Swan Coastal Districts Flora Conservation Officers in conjunction with Science and Conservation Division Research Scientist Leonie Monks. These positions are ongoing, internally funded DPaW positions and therefore the proponents are willing to make a commitment to monitor the translocation beyond the availability of the State NRM funding.

7. ACKNOWLEDGMENTS

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Robert Huston - Dept. Parks and Wildlife, Perth Hills District
Val English and Jill Pryde – Dept. Parks and Wildlife, Species and Communities Branch
Vanda Longman - Dept. Parks and Wildlife, Swan Region

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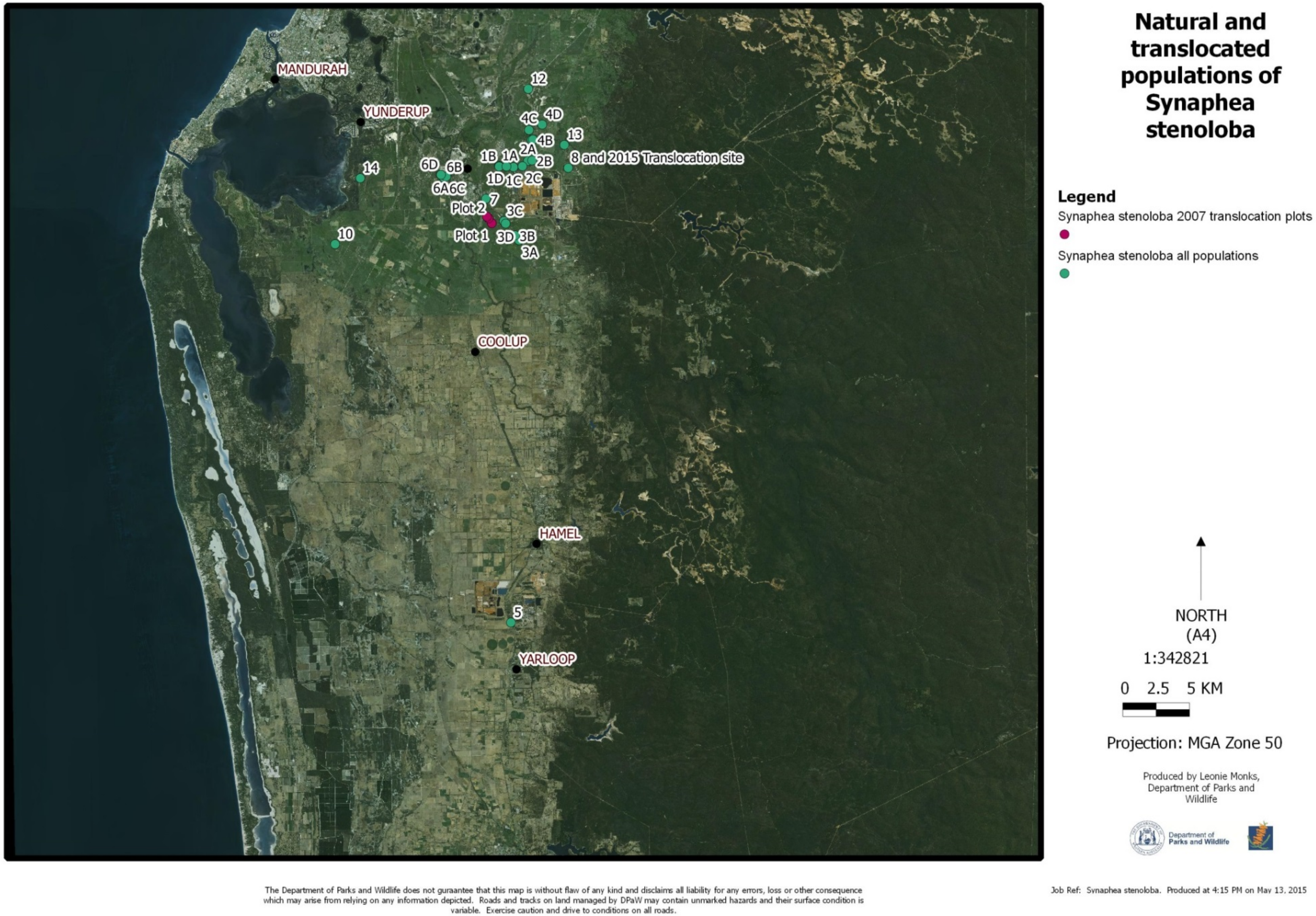
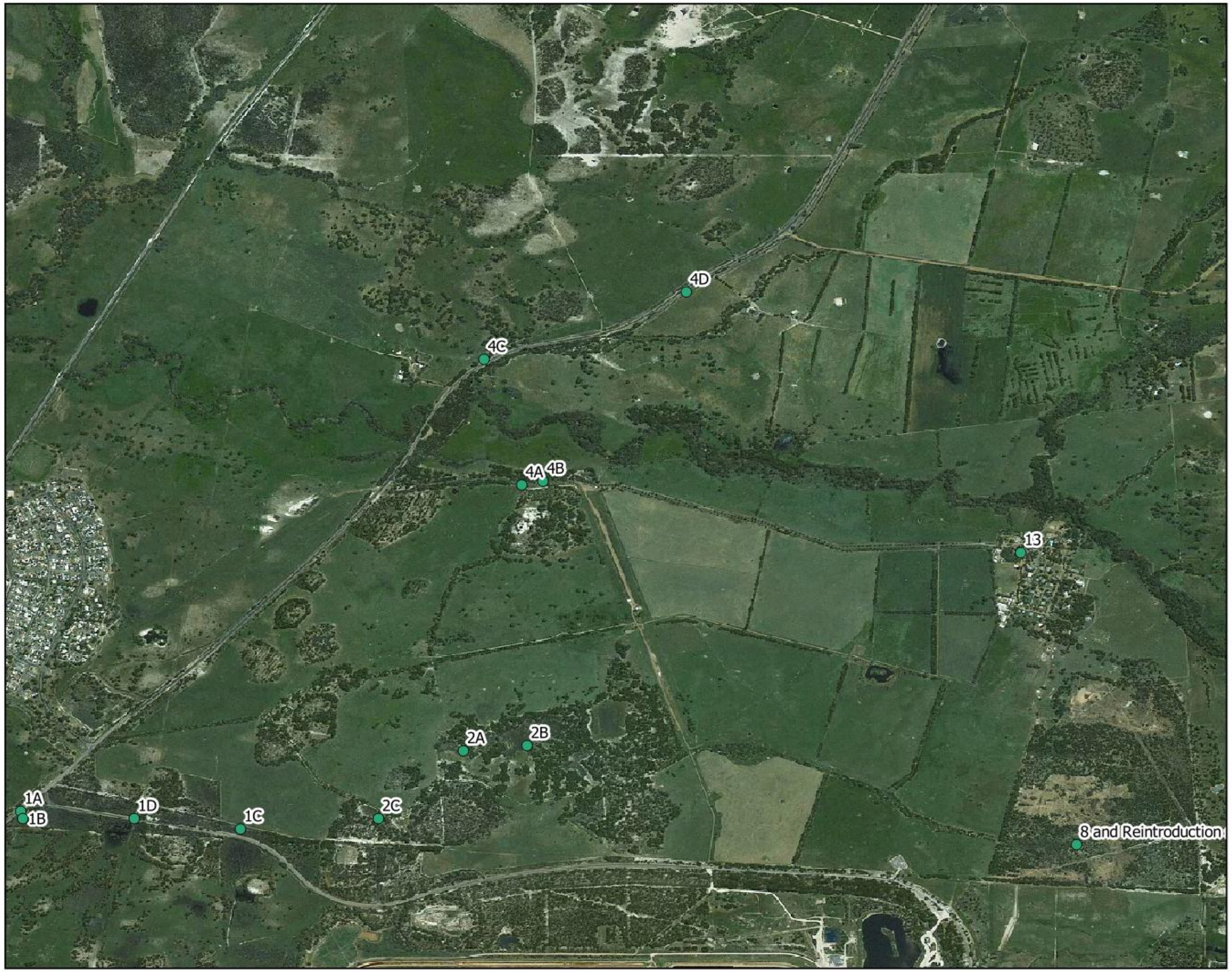
Appendix 1 – Maps of natural population and translocation site locations.





