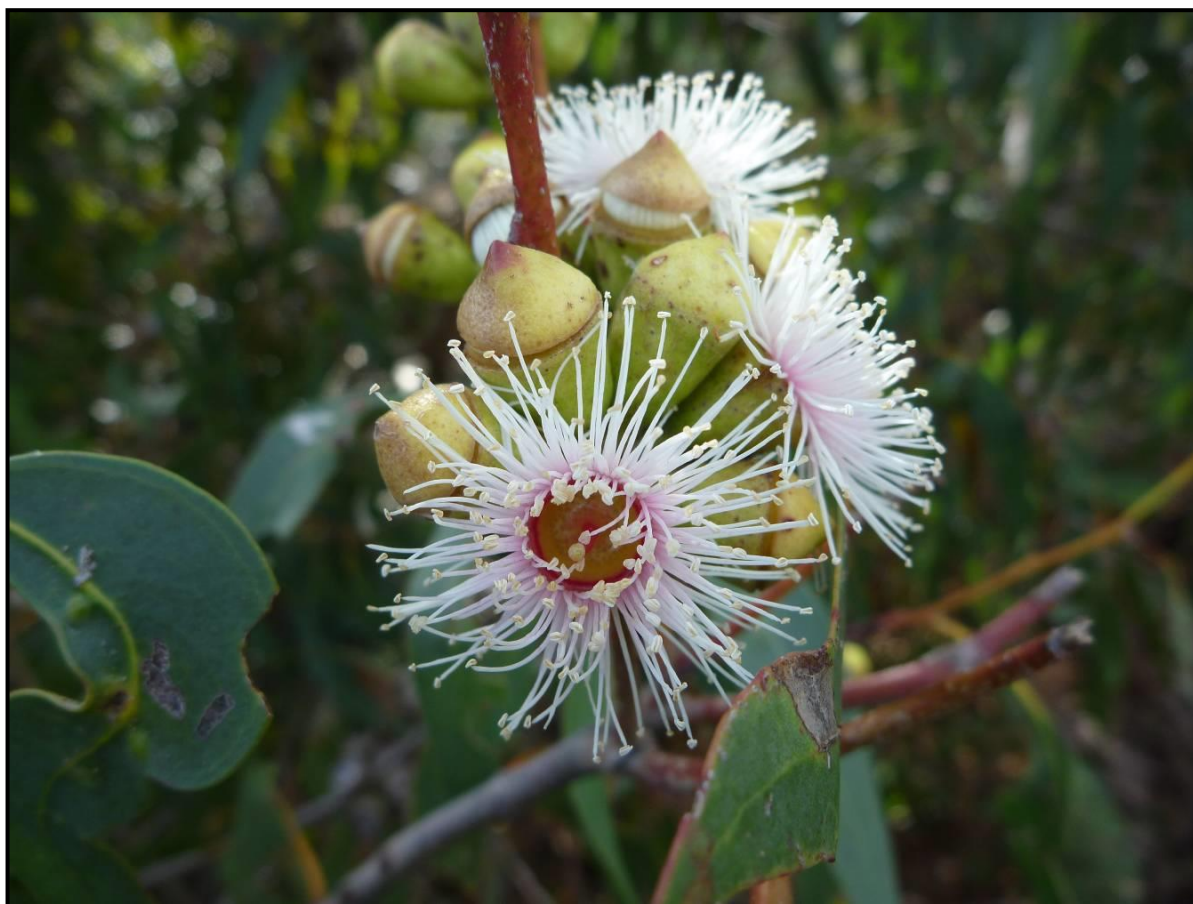


**Recovering the Nationally Endangered Mt Compass Marsh gum
(*Eucalyptus paludicola*) on the Fleurieu Peninsula in South Australia**

Round 4 - Bjarne K Dahl Trust Project 07451



2013

Final Report

Tim Jury & Joe Quarmby



Threatened
Plant
Action
Group



Acknowledgements

Thanks to the Bjarne K Dahl Trust for funding this project. We are grateful to all of the landholders who permitted us access to their properties to undertake fencing, planting, surveys, tissue sampling and seed collection, many of whom assisted with this work. We would like to thank Threatened Plant Action Group (TPAG) members David Keane, Rob Bates and Tom Hands for their help with fencing and planting, Andrew and Sharon Beckman, Rachel Gein, Samantha Williams, Jason van Weenen, and Peter Watton for assisting with field work, and Madeline Thompson and Kelly Woolerton for assisting with data entry, processing tissue samples and seed cleaning. We acknowledge Luke Price for undertaking surveys, seed and tissue sampling and Michelle Maycott, Kor-jent van Dijk, Ed Biffin and Hugh Cross for the analysis of genetic samples. We also acknowledge members of the Marsh Gum Recovery Team for general project assistance and support, and Amanda Stewart from the Nature Conservation Society of South Australia (NCSSA) for assistance with project administration.

