

VEGETATION MONITORING, KARAAF WETLANDS



**Report to Surf Coast Shire, by Doug Frood (Pathways Bushland
and Environment, Marraweeney, Victoria), November 2023.**

ACKNOWLEDGEMENTS

The Karaaf is located on the lands of the Wadawurrung People of the Kulin nation. The author acknowledges them as the Traditional Owners of this place and pays respect to their Elders past, present, and future.

The author wishes to extend his appreciation to the staff of Surf Coast Shire for their support for this project, in particular to Leanne Lucas and Robyn Neville. Thank you also to Jamie McMahon of ABZECO Pty Ltd for preparation of the aerial photography for use in the field and Surf Coast Shire for digitizing the mapping information.

EXECUTIVE SUMMARY

The Karaaf is a 130 ha site managed by Parks Victoria and has a catchment that straddles two local government areas. The Surf Coast Shire Council (Council) is the stormwater drainage authority for the majority of the Karaaf and Thompson Creek catchments to the north and west of the site. The Karaaf is part of the Thompson Creek estuary and is a subsection of the broader Breamelea Flora and Fauna Reserve saltmarsh system. The Karaaf lies within Wadawurrung Country and is noted to be of high environmental, community and living cultural heritage significance.

Previous work (Frood, 2022) was commissioned by Council to provide assessment of the extent and quality of existing vegetation at the Karaaf, and identify the impacts resulting from stormwater flows from the western outlets connected to residential development. Following on from this work, Pathways Bushland and Environment was commissioned by Council to initiate a monitoring program for the vegetation of the Karaaf. The monitoring program considers two components, these being sampling of vegetation and soils. While the vegetation component is the main focus of the monitoring, the design of the program includes analysis of some soil samples to establish baseline values for salinity, comparing sites with more modified vegetation to some supporting relatively intact shrubby saltmarsh communities.

The vegetation component involves strategically placed 10 x 10 metre square quadrats, recording the estimated covers provided by individual plant species within the sampling area as well as general notes on other features of the locations. The purpose of this monitoring is to provide clear indications of progressive changes in the structure or floristics within the local vegetation. Twenty-one quadrats were selected for the initial sampling, to provide coverage of the plant communities modified by stormwater inputs and also the range of proportional extent of dieback of saltmarsh shrubs.

Soils were sampled at eight locations, with sections of cores from between 15 and 20 cm depth sent for laboratory measurement of the Electrical Conductivity (EC) as an indicator of relative salinity. The eight locations were selected to include tidally influenced parts of the saltmarsh and healthier shrubby glasswort dominated vegetation outside of normal tidal inundation (e.g. near the central southern boundary), to enable comparison with areas where the vegetation has been converted to brackish wetland and sites where there has been comprehensive dieback of glasswort shrubs. Brief descriptions of the soil sample sites and associated EC determinations are provided.

It is evident that the soil salinity levels are substantially lower at the sites where the saltmarsh vegetation has been converted to Brackish Wetland by stormwater inputs. The relationship between soil salinity and various levels of dieback of the saltmarsh shrubs appears to be less meaningful, with only relatively small differences between sites of vastly different condition.

The vegetation quadrat data has been hand-sorted into a two-way table to indicate species groups and their representation within the relevant quadrats. Four groups are delineated in the table – these are to some extent loosely defined as they represent sections of a more or less continuous ecological gradient. The groups are defined by the progressive replacement of saltmarsh species by those of sequentially less saline wetland habitats, i.e. the conversion of Coastal Saltmarsh to adventive Brackish Wetland and ultimately opportunistic assemblages of freshwater wetland species.

While apparent changes noted in the vegetation since the 2022 survey are described, the current assessment represents the initial phase of monitoring, providing baseline information to evaluate future responses of the vegetation according to potential future management of stormwater inputs.

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1. INTRODUCTION AND BACKGROUND

The Karaaf is a 130 ha site, including approximately 95 ha of saltmarsh vegetation (Map 1). It is managed by Parks Victoria and has a catchment that straddles two local government areas. The Surf Coast Shire Council (Council) is the stormwater drainage authority for the majority of the Karaaf and Thompson Creek catchments to the north and west of the site. The Karaaf is part of the Thompson Creek estuary and is a subsection of the broader Breamlea Flora and Fauna Reserve saltmarsh system. The Karaaf lies within Wadawurrung Country and is noted to be of high environmental, community and living cultural heritage significance.

Previous work (Frood, 2022) was commissioned by Council to provide assessment of the extent and quality of existing vegetation at the Karaaf, and identify the impacts resulting from stormwater flows from the western outlets connected to residential development. Key conclusions of that study include the following:

- While saltmarsh plants of the intertidal zones are adapted to regular inundation to a particular depth, sustained and deeper inundation can exceed their tolerances. Species adapted to highly saline conditions can be intolerant of sustained conditions of low salinity, further increasing their vulnerability to freshwater inputs.
- Inflows from stormwater have dramatically altered the environmental conditions, particularly where they have led to unnaturally wet conditions over summer.
- The vegetation in a zone abutting the western boundary of the Karaaf has been transformed by the expansion of an adventive Brackish Wetland community and colonisation by patches of Cumbungi (*Typha* spp.), as a consequence of stormwater inputs from adjacent development.
- In addition to an ecological shift towards wetland species indicative of less saline habitats in the western section of the reserve, there has been substantial mortality of the succulent shrubby glasswort species which dominate much of the extent of the Karaaf saltmarsh.

- Dieback of these shrubby saltmarsh species occurs when the saltmarsh experiences flooding over prolonged periods as part of the cycle of intermittent closing of the Thompson Creek estuary.
- Impoundment and harvesting of water for agricultural use, in conjunction with climate change, may be influencing the natural cycles of stream opening and closure.
- Evidence such as the remains of algal growth attached to the stems of dead glasswort shrubs indicates that these plants have been subject to prolonged inundation well above the depth reached by normal tidal inflows. As evidenced by the frequent retention of finer branch structures on dead plants, much (but not all) of this impact is relatively recent, apparently within the last few years.
- Mortality rates of glasswort shrubs were particularly high in the western section of the Karaaf, with broad areas of virtually total stand death evident.
- It is considered highly probable that, in this western section, stormwater inputs have compounded the deleterious effects of ponding in the saltmarsh during intermittent periods of estuary closure.
- Comparative observations from previous studies indicated that both the extent of dieback of saltmarsh shrubs and the area dominated by species indicative of less saline conditions in the western part of the Karaaf had expanded substantially over the preceding five years.

Following on from this work, Pathways Bushland and Environment was commissioned by Council to initiate a monitoring program for the vegetation of the Karaaf. This program is intended to be conducted in conjunction with the implementation of infrastructure management actions designed to regulate stormwater inputs into the Karaaf.

MAP 1. THE KARAAF WETLANDS STUDY AREA AND SURROUNDS



2. METHODS

The monitoring program considers two components, these being sampling of vegetation and soils. While the vegetation component is the main focus of the monitoring, the design of the program includes analysis of some soil samples to establish baseline values for salinity, comparing sites with more modified vegetation to some supporting more intact shrubby saltmarsh communities. The GPS locations of both the vegetation and soil sampling sites as outlined below are included as Appendix 1.

2.1 VEGETATION SAMPLING

The vegetation component involves strategically placed quadrats, recording the estimated covers provided by individual plant species within the sampling area as well as general notes on other features of the locations, as outlined below. The purpose of the monitoring is to provide clear indications of progressive changes in the structure or floristics within the local vegetation. Due to the magnitude of the impacts on the vegetation caused by hydrological events that have occurred within the wetlands, there was no perceived need for analysis of a statistical nature in order to track any significant changes, such as regeneration of saltmarsh species into either areas of dieback or modified brackish vegetation. Sampling during late spring to early summer was considered optimal to capture the maximum expression of annual species (both native and introduced) where these are present.

The capacity to control the entry of stormwater into the wetland would be highly relevant to development of a monitoring schedule subsequent to the first year's evaluation, particularly for sites within the zones of impacted vegetation towards the western end of the Karaaf. If stormwater can be excluded or at least substantially reduced, assessment of the quadrats within this area would be warranted the following year, with baseline data collected if there has been a substantial gap since prior monitoring. Suggestions for subsequent monitoring would be based on responses detected over this first year of reduced impacts. A longer term monitoring program over five year intervals at selected sites may be appropriate if it is desired to track the vegetation

responses over a longer period and no further major dieback events have been detected.

10 x 10 metre square quadrats have been previously found to be of a practical size for the monitoring of vegetation within wetlands and were adopted for this study. Twenty-one quadrats were selected for the initial sampling, to provide coverage of the plant communities modified by stormwater inputs and also the range of proportional extent of dieback of saltmarsh shrubs. Depending on observed vegetation responses, the optimal number of sample sites may warrant review over a longer period of monitoring. The spread of quadrats across the range of variation in the vegetation is outlined below.

2.2 TARGETED QUADRAT SAMPLING STRATEGY

Strategic placement of the 21 quadrats was based on the condition zones as outlined by Flood (2022), with planned sampling locations selected prior to field work, through consideration of suitable vegetation patches identified from the mapping of that project. The attributes of the selected sites were as follows:

Adventive Brackish Wetland: 3 sites

Claypan fringes with signs of transition, to west of main area of Brackish Wetland: 1 site

Abutting *Typha* patches at ecotone with fringing brackish wetland: 2 sites

Dieback Condition 5 (90 - 100% mortality): 5 sites (2 in prior Shrubby Glasswort on flats, 2 in prior mixed woody glasswort species stands in shallow depressions, 1 in mixed woody glasswort species with Beaded Glasswort colonisation)

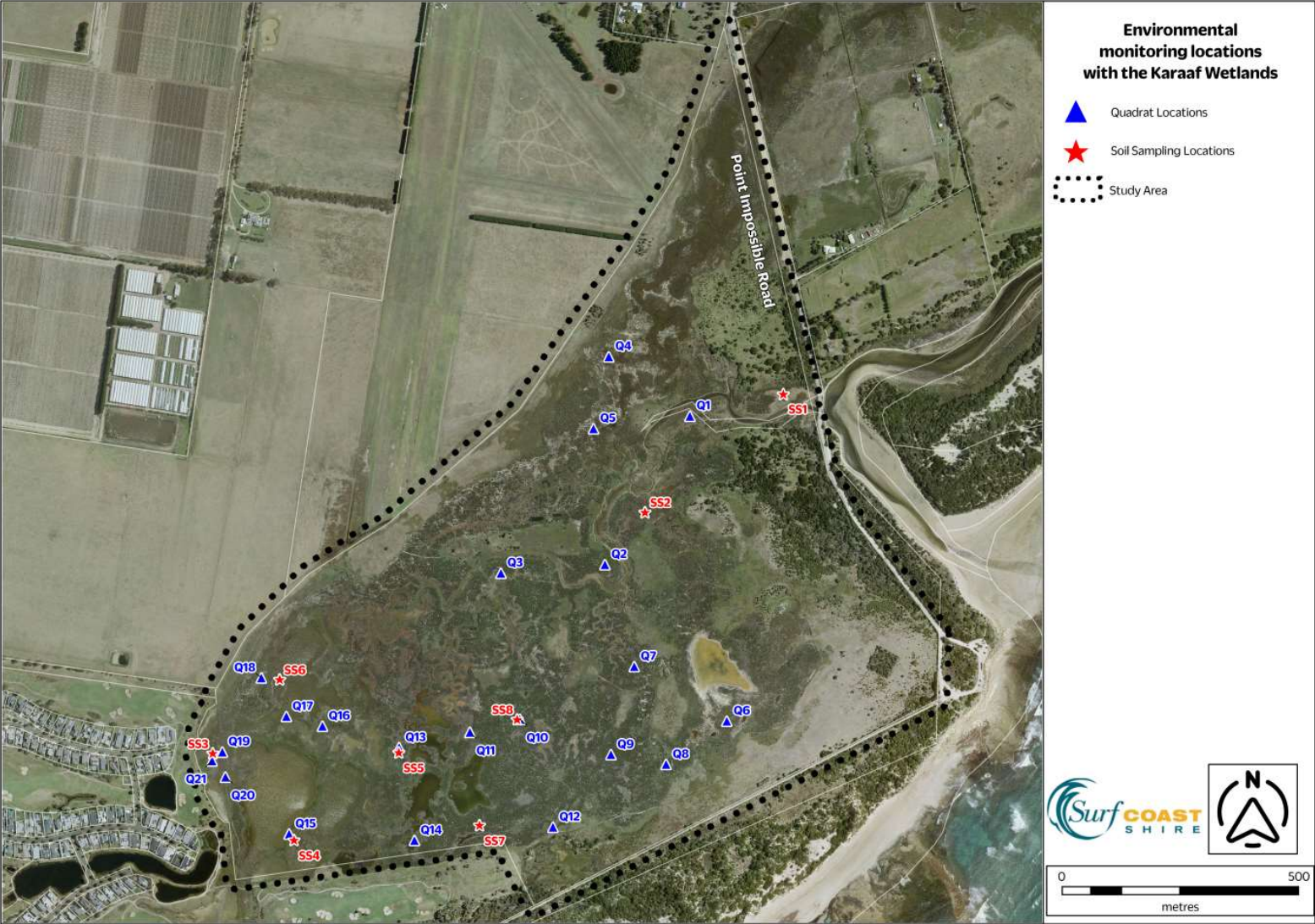
Dieback Condition 4 (60 - <90% mortality): 4 sites (2 in Shrubby Glasswort, 2 in mixed woody glasswort species)