Natural populations and proposed reintroduction site for Synaphea stenoloba

Legend

Synaphea stenoloba all populations

N

1:20,000 (A4)

0 100 200 300 m

Geographic Projection
Datum: GDA94

Produced by Leonie Monks, Department of Parks and Wildlife

Department of Parks and Wildlife

Job Ref: 1
Produced at 02:27 PM on November 17, 2015

The Department of Parks and Wildlife does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted. Roads and tracks on land managed by DPAW may contain unmarked hazards and their surface condition is variable. Exercise caution and drive to conditions on all roads.

Appendix 2

Agreement for the use of the Alcoa Bushland Site.

Vertebrate browsing impacts in a threatened montane ecosystem

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Abstract

Montane ecosystems are vulnerable to the removal of vegetation cover through grazing or browsing by feral or native vertebrate fauna. The highest elevation peaks of the Stirling Range in Western Australia provide habitat for a highly endemic plant community, critically endangered due to plant disease, frequent fire and an emerging threat of browsing by vertebrate fauna. Survey has confirmed that the introduced rabbit (*Oryctolagus cuniculus*) and native quokka (*Setonix brachyurus*) are present. Dietary analysis through faecal examination revealed contrasting diet and implicates native rather than feral species in causing the impacts observed to dicotyledonous species, and in particular those of conservation significance. Exclosure experiments conducted over one year revealed significant changes in abundance, cover and height of perennial herbs and an increase in growth or reproduction of three threatened endemic plants. Detrimental impacts caused by native browsing fauna are not unprecedented and suggest disequilibrium in normal ecosystem process, potentially due to multiple interacting threats. Montane ecosystems may be particularly vulnerable to browsing due to their naturally slow recovery after fire while browsing may also create environmental conditions more conducive to plant disease. For plant species with critically low population numbers, the impact of browsing poses a threat to population persistence and undermines investment into other conservation recovery actions.

Introduction

Montane ecosystems are highly vulnerable to the removal of vegetation cover due to slow plant growth rates and high erosion hazards (Kirkpatrick 1997). Vegetation removal though grazing or browsing by feral animals is implicated in detrimental impacts in several mountainous biomes. For example, pig and goat have caused severe damage to tropical montane habitats and livestock grazing by sheep, cow, goat and horse in the feldmark of Eastern Australia have caused large areas of erosion (Cole *et al.* 2012, Scowcroft *et al.* 1987, Pickard *et al.* 1976, Leigh *et al.* 1987). Similarly, rabbit, hare, several deer species and brushtail possum have had significant impacts in New Zealand (Norbury 1996, Wong and Hickling 1999, Bellingham *et al.* 1999). Within Western Australia, livestock grazing has been reported to significantly alter environmental conditions and processes in Eucalypt woodlands and has contributed to the decline of a lowland Threatened Ecological Community (TEC) (Yates *et al.* 2000, Gibson *et al.* 1999). Grazing generally refers to the consumption of grasses and forbs, whereas browsing is defined as eating plant material of any description, often including leaves and stems of perennial plants.

Browsing by native vertebrate fauna was also reported to cause significant floristic and structural changes to native jarrah (*Eucalyptus marginata*) forest (Shepherd *et al.* 1997). However, browsing by native fauna is rarely considered detrimental unless numbers of browsing individuals become unnaturally elevated due to imbalance in the ecosystem, as reported for koala populations in the Mt Lofty Ranges (Bryan 1996). In montane biomes, examples of grazing and browsing impacts by feral species are frequent, but a paucity of studies exists on impacts resulting from native fauna.

The "Montane Heath and Thicket of the Eastern Stirling Range" is a Threatened Ecological Community (TEC), ranked critically endangered in Western Australia due to the root-rot disease, *Phytophthora* dieback, caused by the plant pathogen *Phytophthora cinnamomi,* frequent fire and more recently from browsing (Barrett 1999, Keith *et al.* 2014). The upper slopes of Bluff Knoll form the highest elevated plateau in the Stirling Range and contain the largest contiguous extent of this community. Only 14 per cent of the TEC retains a representation of the original suite of plant species and many *Phytophthora* dieback-susceptible species have become locally extinct (Barrett *et al.* 2015). The emerging impact of browsing in this TEC became apparent after fire in 2000, with faecal evidence of the native macropod quokka (*Setonix brachyurus*) and feral rabbit (*Oryctolagus cuniculus*). Rabbit control using 1080 oats and the establishment of plant cages was associated with a significant recovery of selected threatened flora (Rathbone *et al.* 2011).

