POPULATION CHARACTERISTICS OF *FRANKENIA PARVULA* (DRUMMOND'S FRANKENIA)

A framework for monitoring change

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Anne Harris
WATSCU, Department of Conservation and Land Management

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DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

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1.0 INTRODUCTION

There are 32 described taxa of *Frankenia* found in Western Australia of which one is a weed (Paczkowska and Chapman 2000). The Department of Conservation and Land Management (CALM) currently recognises one Presumed Extinct, two Declared Rare and a further six Priority taxa that are poorly known and in need of further study (Atkins 2003).

This study focuses on one of the Declared Rare Flora species, *Frankenia parvula,* identified as being seriously threatened by salinity and waterlogging. Funds made available through the State Salinity Strategy have enabled this study, which aims to increase the understanding of the species biology and ecology.

Frankenia parvula occurs in seasonal wetlands within the wheatbelt of Western Australia. These wetlands have suffered marked changes due to clearing for agriculture and associated land management practices, with many wetlands, including some in nature reserves, becoming highly saline (Schofield *et al.* 1988; Halse *et al.* 1993). Salinization of inland wetlands in south-west Western Australia has caused both a decline in species richness and a marked change in the species composition, particularly for saline and hypersaline sites. Many species occur only within a restricted salinity range (Halse *et al.* 1993; Sanders 1991).

In addition to clearing, climatic change may also influence the hydrology and salinity of lake chains and this also needs to be factored into conservation consideration (Hobbs and Hopkins 1991).

1.1 History and conservation status

James Drummond first collected *Frankenia parvula* in 1847 from the Mt. Stirling and Mt. Caroline areas in the central wheatbelt of southwest Western Australia. The species was presumed extinct until Mike Lyons[1] rediscovered it in October 2000 while establishing floristic survey quadrats as part of a 'Biological Survey of the Wheatbelt' under the Salinity Action Plan (Lyons *et al.*, in press). Two unconfirmed populations found in 1988 and 1997 were then revisited and confirmed.

The species was listed as Rare Flora in 2000 but not ranked at that time as insufficient population and threat information was available. Following further surveys which located three populations on private property, nature reserves and unvested crown land it was recommended that it be ranked as Endangered (EN) in March 2004 under World Conservation Union (IUCN) Red List Criteria B1ab(iii)+2ab(iii) (IUCN 2000).

1.2 Plant description

Frankenia parvula is a small shrub with creeping stems and numerous short, upright branches. Tiny leaves, 1.5 to 3 mm long, are stalked, narrowly oblong, circular in cross-section, slightly hairy on the upper surface and have curled under margins. The leaf sheath is half as long as the blade. Flowers, on the ends of the branches, may be solitary or in heads of 2 or 3. The thickly ribbed calyx has a mixture of spreading bristly hairs and short flat-lying hairs above, but is hairless below. The 5 petals are 5 to 6 mm long. There are 6 or 7 stamens and a style, which has 3 branches. Eleven to 15 ovules are attached to the walls of the ovary (Brown *et al.* 1988). Flowering occurs from October to January.

1.3 Distribution and habitat

Populations of *Frankenia parvula* are found in CALM's Merredin District, within lake chains and major drainage lines in the Avon catchment of the Wheatbelt region of southwest Western Australia. Surveys from 2000 to 2003 located three populations, one of which is located on a threatened ecological community (TEC) (English and Blyth 1999), the 'Salt Flats Plant Assemblages of the Mortlock River (East Branch)'.

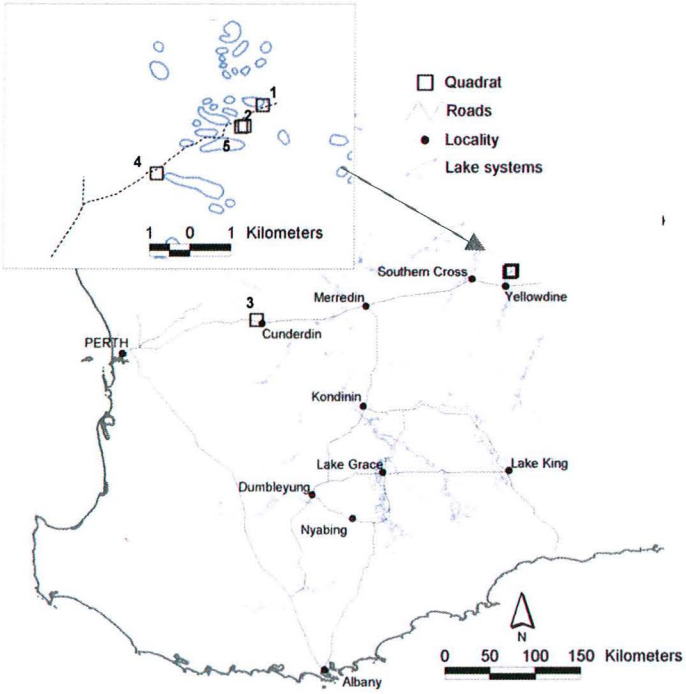
[1] Mike Lyons, Research Scientist, CALM Science Division

The preferred habitat for *Frankenia parvula* is white to brown sand over sandy clay around the high water mark of major drainage channels where it grows both independent of and within fringing vegetation. Associated species include *Melaleuca halmaturorum*, and *Halosarcia halocnemoides*, along with many ephemeral species. (See site and quadrat descriptions pages 27-31).

Two of the three known populations were selected for long-term monitoring and collection of reproductive data. These are located at Cunderdin and Yellowdine, some 244 km apart within the Shires of Cunderdin and Yilgarn (Figure 1). Populations' 2a and 2b at Cunderdin occur on one of the most extensive braided saline drainage lines in the southwest agricultural zone (Luu 2004). Plants are located on private property which has been cleared for agriculture and is now fenced from grazing stock.

Population 1 at Yellowdine occurs within OCR (Other Crown Reserve) 18966 and is surrounded by Duladgin and Yellowdine Nature Reserves, which together comprise over 34,000 hectares of land to the north and west.

Figure 1. Location of selected *Frankenia parvula* populations with established quadrats



The Wheatbelt region has a Dry Mediterranean climate with cool wet winters and hot dry summers. Weather data from Southern Cross, the nearest centre to the *Frankenia parvula* population at Yellowdine and Cunderdin, are detailed in Table 1 below. Records date back as far as 1889 for Yellowdine and 1914 for Cunderdin.

Table 1. Weather data from Southern Cross and Cunderdin.

Nearest weather centre	Long-term mean rainfall (mm)	5 year trend for total annual rainfall (mm)	Long-term mean temperatures	
Southern Cross	293	1999-646 2000-383.5 2001-366.3 2002-203.8	Warmest month January Max – 34.6°C Min – 17.2°C	Coolest month July Max – 16.3°C Min – 4.4°C

Cunderdin	368.6	2003-418.7 1999-526.4 2000-351.6 2001-300 2002-268 2003-380.2	January Max – 34.1°C Min – 17.4°C	July Max – 16.6°C Min – 6.2°C

Well above average rainfall for 1999 was recorded at both centres. This increase was reflected throughout the mid-Wheatbelt and into the Midwest region. Rainfall is predominantly between May and September at both centres but summer rainfall events are also recorded.

The fire histories of all areas where populations of *Frankenia parvula* occur are not known. However there have been no fires on the Stokes property at Cunderdin since they settled there in 1962 (J. Stokes[2] *pers. comm.*) or on the adjacent Jasper property for over 40 years (D. Jasper[3] *pers. comm.*). Satellite imagery available since 1985, showed no record of burns in Nature Reserves where populations of *F. parvula* are located.

2.0 REPORT OBJECTIVE AND OUTLINE

The in-situ conservation of rare and threatened plant species is contingent upon firstly, detecting changes in population size or condition, secondly, determining the causes of changes and thirdly, in the case of population decline implementing actions that will reverse the trend.

The aims of this project were to establish for *Frankenia parvula* a quantitative monitoring framework and data baseline to obtain information on populations and species growth characteristics and for detecting changes in population abundance, health, life stage structure and reproductive potential.

This report presents data on the characteristics of the *F. parvula* species and populations that will serve as a baseline for detecting change and determining whether management of the populations are meeting conservation objectives.

3.0 METHODS

Populations 1 and 2 were visited to determine the most suitable method of quadrat establishment and if plants were in flower. Flower buds were noted on *Frankenia parvula* plants at Population 1 at Yellowdine and quadrats 1 and 2 were established at this site. Quadrat 3 was established within Population 2a at Cunderdin as it was the most southern of known populations and contained plants that were observed to be significantly different in size.

Although quadrats had already been set up in Population 1, quadrats 4 and 5 were established in the same area as the population is extensive and plants were found to be growing on the shorelines of many drainage channels and within one of the saline pans throughout the area and no other populations were known at that time.