Dieback Condition 3 (40 - <60% mortality): 3 sites (2 in Shrubby Glasswort on flats, 1 in mixed woody glasswort species)

Dieback Condition 2 (10 - <40% mortality): 3 sites (1 in Shrubby Glasswort on flats, 2 in mixed woody glasswort species)

The locations and quadrat identifiers of the relevant sites are indicated on Map 2.

MAP 2.MONITORING QUADRAT AND SOIL SALINITY LOCATIONS



2.3 QUADRAT CHARACTERISTICS AND INFORMATION TO BE RECORDED

The 10 m x 10 m square quadrats have been oriented along the major compass directions and the GPS location (using datum GDA) of the north-west corner recorded. The north-west corners of the quadrats were marked using builders hardwood pegs with cross-sectional dimensions of c. 2.2 x 5 cm. The estimated projected cover provided by all vascular plant species observed as attached within or overhanging the quadrat was recorded using the following cover/abundance (C/A) scale:

+: <1% cover, very few (<5) individuals

1: <1% cover, at least several (5 or more) individuals

2: 1-<5% cover, any number of individuals

Cover equal to or greater than 5%: Estimate of cover to nearest 5%.

In the case of plants with both dead and live branches, the total projected cover was included as cover for the respective species. The estimated percentage cover of other relevant features including that provided by the stems of dead saltmarsh shrubs still attached to the ground, detached plant debris, bare ground, and filamentous algae was also recorded. Notes were also made on any observed regeneration of saltmarsh species (including identification of species and approximate numbers). Reference photos were taken diagonally across the quadrats from the north-west corner. Notes on degree of saturation and extent and depth of inundation were also recorded where relevant. The quadrat data, including GPS location and reference photos, is included as Appendix 2.

2.4 SOIL SALINITY MONITORING

The evaluation of salinity levels in the soil at selected locations through the Karaaf wetlands was considered to be informative to provide some baseline perspective of salinity levels within the saltmarsh shrublands, to aid monitoring of the impacts of stormwater on the saltmarsh habitat, and also to contribute to understanding of the potential for vegetation recovery in impacted sites.

Soils were sampled at eight locations using a 33 mm diameter stainless steel corer. Several sections of core from between 15 and 20 cm depth were sampled, from within a zone of 10 cm diameter, to ensure sufficient material for laboratory analysis. This depth, while determined by the capacity of the corer, is presumed to provide an indication of underlying site conditions, minimizing the influence of either recent surface inundation or salt accumulation at the soil surface due to evaporation under dry conditions.

Soil salinity was evaluated through measurement of the Electrical Conductivity (EC) of samples collected during the field assessment and sent to ALS Environmental Services, Geelong, for analysis.

The eight locations were selected to include tidally influenced parts of the saltmarsh and healthier shrubby glasswort dominated vegetation outside of normal tidal inundation (e.g. near the central southern boundary), to enable comparison with areas where the vegetation has been converted to brackish wetland and sites where there has been comprehensive dieback of glasswort shrubs. The locations and identifiers of the relevant sampling sites are indicated on Map 2. Brief site descriptions and measured soil EC readings ($\mu\text{S}/\text{cm}$ at 25°C) for the eight selected sites are provided in section 3.2 of this report.

3. RESULTS

Field work for the project was undertaken during the 7th-11th November 2023. The vegetation quadrat data is included as Appendix 2. This data has been hand-sorted into a two-way table to indicate species groups and their representation within the relevant quadrats (Appendix 3). These groups are outlined below. Species scientific names follow RBG (2023) and common names follow DEECA (2023). An asterisk before a species name indicates that it is considered introduced in Victoria. Brief descriptions of the soil sample sites and associated EC determinations are also provided.

3.1 VEGETATION DATA ANALYSIS

The two-way table in Appendix 3 has been hand sorted to indicate pattern in the floristic variation in the vegetation. While the cover provided by dead plants of *Tecticornia* species (Shrubby Glasswort and/or Bellarine Glasswort) is included in the quadrat descriptions, the data included in the table has been restricted to cover provided by living plants and annuals which have only recently completed their natural life cycles.

Four groups are delineated in the table – these are to some extent loosely defined as they represent sections of a more or less continuous ecological gradient. The groups are defined by the progressive replacement of saltmarsh species by those of sequentially less saline wetland habitats, i.e. the conversion of Coastal Saltmarsh to adventive Brackish Wetland and ultimately opportunistic assemblages of freshwater wetland species.

The first group (including twelve of the quadrats) is characterised by halophytic saltmarsh species, with varying levels of dieback of the shrubby dominants.

The second group (including four quadrats) retains a component of the characteristic saltmarsh flora, notably a high cover of *Salicornia quinqueflora* (Beaded Glasswort), but has an increased component of introduced salt tolerant annuals, with **Cotula coronopifolia* (Water Buttons) in particular potentially providing substantial covers. These sites are also characterised by a gradient of increased presence of species characteristic of wetter sub-saline sites, notably *Bolboschoenus caldwellii* (Salt Club-

sedge), *Isolepis cernua* (Nodding Club-sedge) and *Triglochin striata* (Streaked Arrow-grass).

The third group (including three quadrats) includes only a minor component of residual saltmarsh species, with most species present indicative of wet brackish conditions. It is also characterised by presence of the mat-forming semi-aquatic *Lilaeopsis polyantha* (Australian *Lilaeopsis*).

The fourth group (two quadrats) is characterised by the presence of a range of essentially freshwater wetland species, a high cover of *Eleocharis acuta* (Common Spike-sedge) and the effective absence of the saltmarsh flora.

Vegetation representative of the third and fourth group is susceptible to colonisation of *Typha* spp. (Cumbungi). While low covers of *Typha* spp. are frequently present in the quadrats allocated to these groups, denser vegetation dominated by more established patches of Cumbungi was not sampled. The extent of patches of *Typha* dominated vegetation was indicated in Flood (2022), and future changes in the extent of this vegetation could be evaluated by review of the relevant mapping.

3.2 SOIL SAMPLE SITES

1. 55H 0270267 / 5757634 (+/- 3 m): EC 3400 uS/cm. Mudflat abutting Mullet Creek, in the intertidal zone when the Thompson Creek entrance is open. Gap in vegetation, with *Salicornia quinqueflora* and dead *Tecticornia arbuscula* adjacent. The soil was damp, comprising a clay and sand mix, grey in colour.
2. 55H 0269982 / 5757379 (+/- 4 m): EC 4400 uS/cm. Shrubland of *Tecticornia* spp., with c. 50% of plants dead. The soil was damp, consisting of a yellow-grey clay.
3. 55H 0269083 / 5756850 (+/- 5 m): EC 1800 uS/cm. Brackish Wetland (modified vegetation), with *Bolboschoenus caldwellii*, **Cotula coronopifolia* and *Senecio pinnatifolius*. The site was inundated to c. 10 cm depth. The soil consisted of a sloppy black organic layer over greyish clay with yellow touches.
4. 55H 0269260 / 5756674 (+/- 5 m): EC 2800 uS/cm. Largely bare mudflat, adjacent to Brackish Wetland (modified vegetation) with *Bolboschoenus caldwellii*, *Eleocharis*

acuta, **Cotula coronopifolia* and *Thyridia repens* providing a total of c. 5% cover. The site was saturated, with soils consisting of a black anaerobic organic silty layer over yellow-grey clay.

5. 55H 0269475 / 5756863 (+/- 5 m): EC 3700 uS/cm. *Tecticornia* spp. shrubland with most plants (>90%) dead, with *Salicornia quinqueflora*, **Cotula coronopifolia*, *Triglochin striata*, **Polypogon monspeliensis* and incidental *Bolboschoenus caldwellii*. The site was more or less saturated, with the soil consisting of grey clay.

6. 55H 0269220 / 5757008 (+/- 5 m): EC 3800 uS/cm. Shrubland with dead and regenerating *Tecticornia* sp. (Connewarre), dominated by *Salicornia quinqueflora* and with *Isolepis cernua*, *Apium annuum* and **Cotula coronopifolia*. The site was located on a narrow tongue of slightly higher ground between adjacent ponds on both sides. The top soil was wet but not inundated. The soil comprised yellow-grey clay, with a loose flaky gravelly layer and watertable present below c. 15 cm depth.

7. 55H 0269651 / 5756716 (+/- 6 m): EC 4800 uS/cm. *Tecticornia arbuscula* shrubland, with *Salicornia quinqueflora*, *Frankenia pauciflora* and **Polypogon monspeliensis*. The shrubs were mostly living, with c. 90% of the canopy healthy. The soil was moist, with a layer of peaty sand over yellow-grey clay.

