Action Plan for the Bitterbush blue butterfly (*Theclinesthes albocincta*): Northern Adelaide Plains – Kangaroo Island

Richard V. Glatz, David A. Young, Jessica Marsh & Aileen Swarbrick

25 June 2017

Email Contacts

Survey Team

Richard Glatz, richard@dess.net.au
David Young, dayoung@adam.com.au
Jessica Marsh, marsh_jess@hotmail.com

Birdlife Australia

Kasun Ekanayake, kasun.ekanayake@birdlife.org.au

Adelaide and Mount Lofty Ranges Natural Resources

Tony Flaherty, Tony.Flaherty@sa.gov.au
Warrick Barnes, WBarnes@apc.sa.gov.au

Acknowledgements

The Bitterbush Blue Butterfly study is part of the Samphire Coast Icon Project, supported by the Adelaide and Mount Lofty Ranges Natural Resources Management Board through funding from the Australian Government. Thank you to BirdLife Australia and staff, particularly Jean Turner, Aleisa Lamanna and Kasun Ekanayake for their enthusiasm, guidance and advice. Kasun also provided edits of the draft plan. Thanks also to Tony Flaherty (AMLR NRM) who played a major role in establishing and guiding this project and the Samphire Coast Icon Project more broadly. We are grateful to Warrick Barnes (AMLR NRM and Adelaide Plains Council) who provided valuable advice about potential locations for *Adriana* and advice on regional revegetation programs. Thanks to Kerri Bartley (AMLR NRM & City of Holdfast Bay) for advice on recent *Adriana* revegetation on the metropolitan coast. Thank you to Andrew Winkler and Friends of Torrens Island for helping with access to Torrens Island and providing advice about previous activities in the area. Thanks also to Danny Male (Department of Environment and Natural Resources) for providing a map of KI *Adriana* records. We are grateful to Dr Michael Braby (Australian National Insect Collection) who kindly provided comments on the draft plan.

Cover Photographs

Left: late instar larva of *Theclinesthes albocincta* feeding on male inflorescence of *Adriana quadripartita*. A meat ant (*Iridomyrmex purpureus*) has just interacted with the larva (Photograph: Richard Glatz, Mouth Flat Road, Kangaroo Island). Right: adult *Theclinesthes albocincta* perched on foliage near host *Adriana* plants (Photograph: Andy Young, Parham).

Cite document as:

Glatz, R.V., Young, D.A., Marsh, J. & Swarbrick, A. (2017). Action Plan for the Bitterbush blue butterfly (*Theclinesthes albocincta*): Northern Adelaide Plains – Kangaroo Island. Final Report to Adelaide and Mount Lofty Ranges Natural Resources Management. D'Estrees Entomology and Science Services, Kangaroo Island, Australia: 71 pp.

CONTENTS

List of Figures

List of Tables

Abbreviations

AMLR	Adelaide and Mount Lofty Ranges
approx.	approximately
BBB	Bitterbush blue butterfly (*Theclinesthes albocincta* (Waterhouse))
cm	centimeter
DENR	(SA) Department of Environment and Natural Resources
e.g.	for example
Fig.	Figure
FP	Fleurieu Peninsula
g	gram(s)
GPS	global positioning system
HAT	Highest Astronomical Tide
KI	Kangaroo Island
km	kilometre
L	litre
m	metre
mm	millimetre
MANCAP	Metropolitan Adelaide and Northern Coastal Action Plan 2009
Metro	Metropolitan – referring to the survey area from Torrens Island-West Beach
NAP	Northern Adelaide Plains
NCCARF	National Climate Change Adaptation Research Facility (Gold Coast, Australia)
NRM	Natural Resource Management
pers. comm.	personal communication
pers. obs.	personal observation
pH	potential hydrogen (a measure of acidity)
RCP	Representative Concentration Pathway (for greenhouse gas emissions)
SA	(state of) South Australia
SASCC	South Australian Seed Conservation Centre
SCIP	Samphire Coast Icon Project
sp.	species (singular)
spp.	species (plural)

Aims and Scope of the Action Plan

This action plan has arisen from a survey of the Bitterbush blue butterfly (BBB; *Theclinesthes albocincta*) and its host plant, Coast bitterbush (*Adriana quadripartita*), conducted from spring 2016 to autumn 2017. The principal survey covered an area from Parham at the north of the Adelaide Plains region, south to Tennyson on the metropolitan coastline. This work was supported by the Adelaide and Mount Lofty Ranges Natural Resources Management Board's Samphire Coast Icon Project through funding from the Australian Government. In order to gain a broader picture of BBB distribution, value-add to existing efforts and better inform management across the region, D'Estrees Entomology & Science Services performed in-kind surveys of the Fleurieu Peninsula and Kangaroo Island.

The aims of the action plan were to:

1. Summarise current knowledge of biology of BBB and *Adriana quadripartita*
2. Determine the current distribution of BBB and *Adriana* in the survey area
3. Assess the current health of these sites
4. Identify threats to each site and provide threat ratings, taking into account sea-level rise
5. Assess the biological requirements that allow BBB and *Adriana* to persist
6. Identify and prioritise management actions to consolidate current populations
7. Identify and prioritise management actions to re-establish BBB colonies in areas where they have become extinct
8. Disseminate relevant information to stakeholders and the general public
9. Develop a survey protocol for BBB
10. Identify areas for further research with regard to ecology of BBB and *Adriana*

Importantly, the action plan ultimately aims to inform NRM-related investments in the short and longer terms, to provide the best possible outcome in terms of impacting the conservation of *A. quadripartita* and *T. albocincta,* and the broader biodiversity values of the region.

.

Dr Richard Glatz
25 June 2017

Executive Summary

This report presents data from a survey of the Bitterbush blue butterfly (BBB; *Theclinesthes albocincta*) and its host plant, the Coastal bitterbush (*Adriana quadripartita*). Findings from the survey are discussed and recommendations provided regarding conservation of BBB and further research. The survey and subsequent analysis was supported by the Adelaide and Mount Lofty Ranges Natural Resources Management Board's Samphire Coast Icon Project through funding from the Australian Government, and D'Estrees Entomology and Science Services.

Due to its extinction from a large area of former habitat along the Adelaide metropolitan coast, and a perceived contraction of populations in the Northern Adelaide Plains region, it was previously identified as a Focal Species for conservation by the *Metropolitan Adelaide and Northern Coastal Action Plan* (MANCAP) (Caton 2009).

The survey was conducted between spring 2016 and autumn 2017 and covered four broad regions:

- Northern Adelaide Plains (NAP) coast (from Parham at the northern margin, south to Port Gawler)
- Metropolitan (Metro) coast (from Torrens Island and Le Fevre Peninsula south to West Beach)
- Fleurieu Peninsula (FP) (from Port Stanvac south to Goolwa)
- Kangaroo Island (KI)

This work has produced the most comprehensive picture yet of BBB across the region. The main discoveries arising from the survey were:

- four small, isolated *Adriana* patches on the NAP coast that supported new BBB colonies
- a large, healthy BBB population at Light Beach
- two small BBB populations on the Le Fevre Peninsula which may indicate connection with the nearby population at Torrens Island (these are the only Metro populations known to remain)
- first record of an isolated BBB population still exiting in the Normanville dunes
- discovery of several large BBB populations on KI and an extension of the known range westward on north and south coasts of KI
- detection at coastal sites of reduced-colour forms of BBB (≈20% of butterflies) that appear to be what are considered as "inland forms"
- high sensitivity of using BBB eggs to detect small populations in all weather conditions
- the largest recorded *A. quadripartita* plants occurring at Breakneck River on KI

Adriana almost always occurred on previously disturbed land that is largely unmanaged and not in intact native vegetation. Investigation of inundation maps clearly show that *Adriana* was associated with the margins of land inundated during the highest tides. On the NAP, there are three large BBB colonies that appear robust at present. These occur at Port Gawler, Light Beach and Parham and appear to be isolated from each other. There has been some evidence that the Port Gawler population displays reduced diversity compared to populations in south east SA and Yorke Peninsula (Collier, 2010) and so a long-term aim of joining these colonies may be appropriate. This needs further investigation because our study shows that they considered only small parts of BBB populations remaining, and there is limited evidence for a historical decline of these large BBB populations in the NAP region.

The most pressing issue for the NAP region is strengthening a number of small, newly discovered BBB populations clinging to small *Adriana* patches (less than 50 plants) which are mostly at High risk of loss due to their small size and/or link to housing subdivisions and unmanaged land. These populations occur at Webb Beach, Thompson Beach, Middle Beach and Buckland Park. Some of these patches may provide BBB with a link to larger patches but this is unknown. There is a good chance to strengthen these populations through revegetation and community engagement because BBB appears to be able to survive on small patches of *Adriana* (achievable by individuals and volunteer revegetation programs) and only a very small amount of the available habitat at these sites is currently utilised.

On the Metro coast, BBB is largely extinct despite it being the longest unbroken patch of suitable habitat on the east coast of St. VIncent Gulf. Encouragingly we discovered two small new BBB populations on the Le Fevre Peninsula at Biodiversity Park and Mutton Cove. These populations may be connected to that known from Torrens Island and together these three sites comprise the only known BBB sites in the Metro region. We have some concerns about fire risk and regeneration of *Adriana* at Torrens Island, however, ongoing management of this site would be required to improve the situation. Torrens Island was another colony that was considered to show reduced diversity (Le Fevre Peninsula sites were not included in sampling) (Collier, 2010).

We consider that the key management goal for the Metro region is to strengthen the foothold of BBB on the Le Fevre Peninsula with a view to reintroduction along the Metro coast over the longer term. In the Metro region, there are many potential sites to establish *Adriana*. These sites include public green spaces, residential and council gardens, schools and industrial sites. Larger BBB colonies on Le Fevre Peninsula would also provide (along with Torrens Island) a population that could be used for translocation of BBB cohorts to strategic sites where *Adriana* has been established along the coast.

On the FP, we discovered that BBB still persists at Normanville dunes where it has never been recorded and is at High risk. This colony is apparently completely isolated and its protection and strengthening is the main priority for the FP. Another priority is reintroduction of *Adriana* and BBB to the north coast of the FP which comprises the southern suburbs of Adelaide such as Noarlunga and Aldinga, and links to the Metro region. BBB colonies at Newland Head and around Hindmarsh Island do not require management at this time.

Eastern KI is an isolated stronghold for BBB, supporting a range of large populations. The lack of BBB in the west of KI is intriguing, however, it is hard to interpret due to the paucity of historical *Adriana* records from the area and the fact that BBB was not recorded west of American River prior to our study. We discovered four new BBB populations on KI, each supported by medium-large *Adriana* srtands. These occurred at Antechamber Bay, Mouth Flat Road, D'Estrees Bay Road and Emu Bay. BBB populations on KI do not require management at this time and are generally at Low risk.