3.1 Population details

The project involved:

1. Establishing five permanently marked quadrats of $25m^2$, (5 x 5 m where possible) at five different locations within known populations of *Frankenia parvula*.
2. Permanently labelling at least 100 *Frankenia parvula* plants for long-term monitoring.
3. Assessing canopy dimensions of each labelled plant by measuring width at the widest diameter and at 90° to the widest diameter.
4. Assessing the health and vigour of each plant by estimating the percentage of live canopy.
5. Counting the total number of inflorescences on each *F. parvula* plant labelled.

[2] John Stokes, private property owner, Cunderdin.
[3] Darren Jasper, private property owner, Cunderdin.

6. Recording life-stage classification of each plant assessed, ie. mature or juvenile (juvenile plants are those that were non-flowering and had smaller canopy areas than those plants that were flowering within the same quadrat.
7. Recording other ecological and biological observations relevant to *F. parvula* populations that will assist in management of the species.

A subset of 312 plants in five study sites was permanently identified for monitoring with labelled wire stakes placed into the ground adjacent to each one. Quadrats 1 and 2 were established at Population 1 on the 18th and 19th of November and Quadrats 4 and 5 on the 3rd and 4th of December 2003. Quadrat 3 was established within Population 2a on the 20th of November 2003.

Plants at Population 1 occur along the shorelines and within a saline pan at sufficient density and over a large enough area to enable the establishment of 5 x 5 m quadrats. Plants at Population 2a occur in a narrow strip on the shoreline of a raised sand dune, therefore it was necessary to establish a transect measuring 12.5 x 2 m, which would contain the most number of plants.

All of the $25m^2$ quadrats and transects have five $1m^2$ subquadrats permanently marked within them to monitor a random subsample of each population. As the labels may disappear over time the area and location of each plant within subquadrats was graphed for future reference. The graphs are held in CALM files at WATSCU. Plant characteristics were assessed at the time of quadrat establishment (Table 12).

Characteristics of each quadrat were also recorded at the time of establishment and are detailed in Appendix 1. Characteristics include: soil descriptions, plant community classification according to Muir (1977), estimation of percentage cover of each strata including bare ground (Table 11) and location descriptions. The method of percentage cover estimation uses that of Keighery (1994). Associated species in all quadrats and occasional plants common to each site were also noted. Samples of unknown species were collected and identified at the State Herbarium.

Photographs (transparencies are lodged with WATSCU) were taken of all study sites to monitor change (Figures 7-11). GPS readings were also taken at all populations and quadrats and at all landmarks considered relevant for the relocation of the populations for long-term monitoring (Table 13).

3.2 Plant size and vigour

Measurements taken to assess the size and vigour of the 312 labelled plants were:
1. Height.
2. Width of the canopy at the widest point and the width at 90° to the widest point.
3. Percentage of live canopy.

Canopy area for each plant was calculated using the equation for an ellipse (long axis x short axis x 0.7854). Results were graphed using canopy area size classes of 0-1, 1.1-10, 10.1-50, 50.1-100, 101.1-500 and >500 cm^2, which allows for adequate viewing of the size distribution over all study sites (Figure 2). Then the number of plants within each of the size classes that had 0, 1-25, 26-50, 51-75, 76-99 and 100% live canopy were calculated (Figure 3).

Plants that exhibited signs of stress were recorded on the field data forms and numbers tabled in results under 4.3 (Table 4). Signs of stress include:
1. Partial canopy death (plants within the 51-75% live canopy or less)
2. Obvious damage to plant from eg. animals or insects
3. Vegetation colour changes eg. Chlorosis

Frankenia parvula plants grow as discrete shrubs at Population 1 and both shrubs and mat forming plants at Population 2a. The mat forming plants were separated for labelling by determining the perimeter of each clump by shallow excavation to exclude further stem production.

Photographs were taken showing growth habit and root structure and also of stressed and healthy plants for future comparison (Figure 5).

3.3 Reproductive characteristics

Reproductive characteristics were investigated over a single flowering season in 2003. It was impractical and damaging to permanently label stems or inflorescences on each plant due to their small size, fine multiple stems and in some populations mat-forming growth habit. Therefore, reproductive potential of *Frankenia parvula* plants was assessed by:

1. Selecting the first 4 plants within each subquadrat for flower and fruit monitoring.
2. Counting the total number of buds and flowers on each plant.
3. Counting the total number of fruits on each plant.
4. Collecting fruits for assessment of seed production.

Buds and flowers were counted at quadrat establishment in mid November and again in December 2003 and January and March 2004. Fruits were counted and collected on the 21st of January and the 31st of March 2004. Collections from each plant were stored separately and the seeds counted under a stereomicroscope. An assessment of viable seeds per fruit was made (Table 8). Seed viability was assessed by their size, form and firmness, as they were too small to cut. Wrinkled and flat seeds were considered unviable.

Another reproductive characteristic noted for *Frankenia parvula* in Population 2a, was that on close inspection, stem and root arrangement suggested clonal reproduction. Further investigation included excavations of one plant each at Populations 1 and 2a to determine whether underground connections existed.

The mean and total number of flowers and fruits per plant for each population were then calculated (Tables 5 and 6).

3.4 Soil characteristics

Descriptions of surface soil were recorded at the time of plant assessment and soil samples were taken for salinity and pH testing on the 18th and 19th of November and 3rd of December 2003. The samples were taken at root zone depth (10-12 cms) from each corner and in the centre of all quadrats using a 5 cm diameter augur. Soil from each hole was placed in labelled press lock plastic bags for transport and then stored in open bags under cover to air dry. Testing was undertaken at the Department of Conservation and Land Management research laboratory in Como.

Electrical conductivity (EC) and pH tests were undertaken after the samples were amalgamated for each site and then oven dried at 40°C for 3 days. Dried soil aggregates were broken down and passed through a 2 mm sieve then particles 2 mm or less was reduced in volume to approximately 250 ml by repeated cone and quarter method (Table 10).

4.0 RESULTS AND DISCUSSION

4.1 Population size

Further surveys carried out in spring of 2003 by Diana Papenfus[4] located new populations of *Frankenia parvula* with confirmation of collections from two areas still to be finalised (Papenfus 2004). Accurate counts of plant numbers were difficult to assess in some populations because of the large numbers of plants and their small size. Plant numbers have increased substantially as a result of the 2003 search.

Table 2. Population details for *Frankenia parvula* as at December 2003.

Population No. & Location	Year	Number of plants	Population condition

[4] Diana Papenfus, previously Project Officer, CALM

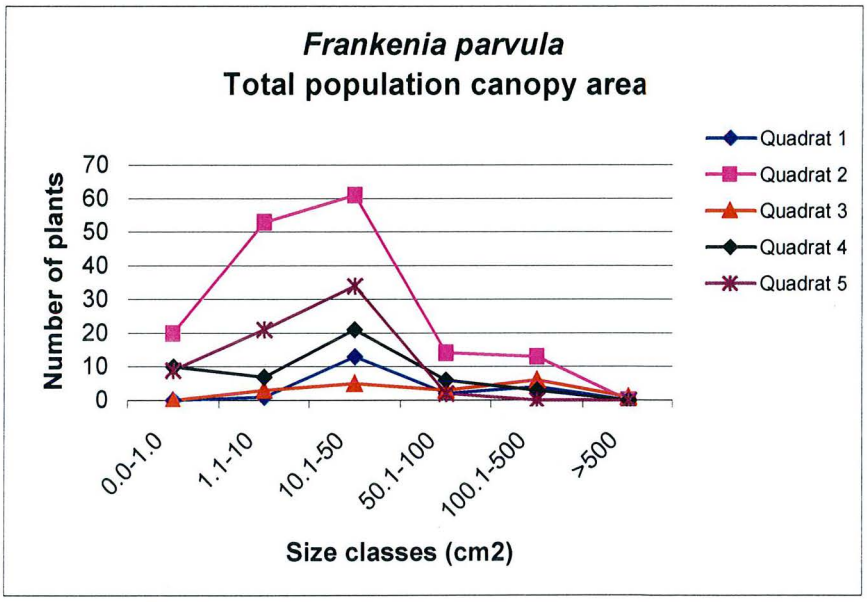
1. Yellowdine	1988 2003	locally abundant 200,000+	Healthy
2a. Cunderdin	2000	40	Moderate
2b. Cunderdin	2001	117	Moderate
3. Kellerberrin	2003	7	Healthy

4.2 Size class structure and individual health

The distribution of *Frankenia parvula* plants was skewed to the lower three canopy area size classes with 82.6% of plants measuring less than 50 cm^2 (Figure 2). The majority of plants within these size classes occurred within Quadrats 2 and 5 at Yellowdine, which occur on the same drainage channel. Plants within Quadrat 3 at Cunderdin were distributed more evenly throughout size classes. Fewer plants occurred within this population, which grow in closer association to other species than plants within the other four quadrats. The largest proportion of plants assessed for all study sites, 42.9%, fell into the 10.1 - 50 cm^2 canopy area size class.