Cover photo: Luke Price

Maps: J. Quarmby & L. Price

Citation: Jury, T. & Quarmby, J. (2013) Recovering the Nationally Endangered Mt Compass Marsh gum (*Eucalyptus paludicola*) on the Fleurieu Peninsula in South Australia. Final Report for Bjarne K Dahl Trust Project 07451. Nature Conservation Society of South Australia, Adelaide.

Contacts:

Tim Jury – Threatened Plant Action Group Coordinator
Nature Conservation Society of South Australia
Phone: 08 7172 4630 Email: tpag@ncssa.asn.au

Joe Quarmby –Threatened Flora Ecologist
Department of Environment, Water and Natural Resources
Phone: 8336 0906 Email: joe.quarmby@sa.gov.au

Professor Michelle Waycott – Chief Botanist, State Herbarium of South Australia and
School of Earth and Environmental Sciences, The University of Adelaide
Phone: 0429 345 191 Email: michelle.waycott@adelaide.edu.au

1. Project and species description

The Mount Compass Marsh Gum (*Eucalyptus paludicola*) is a nationally endangered eucalypt species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Marsh gum is endemic to the Fleurieu Peninsula and Kangaroo Island regions of South Australia. Prior to 2012 it was estimated that there were less than 620 individuals remaining and it is estimated that 85% of the species range has been cleared for agriculture. Remaining populations are small, isolated and confined to degraded habitat remnants or grazing land. Most populations are declining through a lack of regeneration. The species generally grows in low-lying, wet eucalypt woodland with a heathy understorey, and prefers sand to sandy loam soils. It is typically found growing along watercourses in broad gullies, and in and around swamps (Quarmby 2012).

The species was described by Nicolle (1995), and was listed under the EPBC Act in 2005. At this time there were only 15 recorded populations, and knowledge of the species was limited. There was also some taxonomic uncertainty about the species and its relationship with *E. cosmophylla* and *E. ovata*. A recovery program for the species was established in 2011, and one of the initial actions was to investigate the genetic status of the species. This study found that *E. paludicola* was genetically distinct from closely related species (Ottewell et al 2011), however several samples appeared to be putative hybrids between *E. paludicola* and *E. cosmophylla*. Genetic diversity and population relatedness was also investigated, but analysis was limited due a small sample size.

At the commencement of this project *Eucalyptus paludicola* was known from 28 populations on the Fleurieu Peninsula (Quarmby 2012). The population size of *E. paludicola* on the Fleurieu Peninsula was estimated to be between 590-620 individuals, however accurate population counts had not been undertaken for many populations. There was also a need for further searches of suitable habitat across the known range of the species. Seed had been collected from several populations in 2011, and seedlings were being grown for translocations to occur in 2012. However, more seed collection was required to upscale translocations and enable long-term seed storage. More information was also needed about the genetic diversity and structure of the species to prioritise management actions and guide translocations.

The aim of this project is to enhance the viability of Marsh gum sub-populations and increase the total number of individuals in the wild. Funding will enable 2 sites to be fenced off from grazing and 5 small populations to be augmented through targeted translocation plantings. Surveys will also be undertaken to search for further populations and to collect seeds and leaf samples for genetic analysis. The obtained genetic information will clarify population boundaries across the species range and guide best practice management. A number of other important, co-occurring Eucalyptus species will benefit from the projects actions.

The project aligns with the principal purpose of the Bjarne K Dahl Trust Small Grants Program by enhancing the protection, conservation and understanding of eucalypt species as a significant aspect of the natural environment. The grant will provide crucial support to the community for undertaking eucalypt cultivation and establishment and will also provide important information to increase our value and ecological understanding of an endangered eucalypt species and improve the prospects for its long-term conservation.

1.2 Project actions

The project proposed the following actions.

1. Increased viability for 5 remnant populations of *Eucalyptus paludicola* through augmentation plantings and stock proof fencing for 2 sites.

ACTIONS: Augmentation plantings for 5 sites; Stock-proof fencing for 2 sites.

2. Management of threats to populations and procurement of back-up seed collections.

ACTIONS: Threat management; Seed collection.

3. Increased knowledge on existing species populations, distribution and abundance.

ACTIONS: Species surveys; Data collection and mapping.

4. An improved understanding of the genetics of *Eucalyptus paludicola* and mapping of population boundaries in the wild to ensure best practice translocation.

ACTIONS: Tissue sampling; Genetic analysis and reporting.

5. Increased community education and involvement in the protection and conservation of an endangered eucalypt species.

ACTIONS: Facilitate community education and involvement in species recovery.

1.3 Project outcomes

1. Increased viability for 5 remnant populations of *Eucalyptus paludicola* through augmentation plantings and stock proof fencing for 2 sites.

Planting of 916 propagated *Eucalyptus paludicola* seedlings was undertaken at a total of 25 sites to augment small remnant sub-populations. Project participants supported the planting at many of the recipient sites including Minko Winery, Stipitirus Conservation Park, Boundary Ridge, Frahn's Heritage Agreement, Goldsmith property, Koolah, Haskett Road, Byrt's property, and Leane Road. The plantings at Stipitirus Conservation Park were undertaken as part of 'Swamp Fest', an annual revegetation event organised by the South Australian Department of Environment, Water and Natural Resources (DEWNR). Survivorship of planted seedlings is being monitored by members of the Marsh gum Recovery Team.