Significant investment has been made in conservation actions for several endemic plants in the Montane Heath and Thicket. These comprise of either threat mitigation i.e. application of the fungicide phosphite to mitigate *Phytophthora* dieback or *ex-situ* conservation strategies i.e. germplasm storage and translocations. Underpinning these actions is a reliance on extant populations reaching maturity and producing flowers and viable seed. Consequently, integrated management that addresses threats of browsing in combination with management of dieback and fire is vital in this ecosystem (Rathbone *et al.* 2011). Selection of appropriate management actions to mitigate browsing is further complicated by the presence of both native and feral browsing species.

The objective of this study was to provide novel information about browsing of native and feral vertebrate fauna in a threatened montane ecosystem and implications for management. The specific aims were to determine:- What browsers are present? What relative browsing pressure is exerted by native and non-native species?, What impact browsing has in a montane environment?, Does browsing inhibits growth and reproduction of plant species of conservation significance?

METHODS

Study site

The study was conducted in an occurrence of the Montane Heath and Thicket TEC that occurs on the upper slopes of Bluff Knoll in the Stirling Range National Park (Figure 1). All sites were on gently inclined south or south east facing slopes between 960m to 1070m above sea level.

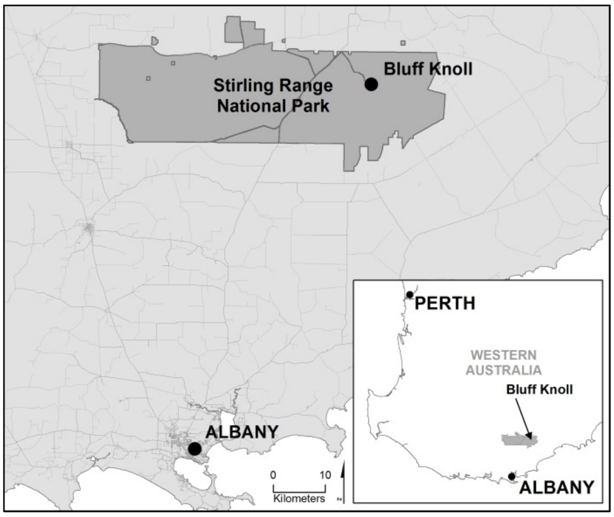

Figure 1. Study site located on the summit of Bluff Knoll in the Stirling Range National Park, Western Australia.

Motion camera trapping

Motion sensing cameras (Reconyx PC900) were used to identify vertebrate herbivores responsible for browsing of native vegetation. One to two cameras per site were deployed intermittently in 2014-2015 targeting areas with browsing, and particularly threatened flora. Images were batch-uploaded into the freeware database tool Camera Base Version 1.6.1 (Tobler 2014). The number of browsing events was scored for all observed fauna species. Events were defined as individuals of a particular species observed with an interval greater than 30 minutes between images.

Diet analysis of browsing fauna

Analysis of plants fragments in the scats of quokka and rabbit were compared with reference plant specimens to determine the relative composition of their diets and to determine if threatened flora were included. Existing protocols for faecal analysis of marsupials (Shepherd *et al.* 1997) and rabbit (Williams 1969) were followed with the following changes: A reference collection was prepared for 24 dicotyledonous and five monocotyledonous species that occurred more than once in 24 1x1m vegetation quadrats. Either entire leaves or fragments of large leaves (approx. 0.5 x 0.5 cm) were incubated at 80 degrees in 50% glacial acetic acid for 48-72 hours. The length of time depended on the thickness and digestibility of the leaf mesophyll tissue. Peels of both adaxial and abaxial leaf surfaces were prepared and stained with 2% Safranin solution for 10-20 minutes and mounted on glass slides with Eukit paramount. Photos and line drawings of key identifying features were compiled using a light microscope mounted camera and IS Capture Imaging Software (Version 2.5.1 Scienon Technology Co. LTd).

Scats of quokka and rabbit were collected over the month of June 2015 from three locations in the study site. Samples were dried then ten scats per species from each location were separated in a mortar and pestle and sorted under a dissecting microscope. Fragments of plant material were identified by morphological features or were stained in 2% Safranin solution for 10-20 mins and inspected under light microscope. Morphological features such as leaf shape, margin and presence of hairs were used to identify partially digested leaves. For smaller fragments a light microscopy was used to identify anatomical features as described by Storr (1961) and Halford *et al.* (1984), including stomata shape, size and density and the presence of oil glands and indumentum. Where possible, all dicotyledonous species were identified to species level and their presence or absence scored in each individual scat. The presence of monocotyledonous species, insects or other material was also noted.