Impacts of sea-level rise were assessed (for mainland sites only) by choosing a relevant emissions projection scenario (2.2°C warming and 0.48cm sea-level rise by 2100) and examining resultant inundation maps. Most of the sites along the NAP and Metro coasts will be impacted to some degree. This means that over the long-term habitat refuges may need to be identified which occur at higher elevations or inland locations. On the NAP, this will require further research and engagement with private landholders to determine potential habitat (hopefully to provide linking corridors) and establish the new sites for BBB. Research is also required to assess how coastal plant communities begin to adapt to sea-level rise to improve our ability to choose and prioritise habitat refuges. Inundation maps also show that parts of the Metro coast (from Semaphore-Grange) will be heavily impacted by rising sea-levels in the absence of engineering solutions. A BBB site risk-rating associated with sea-level rise was produced to facilitate longer-term management decisions with regard to investing in best-bet sites and strategic assessment of inland/higher areas for BBB colonisation.

Separate risk-ratings are provided for short/medium-term threats versus long-term (climate-related) threats. This is to allow short/medium-term investment decisions to be made regarding strengthening and expanding current BBB colonies, whilst facilitating a strategic approach to managing climate effects which may require skewing of investment to different or new sites over the longer term.

Regarding the increase or establishment of *Adriana* patches, there is the potential to increase the efficiency of current revegetation practices, which rely on propagation and transplanting of cuttings. Efficiency benefits could occur through improving germination methods for *Adriana* seed and investigating methods of stimulating germination in and around existing patches through targeted disturbance such as soil disruption or fire.

We found that surveying for BBB eggs on developing male inflorescences of *Adriana* was a highly sensitive way to detect presence of small BBB populations. We believe that analysing numbers of BBB eggs on male *Adriana* inflorescences, and/or male inflorescences that have been utilised, would be an improved method for determining and comparing BBB populations versus observing adults which is the current practice (Collier *et al.* 2008).

Interestingly, we detected reduced-colour forms of adult BBB from a range of coastal locations across all four regions. These specimens match the description of those that have been designated as "inland types". Reduced-colour individuals accounted for 18 of the 90 specimens (20%) captured or raised from larvae. On the FP, these reduced-colour forms made up the majority of adults caught or raised.

The management of *Adriana* and BBB in residential areas of the Metro coast and NAP will benefit from the inclusion of the general public. By promoting the plight of BBB and providing information and materials to establish *Adriana* it should be possible to establish or increase BBB, particularly along the Metro coast where plantings could be spaced strategically to provide a habitat corridor. It would be useful to supply the public with *Adriana* seedlings and information about growing them. It would also be possible to design a simple BBB translocation and management protocol to facilitate reintroduction of BBB by councils and individuals once colonies on the Le Fevre Peninsula are large enough to supply seed material.

The action plan contains and prioritises recommendations for conservation management of *Adriana*/BBB in relevant areas across the survey region. This includes recommendations regarding on-ground works and further research to refine current understanding and inform improvements to current management practices. Recommendations are also presented regarding further research on management practices for *Adriana*/BBB and also other targets for conservation in the region.

It is hoped that this work will lead to long-term conservation of *Theclinesthes albocincta* in areas where it is under threat, and to increased range and abundance. We also hope that this project will help to promote the importance of invertebrates and also increase the disproportionally limited attention paid in NRM programs to this diverse, functionally important group.

Recommendations

The following recommendations are provided for conservation and management of *Theclinesthes albocincta* in the survey area. Recommendations are also provided for further BBB research and other conservation targets for the region covered by MANCAP, and the AMLR NRM region more broadly. Recommendations are broken into those of *Higher Priority* (immediate and short-term implementation) and *Lower Priority* (medium-long-term implementation).

Northern Adelaide Plains

Higher priority

- increase abundance (to at least 100 plants) and spread of *Adriana* around small BBB populations at Webb Beach, Thompson Beach, Middle Beach and Buckland Park through revegetation and engagement of councils and residential communities

Lower priority

- identify areas of higher elevation or inland location where habitat refuges from sea-level rise can be established. This will likely include agricultural or other private land.
- further increase size of sites at Low Risk of inundation through sea-rise (skewing resources away from High Risk sites), and search for other small BBB populations in the region
- identify land to establish long-term habitat corridors between large BBB populations at Parham, Light Beach and Port Gawler

Metropolitan Area

Higher priority

- increase abundance (to at least 100 plants) and spread of *Adriana* around small BBB populations at Biodiversity Park and Mutton Cove through revegetation and engagement of councils and residential communities
- identify and augment other small *Adriana* patches on the Le Fevre Peninsula to provide a strong seed population to perhaps translocate southward along the coast
- identify public green spaces and industrial sites where *Adriana* could be established to provide a spread of patches on the Le Fevre Peninsula
- engage residents on the Le Fevre Peninsula to plant and maintain *Adriana* in private gardens

Lower priority

- management of the Torrens Island site to reduce risk from fire and stimulate regeneration of *Adriana*
- choose strategically placed sites (≈1km apart) along the Metro coast where medium sized patches of *Adriana* (at least 50 plants) can be established to act as translocation sites for reintroduction BBB. These sites can be public green spaces, industrial land or private/council gardens
- develop a translocation protocol that can be used by NRM workers and adapted to members of the public to facilitate reintroduction of BBB at various sites
- publicity to promote the plight of BBB and link to members of the public interested in monitoring or establishing BBB on their properties, spread along the metro coast

Fleurieu Peninsula

Methods of determining sites for on-ground works and engaging the public to establish new *Adriana* patches (and to subsequently introduce or monitor BBB) are as for the Metro and NAP regions.

Higher priority

- further assess BBB population along the Normanville dunes
- if needed, increase abundance (to at least 100 plants) and spread of *Adriana* around this population
- produce a long-term plan for this site in accordance with current plans and taking sea-level rise into account

Lower priority

- scope sites for reintroduction of *Adriana*/BBB on the coast of the southern suburbs of Adelaide (e.g. Noarlunga, Aldinga, Port Stanvac).
- undertake on-ground works and community engagement to establish *Adriana* (and subsequently BBB) in these areas which would link to the Metro region
- further increase amount *Adriana* at Normanville to 500 plants or more with a focus on establishment on higher ground to mitigate against sea-rise

Obtaining and Establishing New Sites for BBB

Higher priority

- negotiate with relevant councils to routinely plant *Adriana* in ornamental and amenity plantings
- develop a user guide to planting and growing *Adriana*
- map larger potential sites such as public green spaces and industrial sites and prioritise them based on their biological suitability, position and management requirements
- undertake publicity to engage interested members of the public to plant and maintain *Adriana*
- engage owners of industrial/commercial sites to allow larger *Adriana* plantings on unused land (e.g. Port Stanvac desalination plant)

Lower Priority

- develop a protocol for NRM workers and the public to monitor and manage BBB that are translocated
- engage interested members of the public at strategic sites to translocate and manage establishment of BBB into *Adriana* patches that provide an ongoing spread of BBB across a defined area

Climate Change

Higher Priority

- prepare strategic plan which prioritises management to BBB populations that are at lower risk from sea-level rise (prioritised for conservation and augmentation over the long-term) and identify sites and actions to keep them linked, or link them in the future
- undertake high resolution spatial analysis to determine areas of sufficient elevation (or inland position) to mitigate against predicted sea-level rise and that contain likely refuge habitat for *Adriana.* This will likely include agricultural/horticultural land or other private property

Lower priority

- undertake monitoring of coastal vegetation associations to assess how they respond to increasing pressure from sea-level rise
- keep abreast of refined climate modelling and mapping in coming decades, to better inform management options in the future

Further Research

Higher priority

- develop methods for improvement of revegetation and regeneration of *Adriana*. This should include investigating disturbance (e.g. fire, soil disturbance) because it has a large effect naturally and has the capacity to significantly reduce labour associated with propagation and revegetation. Improving seed germination methods would remove the need to establish cuttings
- quantify the dispersal ability of the BBB. This would help define the maximum distance that can be allowed between patches without isolating them. It might also provide the optimum spacing to facilitate dispersal with the least on-ground effort and resources
- refine the use of BBB eggs to obtain population counts of BBB for monitoring and research

Lower priority

- characterise the parasitoid suite that is associated with BBB and its impact
- determine the significance of the reduced-colour (inland) forms of adult BBB found at coastal sites

Other Conservation Targets

Invertebrates receive a disproportionally small amount of research and conservation effort, given their massive contribution to biodiversity and ecosystem functioning. We prioritised broad groups of invertebrates that would be worthy of consideration in the area covered by the MANCAP and the broader NRM region. It would be wise to refine this with a scoping study to assess and prioritise invertebrates of conservation or functional importance for the region.

Higher priority

- important functional groups such as those that pollinate or degrade organic matter
- invertebrate suites associated specifically with rare plants
- invertebrate groups displaying particularly high diversity e.g. true bugs, flies, beetles, moths

Lower priority

- two rare skipper butterflies (Cynone grass-skipper and Black and white sedge-skipper)
- agricultural pest and beneficial species to facilitate revegetation projects associated with agricultural land
- iconic invertebrates from other taxonomic groups, e.g. bees, ants, wasps, spiders, dragonflies, grasshoppers, beetles, flies, moths

Introduction to the Action Plan

The Bitterbush blue butterfly (BBB) (*Theclinesthes albocincta* (Waterhouse, 1903)) (Figure 1) belongs to the insect family Lycaenidae, in the subfamily Polyommatinae (Grund and Sibatani 1975, Braby 2000a). Larvae of *T. albocincta* feed exclusively on either of two plant species in the genus *Adriana* commonly known as "bitterbushes", *viz*: *A. quadripartita* and *A. tomentosa*. Inland and coastal colour "forms" of the butterfly have been recognised which also apparently exhibit seasonal variation. It is currently accepted that the coastal form of BBB occurs only in the southern coastal regions of SA on *A. quadripartita*, whilst the inland form occurs in various states of Australia on *A. tomentosa* (Figure 2) (Grund 1996, Braby 2000b). However, we were able to raise butterflies reminiscent of inland forms from a range of coastal sites spanning the survey area (see Tables 6 & 7).