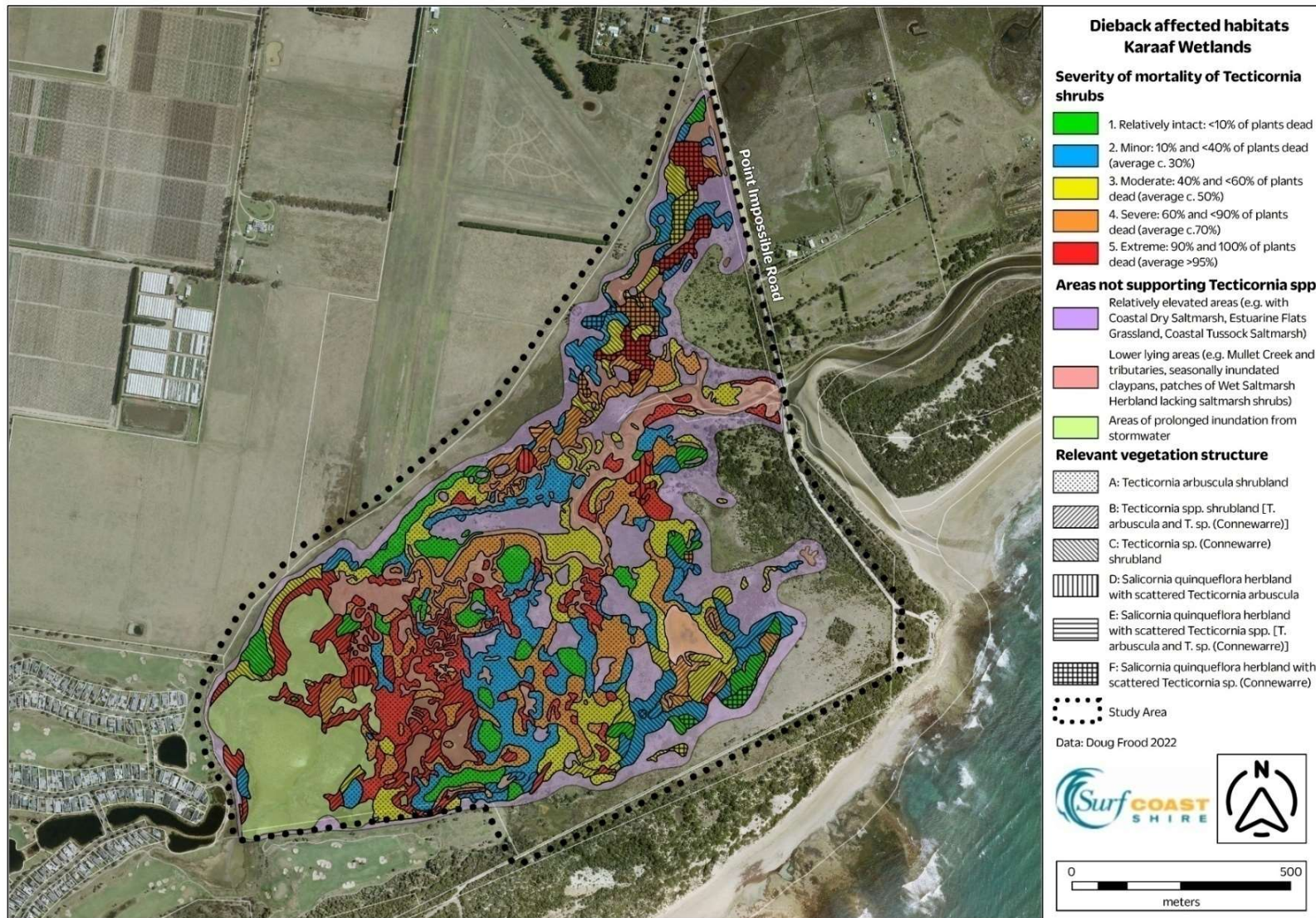
8. 55H 0269274 / 5756939 (+/- 5 m): EC 3900 uS/cm. *Tecticornia* spp. shrubland (<1 m tall) , locally in the range of 10-40% mortality, with *Salicornia quinqueflora*, *Frankenia pauciflora*, *Apium annuum*, **Polypogon monspeliensis* and **Melilotus indica*. The soil was moist but not saturated, with c. 10 cm of peaty sand over a layer of yellow-grey clay, then pale sand at c. 18 cm depth.

4. INTERPRETATION OF INFORMATION AND DISCUSSION

4.1 VEGETATION

Frood (2022) mapped levels of mortality of saltmarsh shrubs into classes based on dominant species and ranges of proportion of plants killed (see Map 3 on the following page).

MAP 3. DIEBACK OF SALTMARSH SHRUBS (from Frood, 2022).



In many cases, little if any associated flora was evident during the winter survey of Flood, particularly in stands of *Tecticornia* spp. where the greater majority of individual plants had died (following photo and caption from that report).



Broad-scale death of Shrubby Glasswort towards the western side of the Karaaf. Remnants of algae attached to the stems are indicative of a sustained inundation event (image from winter 2022)

The current assessment includes quadrats from such sites, but often with a greater diversity of species present than was the case in 2022. Rather than just dead stems of *Tecticornia* spp. with scattered living individuals, associated species such as *Salicornia quinqueflora* (Beaded Glasswort), *Suaeda australis* (Austral Seablite) and *Apium annuum* (Annual Celery) were often conspicuous in such impacted sites. It is suspected that recent deep ponding occurring during estuary closure had suppressed the associated flora in 2022, but that rootstocks of *S. quinqueflora* had survived and subsequently resprouted, and that other species had germinated from the soil-stored seedbank. Nevertheless, observed regeneration of *Tecticornia* spp. was largely restricted to sites with a lower percentage of mortality (generally <50%), and at least in the case of *T. arbuscula*, may largely comprise root suckers from surviving plants. The potential longer term responses of more heavily impacted sites are not yet apparent.

It was also evident that at least some of the *Typha* patches have increased in extent since the 2022 assessment (e.g. plants now extend across the gap between two of

the westernmost ponds which previously included a band of more readily traversed *Bolboschoenus caldwellii* sedgeland). *Eleocharis acuta* (Common Spike-sedge) also appears to have increased in extent in the Brackish Wetland on the western margins of the Karaaf, indicative of a shift towards more freshwater conditions arising from stormwater inputs.



*Opportunistic colonisation of Cumbungi around the verges of a shallow lagoon in the western portion of the Karaaf wetlands. The smaller mat-forming plant in the foreground is Water Buttons [*Cotula coronopifolia*] (Image and caption from Froud, 2022).*



Brackish Sedgeland component of the Brackish Wetland Aggregate, dominated by Salt Club-sedge, developed on the margins of a shallow lagoon near the western margins of the Karaaf wetlands (Image and caption from Froid, 2022).



Extensive displacement of prior saltmarsh vegetation by adventive Brackish Wetland at the western end of the Karaaf (Image and caption from Froid, 2022).

4.2 SOIL SALINITY

The following table lists the soil sampling sites in order of highest to lowest salinity readings:

Sample No.	EC (uS/cm)	Saltmarsh Shrub Condition	Vegetation in immediate vicinity
7	4800	Class 1 (<10% mortality)	<i>Tecticornia arbuscula</i> shrubland
2	4400	Class 3 (40-<60% mortality)	<i>Tecticornia</i> spp. shrubland
8	3900	Class 2 (10-<40% mortality)	<i>Tecticornia</i> spp. shrubland
6	3800	Class 5 (90-100% mortality)	<i>Tecticornia</i> sp. (Connewarre) shrubland
5	3700	Class 5	<i>Tecticornia</i> spp. shrubland
1	3400	Adjacent to Class 5	Mudflat adjacent to dead <i>T. arbuscula</i>
4	2800	NA	Mudflat, adjacent to Brackish Wetland
3	1800	NA	Brackish Wetland

It is evident that the salinity levels are substantially lower at the sites where the saltmarsh vegetation has been converted to Brackish Wetland by stormwater inputs, with the shallowly inundated site 3 recording the lowest salinity reading. While relevant data is clearly limited, the relationship between salinity and various levels of dieback of the saltmarsh shrubs appears to be less meaningful, with only relatively small differences between sites of vastly different condition (e.g. sites 6 and 8). Site 1 is from the intertidal zone adjacent to Mullet Creek and is essentially more estuarine than others. Given the high sand fraction in the soil at this site, it would not be surprising if the salinity levels fluctuated according to whether the entrance of Thompson Creek was open or otherwise. Though the usual soil character within the range of the sample depth comprised a very heavy yellow-grey clay, it is notable that

in two cases more permeable layers were encountered at relatively shallow depth (damp pale sand at site 8 and wet flaky gravel at site 6), indicating potential for complexity in the local groundwater interactions. While most of the saltmarsh soils distant from the stormwater inputs were damp rather than wet, the soils at site 5 were saturated. Though currently with only slightly lower salinity levels than other impacted shrubland sites, site 5 is in close proximity to shallow claypans and the outer edge of the zone supporting brackish wetland and may provide useful indication as to whether a zone of reduced salinity is expanding due to stormwater inputs. Similarly if stormwater inputs can be controlled, sites 3 and 4 may provide indications of the potential for recovery of salinity levels in the western section of the Karaaf.

5. REFERENCES

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APPENDIX 1. VEGETATION AND SOIL SAMPLING SITE LOCATIONS

Vegetation Quadrat Locations (Zone 55H, GDA)

Quadrat 01: Easting: 0270071, Northing: 5757581

Quadrat 02: Easting: 0269900, Northing: 5757266

Quadrat 03: Easting: 0269681, Northing: 5757242

Quadrat 04: Easting: 0269896, Northing: 5757700

Quadrat 05: Easting: 0269868, Northing: 5757549

Quadrat 06: Easting: 0270167, Northing: 5756947

Quadrat 07: Easting: 0269968, Northing: 5757055

Quadrat 08: Easting: 0270041, Northing: 5756853

Quadrat 09: Easting: 0269924, Northing: 5756870

Quadrat 10: Easting: 0269730, Northing: 5756938

Quadrat 11: Easting: 0269625, Northing: 5756908

Quadrat 12: Easting: 0269806, Northing: 5756715

Quadrat 13: Easting: 0269476, Northing: 5756872

Quadrat 14: Easting: 0269514, Northing: 5756679

Quadrat 15: Easting: 0269249, Northing: 5756685

Quadrat 16: Easting: 0269313, Northing: 5756912

Quadrat 17: Easting: 0269236, Northing: 5756930

Quadrat 18: Easting: 0269181, Northing: 5757009

Quadrat 19: Easting: 0269103, Northing: 5756852

Quadrat 20: Easting: 0269111, Northing: 5756800

Quadrat 21: Easting: 0269082, Northing: 5756833

Soil Salinity Sampling Site Locations and EC values

Soil Sampling Site 1: Easting: 0270267, Northing: 5757634 (EC 3400)

Soil Sampling Site 2: Easting: 0269982, Northing: 5757379 (EC 4400)

Soil Sampling Site 3: Easting: 0269083, Northing: 5756850 (EC 1800)

Soil Sampling Site 4: Easting: 0269260, Northing: 5756674 (EC 2800)

Soil Sampling Site 5: Easting: 0269476, Northing: 5756863 (EC 3700)

Soil Sampling Site 6: Easting: 0269220, Northing: 5757008 (EC 3800)

Soil Sampling Site 7: Easting: 0269651, Northing: 5756716 (EC 4800)

Soil Sampling Site 8: Easting: 0269724, Northing: 5756939 (EC 3900)

APPENDIX 2. QUADRATDATA

An asterisk preceding a species name indicates that it is considered to be introduced in Victoria.

QUADRAT NUMBER: 01

DATE: 8/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0270071 / 5757581 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Prior *Tecticornia arbuscula* shrubland, with nearly all plants dead. Fringed by healthy *Salicornia quinqueflora* to north, with *Austrostipa stipoides* grassland with *Gahnia filum*, *Suaeda australis* and living *Tecticornia arbuscula* to south. No regeneration of *T. arbuscula* was evident. With plentiful crab burrows present, but algal mats not evident. The soil comprised grey clay, and was damp but not inundated.

SPECIES AND COVERS:

- 2 *Salicornia quinqueflora* subsp. *quinqueflora* [dead stems]
- 2 *Tecticornia arbuscula* [live plants]
- 30 *Tecticornia arbuscula* [dead plants]

Bare ground 90%

Litter 5%

Additional species nearby: *Gahnia filum*, *Suaeda australis*



QUADRAT NUMBER: 02

DATE: 8/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269900 / 5757266 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: *Tecticornia arbuscula* shrubland, plants mostly living. The soil was dry, with organic sand overlying clay. Kangaroo trails with droppings were present, but were not deeply pugged or incised. Seedlings of *T. arbuscula* were not evident, but the vegetation was generally lacking gaps for colonisation. Detail of inspection of the vegetation was restricted to available viewpoints in order to minimise damage to the relatively intact and fragile vegetation – covers may be coarser estimates than for other sites. It is recommended that any follow-up sampling of this site is both Infrequent and very carefully conducted.