Cattle-proof fencing was erected to exclude livestock grazing for three sites containing remnant *Eucalyptus paludicola* (2 sites on private land at 'Boundary Ridge', 4 kilometres east of Myponga, and another on Bromell's property adjacent to Stipitirus Conservation Park). These sites were fenced through the project to protect remnant trees and encourage natural regeneration of the species. These sites were also targeted for planting of *Eucalyptus paludicola* seedlings to augment numbers for these small sub-populations. Pictures 1 and 2 below indicate some of the fencing work implemented through the project.



Picture 1: Fencing and planting *Eucalyptus paludicola* at 'Boundary Ridge' property near Myponga (Photo: T. Jury)



Picture2: Landholder and TPAG members fencing *Eucalyptus paludicola* on private land at ‘Boundary Ridge’ near Myponga (Photo: D. Keane)

2. Management of threats to populations and procurement of back-up seed collections.

Significant flora markers were installed along four roadsides containing *Eucalyptus paludicola* and liaison was undertaken with 7 organisations, 3 local councils, and 24 landholders over the status and threats to the species on public and private land. Weed threats were managed at 12 sub-population sites to reduce the extent and impact of invasion.

Population summaries were also prepared for 54 sites to help guide future management actions for all sub-populations visited during the project. A minimum of one representative site photo was made at all sites visited, with additional photos taken to document particular site or individual tree features. See Appendix 2 for an example.

Seed collection

The project aimed to collect seed from populations of *Eucalyptus paludicola* for propagation and long-term storage. Sub-populations from which seed collections had not been previously taken were identified and targeted for collection (Table 1).

Seed collection involved taking ripe fruit (nuts) from numerous individuals throughout a sub-population. Fruits were placed in paper bags and labelled with sub-population numbers, and where necessary a

distinction was made between secondary sites within a sub-population e.g. Pop no. 1a and 1b. Fruits were then dried to release the seed at room temperature, and then cleaned and stored in paper Geochem bags.

Voucher specimens were collected from sub-populations for which no specimens had been lodged with the state herbarium. Additionally, if an individual exhibited unusual morphology, a voucher was collected at the same time as a tissue sample was taken and, both were given the same unique code so that the voucher can be linked to the individual's genotype.

Nine sub-populations were identified as requiring seed collections at the start of this project (Table 1). Seed was collected from all of these except Pop. 25 and 28 due to property access restrictions. An additional nine sub-populations were discovered during the phase of the project, eight of which had seed collections made (seed was not collected from Pop. 35). In total seed was collected from 14 sub-populations.

Voucher specimens were collected from six sub-populations for lodgement with the state herbarium. Vouchers with a corresponding tissue sample number are labelled accordingly. Detailed collection data is presented in Table 1.



Picture 3: TPAG botanist Rob Bates collecting *Eucalyptus paludicola* seed along Blackfellows Creek (P: T. Jury)

3. Increased knowledge on existing species populations, distribution and abundance.

Survey Methods

The project objective was to undertake targeted surveys in suitable habitat to locate additional populations. A contractor (Luke Price) was engaged to undertake the surveys. It was decided to focus the survey effort on the Burnfoot property (approx. 1770 ha) within the vicinity of Mount Cone in the Hindmarsh Valley (Map 2). This property was already known to support several populations of *Eucalyptus paludicola*, and contained large areas of suitable habitat that had not been previously searched. Surveys involved systematically searching along gully and swamp systems, targeting suitable areas of habitat. The locations of new *E. paludicola* populations were recorded using GPS and the numbers of individuals were counted (see Table 1 below). Notes were also taken regarding the status of new populations (eg. tree health, threats, management requirements). Voucher specimens for new discoveries were also collected for the State Herbarium.

Census data was also collected from all sampled sub-populations (Table 1), in an attempt to more accurately determine total population size. The number of individuals in each sub-population was counted by tracing every trunk to their origin and determining if they were currently, or may have previously been, connected to another trunk. All connected trunks were classified as 'individual' trees.

Survey Outcomes

Searches were conducted across all areas of suitable habitat on the Burnfoot property. This led to the discovery of a new sub-population (19c) as well as the rediscovery of population 18 on the neighbouring property (Sprod), which had not been relocated since 1997 despite several search attempts. Despite finding that large areas of suitable habitat did not currently support the species, there were many sites across the property that would be suitable for future translocations.

Another population (35) was incidentally discovered at Nangkita whilst visiting a parcel of land which was for sale (Map 1), but could not be properly surveyed at the time and requires another visit. A further five new sub-populations were also discovered during site visits for this project (10d, 13e, 14b, 26c and 26d). In addition to this a new population was found by Peter Watton at Nangkita (36), and an outlying tree was found at Blackfellows Creek by Jason Van Weenen (1b), both of which were subsequently visited and sampled.