Figure 1. Pinned specimens of *Theclinesthes albocincta*. Males are on the left and females on the right. Top photographs showing the dorsal view of the butterfly and the bottom photographs are of the ventral view. (Modified from Braby, 2000b)

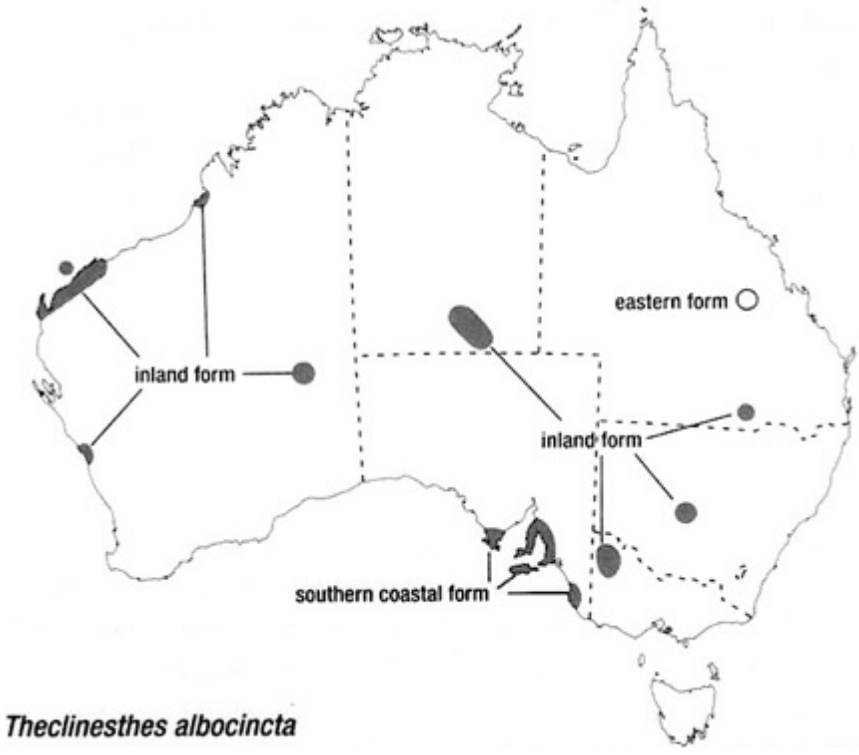


Figure 2. Distribution of colour forms of *Theclinesthes albocincta*. Inland forms occur on *Adriana tomentosa*. The southern coastal form occurs on *A. quadripartita*; this action plan relates to the AMLR NRM region where *T. albocincta* has declined historically, primarily in the Adelaide metropolitan area. (Modified from Braby, 2000a)

In 2007, a Flinders University study indicated that *T. albocincta* populations in the Adelaide and Mount Lofty Ranges (AMLR) NRM region had become fragmented and that this was manifest as genetic stratification of the isolated sub-populations, relative to supposedly less fragmented populations of the Yorke Peninsula and the south east of SA (Collier 2007, Collier *et al.* 2010). It should be noted that the distribution of BBB in that study is more simplistic than our survey revealed.

In 2009, the *Metropolitan Adelaide and Northern Coastal Action Plan* (MANCAP) identified both *A. quadripartita* and BBB as Focal Species for conservation in the AMLR NRM region (Caton *et al.* 2009). This was due to the almost complete loss of *Adriana* and BBB from metropolitan coasts due to development, and the patchy distribution of *Adriana* along the coast north of Adelaide extending beyond Parham; in some cases known colonies were thought to be threatened in the long-term by further development or sea-level rise due to climate warming.

The MANCAP (Caton *et al.* 2009) recommended the following actions be undertaken:

- creation of corridors for BBB in various coastal sites
- inclusion of *A. quadripartita* in revegetation programmes

In 2016, BirdLife Australia and the AMLR NRM board commissioned D'Estrees Entomology & Science Services to undertake a one-year project to determine the current distribution and conservation status of BBB in the AMLR NRM region. The broad aim of this project was to develop a dedicated action plan for management and conservation of BBB in the AMLR region. A key part of this plan was to develop recommendations for on-ground works based on priority sites which could sustain/strengthen or link existing BBB colonies, taking into account potential changes to coastal sites due to a rising sea level. The report/plan presented here represents the outputs of this one-year project.

An existing vehicle for on-ground works is the federally-funded Samphire Coast Icon Project (SCIP) of the AMLR NRM Board. The SCIP identified scoping of potential actions for butterfly conservation, including:

- revegetating with butterfly host plants
- increasing community awareness
- scoping potential rehabilitation, monitoring, awareness and reintroduction programmes
- scoping of further projects to investigate conservation status of key coastal invertebrates

It is hoped that the action plan we have developed here will be useful for informing on-ground works of the SCIP to conserve *Adriana* and BBB in an area extending from Tennyson Dunes in metropolitan Adelaide, approximately 50km north to Parham. The 2016-17 BBB survey covered an area from Hindmarsh Island to just north of Parham (including Kangaroo Island) and so the plan may be applied more broadly. We also hope that this project/plan can act as a model for other projects aimed at conservation of other butterflies, plant-feeding invertebrates and invertebrates more generally.

The BBB Larval Food Plant, *Adriana quadripartita*

In the AMLR region, *Theclinesthes albocincta* larvae feed exclusively on *Adriana quadripartita* (Coastal bitterbush) and therefore the survival of the butterfly is inextricably linked to the continued existence of sufficient *A. quadripartita* where it currently occurs. The historical decline of BBB, particularly along metropolitan beaches, is due to the loss of *Adriana*. The reliance on *Adriana*, also gives potential opportunities to improve or re-establish BBB populations through revegetation of *Adriana*. Therefore, to manage *Adriana* and BBB, it is important to understand:

- the distribution of *A. quadripartita* in the landscape
- the factors that affect *A. quadripartita* distribution and abundance
- how *A. quadripartita* distribution and abundance relate to BBB populations

Adriana spp. are members of the plant family Euphorbiaceae and are all dioecious (have separate male and female plants). Male and female flowers and buds of *A. quadripartita* are shown in Figures 3, 7 & 9. Most flowering occurs from winter through to mid-summer although plants can flower sporadically at most times (Beaumont *et al.* 2016; pers. obs.).

Figure 3. *Adriana quadripartita* is dioecious with distinctive male flowers (left) and female flowers (right) occurring on separate plants. (Photographs, Richard Glatz)

Adriana quadripartita occurs mainly in coastal situations (Black 1986, Gross and Whalen 1996, SASCC 2017), primarily in secondary sand dunes of beaches and dunes associated with tidally inundated areas such as samphire flats. To a lesser degree it can occur at the top of elevated rocky coastal areas often associated with limestone (Caton *et al.* 2009). These habitats are inherently dynamic and the occurrence of plants within a given habitat is likely to be variable in the medium-term. *Adriana quadripartita* is known as a colonising plant in disturbed situations (Bonney 2003, SASCC 2017). Indeed, most *Adriana* plants we surveyed were associated with previous disturbance (roadsides or previously cleared land) and usually occurred in weed-infested situations (pers. obs.) (Figure 4). Adult plants were hardly ever seen in intact native vegetation. Foliage of *A. quadripartita* is variable (see Gross, 1996) with leaves ranging from being broad and loosely serrated (typical of KI) to lanceolate with smooth margins (e.g. Thompson Beach).

When water is sufficient plants tend to form well-vegetated bushes up to about 3m high (Black 1986, SASCC 2017). Plants that are old, in dense vegetation or water-stressed can become leggy and appear woody. The lack of large colourful flowers and this tendency to become leggy has meant that the species has rarely been used for purely ornamental purposes. Plants with abundant water have profuse vegetative cover and large leaves; at one site (Breakneck River on KI), plants growing in a creekline were around 5m in height with one reaching around 7m (Figure 5) and we believe these are the largest recorded examples of *A. quadripartita*.

Figure 4. Typical contemporary habitat where *Adriana quadripartita* is found in the AMLR NRM region. Land is generally weed infested and unmanaged with former disturbance evident. Clockwise from top left: Torrens Island, Le Fevre Peninsula (Biodiversity Park), Buckland Park and Parham. (Photographs, Richard Glatz)

Adriana quadripartita is believed to be primarily wind pollinated due to the nectarless flowers (Gross and Whalen 1996). Extrafloral nectaries are present at the base of male and female flowers and the base of stipules; male inflorescences present greater numbers of extrafloral nectaries (Beaumont *et al.* 2016). Insect visitation of flowers can be quite high but is concentrated on blossoming male plants (pers. obs.). At Torrens Island, a previous study indicated that ants were involved in moving *Adriana* seed outside of the plant canopy and that a common *Rhytidoponera* sp. was responsible for 93% of ant-derived seed movement (Beaumont *et al.* 2009).

Currently it seems that propagation of *Adriana* using collected seed is problematic due to low germination rates (pers. comm. Veronica Bates, 2017) and current revegetation with *Adriana* in the region utilises cuttings (pers. comm. Warrick Barnes, 2017). *Adriana* seed is known to have a physiological dormancy mechanism and germination rates were quoted as 65-72% using seed from several sites (SASCC 2017). A range of germination treatments has been compared such as use of heat pre-treatment and varying incubation conditions such as addition of gibberellic acid at various concentrations, and altering temperature and light regimes (SASCC 2017). These treatments produced germination rates ranging from 0-60%. The best germination was achieved using no pre-treatment, incubation on 1% agar with 1g/L (pH 6.) with 14 hours dark at 15°C and 10 hours light at 30°C (SASCC 2017). This method produced germination of the first seeds in 15 days and germination of 50% by 29 days. Although the exact dormancy mechanism is apparently still not characterised, it is clear that germination of *A. quadripartita* seed is stimulated by disturbance such as soil disturbance and fire. It was noted at D'Estrees Bay Road (KI) that germination could also be stimulated by death of over-story plants (pers. obs.), which is interesting in the context of the ant movement of *Adriana* seed beyond the canopy from which they derived (Beaumont *et al.* 2009). Bonney (2003) states that *A. quadripartita* seed has been successfully sown in broad-acre revegetation and can be directly seeded by passing seed through a tyne into lightly tilthed soils then pressing in. Also, it was recommended to sow seed in autumn or winter to 5mm depth in propagating sand, "cover lightly" and keep moist (Bonney 2003). It may be worth investigating the use of targeted disturbance (and subsequent management such as weeding) in areas where *A. quadripartita* occurs, as a means of generating new plants.

Figure 5. *Adriana quadripartita* bushes vary widely depending on growing conditions. Healthy plants usually produce heavily vegetated bushes up to about 3m that are glossy dark green (top Left; Thompson Beach) but plants that are aging or water stressed can become leggy (top Right; Emu Bay, KI). Plants in the creekline at Breakneck River (KI) had large leaves with one individual reaching around 7m (bottom); many plants were ≈5m tall and we believe these are the largest recorded *A. quadripartita*. (Photographs, Richard Glatz)

Life-cycle and Biology of *Theclinesthes albocincta*

Adult BBB are shown in Figures 1,6 & 12. The first adults usually emerge in mid-late spring in the AMLR region and then mating occurs. Female butterflies lay eggs only on flowers and foliage of *A. quadripartita*; eggs are laid singly and heavily concentrated on young male inflorescences (Braby 2000a, Grund 1975, Fisher 1978, pers. obs.) (Figures 6-8).

Figure 6. Left: female *Theclinesthes albocincta* laying an egg on a young male inflorescence. Note presence of several other eggs already laid. Eggs are heavily concentrated on male inflorescences although leaves and female flowers/fruits are also laid upon. (Photographs: left, Richard Glatz; right, Andy Young)

The developmental rates affecting the time for eggs to hatch, and for larvae to grow and to complete pupation, are proportional to temperature. Eggs are greenish-white with a reticulated surface and usually take about a week to hatch producing the first instar larva (Figure 8, left). Larva hatching on male inflorescences chew holes in developing male buds producing characteristic damage (Figures 8 & 9), and often feed inside the flower bud. Older larvae (Figure 9) are broad, slightly flattened and humped. Braby (2000a) describes a complex series of four "main" larval colour forms, two of which "predominate in coastal SA". Often the larvae have one or several stripes on their dorsal surface. We observed in captivity, that the colour of an individual can be variable, changing with the part of the plant upon which they are feeding, hence they usually appear camouflaged if feeding on one part of a host plant for an extended period. Often older larvae fed on the outside of the male inflorescences and move onto foliage when they have depleted the floral food source. On leaves, larvae also produce characteristic damage appearing as linear tracks where only the upper leaf surface is removed (Figure 10).