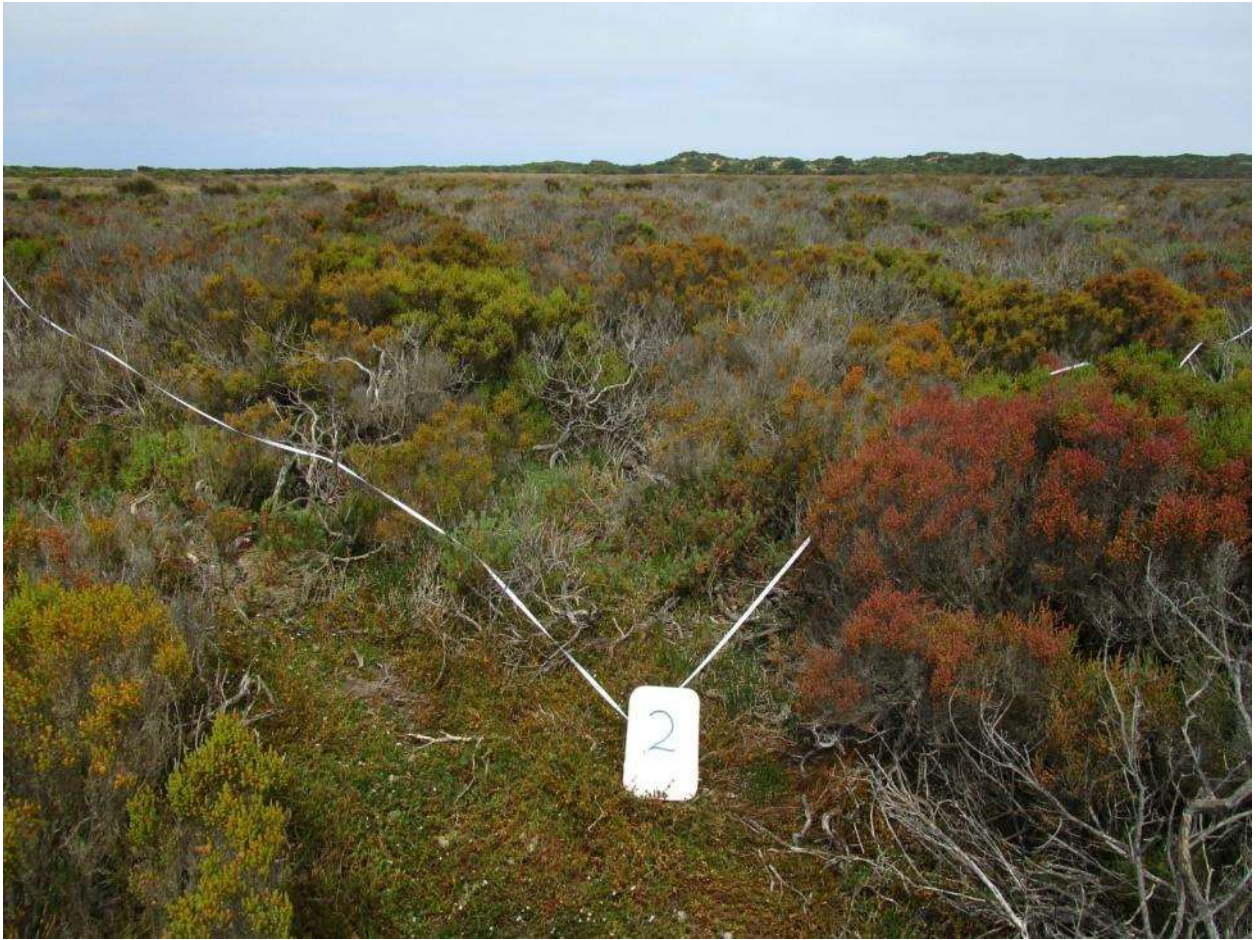
SPECIES AND COVERS:

- 1 *Disphyma crassifolium* subsp. *clavellatum*
- 2 *Salicornia quinqueflora* subsp. *quinqueflora*
- 1 *Samolus repens*
- 10 *Suaeda australis*
- 60 *Tecticornia arbuscula* [live plants]
- 2 *Tecticornia arbuscula* [dead plants]

Bare ground 15%

Litter 15%

Additional species nearby: *Apium annuum*, *Frankenia pauciflora* var. *gunnii*,
**Plantago coronopus*, *Spergularia marina*



QUADRAT NUMBER: 03

DATE: 8/11/23

RECORDER: D. Froot

GPS LOCATION OF MARKER POST (NW corner): 55H 0269681 / 5757242 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Patch of *Suaeda australis*, with associated *Tecticornia* spp. mostly dead. This vegetation was locally occurring in mosaic with open ground with algal mats, forming a reticulate pattern. The soil was dry, with variable surface texture (variously organic silt, sand veneer, decomposing algae or surface clay) overlying yellow-grey clay. Kangaroo trails were present through the vegetation and deeply pugged. Seedlings of *Tecticornia* species were not evident.

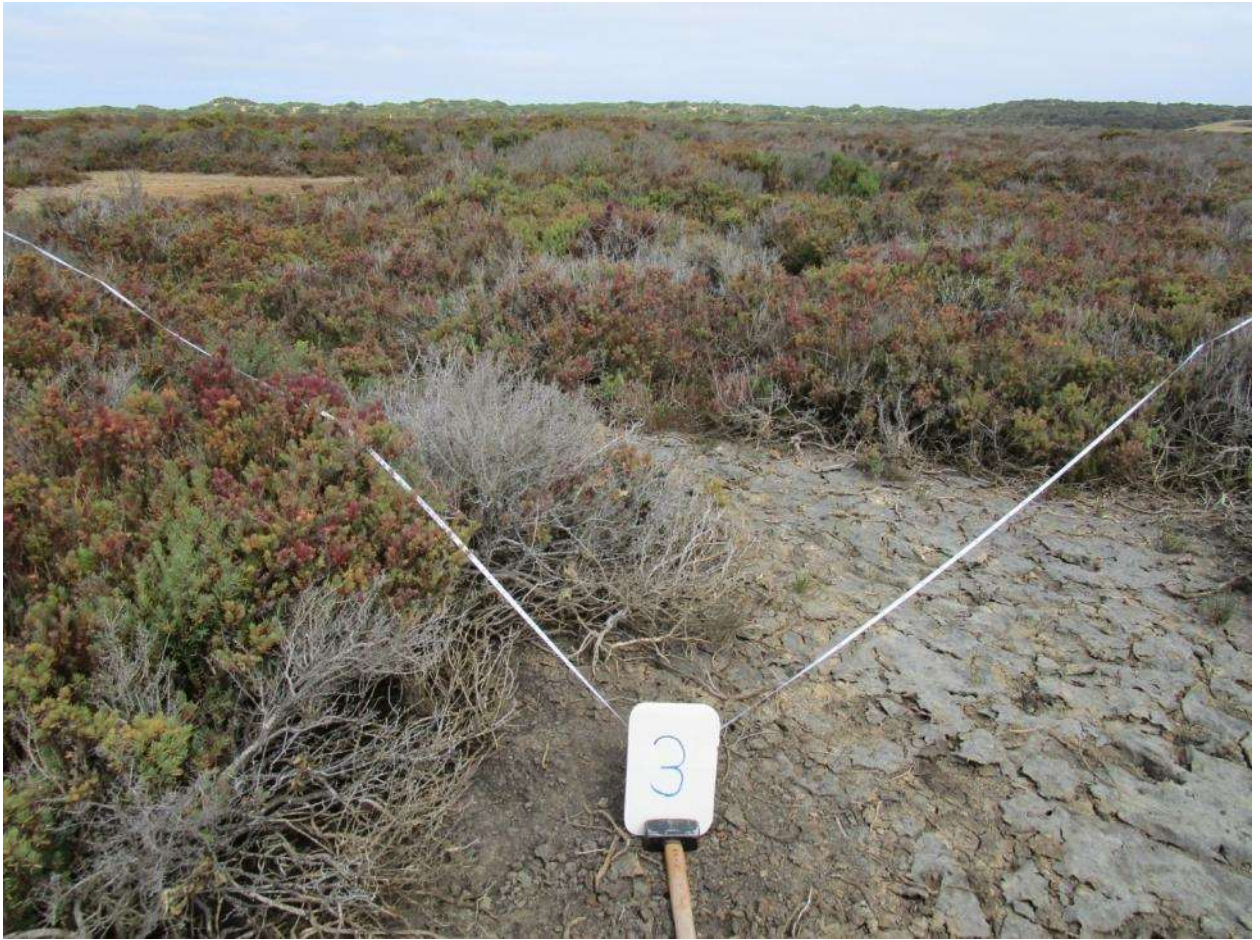
SPECIES AND COVERS:

- 10 *Salicornia quinqueflora* subsp. *quinqueflora*
- 60 *Suaeda australis*
- 2 *Tecticornia arbuscula* [live plants]
- 2 *Tecticornia arbuscula* [dead plants]
- 2 *Tecticornia* sp. (Connewarre) [live plants]
- 10 *Tecticornia* sp. (Connewarre) [dead plants]

Algal crust 20%

Bare ground 10%

Litter 10%



QUADRAT NUMBER: 04

DATE: 8/11/23

RECORDER: D. Flood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269896 / 5757700 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Open shrubland of *Tecticornia* sp. (Connewarre) with *Salicornia quinqueflora*, with small bare gaps occurring in a mosaic. The soil was dry, with a peaty layer over clay. With light kangaroo pugging only. Seedlings of *Tecticornia* sp. were not evident.

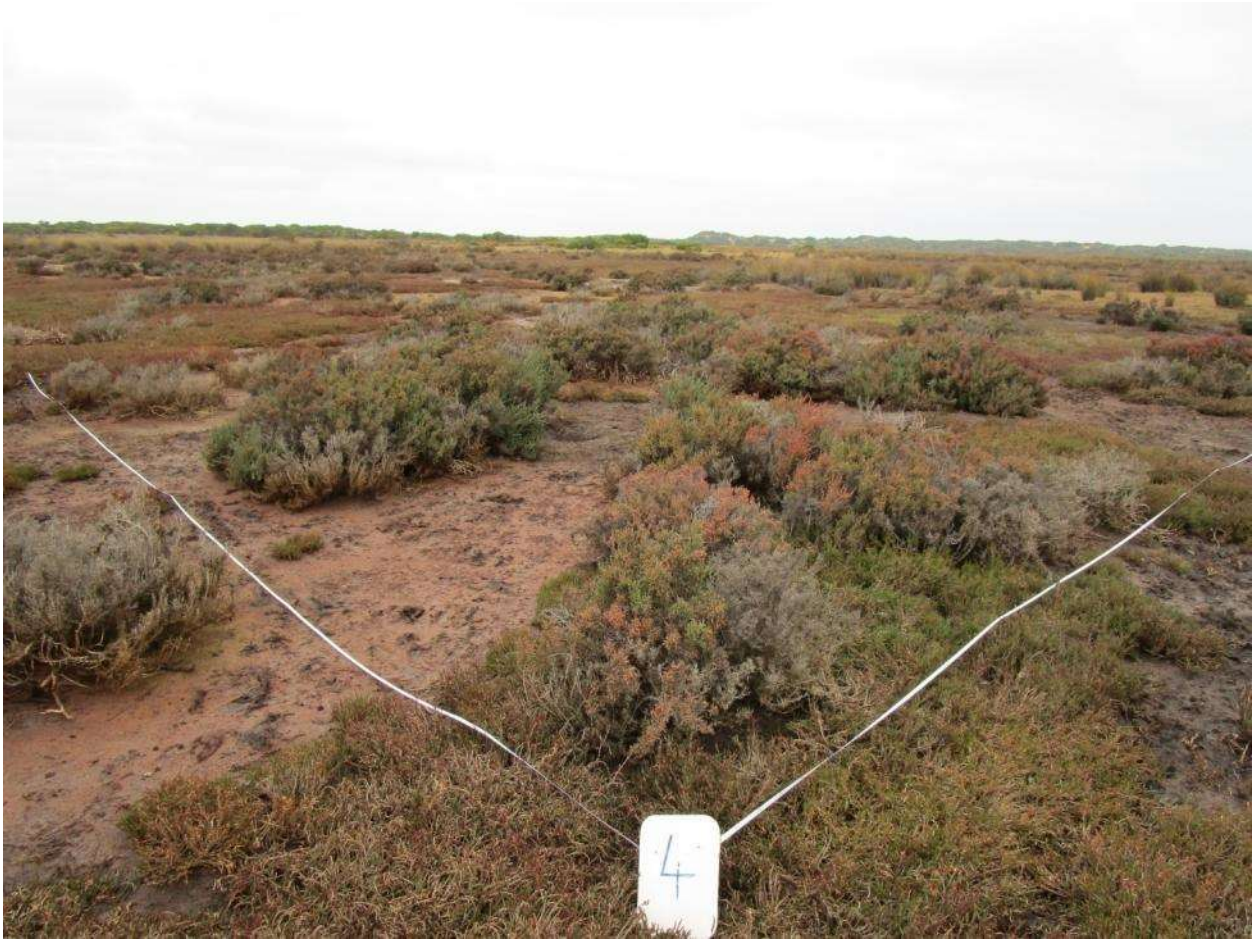
SPECIES AND COVERS:

- + *Frankenia pauciflora* var. *gunnii*
- 5 *Salicornia quinqueflora* subsp. *quinqueflora*
- 20 *Tecticornia* sp. (Connewarre) [live plants]
- 5 *Tecticornia* sp. (Connewarre) [dead plants]

Algal crust 15% (full extent becoming somewhat ambiguous due to decomposition)

Bare ground 60%

Litter 3%



QUADRAT NUMBER: 05

DATE: 8/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269868 / 5757549 (+/- 5 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Open shrubland of *Tecticornia* sp. (Connewarre) with *Salicornia quinqueflora*, with small bare gaps in mosaic, abutting *Gahnia filum* sedgeland. The quadrat area was dry, but with residual small ponds present nearby. The soil consisted of a loamy friable layer over clay. Algal mats extended across much of the surface, mostly at ground level, but including older remnants elevated up to c. 40 cm on shrub stems. Kangaroo trails with deep pugging were present. Seedlings of *Tecticornia* species were not evident. Mortality of *T. arbuscula* had arisen from multiple events (including older more decomposed stems as well as relatively recently killed plants).