Addendum

In 2013 a contractor (Lee Jeffery) was engaged as part of the species' recovery program to search for new populations in the Murray-Darling Basin region. This resulted in the discovery of an additional 450-540 individuals in 16 sites across 11 properties. Many of these sites were in close proximity to each other and, or near to previously known populations. Tissue samples and seed were also collected from most of the new sites. These sites are not included in Table 1 or the maps.

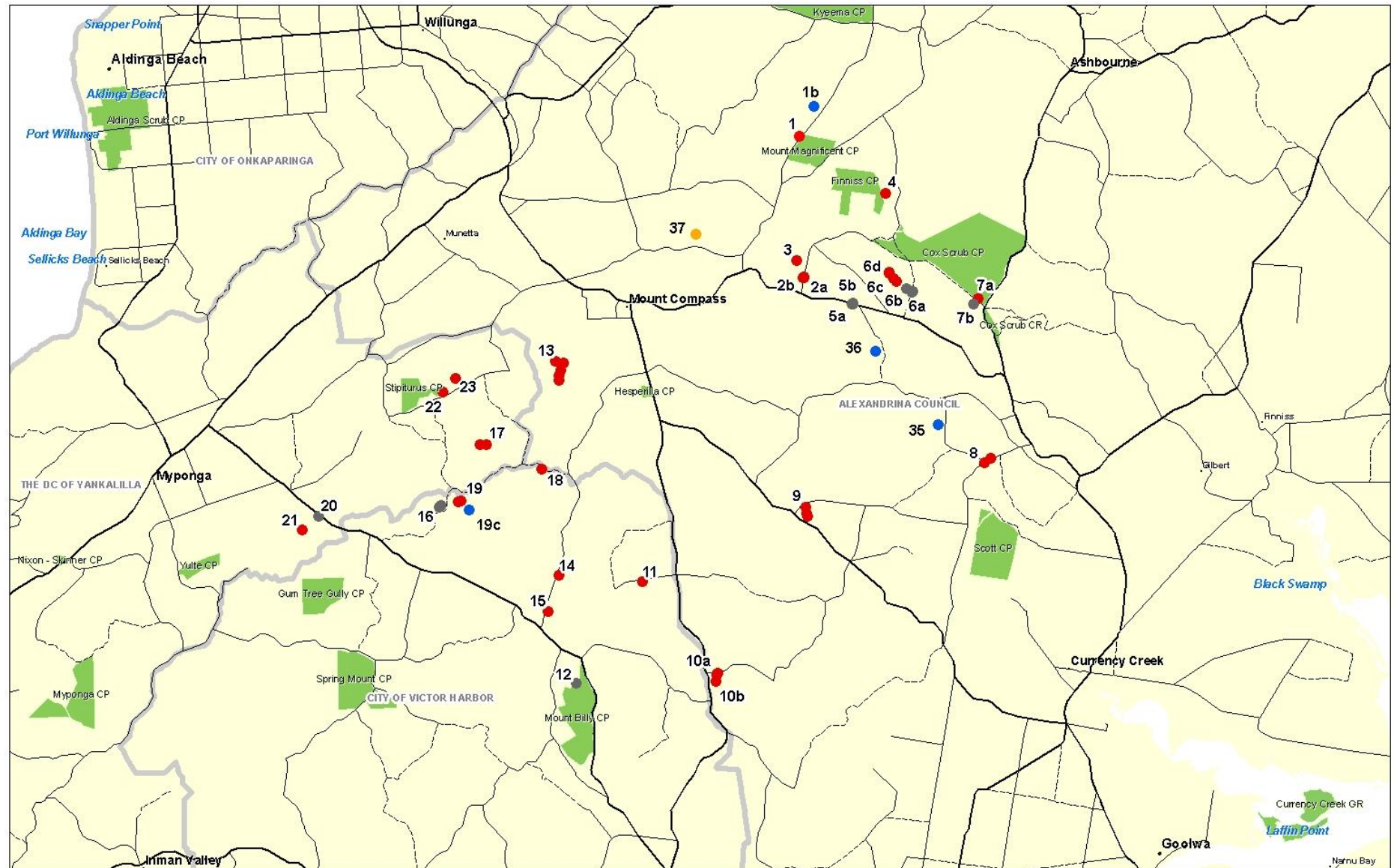
Table 1.List of current sub-populations of *Eucalyptus paludicola* on the Fleurieu Peninsula, South Australia. Table modified from the Action Plan for Marsh Gum (Quarmby, 2012). All sub-populations visited during this project are highlighted in bold. Completion of tissue sampling and seed collection are indicated as Y (yes) or N (no), with collections made prior to this project italicised. Data was collected and compiled by Luke Price and Joe Quarmby.