Exclosure construction

Ten fenced exclosures were constructed between December 2013 to March 2014. The exclosures were located in sites that were completely or partially burnt by wildfire in 2000 and were chosen to protect focal areas of the TEC that contained high densities of threatened flora. Locations were selected to ensure minimal visual impact from the adjacent walk trail.

Exclosure walls were approximately 625 m^2 in area, 90 cm high with a 30 cm skirt, both constructed of heavy duty plastic coated netting with a 4 cm aperture. Netting was held by horizontal top and bottom lengths of plastic coated in 1.6 mm fencing wire. Corner straining boxes were constructed with galvanised star iron pickets. Extensive rock and shallow soil prevented hammering pickets into the ground; therefore they were modified with a metal plate that was fixed onto the underlying rock by a chemically anchored bolt (Figure 2). After construction the exclosures were inspected throughout the study period to ensure their integrity.

Figure 2. Modified star iron used to fix corner posts of exclosure. 8 x 60 mm threaded rod was held in rock by Sika AnchorFix chemical anchor into holes drilled with a cordless rotary hammer TE 6-A36-AVR.

Figure 3. Corner straining box constructed of galvanized star iron pickets.

Figure 4. Example of a 25 by 25 m wire exclosure.

Monitoring of browsing exclusion

Vegetation cover and plant growth and abundance were quantified at establishment and after one year at four of the ten exclosures. Changes in vegetation cover and abundance were assessed within 1 x 1 m permanently marked floristic quadrats. Three quadrats inside and outside four different exclosures (n= 24) were scored for count (number of individuals), foliage cover, and maximum height for every plant species present. Only individuals rooted in the quadrat were counted, any overhanging foliage of surrounding plants was included in cover estimate. To assess browsing impacts in relation to natural growth rates, the change in count, foliage cover and height was calculated for each species between the time of establishment and after one year with comparisons between fenced exclusion and non-fenced treatments. Foliage cover was Arcsine transformed prior to analysis. Unpaired, two tailed t-tests were conducted for each species individually and as well as by life form.

Three critically endangered, threatened flora were selected to monitor the effects of grazing on growth and reproduction, *Darwinia collina*, *Latrobea colophona* and *Leucopogon gnaphalioides*. For each species two sets of 20 to 40 individuals were selected along a randomised transect inside and outside fenced exclosures at a minimum of two different sites. Individual plants were identified with a metal tag and the following was recorded:- GPS location, height, two perpendicular widths, flower and fruit abundance and signs of grazing. All plants were monitored at the time of exclosure construction and after one year. Plant volume (cm^3) was calculated for each individual and log-transformed prior to analysis. Unpaired, two tailed t-tests were conducted on counts of reproductive structures and transformed plant volume and between fenced and non-fenced treatments for each threatened species.

RESULTS

A total of 197 camera days and 4728 hours of footage captured 60 events triggered by five fauna species, with 85% of events due to quokka (Table 1).

Quokka was the only strictly herbivorous vertebrate fauna species recorded, other species were carnivorous or omnivorous - mardo (*Antechinus flavipes*), bush rat (*Rattus fuscipes*), quenda (*Isoodon obesulus*) and *cat (*Felis catus*). Quokka were captured browsing on two threatened species - *Leucopogon gnaphalioides* (Fig. 5) and *Latrobea colophona.* No rabbit events were recorded over the period of study. While present on Bluff knoll, this data suggests that their contribution to herbivory may be orders of magnitude less than that of the quokka.

Table 1. Number of browsing events for each species recorded over 197 camera trapping days on Bluff Knoll 2014-2015. Events were defined as individuals of a species observed with an interval greater than 30 minutes between visitations.

Species	Number of events
Quokka (*Setonix brachyurus*)	51
Mardo (*Antechinus flavipes*)	5
Bush rat (*Rattus fuscipes*)	1
Quenda (*Isoodon obesulus*)	1
Cat (**Felis catus*)	2
Total	**60**

Figure 5. Quokka browsing on *Leucopogon gnaphalioides*

Diet analysis

Monocotyledonous species were the most frequently observed component of scats of quokka and rabbit, indicating that these species constitute a major part of both quokka and rabbit diet (Table 2). Dicotyledonous species were less frequent overall but were present in the scats of both species. Quokka scats contained a wider variety of dicots than rabbit scats with an average of nine and one species per scat identified, respectively. The analysis identified plant species included shrubs and perennial herbs from four different families. Four species of conservation significance were incorporated in the diet of quokka, including two threatened flora and two priority species (Table 2).