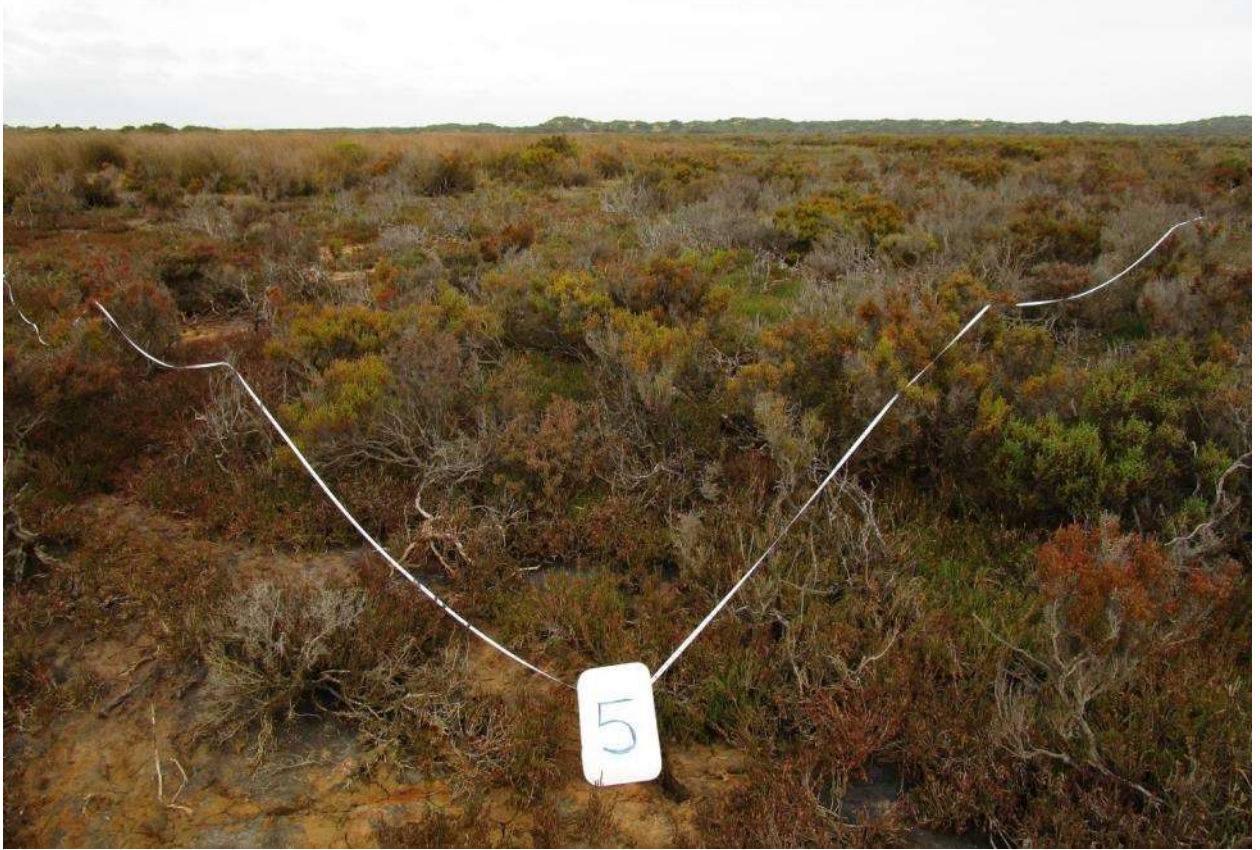
SPECIES AND COVERS:

- 70 *Salicornia quinqueflora* subsp. *quinqueflora*
- 10 *Tecticornia arbuscula* [live plants]
- 5 *Tecticornia arbuscula* [dead plants]
- 2 *Tecticornia* sp. (Connewarre) [live plants]
- 2 *Tecticornia* sp. (Connewarre) [dead plants]

Algal crust 50% (full extent somewhat ambiguous as extending beneath the *S. quinqueflora* cover)

Bare ground 5% (primarily pugging)

Litter 2%



QUADRAT NUMBER: 06

DATE: 9/11/23

RECORDER: D. Flood

GPS LOCATION OF MARKER POST (NW corner): 55H 0270167 / 5756947 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Open shrubland of *Tecticornia* spp., relatively diverse. Plants of *Tecticornia* species were of mixed age and condition, with scattered young plants 20-40 cm, presumably including root suckers, but lacking mass recruitment. Also with the *Suaeda australis* plants being of mixed age and patches of *Spergularia marina* seedlings present. The quadrat area was dry, with a thin salt crust present on the soil surface. The soil consisted of an organic sandy surface over grey clay. The site was traversed by pugged kangaroo trails.

SPECIES AND COVERS:

- 2 *Apium annuum*
- 1 **Atriplex prostrata*
- 1 **Cotula coronopifolia*
- + *Disphyma crassifolium* subsp. *clavellatum*
- 2 *Frankenia pauciflora* var. *gunnii*
- 1 **Hordeum marinum*
- 1 **Parapholis incurva*
- 1 **Polypogon monspeliensis*
- 2 *Puccinellia stricta*
- 5 *Salicornia quinqueflora* subsp. *quinqueflora*
- 1 *Senecio halophilus*
- 1 *Spergularia marina*
- 15 *Suaeda australis*

- 10 *Tecticornia arbuscula* [live plants]
- 10 *Tecticornia arbuscula* [dead plants]
- 10 *Tecticornia* sp. (Connewarre) [live plants]
- 10 *Tecticornia* sp. (Connewarre) [dead plants]

Bare ground 25%

Litter 35%

Additional species nearby: *Samolus repens*



QUADRAT NUMBER: 07

DATE: 9/11/23

RECORDER: D. Flood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269968 / 5757055 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Open shrubland of *Tecticornia* spp. The quadrat area was not inundated, but the soil was still damp and with localised patches of salt crust. The soil surface was peaty with a minor component of sand, over grey clay. Pugged kangaroo trails were locally present, but only of minor occurrence within the quadrat area. The quadrat included abundant (100s of plants) regeneration of *Tecticornia arbuscula* c. 10-40 cm in height, with more or less full recruitment present in gaps (recruitment estimated at c. 7% cover, mature plants at c. 10%).

SPECIES AND COVERS:

- 15 *Tecticornia arbuscula* [live plants]
- 10 *Tecticornia arbuscula* [dead plants]
- 1 *Tecticornia* sp. (Connewarre) [live plants]
- 1 *Tecticornia* sp. (Connewarre) [dead plants]
- 2 *Frankenia pauciflora* var. *gunnii*
- 5 *Salicornia quinqueflora* subsp. *quinqueflora*
- 10 *Suaeda australis*

Bare ground 40%

Litter 35%



QUADRAT NUMBER: 08

DATE: 9/11/23

RECORDER: D. Froot

GPS LOCATION OF MARKER POST (NW corner): 55H 0270041 / 5756853 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Denser shrub canopy of *Tecticornia* sp. (Connewarre). No regeneration of *Tecticornia* species was evident, but the condition of the canopy of mature plants was very intact. Dead plants were mainly immediately adjacent to kangaroo trails. The quadrat area was dry, with a salt and algal crust present along these trails. The soil included a sandy layer, over grey clay with a sand fraction evident in at least in the upper portion. Shells of Mediterranean Snail were locally conspicuous. Kangaroo trails in the vicinity were variously entrenched.

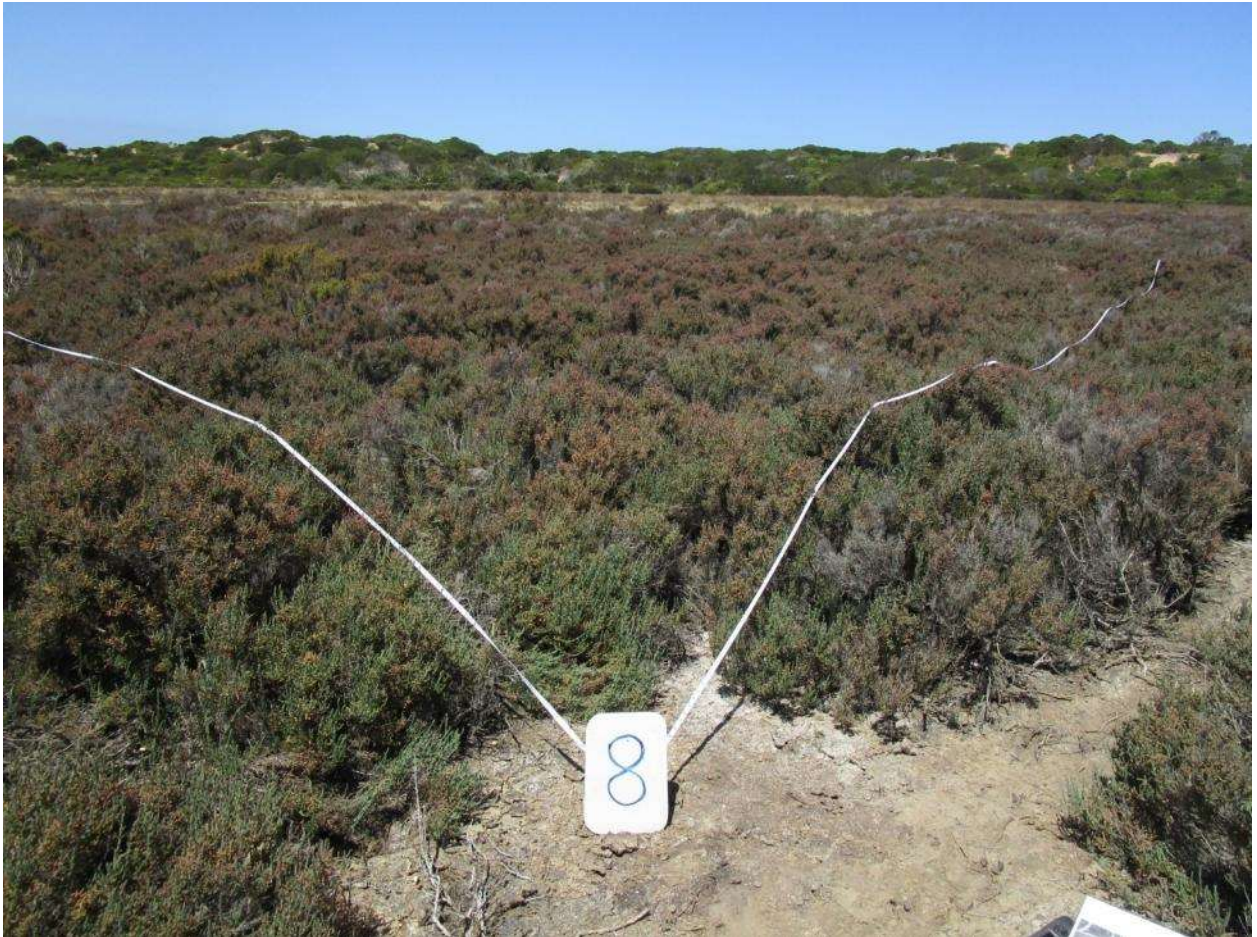
SPECIES AND COVERS:

- 1 *Apium annuum*
- + **Cotula coronopifolia*
- + *Frankenia pauciflora* var. *gunnii*
- 1 **Parapholis incurva*
- 1 **Polypogon monspeliensis*
- + *Salicornia quinqueflora* subsp. *quinqueflora*
- 1 **Sonchus oleraceus*
- 2 *Tecticornia arbuscula* [live plants]
- + *Tecticornia arbuscula* [dead plants]
- 70 *Tecticornia* sp. (Connewarre) [live plants]
- 2 *Tecticornia* sp. (Connewarre) [dead plants]

Algal crust 1.5%

Bare ground 20% (coarse estimate - extent ambiguous under shrub cover)

Litter 30%



QUADRAT NUMBER: 09

DATE: 9/11/23

RECORDER: D. Froot

GPS LOCATION OF MARKER POST (NW corner): 55H 0269924 / 5756870 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Moderately dense canopy of *Tecticornia arbuscula* with considerable plant mortality. The quadrat included patches of regeneration of *T. arbuscula* c. 15-40 cm tall in gaps, totalling c. 200 plants and presumed to include at least a component of suckers (c. 5% cover juveniles, 30% mature plants). Mortality of *T. arbuscula* had arisen from multiple events (including older more decomposed stems as well as relatively recently killed plants). The quadrat area was dry. A very superficial salt crust was present, but algal crust was not evident within the vicinity of the quadrat. The soil included a layer of loamy sand over clay, similar to that of quadrat 8. Major kangaroo trails in the vicinity were pugged or variously entrenched, but not as deeply as in wetter areas.

SPECIES AND COVERS:

- 1 **Polypogon monspeliensis*
- 1 *Salicornia quinqueflora* subsp. *quinqueflora*
- 35 *Tecticornia arbuscula* [live plants]
- 15 *Tecticornia arbuscula* [dead plants]

Bare ground 20%

Litter 60% (somewhat ambiguous as to when litter and when to count as older dead *T. arbuscula* stems)

Additional species nearby: *Frankenia pauciflora* var. *gunnii*



QUADRAT NUMBER: 10

DATE: 9/11/23

RECORDER: D. Froot

GPS LOCATION OF MARKER POST (NW corner): 55H 0269730 / 5756938 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Relatively open shrub canopy of *Tecticornia arbuscula*. Mortality of *T. arbuscula* had arisen from multiple events (including much older more decomposed stems as well as relatively recently killed plants). The quadrat included several localised patches of juvenile *T. arbuscula* c. 10-30 cm tall, presumed to mainly comprise suckers, totalling c. 50 plants. The quadrat area was dry, with a superficial salt crust but algal crusts were not locally evident. A very small patch of a moss species was present. The soil included a shallow layer of loamy sand over grey clay. The extent of pugging along kangaroo trails in the vicinity was variable according to microtopography.

SPECIES AND COVERS:

- 1 *Apium annuum*
- 1 *Disphyma crassifolium* subsp. *clavellatum*
- 2 *Frankenia pauciflora* var. *gunnii*
- 1 **Parapholis incurva*
- 2 **Polypogon monspeliensis*
- 2 *Salicornia quinqueflora* subsp. *quinqueflora*
- 30 *Tecticornia arbuscula* [live plants]
- 5 *Tecticornia arbuscula* [dead plants]

Bryophyte crust 0.02%

Bare ground 40%

Litter 40%

Additional species nearby: *Puccinellia stricta*, *Suaeda australis*



QUADRAT NUMBER: 11

DATE: 9/11/23

RECORDER: D. Froot

GPS LOCATION OF MARKER POST (NW corner): 55H 0269625 / 5756908 (+/- 3 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Relatively open shrub canopy of *Tecticornia* sp. (Connewarre) with high plant mortality and a high cover of *Salicornia quinqueflora*. No regeneration of *Tecticornia* sp. was evident. The soils included a dark organic surface layer over wet grey clay. An adjacent open area included algal cover, with the quadrat area still saturated and deeply pugged by sparse kangaroo tracks.

SPECIES AND COVERS:

65 *Salicornia quinqueflora* subsp. *quinqueflora*

2 *Suaeda australis*

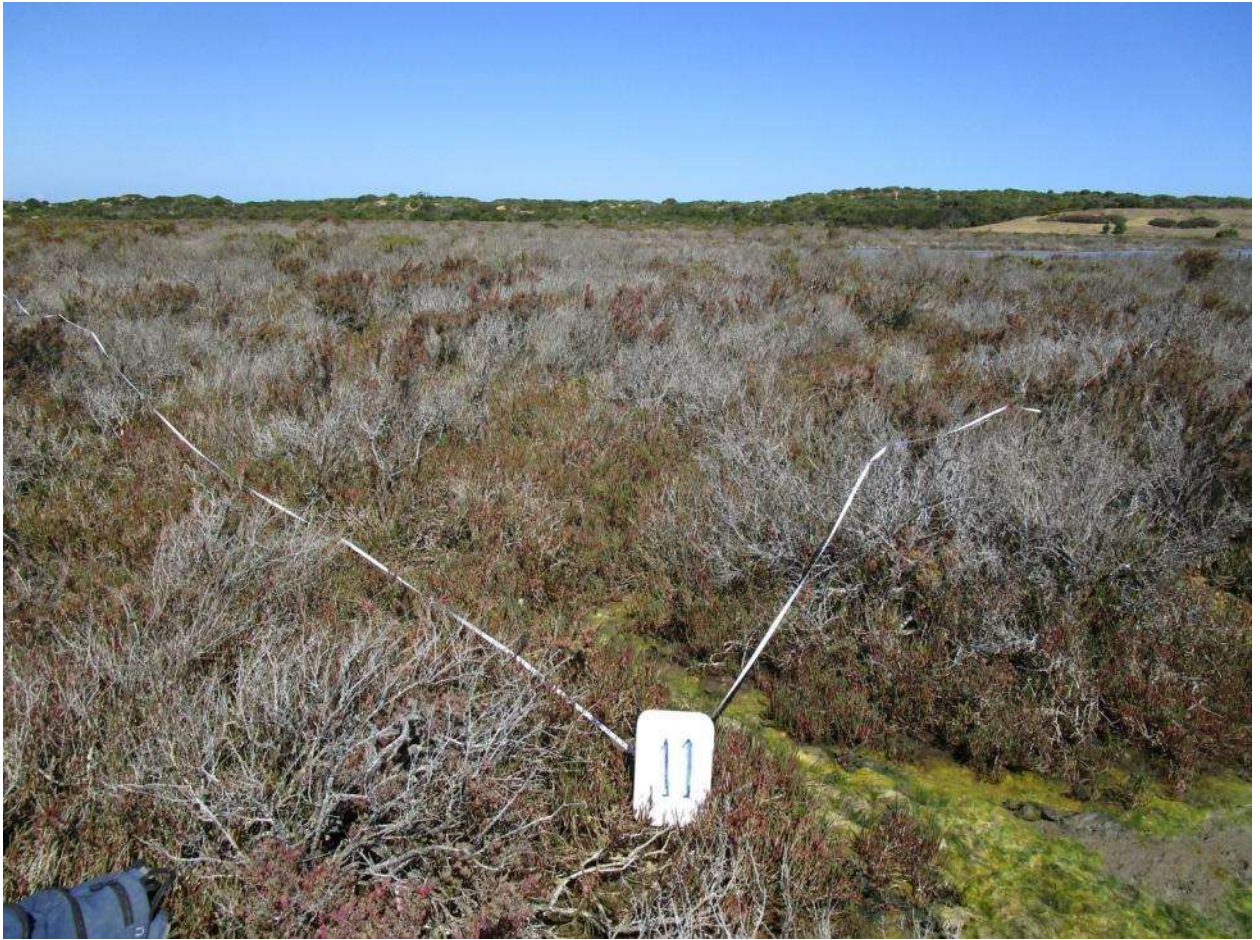
15 *Tecticornia* sp. (Connewarre) [live plants]

20 *Tecticornia* sp. (Connewarre) [dead plants]

Algal crust 5%

Bare ground 15%

Litter 15%



QUADRAT NUMBER: 12

DATE: 9/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269806 / 5756715 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION:

Primarily open low-lying area, with sparse dead plants of both of the *Tecticornia* spp. present, with dead *T. arbuscula* plants structurally more intact and consequently having died more recently than those of *T. sp.* (Connewarre) plants. Only minimal cover of live *Tecticornia* species was evident within the low-lying land feature. Within the quadrat, colonisation by small plants of *Salicornia quinqueflora* was present, but regeneration of *Tecticornia* species was lacking. The quadrat area was currently dry with a salt crust. The soils consisted of a yellowish-brown sandy loam, presumed to be overlying clay at a deeper level. Abundant rabbit sign (droppings and scratching) and some fragments of marine shells were evident in the quadrat area. Pug marks associated with kangaroo tracks were not very deep or well preserved, due to the sandy character of the soil.

SPECIES AND COVERS:

- 1 **Atriplex prostrata*
- + *Disphyma crassifolium* subsp. *clavellatum*
- 2 *Frankenia pauciflora* var. *gunnii*
- 1 **Polypogon monspeliensis*
- 30 *Salicornia quinqueflora* subsp. *quinqueflora*
- + *Senecio halophilus*
- + *Tecticornia arbuscula* [live plants]
- 2 *Tecticornia arbuscula* [dead plants]

2 *Tecticornia* sp. (Connewarre) [dead plants]

Bare ground 70

Litter 5% (somewhat ambiguous in relation to disintegrating *Tecticornia* plants)

Additional species nearby: *Senecio glomeratus*, *Spergularia marina*



QUADRAT NUMBER: 13

DATE: 10/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269476 / 5756872 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Prior *Tecticornia* species shrubland, with majority of individuals dead and *Salicornia quinqueflora* dominated ground layer. Mortality of *Tecticornia* species was from mixed time frames, but primarily recent. The soil was saturated, with algal crust present along kangaroo trails. The top soil comprised a dark organic layer over yellow-grey clay. Kangaroo tracks were deeply pugged.

SPECIES AND COVERS:

- 2 *Apium annuum*
- 2 **Atriplex prostrata*
- + *Bolboschoenus caldwellii*
- 2 **Cotula coronopifolia*
- 2 *Frankenia pauciflora* var. *gunnii*
- 2 *Isolepis cernua* s.s.
- 1 *Lachnagrostis* sp. aff. *filiformis* (glabrous lemmas)
- 1 **Plantago coronopus*
- 5 **Polypogon monspeliensis*
- 1 **Rumex crispus*
- 60 *Salicornia quinqueflora* subsp. *quinqueflora*
- 1 *Senecio pinnatifolius* var. *lanceolatus*
- 1 **Sonchus oleraceus*
- 1 *Spergularia marina*
- 2 *Suaeda australis*

- 1 **Symphyotrichum subulatum*
- 2 *Tecticornia arbuscula* [live plants]
- + *Tecticornia* sp. (Connewarre) [live plants]
- 20 *Tecticornia* spp. [dead plants, primarily *T. arbuscula*]
- 2 *Triglochin striata*

Algal crust 5%

Bare ground 5%

Litter 10% (ambiguous in relation to disintegrating dead *Tecticornia* plants)



QUADRAT NUMBER: 14

DATE: 10/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269514 / 5756679 (+/- 5 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Open shrubland of *Tecticornia arbuscula* with the majority of plants dead, and *Salicornia quinqueflora* and **Cotula coronopifolia* co-dominant in the ground layer. The quadrat was adjacent to a small pond. Within the quadrat, the soil moisture ranged from saturated to very damp. The top soil comprised sandy peat over a clayey-sandy layer with high organic content. Kangaroo tracks were sparse but deeply pugged where present.