Pop. No.		Sub-population Name	Land tenure	Site visited in 2012/13	New in 2012/13	No. of individuals (2012/13)	Previous population estimate (yr.)	Tissues (no.)	Seed
1	a	Blackfellows Creek	Private (Van Weenen)			-	5 (2011)	N	Y
	b	Blackfellows Creek	Private (Van Weenen)	*	*	1	-	Y (1)	Y
2	a	Stones Ford Rd	Roadside (Alexandrina Council)	*		11	11 (2011)	Y (3)	Y
	b	Stones Ford Rd	Private	*		6-9	10 (2011)	Y (6)	Y
3		Stones Ford Rd	Private (Amos)	*		30-35	30-35 (2011)	Y (10)	Y
4		Cole Crossing Rd	Private (Tassie)	*		1-4	4 (2011)	Y (4)	Y
5	a	Nangkita Rd	Roadside (Alexandrina Council)			-	3 (2011)	Y (3)	Y
	b	Nangkita Rd	Private			-	4 (2011)	N	Y
6	a	Griggs Rd	Roadside (Alexandrina Council)			-	5 (2011)	Y (2)	Y
	b	Kuitpo Forest	ForestrySA			-	70 (2011)	Y (9)	Y
	c	Kuitpo Forest	ForestrySA	*		90	90 (2011)	Y (13)	Y
	d	Kuitpo Forest	ForestrySA	*		15-27	15 (2011)	Y (7)	Y
7	a	Cox Scrub Conservation Park	DEWNR	*		20-22	22 (2011)	Y (20)	Y
	b	Bonds Rd	Private			-	24 (2011)	N	Y
8	a	Deep Creek Rd	Roadside (Alexandrina Council)	*		1	1 (2011)	Y (1)	Y
	b	Deep Creek Rd	Roadside (Alexandrina Council)	*		1-2	2 (2011)	Y (2)	Y
9	a	Kokoda Rd	Private (Dyson)	*		50-60	40-50 (2011)	Y (57)	Y
	b	Kokoda Rd	Private (Dyson)	*		4	5 (2011)	Y (4)	Y
	c	Kokoda Rd	Private (Dyson)	*		4-8	3 (2011)	Y (8)	Y
10	a	Mosquito Hill Rd	Roadside (Alexandrina Council)			-	17 (2011)	Y (7)	Y
	b	Cloverlea Dairy	Private (Walker)	*		7	8 (2011)	Y (4)	Y
	c	Cloverlea Dairy	Private (Walker)	*		1	1 (2011)	Y (1)	Y
	d	Cloverlea Dairy	Private (Walker)	*	*	20-30	-	Y (17)	Y
11		Leane Rd	Roadside (City of Victor Harbour)	*		1	1 (2011)	Y (1)	Y
12		Mount Billy Conservation Park	DEWNR			-	38 (2011)	Y (5)	Y

Pop. No.		Sub-population Name	Land tenure	Site visited in 2012/13	New in 2012/13	No. of individuals (2012/13)	Previous population estimate (yr.)	Tissues (no.)	Seed
13	a	Minko Vineyard	Private (Boerema)	*		2	2 (2011)	Y (2)	Y
	b	Minko Vineyard	Private (Boerema)	*		6-7	7 (2011)	Y (7)	Y
	c	Minko Vineyard	Private (Boerema)	*		28	15-20 (2011)	Y (18)	Y
	d	Minko Vineyard	Private (Boerema)	*		9	11 (2011)	Y (9)	Y
	e	Minko Vineyard	Private (Boerema)	*	*	3	-	Y (3)	Y
14	a	Haskett Rd	Roadside (City of Victor Harbour)			-	4 (2011)	Y (2)	Y
	b	Haskett Rd	Roadside (City of Victor Harbour)	*	*	4	-	Y (3)	Y
15		Haskett Rd	Private (Mignanelli)	*		7	7 (2011)	Y (5)	Y
16		Mt Cone (Burnfoot)	Private (Beyeux)			-	30 (2011)	Y (10)	Y
17		Mt Cone	Private (Sprod)	*		24	25 (2011)	Y (13)	Y
18		Mt Cone	Private (Sprod)	*		1-3	1+ (1997)	Y (3)	Y
19	a	Mt Cone (Burnfoot)	Private (Beyeux)	*		19	50-60 (2011)	Y (16)	Y
	b	Mt Cone (Burnfoot)	Private (Beyeux)	*		2	2 (2011)	Y (2)	Y
	c	Mt Cone (Burnfoot)	Private (Beyeux)	*	*	5	- (2011)	Y (5)	Y
20		Hindmarsh Valley Rd	Private (Beckmann)			-	4 (2011)	Y (6)	Y
21		Hindmarsh Valley Rd	Private (Beckmann)	*		9-10	3 (2011)	Y (10)	Y
22		Stipiturus Conservation Park	DEWNR	*		1	1 (2011)	Y (1)	Y
23		Bear Lane	Private (Bromell)	*		5-6	3 (2011)	Y (5)	Y
24	a	Cartwright Rd	Private (Goldsmith)	*		1	1 (2011)	Y (1)	Y
	b	Cartwright Rd	Private (Frahn)	*		4	4 (2011)	Y (1)	Y
25		Range Rd	Private			-	5 (2009)	Y (5)	N
26	a	Koolah	Private (Walter)	*		1	1 (2011)	Y (1)	Y
	b	Koolah	Private (Walter)	*		1-4	2 (2011)	Y (4)	Y
	c	Koolah	Private (Walter)	*	*	2	-	Y (2)	Y
	d	Koolah	Private (Walter)	*	*	1	-	Y (1)	Y
27		Gold Diggings Swamp	Private (Woodland)	*		2	2 (2011)	Y (2)	Y
28		Gold Diggings Swamp	Private (O'Neil)			-	1+ (1997)	N	N
29		Parawa Rd	Private (Woolcock)			-	2 (2011)	Y (2)	Y