Heights ranged from 0.1-3.5 cm with the average height being 0.93 cm overall. The total and mean canopy areas for each site are detailed in Table 3.

Figure 2. The distribution of *Frankenia parvula* plants over canopy area size classes for the five study sites.



The highest number of plants occurred within Quadrat 2, which recorded the largest total canopy area. Conversely, plants within Quadrat 3 have a significantly higher mean canopy area with the least number of plants. The mean canopy area for all study sites is 70.89 (cm^2) with a range of 0.03 – 1969.78 (cm^2).

Table 3. Mean and total canopy area (cm^2) for *Frankenia parvula* plants within subquadrats for the five study sites – December 2003.

Quadrat/Location	Number of plants	Mean canopy area (cm^2) ± SE	Total canopy area (cm^2)
1/Yellowdine	20	75.27 ± 20.81	1505.34

2/Yellowdine	161	33.23 ± 5.06	5349.90
3/Cunderdin	18	200.93 ± 106.86	3616.81
4/Yellowdine	47	29.19 ± 4.40	1371.92
5/Yellowdine	66	15.86 ± 2.01	1046.75

Figure 3 shows Frankenia parvula plants within Population 1 that consistently have small canopy areas and grow as discrete shrubs, compared to plants within Population 2a that have a larger mat-forming growth habit.

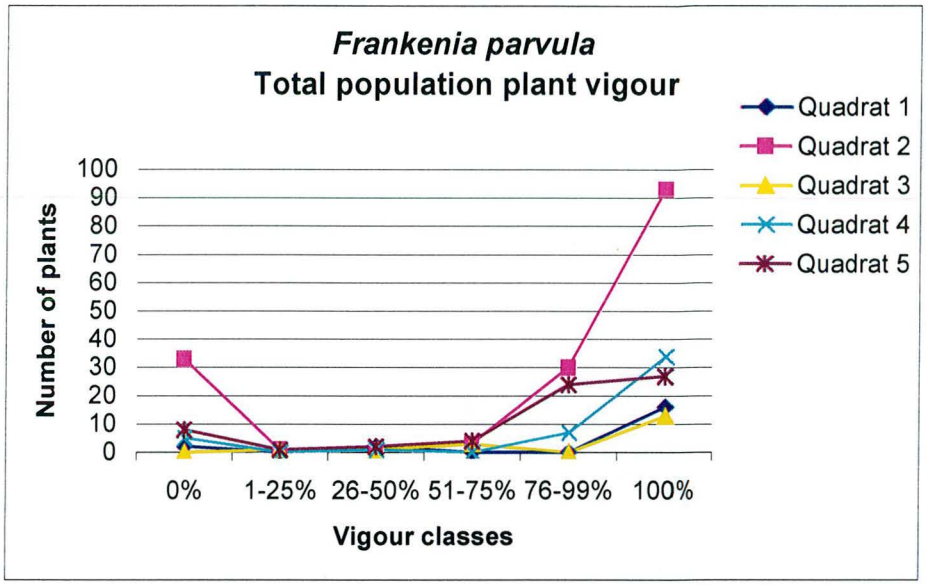
Figure 3. Plant distribution of *Frankenia parvula* within (a) Quadrat 2 and (b) Quadrat 3.

(a)

(b)

The health of *Frankenia parvula* plants varied throughout all populations with over 50% of plants falling within the 100% live canopy class (Figure 4). The highest number of plants in both 100% and 0% live canopy classes however were recorded from Quadrat 2. Fifteen percent of total plants assessed were dead with over 10% of plants occurring from each quadrat of Population 1 (Table 4). The highest proportion of stressed plants were recorded from Quadrats 1 and 3 with 33% and 20% of plants respectively recorded as having partial canopy deaths (51-75% live canopy vigour class or less).

Figure 4. The distribution of *Frankenia parvula* plants across vigour classes for the five study sites.



Juveniles were observed to occur within both populations and were recorded for all quadrats (Table 4) with 22.4% of total plants assessed recorded as juveniles. There were no obvious reasons for the high numbers of dead and stressed plants or for the high proportion of juveniles within Quadrats 2, 4 and 5. However, figures from the nearest weather centres to both populations recorded a marked decrease in average annual rainfall in 2002 and a significant increase to well above the annual average at Southern Cross (near Population 1) in 2003 (Table 1). Water stress may have been one of the factors contributing to the decline in health of *Frankenia parvula* plants and a subsequent flush of freshwater from the increase in rainfall during 2003 would favour the recruitment of juveniles.

Table 4. Number of juveniles, stressed and dead *Frankenia parvula* plants recorded in all quadrats – December 2003.

Location/Quadrat	Juveniles	Stressed plants	Dead plants	Total plants
Yellowdine/1	1	4	2	20
Yellowdine/2	33	4	33	161
Cunderdin/3	1	6	0	18
Yellowdine/4	11	1	5	47
Yellowdine/5	24	8	8	66

4.3 Population dynamics

Plant community structure in the habitat of *Frankenia parvula* was recorded as Dwarf Scrub D at Population 2a (Cunderdin) and Open Dwarf Scrub D to Very Open Mat Plants over Very Open Herbs at Population 1 (Yellowdine) (Muir 1977).

Population 1 at Yellowdine is extensive with *F. parvula* plants numbering many thousands. Plants are however, very small mat plants and although they appear to be quite young, many are mature flowering individuals. Dead plants occur with others that appear to resurrect by re-sprouting. Population 2a at Cunderdin contains larger more mature plants that can spread vegetatively.

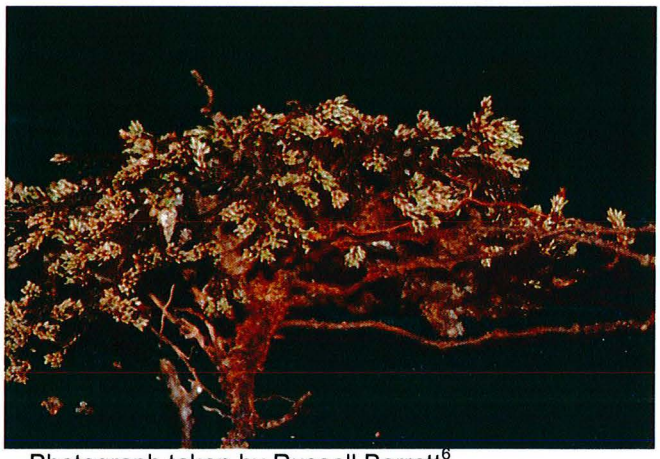
Populations of *Frankenia conferta* occur in fragmented, specialised habitats of saline soils through the northern wheatbelt area where drainage channels occur. Correlations between population health,

fragmentation, plant abundance and rainfall were not investigated within this study. However Mr. J. Stokes has noticed that some parts of the samphire community associated with the *Frankenia parvula*, are dying and drying out. He has observed drought conditions over the past 2-3 years and has noted less or no flushing of the drainage channels within the area. The drainage flat on Department of Agriculture land adjacent to his property has not had sheep grazing on it for about 15 years and the samphires are still dying, therefore he thinks the vegetation stress is not caused by grazing pressure (J. Stokes *pers. comm.*).

Numbers of individuals within populations vary from 7 to >200,000. Smaller sized populations may have limited variability with a smaller gene pool therefore, resulting in less tolerance to various stresses and threats. Losses of any plants within smaller populations could cause irreversible population decreases.

Careful excavation around the roots of one plant from Population 2a at Cunderdin showed the presence of adventitious roots with vegetative recruitment evident. Excavations of another plant from Population 1 at Yellowdine showed that they also proliferate by producing adventitious roots that grow horizontally just under the soil surface (Figure 5). Such roots are placed for maximum benefit from fresh water (Kingsley Dixon[5] *pers. comm.)*, which enhance the ability of the plants to recruit vegetatively.

Figure 5. *Frankenia parvula* plant from Population 1 at Yellowdine showing horizontal and adventitious roots.



Photograph taken by Russell Barrett[6]

Studies undertaken by (Pereira and Kozlowski 1977) into plant responses to environmental stresses found that in woody angiosperms, alterations in root and stem morphology and the production of adventitious roots follow stomatal closure in the responses to flooding. These adaptations to continuing environmental stresses develop relatively slowly. Although *Frankenia conferta* plants recruit vegetatively and grow within winter wet areas the response to prolonged inundation is unknown. Many of the recorded dead plants in Population 1 occurred close to the water line where evidence of re-sprouting was observed.