Table 2. Frequency (Percentage of scats with species present, averaged over three sites) and identity of plant fragments observed in scats of quokka and rabbit. All fragments of plants from the Cyperaceae, Poaceae and Anarthriaceae family where grouped as monocotyledonous species. Several fragments from the Ericaceae family (Ericaceae species) were not identifiable to species level due to similar anatomy.

	% Frequency	
Plant species	**Quokka**	**Rabbit**
Monocotyledonous species	100	100
Myrtaceae		
Kunzea montana	80	-
Calothamnus montanus	70	-
Darwinia collina (threatened)	60	-
Taxandria floribunda	60	-
Beaufortia anisandra	50	-
Astartea montana	10	-
Melaleuca thymoides	10	-
Ericaeae		
Leucopogon gnaphalioides (threatened)	20	-
Dielsiodoxa tamariscina (Priority two)	70	-
Sphenotoma sp. Stirling Range (Priority three)	70	-
Ericaceae species	50	-
Euphorbiaceae		
Amperea conferta	40	-
Apiaceae		
Xanthosia rotundifolia	80	20

Effect of browsing exclusion

Approximately 6,250 square meters of the Montane Heath and Thicket was protected from browsing by vertebrate fauna in ten fenced wire exclosures. A total of 51 plant species were recorded in 24 quadrats inside and outside exclosures (Appendix 1). Species richness varied from nine to 20 species per quadrat with a mean of 13. A trend of higher count, foliage cover and height was observable in the fenced exclusion treatment although no significant difference was detected in pairwise comparisons for each species. When species were grouped by life form, perennial herbs showed a significant ($P<0.05$) increase in count, cover and height after one year of exclusion from browsing (Table 3).

Table 3. Mean change in count (number of individuals), foliage cover (%) and plant height (cm) of different life forms over one year, within and without fenced exclosures. Cover values were Arcsine transformed prior to analysis. Classification of species life form shown in Appendix 1. n = total number of observations.

Life form	No. of species	n	Browsing exclusion			No browsing exclusion		
			count	cover	height	count	cover	height
Re-sprouting shrubs	8	85	1.05	0.45	5.83	0.39	0.07	4.25
Seeding shrubs	15	86	0.23	0.25	8.34	0.74	0.01	5.65
Perennial herbs	9	58	1.16*	0.31**	4.03**	-0.85*	0.00**	0.15**
Annual herbs	8	21	1.71	0.32	1.21	0.14	0.07	0.14
Monocots	8	64	0.47	0.26	1.24	-0.85	0.00	1.67

The response of three selected threatened flora to browsing was measured by comparing the change in plant volume over one year between plants within and without fenced exclosures (Fig 6, Fig 7a). The growth of *Darwinia collina* was significantly greater in the absence of browsing, with a mean change in plant volume of 2,706 cm^3 compared to 177 cm^3 in the non-fenced, browsed treatment (*P<0.0009*). Similarly, the mean change in plant volume of *Leucopogon gnaphalioides* was 1,325 cm^3 without browsing, compared to -26 cm^3 (*P<0.001*); and for *Latrobea colophona* the increment was 44,690 cm^3 without browsing, compared to 2,690 cm^3 (*P<0.00005*) for non-fenced plants. Reproductive output was also measured for *Darwinia collina* as this was flowering at the time of monitoring. Plants protected from browsing had significantly (*P<0.002*) more flowers (mean = 2 ± 1.4) than those in the non-fenced treatment (mean = 0.4 ± 0.2) (Fig. 7b).