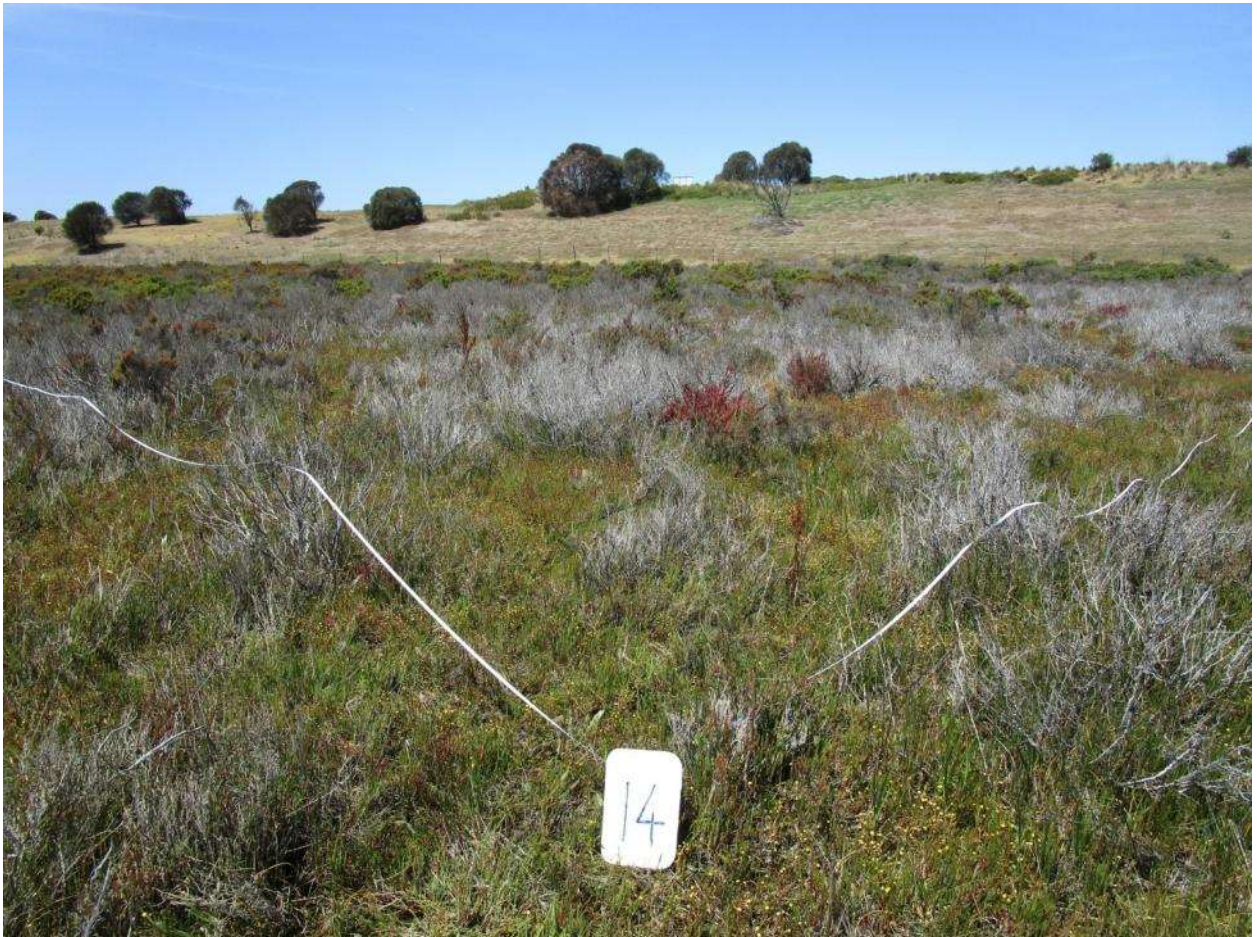
SPECIES AND COVERS:

- + **Atriplex prostrata*
- 2 *Bolboschoenus caldwellii*
- 40 **Cotula coronopifolia*
- 1 *Isolepis cernua* s.s.
- 1 **Polypogon monspeliensis*
- 1 **Rumex crispus*
- 40 *Salicornia quinqueflora* subsp. *quinqueflora*
- 2 *Suaeda australis*
- 2 *Tecticornia arbuscula* [live plants]
- 2 *Tecticornia arbuscula* [dead plants]
- 5 *Tecticornia* sp. (Connewarre) [live plants]
- 10 *Tecticornia* sp. (Connewarre) [dead plants]
- 2 *Triglochin striata*

Algal crust 10%

Bare ground 2%

Litter 7%



QUADRAT NUMBER: 15

DATE: 10/11/23

RECORDER: D. Flood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269249 / 5756685 (+/- 5 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION: Mudflat with scattered dead *Tecticornia* species and patchy Brackish Wetland species, surrounded by patches of *Typha* spp. *Salicornia quinqueflora* was mainly present as small seedlings. *Bolboschoenus caldwellii* shoots were still emerging. Within the quadrat, the surface ranged from being saturated to superficially inundated. The soil comprised black anaerobic ooze over yellow-grey clay (as for soil collection site 4).

SPECIES AND COVERS:

- 1 *Apium annuum*
- 1 **Atriplex prostrata*
- 5 *Bolboschoenus caldwellii*
- 10 **Cotula coronopifolia*
- 1 *Crassula helmsii*
- + *Eleocharis acuta*
- 1 *Epilobium billardierianum* subsp. *intermedium*
- 2 *Lemna disperma*
- 15 *Lilaeopsis polyantha*
- + *Lythrum hyssopifolia*
- 1 **Polypogon monspeliensis*
- + **Rumex crispus*
- 1 *Salicornia quinqueflora* subsp. *quinqueflora*
- 1 *Senecio pinnatifolius* var. *lanceolatus*

- 1 **Symphyotrichum subulatum*
- 5 *Tecticornia* spp. [dead plants]
- + *Thyridia repens*
- + *Typha* spp.
- 1 *Triglochin striata*

Algal crust 10%

Bare ground (mud) 65%

Litter 1%



QUADRAT NUMBER: 16

DATE: 10/11/23

RECORDER: D. Flood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269313 / 5756912 (+/- 3 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION:

Prior shrubland of *Tecticornia arbuscula* with nearly all plants dead. *Salicornia quinqueflora* and **Cotula coronopifolia* were co-dominant in the ground layer with Brackish Wetland species. Within the quadrat, the soil was saturated with an algal crust in gaps. The soil variously comprised peaty loam or black ooze over grey clay. Deep pugging was present along incidental kangaroo tracks in the vicinity.

SPECIES AND COVERS:

- 2 *Apium annuum*
- + **Atriplex prostrata*
- 10 *Bolboschoenus caldwellii*
- 20 **Cotula coronopifolia*
- + *Frankenia pauciflora* var. *gunnii*
- 1 *Isolepis cernua* s.s.
- + **Lolium rigidum*
- 10 **Polypogon monspeliensis*
- + *Puccinellia stricta*
- 1 **Rumex crispus*
- 30 *Salicornia quinqueflora* subsp. *quinqueflora*
- + *Sonchus hydrophilus*
- 1 **Symphyotrichum subulatum*
- + *Tecticornia arbuscula* [live plants]

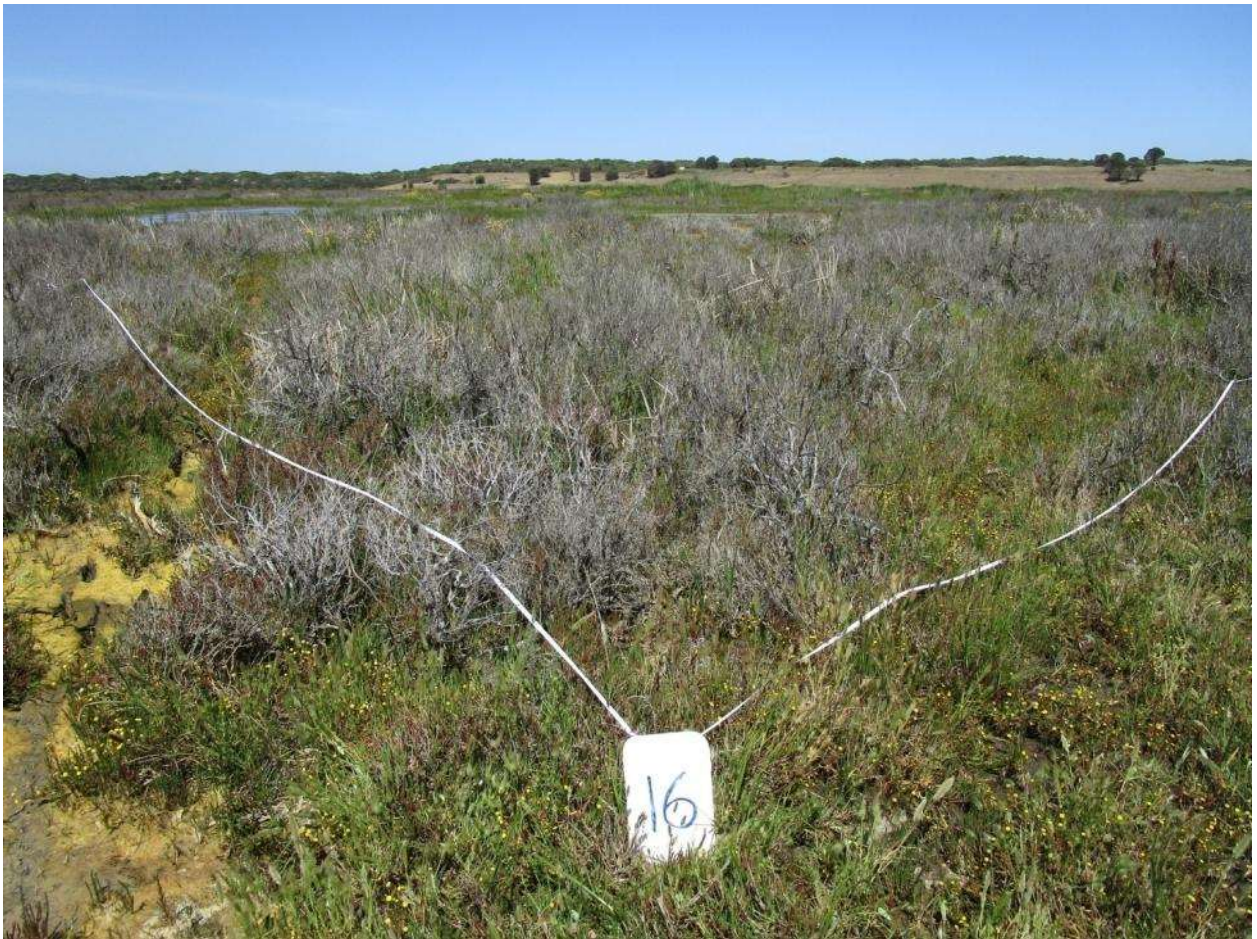
- 15 *Tecticornia* spp. [dead plants – most if not all *T. arbuscula*]
- 1 *Thyridia repens*
- 5 *Triglochin striata*
- 1 *Typha* spp.

Algal crust 5%

Bare ground 15%

Litter 5%

Additional species nearby: *Senecio pinnatifolius* var. *lanceolatus*



QUADRAT NUMBER: 17

DATE: 10/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269236 / 5756930 (+/- 5 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION:

The quadrat was located on a mudflat between two ponds and included a portion of shallow fringing pond. The main vegetation comprised a dwarf herbland of Brackish Wetland species. A sparse component of dead *Tecticornia* spp. from an earlier dieback event was also present. The covers of species occurring as intermixed components within the dwarf herbland vegetation were difficult to interpret accurately. Within the quadrat, the soil was saturated, with c. 10% inundated to up to around 10 cm depth. The soil consisted of silty black ooze over grey clay.