Pop. No.		Sub-population Name	Land tenure	Site visited in 2012/13	New in 2012/13	No. of individuals (2012/13)	Previous population estimate (yr.)	Tissues (no.)	Seed
35		Cleland Gully Rd	Private (McKenzie)	*	*	2+	-	N	N
36		Waterfall Drive	Private (Gollop)	*	*	6-7	-	Y (7)	Y
			Total	41	9	620-676	592-622	4 (280) 0	15

Map 1 - Distribution of *Eucalyptus paludicola* - Fleurieu North



***Eucalyptus paludicola* sub populations**

- Previously sampled
- New population
- Sampled
- Not sampled

- DENR Reserves
- Local Govt Areas (LGA)
- Main Road
- Minor Road
- Track



0 0.7 1.4 2.1 2.8 3.5
Kilometres

1:105,400

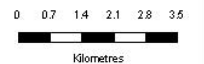
Map 2 - Distribution of *Eucalyptus paludicola* - Fleurieu South



***Eucalyptus paludicola* sub populations**

- Previously sampled
- New population
- Sampled
- Not sampled

- DENR Reserves
- ▭ Local Govt Areas (LGA)
- Main Road
- Minor Road
- Track



1:105,400

4. An improved understanding of the genetics of *Eucalyptus paludicola* and mapping of population boundaries in the wild to ensure best practice translocation.

Tissue sampling

We engaged a contractor (Luke Price) to collect tissue samples from populations of *Eucalyptus paludicola* for genetic analysis. Prior to the commencement of sampling we identified sub-populations that had not previously had tissue samples taken. We excluded sites which had already been adequately sampled to minimise unnecessary duplication (Table 1).

The sampling strategy involved attempting to collect tissue samples from all individuals in small sub-populations (<10 trees), and at least 15-20 trees in larger sub-populations. Because small amounts of tissue yield large quantities of DNA a small number of leaf samples were collected from each tree. All tissue samples collected were labelled with a unique code (tissue number) and stored individually in silica gel desiccant. The date of collection, tissue number, location details and various site specific information was recorded for each sample.

Given the complex growth habit of *E. paludicola*, which is often characterised by multiple sprawling or upright connected trunks, the connectivity of trunks was explored before tissue samples were made. Particular care was made to identify individual trees in a sub-population so that duplication of tissue sample collections was minimised. Following examination, if trunk relatedness was still uncertain tissue samples were taken from both possible 'individuals' and their uncertain individuality was documented. Most samples of this nature were labelled with the same tissue number but given the suffix a, b, c and so on. However some were given unique tissue numbers and a note made about their possible relatedness.

Eighteen sub-populations were identified as requiring tissue sampling at the start of this project (Table 1). All of these populations were visited with the exception of Gold Diggings Swamp (Pop. 28), which could not be sampled due to issues with property access. An additional nine sub-populations were discovered during the phase of the project, eight of which were sampled (Pop. 35 was not sampled). The location of sampled populations is shown in Maps 1 and 2. A total of 280 tissue samples of *E. paludicola* were collected from 40 sub-populations. A single tissue collection and voucher was collected from an unusually large fruited *Eucalyptus ovata* at sub-population 10. Additionally, a single tissue collection of *Eucalyptus cosmophylla* was made at population 29.

Genetic analysis

The University of Adelaide was engaged to undertake genetic analysis of tissue samples collected from *E. paludicola* and to provide a report explaining relevant findings and any implications for species recovery and management.

Background

Extract from Van Dijk KJ, Waycott M, Biffin E, Cross H. (2014) Population genetic analysis of Eucalyptus paludicola. Final report to Department of Environment, Water and Natural Resources (DEWNR). University of Adelaide, Adelaide, South Australia, 2014.

Analysis of *Eucalyptus paludicola* genetic diversity completed previously by Ottewell et al. (2011) utilised a method called AFLPs (Amplified Fragment Length Polymorphisms, sensu Vos et al. 1995, Bussell et al.