Re-sprouting from underground stems or roots as a response to pressures such as grazing, fire and inundation has been well documented and is recognized as one approach used to classify species for comparisons of fire response on a regional, national and international basis. (Pate and McComb 1981).

There are no records of fires having occurred in the areas or reserves where *Frankenia parvula* populations are located and it is unlikely that future hot or frequent fires would occur within the plants habitat.

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[5] Kingsley Dixon, Assistant Director (Plant Science) Kings Park Botanical Gardens and Parks Authority.
[6] Russell Barrett, Research Scientist (Plant Science) Kings Park, Botanical Gardens and Parks Authority

Multiple sized plants and life stages, non-reproductive juveniles and reproductive adults, were observed in all populations (Table 12).

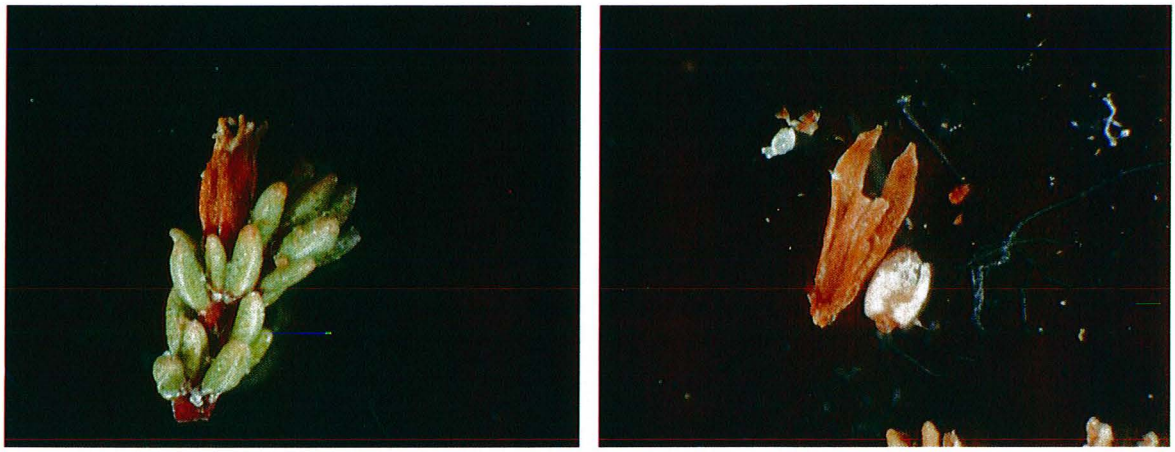
4.4 Inflorescence, fruit and seed production

Flowers were produced from November 2003 through to late March 2004, when fruits started to mature. *Frankenia parvula* plants have either solitary or compound inflorescences of 2 or 3 flowers. For the purposes of this study single flowers, and buds where flowers had not developed, were counted. Both flowers and fruits were very small, 3-7 mm and 3-5 mm respectively, and a hand lens was necessary to assess them (Figure 6).

The total number of flowers for 312 permanently labelled plants throughout the five populations was 3,717 and ranged from 0-273 per plant. 150 live adult plants had not produced any inflorescences at the time of quadrat establishment and 48 were dead.

Figure 6. *Frankenia parvula* (a) stem with leaves and fruit (magnified 4x) and (b) cut fruit and ovary (magnified 7x).

(a) *(b)*



The mean number of flowers and fruits per plant for the 75 plants randomly selected for reproductive assessment within each quadrat was calculated and is shown in Table 5. Each *Frankenia parvula* flower may form one fruit that can produce many seeds. Results of flower and fruit analysis show a higher fruit to flower ratio. This is because more fruits were produced than the number of flowers counted, as it was impossible to label each flower or to survey at shorter intervals.

Table 5. Mean number of *Frankenia parvula* flowers and fruits per plant for the five study sites-March 2004.

Quadrat/Location	Mean no. of flowers per plant ± SE	Mean no. of fruits per plant ± SE	Total no. of flowers per plant	Total no. of fruits per plant
1/Yellowdine	39.45 ± 17.95	30.73 ± 9.19	434	338
2/Yellowdine	1.80 ± 1.25	3.50 ± 2.47	36	70
3/Cunderdin	86.93 ± 24.17	122.29 ± 41.13	1217	1712
4/Yellowdine	21.94 ± 10.23	26.13 ± 12.42	351	418
5/Yellowdine	3.14 ± 1.96	2.00 ± 1.13	44	28

Both flower and fruit numbers were low in Quadrats 2 and 5. The reason for this is unknown, however the highest incidence of dead and mature plants that had not produced flowers occurred within these quadrats, which are located on the same drainage channel.

Flowers of *Frankenia conferta* plants are not self-pollinating due to the different maturation times for stigmas and anthers, however no specific pollinators were observed on flowers at any of the monitoring sites.

Results showed a variable relationship between plant canopy area and flowers per plant for each monitoring site (Table 6). While plants in Quadrat 5 produced the lowest number of flowers for the smallest canopy area, plants in Quadrat 2 that had the largest canopy area did not produce the most flowers.

Table 6. *Frankenia parvula* total flowers and mean flowers per canopy area.

Quadrat/Location	Total Canopy area	Mean flowers per cm^2	Total flowers
1/Yellowdine	1505.34	0.48	601
2/Yellowdine	5349.90	0.06	513
3/Cunderdin	3616.81	0.50	1290
4/Yellowdine	1371.92	0.64	1250
5/Yellowdine	1046.75	0.05	63

Frankenia parvula plants within Quadrat 3 at Cunderdin, not only recorded a significantly higher number of fruits but also the highest proportion of fruits that produced viable seed (Table 7). The mean proportion of fruits that produced viable seed over the five monitoring sites was 29.57%. The total seed production for each site is shown in Table 7 below. The mean number of fruits to set seed (unviable and viable) over the total population was 68.71%.

Table 7. Total number of *Frankenia parvula* assessed fruits, seeds produced and viable seeds – March 2004.

Quadrat/Location	Total fruit counted	Total fruit assessed	Total seed produced	Total viable seed
1/Yellowdine	338	149	209	68
2/Yellowdine	70	36	32	13
3/Cunderdin	1712	462	2086	798
4/Yellowdine	418	187	729	117
5/Yellowdine	28	13	15	12

Table 8. Percentage of viable seed, and fruits with viable seed from *Frankenia parvula* study sites – March 2004.

Quadrat/Location	% viable seed	% fruits with viable seed
1/Yellowdine	32.54	21.48
2/Yellowdine	40.63	19.44
3/Cunderdin	38.26	49.13
4/Yellowdine	16.05	34.76
5/Yellowdine	80.00	23.08

Investigations of soil-stored seed were not possible within the time frame for this project. Although low numbers were recorded for Quadrats 1 and 3, juveniles were found at all study sites. *Frankenia parvula* fruits have a hard outer surface, which suggests that seeds are not immediately dehisced upon fruit maturity but may be held until conditions are favourable for germination. Constant inundation of the habitat and a lack of seed entrapment areas are also factors that may contribute to low recruitment from seed. There was very little predation of fruits at the study sites with only 6 fruits from Quadrat 3 recorded as predated.

Investigations into the reproductive biology of *Frankenia johnstonii* in Texas U.S.A. by Whalen (1980), found that although the seeds are held in a hard semi-impermeable tube (similar to *F. conferta),* they germinate readily after a few days exposure to fresh water. Whalen suggests that the hard tube may encase the seeds until a strong rain can wash them from the fruits and also ensure enough soil moisture for early seedling growth, which is an important factor in a semi-arid climate. *F. johnstonii* also occurs in a saline scrub community with varying percentages of gypsum content.

Comparison of results from reproductive information collected from both *Frankenia parvula* and *F. conferta* shows a similarity in proportion of viable seed per fruit, where the range for *F. conferta* is 25.06% - 90.55% and for *F. parvula* is 16.05% - 80.00%.

There were marked variations in the results for total flowers and fruits per plant, however the proportion of fruits that produced viable seed was similar (Table 9).

Table 9. Comparison of reproductive data analysis between *Frankenia conferta* and *F. parvula.*

	Frankenia conferta	*Frankenia parvula*
Total flowers/plant	43.81 – 404.60	44 - 1217
Total fruits/plant	82.79 – 542.27	28 - 1712
% fruit with viable seed	10.09 – 44.91	19.44 – 49.13

The above comparisons are from one season only and further monitoring of both *Frankenia* species is necessary over a number of reproductive seasons to obtain a more accurate measurement of trends.

4.5 Soil structure

Descriptions of the surface soil differed between quadrats, mostly in the descriptions of soil colour (Site and quadrat descriptions, pages 27-31) with sand over clay the dominant soil type. The soil at Quadrat 4 however, is described as sandy clay/loam. This site is the only one to occur on the floor of a wide claypan.