Larvae are sometimes attended by ants (Figure 11) which obtain larval secretions that are high in sugar. A range of different ants have been recorded interacting with BBB larvae, including representatives of all five major Australian ant subfamilies (Braby 2000a, Collier 2007, pers. obs.). It is presumed that BBB larvae might be afforded some kind of protection from ants, however this is yet to be conclusively demonstrated and anecdotally appears to be short-term and sporadic. Interestingly, we did not raise any egg or larval parasitoids from survey material although this was not a focus of the survey.

Mature BBB larvae are approximately 1cm in size and usually pupate on the inner surface of curled, dry *Adriana* leaves beneath the plant; they can also use other debris (Braby 2000a, pers. obs.). Larvae were raised in containers with *Adriana* foliage, dried bark & paper tubes as part of the recent survey, and utilised all of these substrates, often choosing curled dried *Adriana* leaves. Pupation takes about 1-2 weeks in summer and 2-3 weeks in autumn (Grund and Sibatani 1975). Adult BBB tend to stay within the vicinity of host plants but will land on nearby vegetation (Figure 12) and visit blossom of other plants to obtain nectar (Braby, 2000a; pers. obs.). They often interact in flight, particularly when activity is high in warm conditions. In coastal SA, adults are usually active until May after which temperatures become too cold for butterfly activity; in cold months, butterflies are rarely seen and most individuals at this time are likely to exist as pupae in leaf litter. In survey season of 2016-2017, there appeared to be three non-discrete generations: late spring, mid-summer and early autumn.

Figure 7. Left: typical appearance of a young male *A. quadripartita* inflorescence with recently laid BBB eggs on bracts of unopened buds. The eggs are also placed into crevices between the tightly opposed buds (top right). Bottom right: hatched egg with remnants remaining on surface of female fruit of *A. quadripartita*. (Photographs: left, Andy Young; right, Jessica Marsh)

Figure 8. Young BBB larvae make characteristic damage on male *Adriana* inflorescences. Left: first instar larvae of *Theclinesthes albocincta* recently emerged from an egg collected at the Muston Road/Prospect Hill site on KI. Centre: male inflorescence of *A. quadripartita* showing numerous hatched eggs and the characteristic holes chewed by the early instar larvae in the unopened buds and their bracts. Right: eggs, and second instar BBB larva and a hole chewed in the bract of an unopened male bud. An ant is also on the inflorescence, probably foraging at extrafloral nectaries at the base of the buds. (Photographs: left, Richard Glatz; centre & right, Andy Young)

Figure 9. Later-stage larvae of BBB are broad and humped in appearance. They feed on all non-woody parts of the plant and are concentrated on the male inflorescences where they make characteristic holes in unopened buds. The top left photograph shows a larva chewing one of these holes. The larvae vary in colour and usually attain a colour close to their food source so that they are often camouflaged. (Photographs: top left, Jessica Marsh; top right & centre left, Andy Young; centre right and bottom, Richard Glatz)

Figure 10. *Theclinesthes albocincta* larvae make characteristic "feeding tracks" on leaf surfaces. Top left: early instar larvae feeding on leaf tissue as it moves along, forming a feeding track on the leaf behind it. Once feeding tracks are older they appear as linear brown scars on the leaf tissue which eventually disintegrate leaving holes in the leaves (top centre, top right and centre). Heavily infested plants can sustain significant damage (bottom). Here, three (poorly focused) larvae are feeding on one leaf (surrounded by other heavily damaged leaves), one of which is attended by an ant. (Photographs: top left, Andy Young; remainder, Richard Glatz)

Figure 11. A range of ants will attend BBB larvae, obtaining secretions high in sugar. Photographs show the Meat ant (*Iridomyrmex purpureus*) (left) and a *Camponotus* sp. (right) interacting with BBB larvae. (Photographs, Richard Glatz)

Figure 12. Adult BBB will usually stay in the vicinity of the *Adriana* host plants, landing on any available perch including surrounding vegetation (left) and parts of the host plant (right). (Photographs, Andy Young)

Methods

This section gives a brief description of the methods used in producing this action plan.

Survey of *Adriana* and BBB sites

Surveys were conducted over an area covering the northern outskirts of Parham, south to Hindmarsh Island (including KI). On mainland SA, surveys were conducted in mid-January, early February and early March when it was expected that the activity levels of adults would be high. On KI, surveys were conducted in an *ad hoc* manner throughout the season.

The aims of the survey were to:

- determine the current distribution of *A. quadripartita*
- assess occurrence of BBB at sites containing *A. quadripartita* and thereby gain an understanding of current BBB distribution
- collect site data relating to the perceived extent and health of BBB colonies to develop recommendations for SCIP (and other projects etc.) regarding on-ground works to enhance, stabilise or reintroduce BBB colonies, taking into account sea-level rises

Site selection

There were three criteria used to select sites:

- areas where *A. quadripartita* exists or is thought to have once been present
- areas where no *A. quadripartita* records exist but habitat appears suitable
- areas where BBB exists or is thought to have once been present

Areas with a known association to *A. quadripartita* were obtained through botanical collection records of the State Herbarium and the SA Department of Environment and Natural Resources (DENR). Local experts were consulted regarding known or potential sites. A similar approach was taken for determining BBB-associated areas except using insect collection records from SA Museum and Australian Museum. Google Earth was used to identify potential unknown areas where *Adriana* might exist, primarily associated with sandy beaches.

Priority was given to areas thought to contain *Adriana* either due to old records or through knowledge of its current distribution. BBB colonies rely upon *Adriana* and the distribution of *Adriana* is potentially dynamic due to its ability to colonise areas subsequent to disturbance. Therefore, we expected that there was a high chance of *Adriana* occurring in small groups that have not been previously assessed with regard to BBB presence.

Lists of survey sites and their associated data are provided in Survey Results (below).

Developing a survey protocol

In early spring, a range of sites on KI were visited to collect initial survey data to aid in refining a survey protocol for subsequent use in the AMLR region at times of higher BBB activity. Specifically, this involved:

- determining what aspects of a site should be recorded
- developing a survey proforma (Appendix B) to collect relevant survey data
- determining how to cover a search area to assess for *Adriana* presence and extent
- determining how to assess for BBB presence if adults are not unambiguously identified

At this time on KI, *A. quadripartita* was flowering and low numbers of BBB adults were found at several sites but were unable to be located at a range of other sites containing *Adriana*. We observed small numbers of females laying eggs in a stand of male and female *Adriana* and then searched most plants for eggs on flowers and leaves. Although we did not quantify the placement of eggs, it was readily apparent that:

1. eggs were easily seen and distinguishable from extrafloral nectaries
2. eggs were concentrated on young male inflorescences with mostly unopened buds
3. most male plants at the site had eggs present on suitable male inflorescences, therefore:
4. a high proportion of suitable male inflorescences across a site had eggs present
5. eggs were relatively difficult to find on leaves and female flowers
6. young larvae and associated damage were also present on young male inflorescences

It is mentioned in various literature that BBB prefer to lay eggs on male flowers and that larvae feed upon them (Grund and Sibatani 1975, Fisher 1978, Braby 2000a). However, the context of this is usually behavioural and has not been quantified or mentioned in the context of site surveys or population counts, which are usually conducted by counting adults (Collier *et al.* 2008). Examination of eggs on all plant parts of herbarium specimens was used by Grund (1996) to putatively expand the known historical range of the inland form BBB which feeds on *A. tomentosa*. However, the herbarium specimens were from a very wide geographical range, including Western Australia, and there was some question as to whether all eggs were BBB.

We found that examining suitable male inflorescences was a sensitive way to quickly detect BBB eggs at several sites on KI where adults were at too low density for us to observe even with significant effort in good conditions. One of these sites (D'Estrees Bay Road) had no previous record of BBB. As part of validating this method we raised BBB larvae from collected eggs (Figure 8; left) and checked for any evidence of other Lepidoptera using the inflorescences.

The survey protocol

Surveys were usually conducted in pairs. After arriving at a site, it was searched on foot (unless entirely visible from vehicles) for the presence of *A. quadripartita.* If *Adriana* was present an assessment of BBB presence was made by:

1. assessing suitable male inflorescences for eggs, larvae or larval damage (and for other evidence of Lepidoptera utilising the inflorescences)
2. identifying adults either through collection of vouchers or witnessing egg-laying on *A. quadripartita*
3. assessing old foliage/inflorescences for characteristic larval feeding damage

BBB presence was considered confirmed only if one or more of the following criteria were satisfied:

- BBB adults or larvae were observed as present by two or more people
- BBB larvae/adults were collected or raised from collected eggs or plant material
- multiple instances of male inflorescences with eggs and larval damage

If BBB was present, observations of aspects of BBB biology were made and photographed where possible. Ant attendance of BBB larvae was observed and ants collected only if they were unambiguously interacting with BBB larvae and not simply walking near them. Ants were subsequently identified to genus. Small numbers of voucher specimens were taken from most sites, in some cases to confirm presence by hatching eggs or rearing adults. To determine inland forms, we compared our specimens to the figures and descriptions of Braby (2000a & 2000b). Sites were scored as "new" if there we could find no record of BBB having been recorded there in literature or publicly-available biological databases.

Regardless of BBB presence, any stands of *Adriana* were assessed for approximate size and number of plants. All sites were photographed and their GPS data and location recorded. At some sites, the entire search path was recorded by using a GPS receiver. Other aspects of each site were also recorded on the survey proforma (see Appendix B) such as:

- extent of native and weedy vegetation
- soil characteristics and extent of plant litter
- extent of identifiable disturbance
- proximity to beaches
- proximity to other sites
- potential for on-ground works to influence *Adriana*/BBB
- survey time and weather

Other opportunistic observations of butterflies from the families Lycaenidae and Hesperiidae were recorded as these families comprise the rare species that breed in the AMLR region (Caton *et al.* 2009). Other Lepidoptera utilising *Adriana* were also noted.

Raising BBB

Eggs or putatively infested plant material from some survey sites were collected and kept cool until being transferred to individual paper-lined rearing containers, indoors at ambient temperature. Plant material containing eggs was examined under a light microscope to confirm hatching and presence of BBB first instar larvae. Larvae were simply left to feed and pupate with fresh plant material added where needed. Plant foliage, bark and paper tubes were provided as pupation substrates for mature larvae. The colour form of emergent adults was checked. BBB adults were preserved dry and lodged in the D'Estrees Entomology Insect Collection; data and specimens are available for third-party studies. Other emergent Lepidoptera or parasitoids (of larvae or eggs) were recorded.