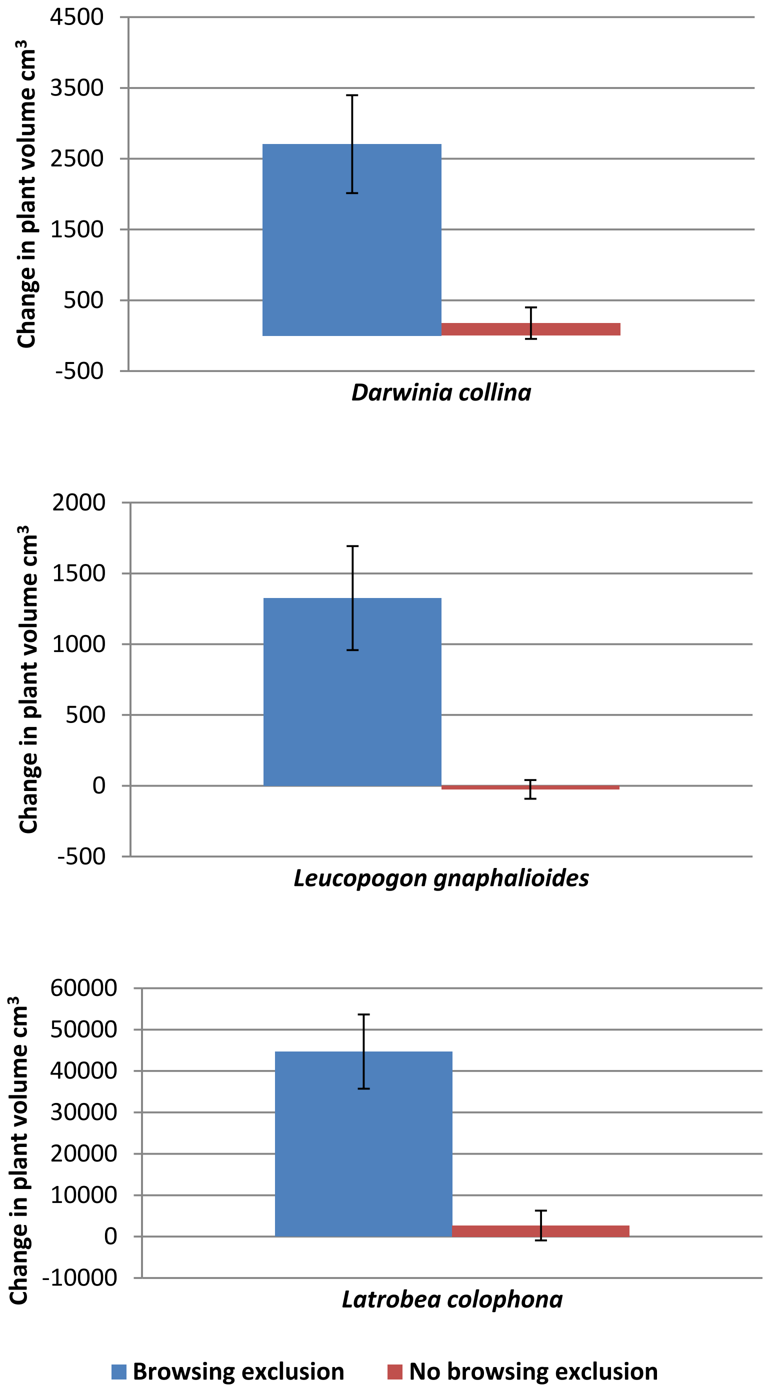

Figure 6. Change in plant volume (cm^3) for three threatened flora after one year for fenced browsing exclusion and non-fenced treatments. Unpaired, two tailed t-tests showed highly significant differences between treatments for each species (**P<0.001*).**

Figure 7a. Recovery of *Leucopogon gnaphalioides* one year after fencing

Figure 7b. Recovery and flowering of *Darwinia collina* one year after fencing

DISCUSSION

Incidence and diet of browsing fauna

During the study period, quokka were a frequent component of the vertebrate fauna of Bluff Knoll based on motion camera data. Rabbits while photographed by motion cameras in 2012, were apparently less abundant I this study, assuming similar trap success rates between species. Trap shyness, feeding behaviours and habitat use may have partially influenced the result. Temporal variation in the abundance of different fauna is also likely, therefore browsing impacts will be the result of past and present population densities. Both rabbit and quokka populations are reported to increase after fire due to an abundance of regenerating species (Leigh *et al.* 1987, Hayward 2005), therefore current populations in predominantly 15 year old vegetation may be lower than at previous times. Rabbit numbers may be also be lower than expected due to control using selective 1080 baits that has been undertaken intermittently since 2008.