Table 10 below shows the results of electrical conductivity and pH analysis of the bulked soil samples for each quadrat.

Table 10. Results of soil analysis for salinity and pH from five *Frankenia parvula* sites – December 2003.

Population	Quadrat	pH (H_20)	pH (CaC_{12})	E.C. (mSm^{-1})	Salinity level (ppm)
Yellowdine	1	4.38	4.15	350	1,750
Yellowdine	2	5.03	4.76	489	2,445
Cunderdin	3	4.83	4.53	531	2,655
Yellowdine	4	4.92	4.66	467	2,335
Yellowdine	5	5.03	4.79	494	2,470

All samples were taken in November and December 2003. It is probable that the salinity readings will increase before the next winter rainfall occurs. The relationship between salinity, pH and plant health is unknown. Results presented above serve as a baseline for comparison against any further research. Research on salinity levels of agricultural soils and water bodies utilised by livestock is available, however information on inland salt lakes and halophytic plants is limited.

4.6 Relocation information

Table 13 details all GPS readings taken in and around the *Frankenia parvula* populations. Waypoints in degrees, minutes and seconds using WGS 84 datum were recorded from all quadrats and at road intersections where necessary, to relocate sites.

4.7 Associated vegetation

Associated species growing within Quadrats 1-5 were recorded at the time of establishment. Samples of unknown species were collected and identified from voucher specimens held at the West Australian Herbarium and by enlisting the aid of Paul Wilson[7] for Chenopodiaceae and Asteraceae specimens, Frank Obbens[8] for *Calandrinia* sp. and Rob Davis[9] and Mike Hislop[10] for confirmation of preliminary identifications.

One species of priority flora, *Drosera salina* (P2), was identified growing within Quadrat 2 and two species - *Stylidium pulviniforme* (P3) and *Verticordia mitodes* (P3) were found to be common within the habitats near Quadrat 2 at Yellowdine and Quadrat 3 at Cunderdin. Priority flora are those that may be rare or threatened but have insufficient survey data to accurately determine their status. They are grouped and ordered according to the perceived urgency for further survey as follows (Atkins 2003).

Priority 1 - Poorly Known Taxa.
Taxa which are known from one or a few (generally <5) populations which are under threat.
Priority 2 – Poorly Known Taxa.
Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat.
Priority 3 – Poorly Known Taxa.
Taxa which are known from several populations which are not believed to be under immediate threat.
Priority 4 – Rare Taxa.
Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors.

Species collected for each location are provided in Appendix 1 under Site and Quadrat Descriptions. A total of 28 taxa from 13 families and 19 genera were recorded for all five-study sites. The most species diverse families were Asteraceae (7 taxa) and Chenopodiaceae (4 taxa).

Frankenia parvula grows within vegetation communities of Dwarf Scrub D or Open Dwarf Scrub D to Very open Mat Plants over Very Open Herbs (Muir 1977). In three of the study sites where *F. parvula* grows on the shorelines of drainage channels, associated species were few and predominantly annuals (Quadrats 1, 2 and 5). In Quadrat 3, however plants grow in close association with halophytes, predominantly *Halosarcia* spp., and few perennial or ephemeral species. At the time of establishment some annual species had senesced and were therefore unable to be identified. These were recorded under dead shrubs/litter in cover percentages, which are detailed in Table 11.

One weed species was recorded from the family Poaceae and is identified within the species lists with an asterisk. This weed occurred in low numbers and is therefore not considered to be a threat to the *Frankenia parvula* populations.

Cover of *F. parvula* plants was highest in Quadrat 2 where plants were abundant but very small. Native plant coverage was highest within Quadrat 3 where the *F. parvula* plants were growing within the canopies of *Halosarcia* spp. High percentages of bare ground were recorded within populations that occurred on the shorelines of drainage channels (Quadrats 1, 2, 4 and 5).

Table 11. Percentage cover of *Frankenia parvula,* native plants, weeds, dead shrubs/litter and bare ground within Quadrats 1-5 - December 2003.

Population /Quadrat	Number of tagged *F. parvula* in subquadrats	COVER %

[7] Paul Wilson, Contract Consultant, West Australian Herbarium
[8] Frank Obbens, Consultant and Volunteer, West Australian Herbarium
[9] Rob Davis, Technical Officer, West Australian Herbarium
[10] Mike Hislop, Contract Consultant, West Australian Herbarium

		F. parvula	Native plants	Weeds	Dead shrubs/litter	Bare ground
1/1	20	2.5	0	0	0	97.5
1/2	161	20	1.5	0	0	78.5
2a/3	18	3	50	0.5	4.5	41.5
1/4	47	1	3	0	0	96
1/5	66	1.5	10	0	2	86.5

5.0 CONCLUSIONS

This project established a quadrat based monitoring framework for *Frankenia parvula.*

1. Recent surveys have increased the known number of *Frankenia parvula* populations.
2. Plant numbers in Population 1 are known to be in the order of hundreds of thousands, however the habitat is highly restricted with plants occupying a narrow band on shorelines of drainage channels.
3. More thorough surveys of Population 1 are recommended to qualify the existence of several separate populations within the one locality.
4. Regular monitoring using the framework established by this project is necessary to quantify future population trends.
5. Evidence of re-sprouting was observed, which suggests that *Frankenia parvula* plants may have the ability to recover from disturbance events.
6. Although *Frankenia parvula* plants have the capacity to spread with the largest plant recorded at 1969.8 cm^2, over 80% of plants are small with a canopy area of less than 50 cm^2.
7. The highest number of plant deaths occurred close to the waterline within Quadrat 2 at Yellowdine. Evidence from previous studies, in particular the Kondinin Saltmarsh, suggests that changes in the hydrology adversely affect plant communities. Implications are that any activity that influences hydrology could adversely affect plant species and lead to the demise of whole plant communities (Mattiske 1995).
8. Flower and fruit production varied and the proportion of fruits with viable seed was under 50% over all study sites. The reproductive potential of the population cannot be adequately assessed without further monitoring and comparison with a common and close relative.
9. *Frankenia parvula* recruits both sexually and vegetatively. Plants spread clonally by the production of adventitious roots. Though advantageous for survival through unfavourable seasons, the effects of prolonged inundation, rising salinity levels and drought are unknown.
10. Soil analysis undertaken within this project to provide a baseline needs to be repeated during differing seasons to more adequately assess the affect of salinity and pH on population condition.

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APPENDIX 1

Table 12. Plant dimensions (height, width at widest point and at 90°), percentage of live canopy, number of inflorescences per plant and life stage classification for *Frankenia parvula* as at November 2003.

Location/ Quadrat (Pop'n no.)	Subquadrat number	Plant number	Height (cm)	Width @ widest point (cm)	Width @ 90deg (cm)	% Live canopy	Number of inflorescences	Mature (M) Juvenile (J) Dead (D)
Yellowdine/1	1	0						
(1)	2	1	0.5	4.2	4	100	3	M
		2	0.4	23	9	100	10	M
		3	0.3	3.7	2.8	100	0	J
		4	0.5	16.5	11	100	209	M
		5	2	22	19	50	65	M
		6	1.6	25	16	40	19	M
		7	1.2	10	9	100	34	M
		8	0.5	6.5	4.5	0	0	D
		9	0.5	5	4	0	0	D
	3	1	1	8.5	7.5	100	65	M
		2	0.3	7	5	100	16	M
	4	1	0.7	10	8.5	100	25	M
		2	0.5	7	5.5	100	38	M
		3	0.5	9.5	6	100	38	M
		4	0.5	8.5	7.5	100	25	M
		5	0.5	7	4	100	18	M
		6	1	7.5	7	100	5	M
		7	0.5	5.5	5.5	100	28	M
		8	0.3	8	7.5	100	3	M
	5	1	0.3	6	5	100	0	M
Yellowdine/2	1	1	0.5	3.8	3	0	0	D
(1)		2	1	2.8	1	100	0	J
		3	1.4	2	1	100	0	J
		4	1.5	3.6	3	100	0	M
		5	0.2	0.5	0.5	0	0	D
		6	1	6	5.5	0	0	D
		7	1.5	5	5	99	0	M
		8	1	1.5	0.5	100	0	J
		9	1.3	6	5.5	0	0	D
		10	0.5	2	1.5	0	0	D
		11	1	4	3.5	0	0	D
		12	1.3	3	3	100	0	M
		13	1.5	3	2	0	0	D
		14	1.2	8.3	7	98	0	M
		15	1.2	7.5	6	100	0	M
		16	1.2	4.5	3.5	100	0	M
		17	1.5	1.5	1	100	0	J
		18	1.5	6	6	0	0	D
		19	0.2	1.2	1	0	0	D
		20	1	5	3.5	0	0	D
		21	0.8	5	3.3	98	3	M
		22	0.2	1	0.8	0	0	D
		23	0.5	4	3.3	0	0	D