Maps of Survey Results and Other Relevant Coastal or Sub-coastal Features

GPS data were downloaded (and edited where appropriate) using Garmin BaseCamp software (Version 4.6.3). Cleaned data were then transferred to Google Earth software (Version 7.1.8.3036 (32-bit)) for production of maps representing search results including *Adriana* and BBB distributions. Google Earth was also used to identify public green spaces with potential for managing BBB in the future, by overlaying the built-in "Parks/Recreation Areas" layer. Maps of existing coastal features were obtained from the CoastAdapt Shoreline Explorer portal with layers set to "Smartline Basic" (accessed online at http://coastadapt.com.au/coastadapt-interactive-map).

Assessing Risk from Sea-level Rise Due to Climate Change

Sea-level rise predictions and/or resultant coastal inundation maps for various climate scenarios, for a range of councils, were accessed via the CoastAdapt website (accessed online at https://coastadapt.com.au/sea-level-rise-information-all-australian-coastal-councils) (CoastAdapt 2016). Inundation maps presented in this plan (Figures 20-23) compare the current and predicted extent of inundation under Highest Astronomical Tide (HAT) conditions, which are defined as the highest level of water that can be predicted to occur under any combination of astronomical conditions (ICSM 2011; Siebentritt 2016).

The most relevant sea-level rise scenario for producing inundation maps, was determined by comparing four sea-level rise prediction models for the study region (CoastAdapt 2016). These scenarios relate to different Relative Concentration Pathways (RCPs) for greenhouse gasses under varying levels of climate change mitigation (NCCARF 2016a, NCCARF 2016b, Siebentritt 2016). When degrees of sea-level rise were compared for the four scenarios in the management region, it was found that the Low RCP and High RCP models (RCP4.5 and RCP6.0, respectively) were almost identical, whereas the Very Low (RCP2.6) and Very High (RCP8.5) were significantly different to each other and the more moderate scenarios.

A High RCP model was chosen for analysis of risk to BBB sites and to provide management advice about mitigating the risk. The reasons for choosing the High RCP model were:

- the Very Low RCP scenario assumes a very high global effort to curb emissions producing only 1°C warming by 2100 and is below levels where climate change is considered dangerous (NCCARF 2016b). This was not considered a likely outcome and in any case would not require mitigation activity for BBB.
- the Very High RCP scenario assumes a very low global effort to curb emissions producing a 3.7°C warming by 2100 (NCCARF 2016b). This was not considered a likely outcome because current agreements aim to reduce emissions below RCP8.5 and would likely intensify if it became apparent that emissions were tracking at that level.
- as mentioned, the Low RCP and High RCP scenarios predicted very similar sea-rise changes and between these models, the High RCP model was chosen because:
    - it is above the 2°C threshold at which climate change was considered to become dangerous and would require mitigation (the Low RCP model was not)
    - it takes a precautionary approach to BBB conservation by assuming that at least some action will need to be taken

Figure 13 shows the observed and predicted sea-rise data for the High RCP scenario which assumes 2.2°C warming and 0.48m sea-level rise by 2100 (NCCARF 2016b, Siebentritt 2016). Inundation maps for the High RCP scenario were examined with respect to BBB sites discovered in the survey and areas where management options could be applied. Inundation maps were available for an area covering West Beach at the southern margin, to just south of Light Beach on the Northern Adelaide Plains Coastline, at the northern margin. These maps were used to determine a climate change risk for BBB sites and to inform management recommendations.

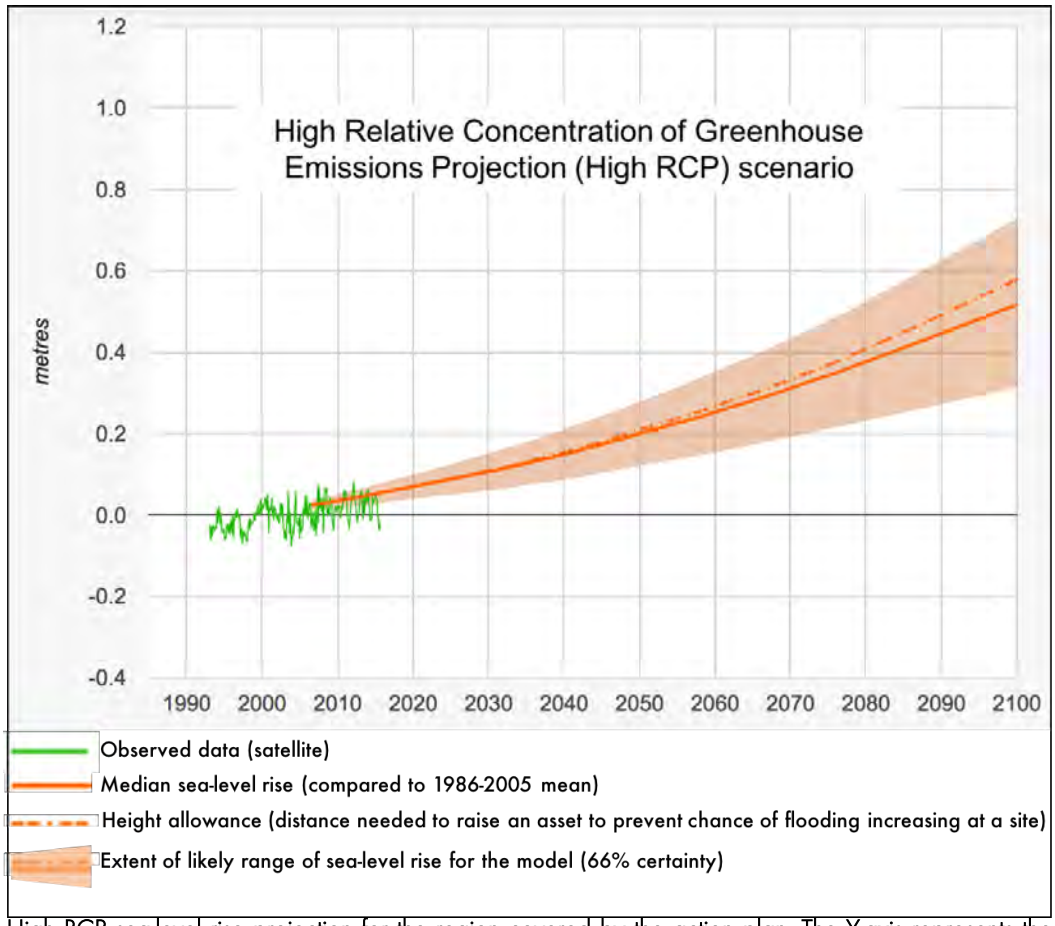


Figure 13. High RCP sea-level rise projection for the region covered by the action plan. The Y-axis represents the relative sea height and the X-axis is time. This scenario assumes a 2.2°C increase in temperature and 0.48m rise in sea-level by 2100. To prevent the chance of flooding increasing at a site, the site would need to be raised by almost 0.6m on average (depending on site characteristics). Modified from NCCARF (2016b).

Survey Results and Site Risk Assessments

To simplify survey results, data are grouped into four broad areas, each of which contains a range of survey sites (Figure 14). These four areas (moving north-south) are:

- Northern Adelaide Plains (NAP): extends from just north of Parham to Buckland Park
- Metropolitan (Metro): extends from Torrens Island and the Le Fevre Peninsula, to West Beach
- Fleurieu Peninsula (FP): extends from Port Stanvac to Hindmarsh Island
- Kangaroo Island (KI)

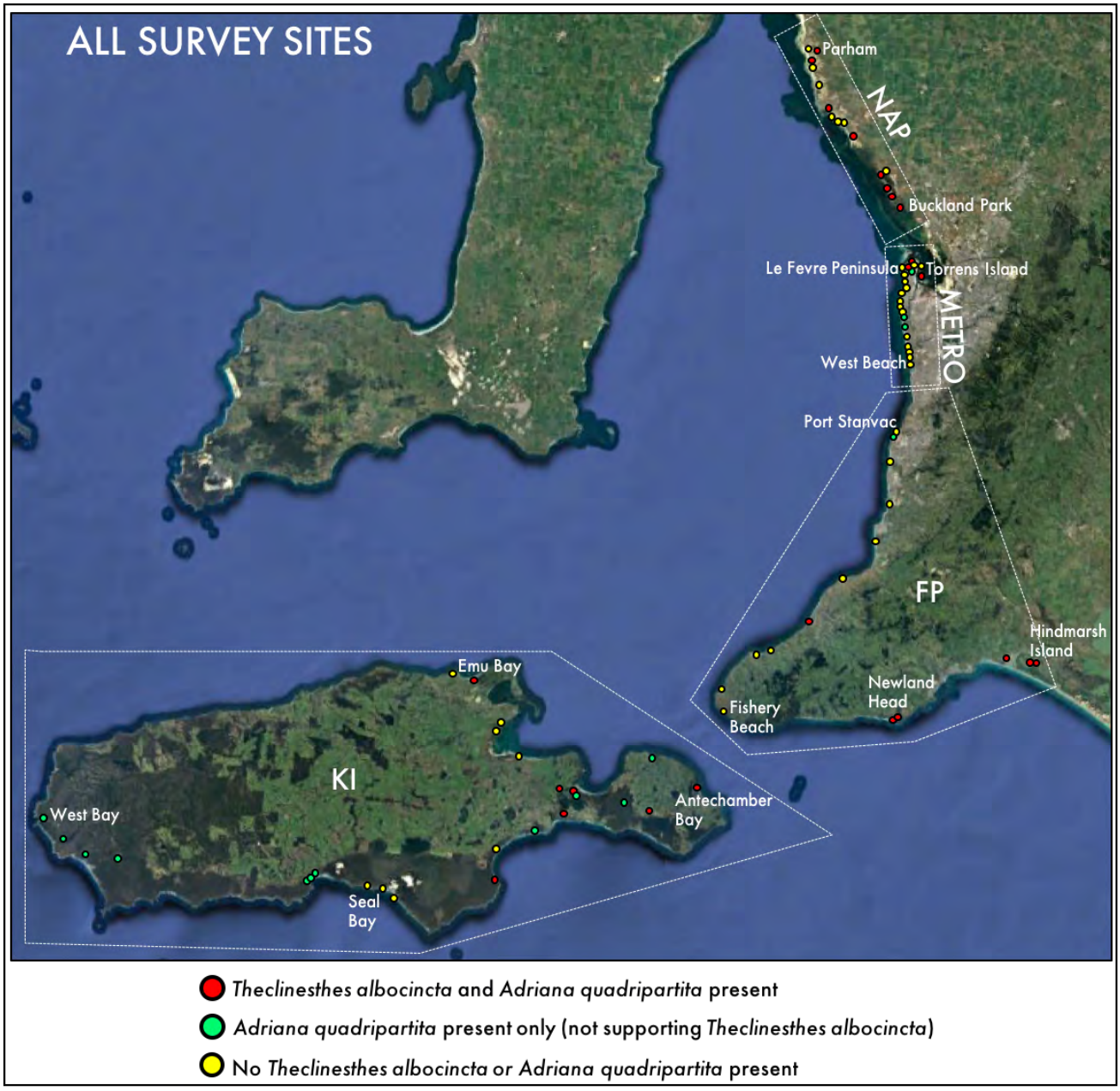


Figure 14. Four broad areas (bounded by dashed boxes) covered by this survey. Area names are shown in large white text. All 78 survey sites are shown with coloured dots. Survey sites at the margins of each area are written in small white text. Survey results are generally broken down into these four areas (see Tables 2-6). NAP: Northern Adelaide Plains coast; Metro: Metropolitan coast; FP: Fleurieu Peninsula; KI: Kangaroo Island. North is at top of page. Base map obtained using Google Earth software.