The relative frequency of different plant species in faecal remnants revealed the contrasting diets of quokka and rabbit in this montane environment. Quokka were found to consume a wide variety of different plants, which is consistent with other studies using comparable faecal assessment techniques (Hayward 2005). Lowland jarrah forest populations of quokka were reported to have a diet of leaves and stems of 29 species, with five dicotyledonous species accounting for 79% of their diet. In contrast, the diet of rabbit in this study was less diverse and constituted mainly monocotyledons species or perennial herbs. Studies of rabbit in other montane regions showed their diets were dictated by the availability of plant types. In montane regions of New Zealand, rabbit diets were mainly composed of native grass species from the Poaceae (Nordbury 1996) while in Kosciusko National Park they predominantly ate forbs (Leigh *et al.* 1987). The current findings are therefore consistent with the availability of monocotyledonous plants and herbs at the feeding height of rabbits in the study area.

Effect of browsing on vegetation and threatened flora

Fenced exclosure experiments demonstrated the effect of the removal of quokka and rabbit on the montane vegetation. The evidence suggested that during the study period, quokka and to a lesser extent rabbit, was responsible for this browsing pressure. Invertebrate species can cause sporadic leaf damage in this community and would not have been prevented by the exclosures.

The growth of this montane vegetation is extremely slow, with the majority of species growing less than three centimetres during the one-year study. Consequently, for many species the recovery from browsing relative to their naturally slow growth rates may have been difficult to detect. Coupled with low statistical power, this would explain the lack of statically significant comparisons between individual plant species. However, when grouped by lifeform, perennial herbs grew significantly more in the absence of browsing, which is consistent with the common occurrence of these species in the diets of both browsing fauna.

Three selected threatened flora showed highly significant growth in the absence of browsing and one species, *Darwinia collina*, also showed significantly more flowers per individual in the absence of browsing. Images of quokka browsing a fourth threatened flora species, *Andersonia axilliflora*, were captured on a mountain near Bluff Knoll in 2015, but these were not included in the camera trapping analysis. Two of threatened flora (*D. collina* and *L. gnaphalioides*) were recovered in the faeces of quokka even though they were relatively uncommon in the study site, each occurring in 12% of the quadrats outside the exclosures.

The data show a comparatively rapid response to browsing exclusion given the one-year study period. The majority of other comparative fencing exclusion experiments report on changes over five to ten years duration. Interesting, a study of goat browsing in tropical montane habitats monitored periodically over three years, showed that the greatest change in cover of herbaceous species occurred in the first year (Scowcroft *et al.* 1987).

Interaction of threatening processes

The decline in the Montane Heath and Thicket TEC experienced in recent decades exemplifies the vulnerability of montane vegetation to disturbance and the synergistic impacts of multiple threatening processes. Frequent fire and its associated vegetation removal has been shown to increase the impact of *Phytophthora* dieback in other montane habitats of the Stirling Range (Moore *et al.* 2015). Fire in Kosciusko National Park also caused elevated rabbit populations that significantly inhibited recovery and perpetuated bare ground cover (Leigh *et al.* 1987). In comparably cool and moist subalpine regions of Tasmania, the expression of *Phytophthora cinnamomi* was highly correlated with removal of vegetation cover and subsequent higher soil temperatures from increased solar exposure (Podger *et al.* 1989). *Phytophthora cinnamomi* poses the greatest threat to susceptible plants within the Montane Heath and Thicket and any actions that contribute to reducing vegetation cover and thereby increasing soil temperatures may create environmental conditions more conducive to disease.

Conclusions

Rabbit and quokka are browsing fauna present in the Montane Heath and Thicket TEC. Quokka are highly abundant and can be implicated from this study in impacts to at least five species of conservation significance including four threatened flora. Rabbits are less abundant and have an apparent dietary preference for monocotyledonous species under current conditions. Despite the generally slow growth of montane species, fenced exclusion experiments resulted in rapid increases in growth and/or reproductive output for three species of conservation significance. Browsing by the native quokka is a natural ecosystem process that may not be in equilibrium due to alteration of the montane ecosystem by multiple threatening processes. For plant species with critically low population numbers the impact of browsing poses a threat to population persistence and undermines conservation recovery actions. Management of browsing by 1080 baiting alone will be insufficient to manage native resistant fauna, therefore protection of high value assets in wire exclosures or by other means is warranted and a high priority.

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