Location/ Quadrat (Pop'n no.)	Subquadrat number	Plant number	Height (cm)	Width @ widest point (cm)	Width @ 90deg (cm)	% Live canopy	Number of inflorescences	Mature (M) Juvenile (J) Dead (D)
Yellowdine/2	1	24	0.8	1.7	1	100	0	J
(1)		25	1	0.8	0.5	100	0	J
		26	1.5	4	3	100	1	M
		27	0.3	0.5	0.5	0	0	D
		28	1.3	1.8	1	100	0	J
		29	0.5	4	3.5	0	0	D
		30	0.7	5.8	5	100	2	M
		31	1.5	1	1	100	0	J
		32	1	2.3	2	100	0	J
		33	1.3	8	5.3	100	2	M
		34	1.5	3.8	3	100	0	M
		35	0.5	1.8	1.5	100	0	J
		36	0.8	2.8	1.5	98	0	J
		37	0.5	1	1	80	0	J
		38	1.4	6.5	5.5	95	0	M
	2	1	0.5	3.5	3	100	0	M
		2	0.5	6.5	3.5	100	0	M
		3	0.5	3	2	100	2	M
		4	1	5	3.5	100	0	M
		5	0.8	2.5	1.3	100	0	J
		6	1	6.5	3.5	100	3	M
		7	0.7	4	1	100	1	M
		8	1.5	9.3	3.5	95	15	M
		9	1	8	5	100	6	M
		10	0.8	8	5	100	2	M
		11	0.3	6	4.5	100	0	M
		12	1	10.5	7	100	0	M
		13	1	7.5	6	100	2	M
		14	1	8.5	8	100	31	M
	3	1	0.5	3	2	100	0	M
		2	0.5	1.8	1.5	100	0	J
		3	0.5	4	2	100	0	M
		4	1	3	3	98	1	M
		5	0.8	6	5	100	1	M
		6	0.5	2	0.8	100	0	J
		7	1.4	5.6	3	100	1	M
		8	0.8	5.5	3.3	100	0	M
		9	1	3.8	3	100	0	M
		10	1	1	0.5	100	0	J
		11	0.8	1	0.8	100	0	J
		12	1	3.2	2	98	0	M
		13	0.8	1.8	0.3	100	0	J
		14	1.6	8	8	100	3	M
		15	1	11	6.5	100	2	M
		16	0.8	8	6.5	100	11	M
		17	0.3	3.5	1.5	0	0	D
		18	1	6.3	5.5	100	0	M
Yellowdine/2	3	19	1.3	4	3	100	0	M
(1)		20	1.5	26	24	100	8	M
		21	0.8	14	11	100	1	M

Location/ Quadrat (Pop'n no.)	Subquadrat number	Plant number	Height (cm)	Width @ widest point (cm)	Width @ 90deg (cm)	% Live canopy	Number of inflorescences	Mature (M) Juvenile (J) Dead (D)
		22	0.5	7	6.5	100	0	M
		23	1	4.3	3.5	95	0	M
		24	0.8	5.5	3.5	100	0	M
		25	0.5	9	5	100	0	M
		26	1	25	14	95	14	M
		27	1	4	3	98	0	M
		28	1	7	6.5	100	1	M
		29	1	43	9	95	33	M
		30	1.5	15	15	100	33	M
		31	0.3	11.5	8.5	100	21	M
		32	0.8	13	9	100	1	M
		33	1	12	11.5	100	30	M
		34	1	19	16.5	100	36	M
		35	1.3	3	2.5	100	0	M
		36	0.5	6.5	6	100	3	M
		37	1.5	7.5	7	100	5	M
		38	1	3.5	3	100	0	M
	4	1	0.5	5	4	0	0	D
		2	0.5	6	4	0	0	D
		3	0.3	2	2	0	0	D
		4	0.3	0.5	0.5	0	0	D
		5	0.3	0.5	0.5	0	0	D
		6	0.3	0.5	0.5	0	0	D
		7	0.5	9	7	0	0	D
		8	0.5	1.3	2	0	0	D
		9	0.5	1.8	1.4	0	0	D
		10	0.8	4.8	2.3	0	0	D
		11	0.5	0.5	0.5	0	0	D
		12	1	3.3	3	0	0	D
		13	1.5	3.5	2.5	98	1	M
		14	1	5	4.5	85	0	M
		15	0.3	6	4	0	0	D
		16	1	6	4	90	4	M
		17	0.5	2	2	0	0	D
		18	0.8	5	3.5	0	0	D
		19	0.3	0.5	0.5	100	0	J
		20	0.8	3	1.5	100	0	J
		21	0.3	3	2	100	0	J
		22	0.5	3	3.5	0	0	D
		23	0.5	6.5	3.4	100	10	M
		24	0.8	2	1	100	0	J
		25	1	2.3	2	100	0	J
		26	0.6	0.5	0.5	100	0	J
		27	1	4.5	4	0	0	D
Yellowdine/2 (1)	4	28	1	6	5.5	95	0	M
		29	1.5	18.5	9	98	8	M
		30	1.5	8.5	7.5	90	0	M
		31	1	2.5	1.8	100	0	J
		32	0.5	5.5	4	100	0	M
		33	0.8	1.5	1.5	100	0	J

Location/ Quadrat (Pop'n no.)	Subquadrat number	Plant number	Height (cm)	Width @ widest point (cm)	Width @ 90deg (cm)	% Live canopy	Number of inflorescences	Mature (M) Juvenile (J) Dead (D)
		34	0.8	2.5	2	100	0	J
		35	0.5	2.3	2	98	0	J
		36	1	2.5	1	100	0	J
		37	1.3	8.5	8.2	100	0	M
		38	0.8	9	5	100	5	M
		39	1	6.5	4	85	0	M
		40	0.5	1	0.3	60	0	M
	5	1	1	21	20.5	50	24	M
		2	0.6	7.5	5	90	0	M
		3	0.8	12	10	100	0	M
		4	0.8	6.5	4	98	0	M
		5	0.5	3.5	2.5	100	0	M
		6	0.5	1.2	1	100	0	J
		7	0.8	2	1.5	100	0	J
		8	0.8	4	4	100	0	M
		9	0.7	4.5	3.5	100	0	M
		10	1	13	12	100	9	M
		11	0.7	9.5	8	100	84	M
		12	0.5	12	8	15	1	M
		13	0.5	7.5	7	98	14	M
		14	0.5	2.5	2	100	2	M
		15	1	5.5	4	0	0	D
		16	1	5.3	3	90	0	M
		17	0.5	1	0.8	100	0	J
		18	0.3	1.5	1	100	0	J
		19	0.5	7.5	3.5	80	0	M
		20	0.5	16.5	11	98	6	M
		21	0.5	6	3.8	100	6	M
		22	0.5	13.5	8.5	100	36	M
		23	0.6	5.5	4.5	100	0	M
		24	1	9	7.5	100	0	M
		25	0.8	10	8	70	1	M
		26	1	15	10.5	85	5	M
		27	0.8	2.8	2.8	100	0	M
		28	0.7	10.5	6.3	100	17	M
		29	1.4	5.5	3.5	98	0	M
		30	1	16	11.5	75	5	M
		31	1	7	6	85	0	M
Cunderdin/3	1	0						
(2a)	2	1	2	26	11	100	143	M
		2	0.5	24	21	100	262	M
Cunderdin/3	2	3	0.3	6	4	100	1	M
(2a)		4	0.5	3.5	1.5	100	0	M
		5	0.3	2.4	2	100	2	M
		6	0.5	2	1.5	100	0	J
		7	0.5	9	9	70	64	M
		8	1.2	6.5	4	100	7	M
	3	1	3.5	18	10	40	50	M
		2	1	16	12	60	85	M
		3	0.8	8	7	20	0	M