Table 1 is a summary of all of sites surveyed by region and the number of sites containing *A. quadripartita* or BBB. 78 sites were surveyed in total. Tables 2-5 are summaries of all survey sites for NAP, Metro, FP and KI, respectively (see also Figure 14). These tables contain site names, locations, survey dates and information on *A. quadripartita* and BBB found at the sites (as well as other opportunistic butterfly records). For mainland regions, sites are listed from north to south, whereas KI sites are listed east to west.

Table 1. Summary of the number of sites surveyed per region, the number of sites supporting *A. quadripartita*, and the number of sites where BBB is confirmed or suspected of being present as at winter 2017.

Survey Region	NAP	Metro	FP	KI	TOTAL
Number of sites surveyed	15	21	16	26	78
Number of sites supporting *Adriana*	8	6	7	18	39
Number of sites supporting BBB	8	3	6	7	24

(NAP, Northern Adelaide Plains; Metro, Metropolitan; FP, Fleurieu Peninsula; KI, Kangaroo Island)

Summary of BBB Distribution and Newly Recorded Sites

Figures 15-18 show maps of the survey results for NAP, Metro, FP and KI, respectively. These maps show all survey sites and indicate the position and relative size of BBB and *A. quadripartita* populations at the sites. Because we did not make counts of BBB populations, we assume that they are proportional to the size of the host plant populations for the purposes of producing these maps.

For the 24 sites where BBB was present or suspected, Tables 6 and 7 summarise site-specific data relating to the colonies the were found for the NAP/Metro and FP/KI regions, respectively. This includes the evidence for BBB presence, counts of adults that were sampled or raised, a BBB colony threat rating, and perceived threats for each site. These threats are considered as being short-medium-term in nature and do not include sea-level rise analysis which was assessed separately due to the much longer time frame associated with mitigation and the funding thereof.

At most sites where BBB was confirmed, adults were either observed, captured or subsequently raised. At one confirmed site (American River Road on KI), only eggs were observed. This was a small roadside site in a broader region containing *Adriana* and BBB. At two mainland sites (Goolwa and Mutton Cove) we are confident that BBB is present but current evidence is below our burden of proof; at Goolwa low numbers of eggs were found and at Mutton Cove a small amount of characteristic larval damage from earlier in the season was found. This is also the case at Antechamber Bay on KI where *T. albocincta* was observed at the site. On East-West Road (KI) a small amount of damage was found on male *Adriana* inflorescences in a small patch of plants but was somewhat atypical and we are unsure about BBB presence there.

We found 12 sites which we believe are newly recorded for BBB (Table 6). Five of these were in the NAP region; four were small sites at Webb Beach, Thompson Beach, Middle Beach and Buckland Park, with the fifth site being large and supporting probably the best BBB colony in the region at Light Beach. In the Metro area, two newly discovered small colonies were on the Le Fevre Peninsula (at Biodiversity Park and suspected at Mutton Cove).

In the FP region, we were able to confirm BBB presence at the south margin of beach dunes at Normanville; they were not recorded previously at Normanville although a small number of *A. quadripartita* were known to occur on the dunes there (Milne 2016). On KI, four new BBB sites were found that contained medium-large *Adriana* stands, *viz*: Antechamber Bay, Mouth Flat Road, Emu Bay and D'Estrees Bay Road. The latter two sites extend the known range of BBB westward on KI at both the north and south coasts. We currently list the Antechamber Bay site as "suspected" of supporting BBB because observation of putative evidence was only achieved by a single observer and we require two observers (or vouchers) to confirm presence. The large *A. quadripartita* colony at Emu Bay was apparently not known before this survey.

Table 2: Summary of all sites surveyed for this action plan in the NAP region (see related map in Figure 15). Sites are listed in order of decreasing latitude (north – south). An estimate of the size of *Adriana* populations is given at sites where they were found. The presence of BBB and other lycaenid or hesperiid butterflies is also provided.

Northern Adelaide Plains: Parham – Buckland Park (15 sites, 8 *Adriana* sites, 8 BBB sites)						
Site Name	Latitude	Longitude	Survey date(s)	*Adriana* population	BBB presence	Other butterflies
Parham primary dune north	-34.417611°	138.251444°	18 Jan 2017	-	-	-
Parham Social Club & township	-34.431263°	138.260589°	02 Feb 2017 06 Mar 2017	>500 plants, extends northward	YES	*Nacaduba biocellata*
Webb Beach (George Street)	-34.443407°	138.261720°	01 Feb 2017	<50 plants	YES	-
Webb Beach South	-34.445667°	138.260556°	17 Jan 2017	-	-	-
Thompson Beach north	-34.467116°	138.263588°	06 Mar 2017	-	-	*Theclinesthes serpentata*
Thompson Beach (Herron Crescent)	-34.492119°	138.292678°	06 Mar 2017	≈40 plants	YES	-
Thompson Beach south	-34.502870°	138.303068°	06 Mar 2017	-	-	-
Port Prime	-34.509139°	138.310472°	18 Jan 2017	-	-	-
Prime Beach Road	-34.507440°	138.327022°	02 Feb 2017	-	-	-
Light Beach	-34.539657°	138.347693°	18 Jan 2017	>1000 plants	YES	-
Middle Beach (inner dune)	-34.602048°	138.412669°	02 Feb 2017	-	-	-
Middle Beach (Esplanade dune)	-34.604308°	138.411041°	02 Feb 2017	≈20 plants	YES	-
Port Gawler north	-34.641778°	138.441556°	01 Feb 2017	>1000 plants, extends north and south	YES	-
Port Gawler south	-34.649639°	138.447694°	18 Jan 2017 07 Mar 2017	>500 plants, extends northward	YES	-
Buckland Park	-34.665361°	138.461676°	02 Feb 2017	≈40 plants	YES	-

Table 3: Summary of all sites surveyed for this action plan in the Metro region (see related map in Figure 16). Sites are listed in order of decreasing latitude (north – south). An estimate of the size of *Adriana* populations is given at sites where they were found. The presence of BBB and other lycaenid or hesperiid butterflies is also provided.

Metro: Torrens Island/Le Fevre Peninsula – West Beach (21 sites, 6 *Adriana* sites, 3 BBB sites)						
Site Name	Latitude	Longitude	Survey date(s)	*Adriana* population	BBB presence	Other butterflies
Torrens Island dunes	-34.773622°	138.523000°	01 Feb 2017	-	-	-
Torrens Island grassland	-34.798028°	138.520745°	01 Feb 2017	≈100-200 plants	YES	-
Mutton Cove north	-34.771512°	138.511339°	07 Mar 2017	≈10-20 plants	SUSPECTED	-
Mutton Cove south	-34.775833°	138.509000°	02 Feb 2017	-	-	-
Biodiversity Park	-34.780083°	138.501222°	01 Feb 2017 07 Mar 2017	≈25 plants	YES	*Nacaduba biocellata*
Outer Harbour	-34.781617°	138.482277°	02 Mar 2017	-	-	-
RB Connolly Reserve	-34.786391°	138.498462°	07 Mar 2017	4 plants	-	-
Largs North	-34.800847°	138.489342°	02 Feb 2017	-	-	-
Largs North (end of Gedville Road)	-34.804245°	138.489989°	01 Feb 2017	-	-	-
Largs Bay Boardwalk north	-34.812772°	138.490726°	01 Feb 2017	-	-	-
Largs Bay Boardwalk south	-34.818357°	138.489695°	01 Feb 2017	-	-	-
Peterhead	-34.830707°	138.483018°	01 Feb 2017	-	-	-
Semaphore north	-34.839451°	138.478740°	01 Feb 2017	-	-	-
Semaphore south	-34.842405°	138.478090°	01 Feb 2017	-	-	-
Fort Glanville primary dune	-34.850422°	138.476736°	01 Feb 2017	-	-	-
Semaphore Park (Recreation Parade)	-34.855761°	138.476923°	01 Feb 2017	1 plant	-	-
Tennyson Dunes south section	-34.879024°	138.483030°	01 Feb 2017	3 plants	-	-
Grange	-34.906255°	138.489902°	01 Feb 2017	-	-	-
West Beach (Hamra Avenue)	-34.951811°	138.504300°	01 Feb 2017	-	-	-
West Beach treatment plant dune north	-34.960119°	138.507092°	01 Feb 2017	-	-	-
West Beach treatment plant dune south	-34.963644°	138.508661°	01 Feb 2017	-	-	-

Table 4: Summary of all sites surveyed for this action plan in the FP region (see related map in Figure 17). Sites are listed in order of decreasing latitude (north – south). An estimate of the size of *Adriana* populations is given at sites where they were found. The presence of BBB and other lycaenid or hesperiid butterflies is also provided.

Fleurieu Peninsula: Port Stanvac – Hindmarsh Island (16 sites, 7 *Adriana* sites, 6 BBB sites)						
Site Name	Latitude	Longitude	Survey date(s)	*Adriana* population	BBB presence	Other butterflies
Port Stanvac north	35.093237°	138.484102°	31 Jan 2017	-	-	*Theclinesthes serpentata* *Nacaduba biocellata* *Candalides heathi* *Antipodia atralba* (old shelters on *Gahnia lanigera*)
Port Stanvac desalination plant walking trail	-35.098454°	138.486706°	31 Jan 2017	≈6 plants (planted)	-	-
Onkaparinga River mouth	-35.160028°	138.470472°	17 Jan 2017	-	-	-
Maslins Beach	-35.234750°	138.471139°	17 Jan 2017	-	-	-
Aldinga Beach (surf lifesaving club)	-35.303194°	138.450083°	17 Jan 2017	-	-	-
Myponga Beach	-35.371878°	138.387892°	28 Jan 2017	-	-	-
Normanville south	-35.472898°	138.290152°	17 Jan 2017 28 Jan2017	≈40 plants	YES	*Nacaduba biocellata*
Goolwa (Willmett Road)	-35.506944°	138.774083°	03 Feb 2017	≈6 plants (some planted)	SUSPECTED	-
Hindmarsh Island (Randell Road 1)	-35.510389°	138.821974°	03 Feb 2017	≈30 plants in roadside	YES	-
Hindmarsh Island (Randell Road 2)	-35.510472°	138.827306°	03 Feb 2017	≈100 plants in roadside	YES	-
Second Valley	-35.511712°	138.217947°	28 Jan 2017	-	-	-
Rapid Bay	-35.525242°	138.187363°	28 Jan 2017	-	-	-
Morgans Beach	-35.596861°	138.104167°	17 Jan 2017	-	-	-
Newland Head north	-35.626413°	138.498031°	17 Jan 2017	>30 plants; extends to Newland Head south site	YES	-
Newland Head south	-35.629031°	138.496269°	03 Feb 2017	>500 plants; extends to Newland Head north site	YES	-
Fishery Beach	-35.632361°	138.115222°	17 Jan 2017	-	-	-

Table 5: Summary of all sites surveyed for this action plan in the KI region (see related map in Figure 18). Sites are listed in order of decreasing longitude (east – west). An estimate of the size of *Adriana* populations is given at sites where they were found. The presence of BBB and other lycaenid or hesperiid butterflies is also provided.