2005). Since this study, additional information to better inform decision making associated with on-ground restoration activities is needed. New locations had been discovered and sampled and ongoing exploration of the distribution of this species had led to the genetic marker system needing to be capable of being applied to samples collected and run at random times in the future. A genetic analysis method recently developed that builds upon the AFLP based work done by Ottewell et al. (2011), while also fulfilling this second requirement, was applied in this study. This new genetic analysis approach, similar to CROPS (van Orsouw et al. 2007) or sometimes referred to as AFLPseq, is based on Next Generation Sequencing (NGS) methods and enables screening across different levels of genetic relatedness and also is able to utilise material from different collections cross referencing the various sets of results.

Ongoing efforts to improve decision making for managing the remaining populations of *Eucalyptus paludicola* prompted this study. In particular enhancing the maintenance of genetic diversity during restoration activities is a desirable management strategy for species capable of inbreeding and occurring in restricted populations.

The aims of this study were to:

1. Identify individuals and populations of *Eucalyptus paludicola* containing hybrids.
2. Determine levels of intra-population genetic diversity.
3. Examine the extent of vegetative reproduction, particularly within closely grouped stands.
4. Examine the inter-population genetic structure of the *Eucalyptus paludicola*.
5. Provide recommendations regarding the conservation of genetic diversity, including the appropriateness of introducing new alleles into disjunct populations via translocations.

To do this we used new samples collected from the Fleurieu Peninsula and Kangaroo Island, and also compared them to reference samples used in Ottewell et al. (2011).

Genetic analysis approach utilised

Populations of *Eucalyptus paludicola*, *E. ovata* and *E. cosmophylla* were analysed using novel genetic markers developed for the assessment of population genetic structure of this group using Next Generation Sequencing methods. A total of 365 samples were screened for 167 single nucleotide polymorphisms across 48 amplified DNA regions. Refer to full report by Van Dijk et al. (2014) for a detailed explanation of the analysis (Appendix 1).

Outcomes of genetic analysis

Eucalyptus paludicola was found to have a genetic signature that contains elements of both *E. ovata* and *E. cosmophylla* suggesting a hybrid origin. However, although not tested for, there is no evidence that it is an unstable or very recent (single generation) hybrid, as its populations operate independently except for occasional hybridization events with other local species. Nor is there evidence of needing parental generation of hybrid offspring. The current genetic signature of the species shows higher degree of affinity with *E. ovata* than *E. cosmophylla* perhaps due to a higher degree of occasional back crossing or hybridization than between *E. paludicola* and *E. cosmophylla*.

There was no clear pattern to the population structure of *E. paludicola*, including no evidence that the Kangaroo Island populations of *E. paludicola* had diverged from mainland populations. All the Kangaroo Island populations have mixed affinities with multiple mainland populations, an unexpected finding based on the assumption that modern gene flow is restricted. A number of individuals (and in some

cases populations) determined as *E. paludicola* grouped within the *E. cosmophylla* or *E. ovata* genetic clusters. *Eucalyptus paludicola*, and possibly some groups of *E. ovata* samples show evidence of clonality.