Location/ Quadrat (Pop'n no.)	Subquadrat number	Plant number	Height (cm)	Width @ widest point (cm)	Width @ 90deg (cm)	% Live canopy	Number of inflorescences	Mature (M) Juvenile (J) Dead (D)
	4	1	1.5	57	44	70	273	M
		2	1.6	18	16.5	100	121	M
		3	2	12.5	9	100	57	M
	5	1	0.8	13.5	12	100	134	M
		2	0.8	9.8	7.5	100	36	M
		3	1.6	9.5	6	100	19	M
		4	1.2	6	5.5	100	36	M
Yellowdine/4	1	1	0.6	7	4.8	100	0	M
(1)		2	0.6	9	7	100	17	M
		3	0.5	6	4.5	100	3	M
		4	0.9	4.6	4.3	95	0	M
		5	1	1.4	0.8	100	0	J
		6	0.9	7.3	5.8	95	25	M
		7	0.7	3.5	2.8	80	9	M
	2	0						
	3	1	1.1	8.3	6.3	100	140	M
		2	1	7.3	6.2	100	81	M
		3	1	6.8	6.3	100	78	M
		4	0.5	4	2.4	100	2	M
		5	1	11.5	7.5	95	56	M
		6	0.6	7.8	7.5	100	16	M
		7	0.5	14	9.5	100	167	M
		8	0.8	8.8	8	100	67	M
		9	0.5	10	9.5	100	171	M
		10	0.8	10.3	4.8	100	61	M
		11	0.9	10	8.3	100	101	M
		12	2	2	2	95	3	M
		13	0.9	7.5	6.8	100	11	M
		14	1.5	4.5	3	100	24	M
	4	1	0.8	7.8	6	100	6	M
		2	0.5	7	5.5	85	7	M
		3	0.5	6	5	100	12	M
		4	0.8	5.5	4.5	100	5	M
		5	0.7	6.5	3.8	100	8	M
		6	0.6	5.8	4.8	95	4	M
		7	1	13.5	10	50	0	M
		8	0.5	8	8	0	0	D
		9	1	6.7	3.5	100	5	M
Yellowdine/4	4	10	0.2	5	4	0	0	D
(1)		11	0.5	3.5	2.5	0	0	D
		12	1.3	11	11	100	14	M
	5	1	0.2	8.5	4	0	0	D
		2	0.2	3.8	3	0	0	D
		3	0.4	0.4	0.3	100	0	J
		4	0.2	0.3	0.3	100	0	J
		5	0.6	3	3	100	21	M
		6	0.1	0.2	0.2	100	0	J
		7	0.2	1.5	0.5	100	0	J
		8	0.2	0.2	0.2	100	0	J
		9	0.1	0.5	0.2	100	0	J

Location/ Quadrat (Pop'n no.)	Subquadrat number	Plant number	Height (cm)	Width @ widest point (cm)	Width @ 90deg (cm)	% Live canopy	Number of inflorescences	Mature (M) Juvenile (J) Dead (D)
		10	0.5	0.5	0.3	100	0	J
		11	0.2	0.4	0.2	100	0	J
		12	0.9	2	1.3	100	0	J
		13	1	12	11	100	136	M
		14	0.2	1.8	0.5	100	0	J
Yellowdine/5	1	1	2.4	6.2	5.2	98	0	M
(1)		2	1.8	5.3	5	95	26	M
		3	3	4.4	3.8	100	11	M
		4	0.9	0.5	0.5	100	0	J
		5	1	0.6	0.3	75	0	J
		6	2.6	6	5.4	50	13	M
		7	0.2	3.5	2.5	0	0	D
		8	0.6	0.5	0.3	0	0	D
		9	0.4	1.9	1.3	0	0	D
		10	0.6	1	0.3	100	0	J
	2	0						
	3	1	1.4	4.5	3	95	0	J
		2	1.9	4	3.4	100	6	M
	4	1	1.6	9	6.3	98	0	M
		2	1.1	2	1.7	100	0	J
		3	0.7	6.5	5.7	60	0	M
		4	1.8	8	5	75	0	M
		5	0.5	0.4	0.3	100	0	J
		6	1	9.5	6	10	0	M
		7	1.6	4.7	4.3	85	0	M
		8	0.6	1	0.7	100	0	J
		9	0.6	2.2	1	98	0	J
		10	1.4	6.8	5	80	0	M
		11	1.2	7.5	6.5	98	0	M
		12	1.3	4.5	2.8	95	0	J
		13	0.6	2.1	1.2	98	0	J
		14	0.8	0.8	0.6	98	0	J
		15	1.4	3	2.5	100	0	J
		16	0.9	2.9	2.8	90	0	J
		17	1.4	5	3.5	98	0	M
Yellowdine/5	4	18	1.4	9.2	6	50	0	M
(1)		19	1.8	7.9	4.5	100	0	M
		20	0.6	1.4	0.7	100	0	J
		21	0.5	2.8	1.3	98	0	J
	5	1	3	2.6	2	100	0	J
		2	2.2	4.1	3.5	90	0	M
		3	2.5	5.5	5.3	100	0	M
		4	2.4	4.8	4.7	80	0	M
		5	1.3	2.5	2	100	0	J
		6	2	5	4.5	100	0	M
		7	1.8	5.2	6.2	98	0	M
		8	1	8.8	7.4	95	4	M
		9	0.2	3.6	2.5	0	0	M
		10	1.5	4	3.6	100	0	M
		11	0.2	3	2	0	0	M

Location/ Quadrat (Pop'n no.)	Subquadrat number	Plant number	Height (cm)	Width @ widest point (cm)	Width @ 90deg (cm)	% Live canopy	Number of inflorescences	Mature (M) Juvenile (J) Dead (D)
		12	1.2	5.8	4.5	100	0	M
		13	1.4	3.8	3	100	0	J
		14	1.3	4.8	5	100	0	M
		15	2.4	2.4	1	100	0	J
		16	1.3	7.2	6.8	100	0	M
		17	0.9	2.3	2.3	0	0	M
		18	1.5	2.5	2.5	90	0	J
		19	1.2	3.4	3.5	100	0	J
		20	0.5	1	1	0	0	D
		21	2	8.1	3.7	100	0	M
		22	1	3.4	2.5	100	0	J
		23	1.5	5.6	4.3	90	0	M
		24	1.1	4.6	3.4	100	0	M
		25	1.2	6	5.7	90	0	M
		26	0.6	7	4.2	100	2	M
		27	2.1	5.3	4.5	100	0	M
		28	2.4	7.5	7	70	0	M
		29	1.4	3.9	1.2	100	0	M
		30	2.2	15.3	7.6	95	1	M
		31	1	5.8	3	85	0	M
		32	0.5	4.5	4	0	0	D
		33	3	3.2	1.3	85	0	M

SITE AND QUADRAT DESCRIPTIONS

POPULATION 1
NB-LOCATIONAL INFORMATION IS CONFIDENTIAL – NOT FOR PUBLICATION

QUADRAT 1-YELLOWDINE GPS: 31° 08.50'S
119° 43.47'E
QUADRAT AREA: 25 m^2 (5 X 5 m)
SUBQUADRAT AREA: 5 m^2 (5 x 1 m)

DATE ESTABLISHED: 18/11/2003

LOCATION: On south-east shoreline of salt lake ~4.5 km north-west along Weowanie Rock track from Yellowdine Rd intersection.

SOIL: Sand over clay sand.

COVER: *Frankenia parvula* – 2.5%
Native plants - 0%
Weeds – 0%
Bare ground – 97.5%
Dead shrubs/litter - 0%

PLANT COMMUNITY CLASSIFICATION (Muir 1977): Very Open Mat Plants.

NUMBER OF TAGGED *FRANKENIA PARVULA* PLANTS IN SUBQUADRATS : 20

CONDITION: Healthy

ASSOCIATED SPECIES IN AREA (NOT QUADRAT) :
Darwinia halophila
Melaleuca halmaturorum
Stylidium pulviniforme (Priority 3)

Figure 7. Quadrat 1 established within Population 1 at Yellowdine. Photograph taken from the west corner of quadrat – 18/11/2003.

POPULATION 1
NB-LOCATIONAL INFORMATION IS CONFIDENTIAL – NOT FOR PUBLICATION

QUADRAT 2 – YELLOWDINE GPS: 31° 09.06'S
119° 43.33'E

QUADRAT AREA: 25 m^2 (5 X 5 m)
SUBQUADRAT AREA: 5 m^2 (5 x 1 m)

DATE ESTABLISHED: 19/11/2003

LOCATION: On north shoreline of drainage channel ~3.9 km north-west along Weowanie Rock track from Yellowdine Rd intersection. Then 150-200m at 110°.

SOIL: White coarse sand over chocolate sand to clay sand over clay.

COVER: *Frankenia parvula* – 20%
Native plants – 1.5%
Weeds –0%
Bare ground – 78.5%
Dead shrubs/litter – 0%

PLANT COMMUNITY CLASSIFICATION (Muir 1977): Open Dwarf Scrub D.

NUMBER OF TAGGED *FRANKENIA PARVULA* PLANTS IN SUBQUADRATS : 161

CONDITION: Poor

ASSOCIATED SPECIES IN QUADRAT:
Angianthus priessianus
Austrostipa pyanostachya
Centrolepis polygyna
Drosera salina Priority 2
Gnephosis multiflora
Halosarcia lylei

COMMON SPECIES IN AREA:
Melaleuca atroviridis
Verticordia mitodes (Priority 3)
Darwinia halophila
Actinostrobus sp.
Melaleuca halmaturorum

Figure 8. Quadrat 2 established within Population 1 at Yellowdine. Photograph taken from southwest corner of quadrat – 19/11/2003.