Kangaroo Island (26 sites, 18 *Adriana* sites, 7 BBB sites)						
Site Name	Latitude	Longitude	Survey date(s)	*Adriana* population	BBB presence	Other butterflies
Antechamber Bay*	-35.788005°	138.065800°	20 Jan 2017 20 Feb 2017	>200 plants	SUSPECTED	-
Mouth Flat Road	-35.833360°	137.957960°	05 Mar 2017	>.500 plants	YES	-
Penneshaw	-35.721852°	137.947824°	05 Mar 2017	≈10 plants	-	
East West Road#	-35.805969°	137.900737°	05 Mar 2017	≈10 plants in roadside with atypical damage to male *Adriana*	UNSURE	-
Island Beach Mitchell Drive	-35.805183°	137.799300°	17 Nov 2016 13 Apr 2017	≈30 plants in roadside	-	*Theclinesthes serpentata* *Zizina labradus*
Island Beach town	-35.790808°	137.786178°	16 Dec 2016 13 Apr 2017	>5000 plants in vicinity	YES	*Theclinesthes serpentata* *Zizina labradus*
Muston Road/Prospect Hill	-35.842850°	137.753350°	29 Nov 2016 11 Jan 2017 13 Apr 2017	>2000 plants in vicinity	YES	*Zizina labradus*
American River Road	-35.796933°	137.750012°	24 Jan 2017 25 Jan 2017	≈ 20 plants in roadside	YES	-
Flour Cask Bay Road	-35.866717°	137.693567°	29 Nov 2016	2 plants in roadside	-	-
Min Oil Road campsite	-35.739609°	137.665515°	19 Apr 2017	-	-	-
D'Estrees Bay Road	-35.977017°	137.617567°	27 Jan 2017	>10,000 plants; extends along roadside for several km	YES	*Theclinesthes serpentata* *Nacaduba biocellata* *Zizina labradus*
Brownlow north	-35.671695°	137.613477°	26 Jan 2017	-	-	-
Brownlow south	-35.685586°	137.605075°	26 Jan 2017	-	-	-
Osmanli Road	-35.926916°	137.601675°	13 Jan 2017	-	-	-
Emu Bay (Wallaby Run)	-35.597828°	137.517178°	25 Jan 2017 06 Feb 2017	>1000 plants	YES	-
Emu Bay west	-35.587994°	137.504193°	06 Feb 2017	-	-	-
Bales Beach east	-36.006867°	137.374394°	25 Jan 2017	-	-	-
Bales Beach west	-35.993137°	137.348721°	25 Jan 2017	-	-	-
Seal Bay	-35.994344°	137.319544°	25 Jan 2017	-	-	-
Vivonne Bay (Flinders Street south)	-35.979872°	137.183044°	21 Jan 2017	≈30-50 plants	-	-
Vivonne Bay (Shell Street)	-35.981992°	137.180839°	21 Jan 2017	≈5 plants (more historically)	-	-
Vivonne Bay powerline	-35.993361°	137.176250°	21 Jan 2017	≈10 plants	-	-
Flinders Chase old apiary site	-35.956324°	136.701092°	09 Feb 2017	>5000 plants	-	-
Snake Lagoon	-35.952488°	136.657377°	09 Feb 2017	6 old plants (plus several dead plants)	-	-
West Bay Road (Breakneck River)	-35.925498°	136.612185°	09 Feb 2017	≈50 plants along creekline (hard to gauge extent of patch). Largest recorded *A. quadripartita*	-	-
West Bay carpark	-35.888657°	136.552966°	09 Feb 2017	≈20 plants in roadside in poor condition	-	*Ogyris otanes*

**T. albocincta* occurrence suspected only
#unsure if *T. albocincta* occurs there

Table 6. Summary of all survey sites where BBB has been confirmed or is suspected in the Northern Adelaide Plains and Metro regions (see related maps in figures 15 & 16, respectively). The evidence of BBB presence is listed for each site as are the number of adults raised or captured (including inland forms) and ants confirmed to be interacting with BBB larvae. A perceived threat level for each site is provided as are a list of threats.

Site	Evidence of BBB	Adults raised or captured	Colour reduced forms	Ant attendance confirmed	Colony threat level	Threats	Comments
Northern Adelaide Plains							
Parham Social Club & township	Adults, larvae, eggs	22	1	*Iridomyrmex* sp.1 *Tapinoma* sp.	LOW	Clearance for further development	Robust population
Webb Beach (George Street)*	Adults, larvae, eggs	-	-		HIGH	Low plant number in sub-division, clearance for further development	High levels of ant activity on plants
Thompson Beach (Herron Crescent)*	Adults, larvae, eggs	6	-		HIGH	Low plant number in a housing subdivision	New population. Most plants on road verge and one vacant house block
Light Beach*	Adults, larvae, eggs	9	-	*Iridomyrmex* sp.2	LOW	Major development	New population; possibly the most robust in the AMLR region. Less plants versus Parham & Port Gawler but is less impacted by weeds
Middle Beach (Esplanade dune)*	Adults, larvae, eggs	-	-		HIGH	Low plant number in subdivision, low level clearance	Small number of plants, most in vacant house block
Port Gawler north	Adults, larvae, eggs	-	-		LOW	Major development	Extensive population, likely contiguous with Port Gawler south site and also extends north
Port Gawler south	Adults, larvae, eggs	16	6	*Crematogaster* sp.	LOW	Major development	Extensive population, likely contiguous with Port Gawler north site
Buckland Park*	Adults, larvae, eggs	-	-		MEDIUM	Low plant numbers, fire, clearance	New population
Metropolitan							
Mutton Cove north*#	Old larval feeding tracks	-	-		MEDIUM	Low plant number, development or infrastructure works	*Adriana* is in a dedicated conservation area being actively planted and conserved. Need to revisit to confirm BBB presence at this new site. Couldn't find clear evidence of nearby colony known at Biodiversity Park on same day
Torrens Island grassland	Larvae, eggs	-	-		MEDIUM	Fire, natural attrition of plants	Most *Adriana* old and with little regeneration
Biodiversity Park*	Adults, larvae, eggs	5	2		MEDIUM	Fire, land use change, small population	New population

*believed to be newly recorded sites for *Theclinesthes albocincta* discovered during this survey
#*T. albocincta* occurrence suspected only

Table 7. Summary of all survey sites where BBB has been confirmed or is suspected on Fleuireu Peninsula and Kangaroo Island (see related maps in figures 17 & 18, respectively). The evidence of BBB presence is listed for each site as are the number of adults raised or captured (including colour-reduced forms matching inland forms) and ants confirmed to be interacting with BBB larvae. A perceived threat level for each site is provided as are a list of threats.

Site	Evidence of BBB	Adults raised or captured	Color reduced forms	Ant attendance confirmed	Colony threat level	Threats	Comments
Fleurieu Peninsula							
Normanville south*	Eggs, larval damage, raised adults from *Adriana* foliage	4	3		HIGH	Low plant and BBB numbers, isolation, development, fire, ongoing low-level human disturbance	New population
Goolwa (Willmett Road)	Eggs	-	-		MEDIUM	Removal of low number of plants	Plants are part of street plantings & removal would not threatened broader population
Hindmarsh Island (Randell Road 1)	Adults, larvae, eggs	3	2	*Iridomyrmex* sp.1	LOW	Roadworks	*Adriana* are in roadside vegetation and adjacent properties
Hindmarsh Island (Randell Road 2)	Adults, larvae, eggs	1	-		LOW	Roadworks	*Adriana* are in roadside vegetation
Newland Head north	Adults, larvae, eggs				LOW	Fire	Extensive population linked to Newland Head south site
Newland Head south	Adults, larvae, eggs	5	3		LOW	Fire	Extensive population linked to Newland Head north site
Kangaroo Island							
Antechamber Bay*#	Eggs, larvae	-	-		LOW	Fire	New population
Mouth Flat Road*	Larvae	-	-	*Iridomyrmex purpureus* (Fig. 11, left)	LOW	Fire	BBB previously recorded there within last 10 years
East West Road^	Larval damage (atypical)	-	-		MEDIUM	Roadworks, fire, natural attrition of plants	Various small stands along East-West road need mapping and checking
Island Beach town	Adults	2	-		LOW	Fire	*Adriana* around Island Beach is extensive and needs mapping
Muston Road/Prospect Hill	Adults, eggs, larvae	4	1		LOW	Fire	*Adriana* and BBB need further mapping of patches on roadsides to west and along Muston Road
American River Road	Eggs	-	-		MEDIUM	Roadworks, fire	Many plants in region so no threat to BBB/*Adriana* in the broader area
Emu Bay (Wallaby Run)*	Adults, eggs, larvae	4	-	*Camponotus* sp. (Fig. 11, right) *Notoncus* sp. *Iridomyrmex* sp.1	LOW	Fire	New population; much ant activity and attendance on one visit
D'Estrees Bay Road*	Adults, eggs, larvae	9	-		LOW	Fire	New extensive population

* believed to be newly recorded sites for *Theclinesthes albocincta* discovered during this survey
#*T. albocincta* occurrence listed as suspected because positive sighting made by only one observer (and no vouchers)
^unsure of *T. albocincta* occurrence because of limited evidence

BBB Distribution Along Northern Adelaide Plains Coastline

There are three large (>500 *Adriana*), healthy BBB populations spread evenly along this coast. These are the colony at Parham at the northern margin, a central colony at Light Beach, and one at Port Gawler (Figure 15). These large patches of *Adriana* appear to be separated by intervening areas where largely tidally inundated land adjoins the margin of agricultural land. In these areas, there appear to be only low numbers of small (<50 plants), sporadic occurrences of *Adriana* on relatively small, scattered dunes flanking the periodically inundated land. These intervening areas occur north of Middle Beach, and between Webb Beach and Prime Beach. The same occurs south of Port Gawler. We could only find four of these small *Adriana* patches, which were all isolated to varying degrees, all supported BBB (Figure 15).

The small populations at Buckland Park and Middle Beach appear to be separated by ≈2km from the large population at Port Gawler. We expect the *Adriana* we observed at Port Gawler extends northward to ≈2km south of Middle Beach because the dune habitat appears to. It would be useful to confirm this in the future. There is no knowledge of the degree to which BBB disperses in the landscape and so the degree to which these populations mix is unknown. We consider it likely that there would be a periodical exchange of adults between Port Gawler and the small "satellite" population but this is speculation.