SPECIES AND COVERS:

- 1 *Althenia bilocularis*
- 2 *Apium annuum*
- 1 **Atriplex prostrata*
- 2 *Bolboschoenus caldwellii*
- 2 **Cotula coronopifolia*
- + *Frankenia pauciflora* var. *gunnii*
- 1 *Isolepis cernua* s.s.
- 1 *Juncus bufonius*
- 10 *Lilaeopsis polyantha*
- 2 **Lolium rigidum*.
- 1 **Plantago coronopus*
- 2 **Polypogon monspeliensis*

- 2 *Ruppia polycarpa*
- 2 *Salicornia quinqueflora* subsp. *quinqueflora*
- 1 *Senecio pinnatifolius* var. *lanceolatus*
- 1 **Symphyotrichum subulatum*
- 5 *Tecticornia* spp. [dead plants – most if not all *T. arbuscula*]
- 2 *Thyridia repens*
- 2 *Triglochin striata*
- 1 *Typha* spp.

Algal crust 10%

Bare ground 65%

Litter 2%



QUADRAT NUMBER: 18

DATE: 10/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269181 / 5757009 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION:

Prior shrubland of *Tecticornia* spp., with a high proportion of these plants dead and with a ground layer dominated by a dense cover of *Salicornia quinqueflora*.

Incidental juvenile plants of *Tecticornia* spp. were present. The soil was damp, but the site was effectively dry. Algal crusts were not evident. The top soil was peaty, grading into clay with an organic component. Deep pugging was localised along occasional kangaroo trails.

SPECIES AND COVERS:

- 1 *Apium annuum*
- 1 **Atriplex prostrata*
- 5 **Cotula coronopifolia*
- 1 *Disphyma crassifolium* subsp. *clavellatum*
- 1 *Isolepis cernua* s.s.
- 2 *Frankenia pauciflora* var. *gunnii*
- + **Hordeum hystrix*
- 1 **Polypogon monspeliensis*
- 85 *Salicornia quinqueflora* subsp. *quinqueflora*
- 1 *Spergularia marina*
- 2 *Tecticornia arbuscula* [live plants]
- 5 *Tecticornia arbuscula* [dead plants]
- 2 *Tecticornia* sp. (Connewarre) [live plants]

10 *Tecticornia* sp. (Connewarre) [dead plants]

Bare ground 10%

Litter 5%

Additional species nearby: *Puccinellia stricta*, **Lolium rigidum*, *Bolboschoenus caldwellii*



QUADRAT NUMBER: 19

DATE: 10/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269103 / 5756852 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION:

Vegetation modified by stormwater discharge, comprising prior saltmarsh now dominated by *Eleocharis acuta*, with colonisation by a patch of *Typha domingensis* (currently c. 4% cover). A sparse component of dead *Tecticornia* spp. from an earlier dieback event was present. The small herb component was difficult to detect due to the dense sward of *E. acuta* and consequently has the potential to be underestimated. The quadrat area was saturated to shallowly inundated (to <5 cm depth). Algal crusts were not evident. The soil comprised silty black organic ooze over clay. Deep pugging was not obvious along kangaroo tracks, as a consequence of the stability provided by the dense ground layer vegetation.

SPECIES AND COVERS:

- + **Atriplex prostrata*
- 2 *Bolboschoenus caldwellii*
- 2 **Cotula coronopifolia*
- 1 *Crassula helmsii*
- 70 *Eleocharis acuta*
- 1 *Epilobium billardierianum* subsp. *billardierianum*
- + *Epilobium hirtigerum*
- 1 **Holcus lanatus*
- 5 *Lilaeopsis polyantha*
- 1 *Lythrum hyssopifolia*
- 1 **Polypogon monspeliensis*

- + **Rumex conglomeratus*
- 1 **Rumex crispus*
- 2 *Senecio pinnatifolius* var. *lanceolatus*
- + **Sonchus oleraceus*
- 1 **Symphyotrichum subulatum*
- + *Tecticornia* sp. (Connewarre) [live plants]
- 5 *Tecticornia* spp. [dead plants]
- 2 *Triglochin striata*
- 2 *Typha domingensis*

Bare ground 5%

Litter 2%

Additional species nearby: *Thyridia repens*



QUADRAT NUMBER: 20

DATE: 11/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269111 / 5756800 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION:

Vegetation modified by stormwater discharge, comprising prior saltmarsh now dominated by *Bolboschoenus caldwellii*. Part of the quadrat comprised a locally taller sward of *B. caldwellii* with small plants of *Typha domingensis*. The surface of the quadrat area was saturated. The soil consisted of black organic ooze over clay. Some local pugging was evident along kangaroo tracks, but the relative impact was somewhat reduced by the organic component at the soil surface.

SPECIES AND COVERS:

- 1 **Atriplex prostrata*
- 70 *Bolboschoenus caldwellii*
- 5 **Cotula coronopifolia*
- 1 *Crassula helmsii*
- 2 *Eleocharis acuta*
- + *Epilobium hirtigerum*
- 1 *Isolepis cernua* s.s.
- 10 *Lilaeopsis polyantha*
- + **Parapholis incurva*
- + **Polypogon monspeliensis*
- + *Puccinellia stricta*
- 1 **Rumex conglomeratus*
- 1 **Rumex crispus*

- 1 **Rumex* spp. (juvenile plants)
- 1 *Salicornia quinqueflora* subsp. *quinqueflora*
- 2 *Senecio pinnatifolius* var. *lanceolatus*
- 1 **Symphyotrichum subulatum*
- 2 *Tecticornia* spp. [dead plants]
- 1 *Typha domingensis*

Algal crust 20%

Bare ground 1%

Litter 20% (rather ambiguous as to what proportion of dead plant matter remained attached)

Additional species nearby: *Juncus kraussii* subsp. *australiensis* (isolated plant)



QUADRAT NUMBER: 21

DATE: 11/11/23

RECORDER: D. Frood

GPS LOCATION OF MARKER POST (NW corner): 55H 0269082 / 5756833 (+/- 4 m)

QUADRAT SIZE: 10 m x 10 m

SITE DESCRIPTION:

Vegetation modified by stormwater discharge into former saltmarsh. Now dominated by *Eleocharis acuta* with *Senecio pinnatifolius*, with associated plants primarily comprising freshwater species. The quadrat is close to the apparent outlet of a pipe into the Karaaf, with a patch of *Typha* spp. and *Schoenoplectus tabernaemontani* present nearby. The quadrat area was waterlogged and effectively shallowly inundated (to <5 cm depth). Algal crusts were evident in parts of the area. The soil consisted of black organic ooze over clay. Pugging from kangaroo tracks was not obvious.

SPECIES AND COVERS:

- 1 **Atriplex prostrata*
- 1 *Bolboschoenus caldwellii*
- 1 **Cotula coronopifolia*
- 1 *Crassula helmsii*
- 60 *Eleocharis acuta*
- 2 *Epilobium billardierianum* subsp. *billardierianum*
- 1 *Epilobium billardierianum* subsp. *intermedium*
- 5 *Epilobium hirtigerum*
- 10 **Holcus lanatus*
- + *Lachnagrostis filiformis* s.s.
- + **Lolium rigidum*
- 1 *Lythrum hyssopifolia*

- + *Persicaria decipiens*
- 1 **Polypogon monspeliensis*
- 1 **Rumex crispus*
- 1 **Rumex* spp. (juvenile plants)
- 25 *Senecio pinnatifolius* var. *lanceolatus*
- 1 **Sonchus asper* s.l.
- 1 **Sonchus oleraceus*

Algal crust 10%

Bare ground 2%

Litter 10% (interpretation somewhat ambiguous)

Additional species nearby: *Schoenoplectus tabernaemontani*, *Typha* spp.



APPENDIX 3.TWO-WAY TABLE OF QUADRAT DATA

	GROUP 1											GROUP 2				GROUP 3			GRP. 4		
	1	5	11	4	12	9	3	7	2	1	8	6	18	14	13	16	17	2	15	19	21
<i>Tecticornia arbuscula</i>	2	10			+	35	2	15	60	30	2	10	2	2		+					
<i>Tecticornia</i> sp. (Connewarre)		2	15	20			2	1				70	10	2	5						+
<i>Suaeda australis</i>	n		2				60	10	10	n		15		2	2						
<i>Frankenia pauciflora</i> var. <i>gunnii</i>				+	2	n		2	n	2	+	2	2		2	+	+				
<i>Apium annuum</i>									n	1	1	2	1		2	2	2		1		
<i>Salicornia quinqueflora</i> subsp. <i>quinqueflora</i>	n	70	65	5	30	1	10	5	2	2	+	5	85	40	60	30	2	1	1		
* <i>Parapholis incurva</i>										1	1	1	n		1						
* <i>Polypogon monspeliensis</i>						1				2	1	1	1	1	5	10	2	+	1	1	1
* <i>Cotula coronopifolia</i>													5	40	2	20	2	5	10	2	1
* <i>Atriplex prostrata</i>					1								1	+	2	+	1	1	1	+	1
<i>Bolboschoenus caldwellii</i>													n	2	+	10	2	70	5	2	1
<i>Isolepis cernua</i> s.s.													1	1	2	1	1	1			
<i>Triglochin striata</i>														2	2	5	2		1	2	
* <i>Rumex crispus</i>														1	1	1		1	+	1	1
* <i>Symphotrichum subulatum</i>															1	1	1	1	1	1	
<i>Senecio pinnatifolius</i> var. <i>lanceolatus</i>															1		1	2	1	2	25
<i>Typha</i> spp.																1	1	1	+	2	n
<i>Thyridia repens</i>																1	2		+	n	
<i>Lilaeopsis polyantha</i>																	10	10	15	5	
<i>Crassula helmsii</i>																		1	1	1	1
<i>Eleocharis acuta</i>																		2	+	70	60
<i>Epilobium hirtigerum</i>																		+		+	5
<i>Lythrum hyssopifolia</i>																			+	1	1
* <i>Sonchus oleraceus</i>											1				1					+	1
<i>Epilobium billardierianum</i> subsp. <i>billardierianum</i>																				1	2
* <i>Holcus lanatus</i>																				1	10

	GROUP 1												GROUP 2				GROUP 3			GRP. 4			
	1	5	11	4	12	9	3	7	2	1	8	6	18	14	13	16	17	2	15	19	21		
<i>Gahnia filum</i>	n																						
<i>Senecio glomeratus</i>					n																		
<i>Disphyma crassifolium</i> subsp. <i>clavellatum</i>					+				1	1			1										
<i>Spergularia marina</i>					n				n				1		1								
<i>Senecio halophilus</i>					+								1										
<i>Samolus repens</i>									1				n										
<i>Puccinellia stricta</i>										n			2	n			+			+			
* <i>Hordeum hystrix</i>														+									
<i>Lachnagrostis</i> sp. aff. <i>filiformis</i> (glabrous lemmas)															1								
* <i>Plantago coronopus</i>									n						1					1			
<i>Sonchus hydrophilus</i>																						+	
* <i>Lolium rigidum</i>																				2	+		+
<i>Juncus bufonius</i>																							
<i>Athenia bilocularis</i>																							
<i>Ruppia polycarpa</i>																							
<i>Juncus kraussii</i> subsp. <i>australiensis</i>																					n		
* <i>Rumex conglomeratus</i>																							+
* <i>Rumex</i> spp. (juvenile plants)																							1
<i>Lemna disperma</i>																							2
<i>Epilobium billardierianum</i> subsp. <i>intermedium</i>																							1
<i>Lachnagrostis filiformis</i> s.s.																							+
<i>Persicaria decipiens</i>																							+
<i>Schoenoplectus tabernaemontani</i>																							n
* <i>Sonchus asper</i> s.l.																							1

The code 'n' denotes species noted from in close proximity to but not within the relevant quadrat