POPULATION 2a
NB-LOCATIONAL INFORMATION IS CONFIDENTIAL – NOT FOR PUBLICATION

QUADRAT 3 – CUNDERDIN GPS: 31° 37.45'S
117° 11.31'E

QUADRAT AREA: 25 m^2 (12.5 X 2 m)
SUBQUADRAT AREA: 5 m^2 (5 X 1 m)

DATE ESTABLISHED: 20/11/2003

LOCATION: 1.6 km north along Stokes Rd, Cunderdin. Then ~100 m at 100° to the edge of a low rise within the drainage flats. In private property.

SOIL: Sand to sandy clay at surface over clay.

COVER: *Frankenia parvula* - 3%
Native plants - 50%
Weeds – 0.5%
Bare ground – 41.5%
Dead shrubs/litter – 5%

PLANT COMMUNITY CLASSIFICATION (Muir 1977): Dwarf Scrub D over Very open Herbs.

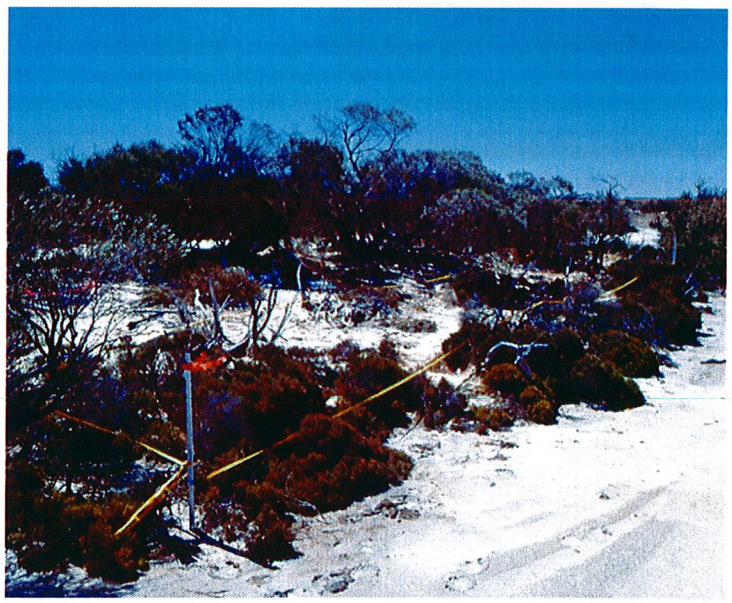
NUMBER OF *FRANKENIA PARVULA* PLANTS IN SUBQUADRATS : 18

CONDITION: Moderate - Poor

ASSOCIATED SPECIES IN QUADRAT:

**Parapholis incurva*
Angianthus priessianus
Atriplex hymenotheca
Austrostipa pyanostachya
Crassula exserta
Gnephosis angianthoides
Gnephosis multiflora
Gunniopsis intermedia
Halosarcia halocnemoides
Melaleuca ?stereophloia
Rhagodia drummondii
Stylidium pulviniforme (Priority 3)

Figure 9. Quadrat 3 established within Population 2a at Cunderdin. Photograph taken from southeast corner of quadrat – 20/11/2003.



POPULATION 1
NB-LOCATIONAL INFORMATION IS CONFIDENTIAL – NOT FOR PUBLICATION

QUADRAT 4 – YELLOWDINE GPS: 31° 09.42.4'S
119° 42.234'E

QUADRAT AREA: 25 m^2 (5 X 5 m)
SUBQUADRAT AREA: 5 m^2 (5 X 1 m)

DATE ESTABLISHED: 3/12/2003

LOCATION: On the claypan floor of the drainage flat, 1.6 km north-west along Weowanie Rock Track from the intersection with Yellowdine Road. Then 80 m at 308°.

SOIL: Chocolate brown sandy clay loam.

COVER: *Frankenia parvula* – 1%
Native plants - 3%
Weeds –0%
Bare ground – 96%
Dead shrubs/litter – 0%

PLANT COMMUNITY CLASSIFICATION (Muir 1977): Very Open Mat Plants.

NUMBER OF *FRANKENIA PARVULA* PLANTS IN SUBQUADRATS : 47

CONDITION: Healthy

ASSOCIATED SPECIES IN QUADRAT:
Calandrinia granulifera
Centrolepis polygyna
Gnephosis brevifolia
Crassula exserta
Disphyma crassifolium ssp. *clavellatum*
Gnephosis acicularis
Gunniopsis rodwayi
Lawrencia squamata

Figure 10. Quadrat 4 established within Population 1 at Yellowdine. Photograph taken from northwest corner of quadrat – 3/12/2003.

POPULATION 1
NB-LOCATIONAL INFORMATION IS CONFIDENTIAL – NOT FOR PUBLICATION

QUADRAT 5 – YELLOWDINE GPS: 31° 09.70'S
119° 43.299'E

QUADRAT AREA: 25 m^2 (5 X 5 m)
SUBQUADRAT AREA: 5 m^2 (5 X 1 m)

DATE ESTABLISHED: 4/12/2003

LOCATION: On eastern shoreline of drainage channel ~3.9 km north-west along Weowanie Rock track from Yellowdine Rd intersection. Then ~60 m at 73°.

SOIL: Caramel to red/brown sand over red clay sand.

COVER: *Frankenia parvula* – 1.5%
Native plants – 10% live
Weeds –0%
Bare ground – 86.5%
Dead shrubs/litter – 2%

PLANT COMMUNITY CLASSIFICATION (Muir 1977): Open Dwarf Scrub D to Very Open Herbs.

NUMBER OF *FRANKENIA PARVULA* PLANTS IN SUBQUADRATS : 66

CONDITION: Healthy

ASSOCIATED SPECIES IN QUADRAT:
Angianthus drummondii
Angianthus sp.
Centrolepis polygyna
Halosarcia halocnemoides
Halosarcia lylei
Triglochin minutissimum

COMMON SPECIES IN AREA:
**Mesembryanthemum nodiflorum*
Melaleuca halmaturorum
Sclerostegia moniliformis

Figure 11. Quadrat 5 established within Population 1 at Yellowdine. Photograph taken from the north corner of quadrat 4/12/2003.

APPENDIX 2

RELOCATION INFORMATION

NB: LOCATIONAL INFORMATION IS CONFIDENTIAL – NOT FOR PUBLICATION

Table 13 below, details all GPS readings taken within the *Frankenia parvula* populations. Waypoints in degrees, minutes and seconds using WGS 84 datum were recorded at all quadrats and landmarks where necessary, to relocate sites.

Table 13. GPS waypoints for *Frankenia parvula* study sites.

Population/Quadrat (Location)	Landmark	GPS reading (Garmin 12 channel)	GPS reading (Magellan 8 channel)
1/1 (Yellowdine)	North corner of quadrat		31° 08' 50"S 119° 43' 47"E
1/2 (Yellowdine)	South-west corner of quadrat		31° 09' 06"S 119° 43' 33"E
2a/3 (Cunderdin)	South-east corner of quadrat		31° 37' 45"S 117° 11' 31"E
1/4 (Yellowdine)	North-west corner of quadrat	31° 09' 25.44"S 119° 42' 14.04"E	
1/5 (Yellowdine)	South-east corner of quadrat	31° 09'42"S 119° 43' 17.94"E	
Waypoints from Ben Bayliss			
1/1 (Yellowdine)	Park Point	31° 08' 51.14"S	119° 43' 47.68"E
1/1 (Yellowdine)	Quadrat Site	31° 08' 50.21"S	119° 43' 47.06"E
1/2 (Yellowdine)	Park Point	31° 08' 59.39"S	119° 43' 32.59"E
1/2 (Yellowdine)	Quadrat Site	31° 09' 06.08"S	119° 43' 32.95"E
2a/3 (Cunderdin)	Park Point	31° 37' 45.34"S	117° 11' 35.56"E
2a/3 (Cunderdin)	Quadrat Site	31° 37' 44.76"S	117° 11' 31.38"E
1/ 4 (Yellowdine)	Park Point	31° 09' 40.46"S	119° 42' 20.81"E
1/ 4 (Yellowdine)	Quadrat Site	31° 09' 42.44"S	119° 42' 23.29"E
1/5 (Yellowdine)	Park Point	31° 09' 03.71"S	119° 43' 24.82"E
1/5 (Yellowdine)	Quadrat Site	31° 09' 06.70"S	119° 43' 30.18"E
Weowanie track turn off from Marvel Loch – (Yellowdine) Rd (Nth)		31° 10' 06.10"S	119° 41' 24.86"E