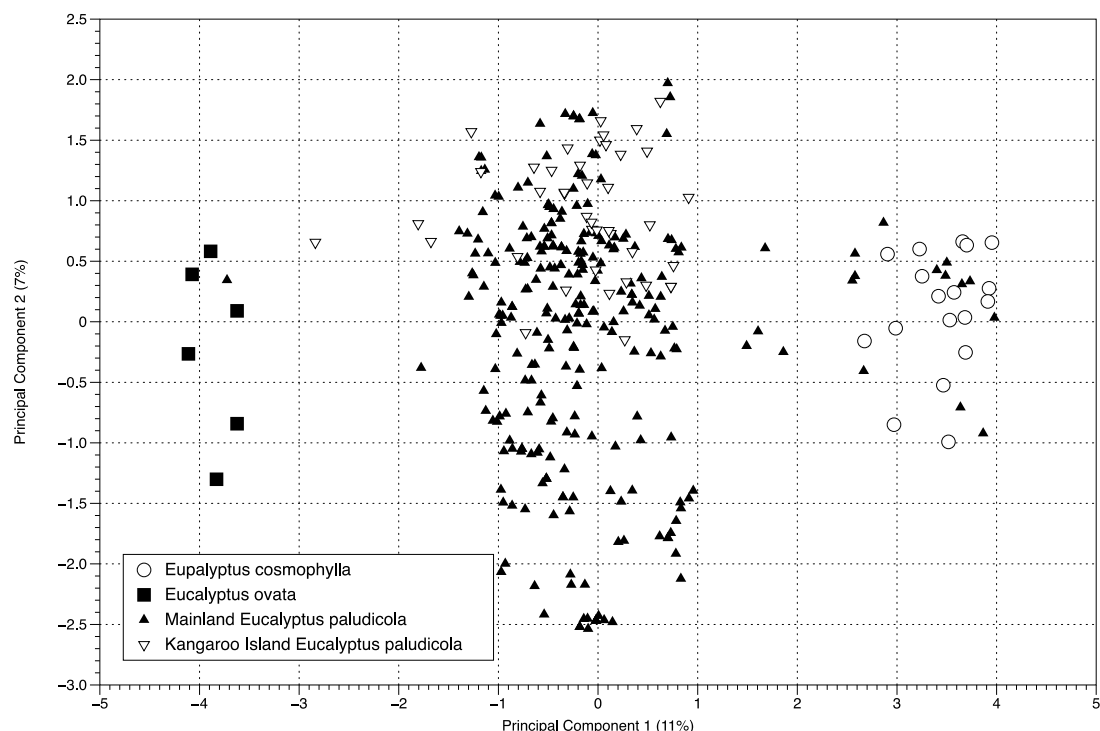


Figure 7. Principal Component Analysis (PCA) of all 365 eucalypt samples based on 167 SNPs. Analysis was based on a covariance matrix. PCA coordinates were generated with Genodive (Meirmans and Van Tierden, 2004).

The graph in Figure 7 was generated with the developed SNP approach and looks almost identical to the results found by Ottewell et al. (2011), supporting the conclusion the two methods are complementary.

Implications for management

It is recommended that a number of individuals of *E. paludicola* should be excluded from propagation and translocation activities as they show evidence of being the result of hybridisation with *E. ovata* or *E. cosmophylla*. Samples collected as *E. paludicola* but which are assigned to one of the other genetic types should also not be used in translocations.

We suggest an additional study that focuses on additional locations where *E. paludicola*, *E. ovata* and *E. cosmophylla* co-occur would be valuable to improve our understanding of the frequency and nature of hybridization among these species.

2. Project evaluation

Evaluation of the project outcomes has been made by measuring success against the following criteria:

1. The establishment and survivorship of re-established *Eucalyptus paludicola* seedlings (Total numbers, % per translocation site etc.).

During the project the total number of re-established *Eucalyptus paludicola* seedlings was 916, at 24 sites. This represents a doubling of the estimated known population size. The percentage survival of planted seedlings has not yet been evaluated for all sites, especially those planted in 2013, but will be monitored in 2014 and can be reported in due course.

2. The contribution made toward improving the species conservation status (assessment against IUCN criteria) as a result of the project.

The plantings implemented through the project have increased the size of 15 remnant sub-populations and established 9 new sub-populations, therefore increasing the species distribution and abundance of *Eucalyptus paludicola* in the wild. By increasing small sub-populations, plantings have also reduced the likelihood for local extinctions and improved the viability of small sub-populations in the short term. Surveys undertaken during the project period have increased the known population size from an estimated 590-620 individuals to 900-1,100 individuals, largely due to the surveys in the Murray-Darling Basin. Further monitoring and recovery work will be required however. Marsh gum is still likely to meet the IUCN criteria for Endangered but recovery work implemented through the project has contributed towards improving the species' conservation status.

3. The level of knowledge increase on species population genetics and the practical applications for management.

The project has increased the level of knowledge on the species' genetic status. *E. paludicola* was found to have a genetic signature with elements of both *E. cosmophylla* and *E. ovata*, indicating a hybrid origin. There was also some indication that occasional back-crossing was occurring, especially with *E. ovata*. It is recommended that a number of individuals of *E. paludicola* should be excluded from propagation and translocation activities as they show evidence of being the result of hybridisation with *E. ovata* or *E. cosmophylla*. Samples collected as *E. paludicola* but which are assigned to one of the other genetic should also not be used in translocations.

4. The number of participating organisations, landholders and individuals.

A total of 10 organisations, 19 landholders and 40 individuals participated in the project. Many of these landholders and individuals were not involved previously, so the project has helped to increase community participation in the recovery and conservation of Marsh gum.

5. The increase in community awareness, appreciation and knowledge of the species.

The project helped to facilitate community education and involvement in the recovery of Marsh gum through direct involvement or landholder participation. The awareness of at least 40 people, approximately half of whom are landholders with Marsh gum on their properties, increased due to the project.

References

Nicolle, D. (1995) A new series, Incognitae, of *Eucalyptus* L'Her., including a new species endemic to Fleurieu Peninsula and Kangaroo Island, South Australia. *Journal of the Adelaide Botanic Gardens* 16:75

Bussell, JD, M Waycott and JA Chappill. (2005). Arbitrarily amplified DNA markers as characters for phylogenetic inference. *Perspectives in Plant Ecology Evolution and Systematics* 7(1): 3-26.

Ottewell, K, D Bickerton, J Quarmby and A Lowe. (2011). Report to Department for Environment and Natural Resources (DENR); Genetic status of the endangered Mount Compass Swamp Gum (*Eucalyptus paludicola*). Adelaide, Department for Environment and Natural Resources. 6 pp.

Quarmby, J. (2012) Action Plan for Marsh Gum (*Eucalyptus paludicola*) 2011-2016. Department of Environment, Water and Natural Resources

Vos, P, R Hogers, M Bleeker, M Reijans, T van de Lee, M Hornes, A Frijters, J Pot, J Peleman, M Kuiper and M Zabeau. (1995). AFLP: a new technique for DNA fingerprinting. *Nucleic Acids Research* 23(21): 4407-4414.