A similar situation exists for the small Webb Beach site with regard to the large Parham site. We have good evidence that the small population at Thompson Beach is isolated by at least 5km from any other population. All of the large populations have only a Low or Medium threat level (Table 6); the greatest concern is Parham because it is located in a township on land that could be disturbed or developed. Three of the small sites occur in housing subdivisions and are thus rated at High risk. The small site at Buckland Park is put at Medium risk because it is in a remote "wasteland" location that is not subject to large scale disturbance and is in an area which appears to be part of a revegetation program.

It is highly possible that a low number of other small-medium *Adriana* patches exist, particularly away from the coast. Areas that were not searched but may contain such patches include:

- inland margin of inundated area at Middle Beach, north and south of the town
- coast and inland dunes between Light Beach and Prime Beach
- raised ground associated with inundated areas inland of Thompson Beach

BBB Distribution in the Metropolitan Area

Prior to development of the coastal fringe, the dune environment of the Adelaide coastline would have represented the largest longitudinal spread of almost unbroken habitat for *Adriana* on the St. Vincent Gulf (Figure 27). There are historical records of *T. albocincta* at Henley Beach in 1936 and West Beach in1938, and records of *A. quadripartita* from West Lakes, Tennyson and Semaphore in the 1960s and 1970s. The only BBB population of note remaining along the city coast is that previously recorded at Torrens Island. We assess this colony to be at a Medium threat level because it is not managed, most of the plants are old and subject to heavy pressure from grass, and fire has a high chance of removing the entire *Adriana* patch. This site is also relatively isolated from other large colonies with the closest being at Port Gawler, ≈14km north. Interestingly, we found two small *Adriana* patches supporting new BBB colonies on the Le Fevre Peninsula ≈2.5km from the BBB colony at Torrens Island. Apart from these sites, we found less than10 *Adriana* plants in the region (Table 3, Figure 16) and are confident BBB is extinct in city suburbs south of Le Fevre Peninsula.

Other areas that would warrant further searches for *Adriana*/BBB would be industrial and park areas on the Le Fevre Peninsula and the grounds of large private facilities along the coast such as the treatment works and caravan park at West Beach.

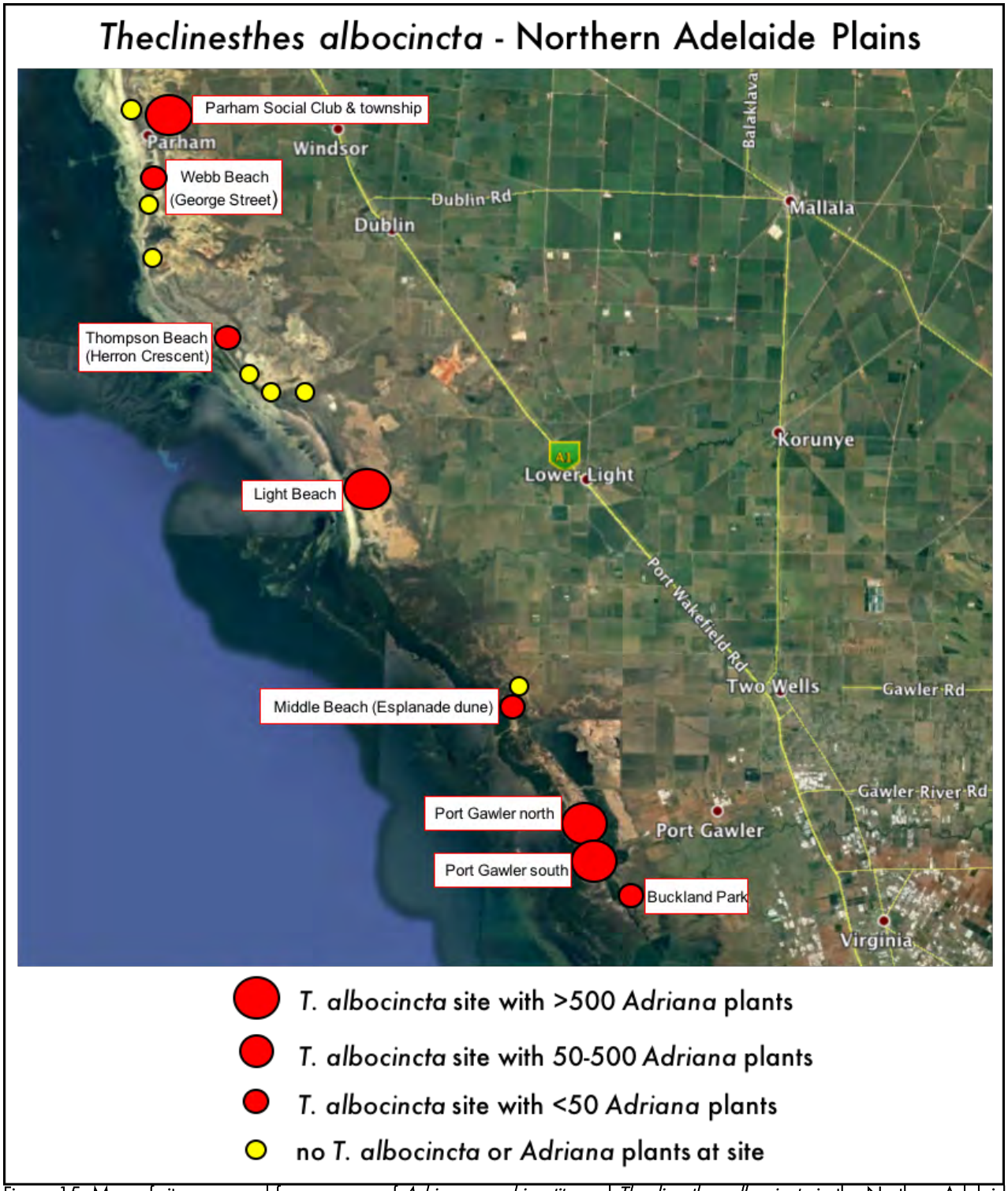


Figure 15. Map of sites surveyed for presence of *Adriana quadripartita* and *Theclinesthes albocincta* in the Northern Adelaide Plains area during summer and autumn 2017. Sites where *T. albocincta* was found are shown with red circles (site names in red boxes) with their size representing the size of the supporting population of *Adriana*. Yellow circles indicate survey sites where *Adriana* was not found. Colonies on the NAP were either large (>500 plants) or small (<50 plants). *T. albocincta* colonies at Webb Beach, Thompson Beach, Middle Beach and Buckland Park are thought to be newly discovered. All sites containing *Adriana* supported *T. albocincta* in this area. North is at top of page. Base map obtained using Google Earth software.

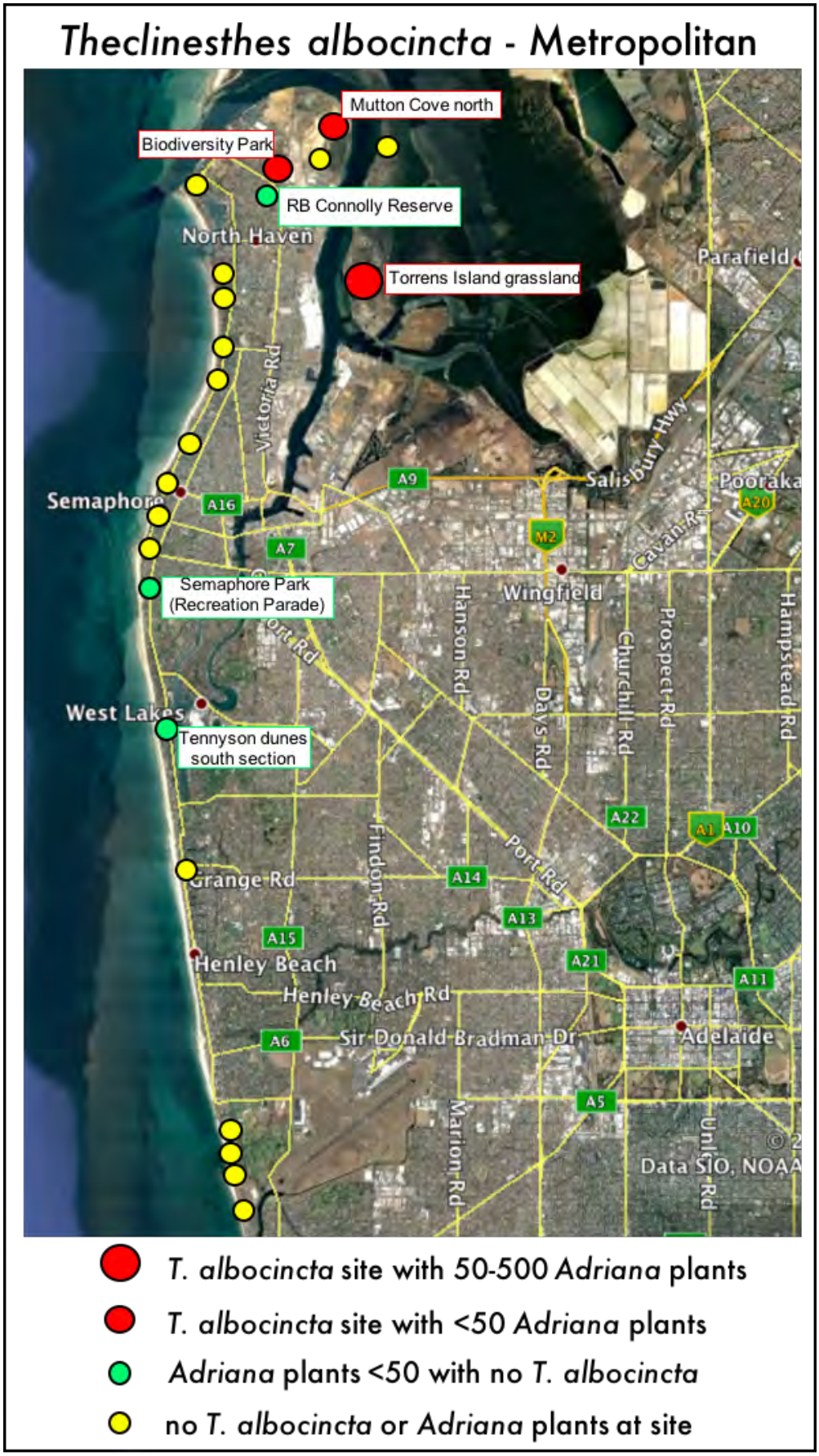


Figure 16. Map of sites surveyed for presence of *Adriana quadripartita* and *Theclinesthes albocincta* in the Metropolitan area during summer and autumn 2017. Sites where *T. albocincta* was found are shown with red circles (site names in red boxes) with their size representing the size of the supporting population of *Adriana*. Small patches of *Adriana* were found with no evidence of *T. albocincta* at three sites (green circles; site names in green boxes). Yellow circles indicate survey sites where *Adriana* was not found. Three sites support *T. albocincta*; one is the medium level colony at Torrens Island and two are newly discovered small colonies at Biodiversity Park and Mutton Cove on the Le Fevre Peninsula. The presence of T. albocincta is listed as "suspected" because only a small amount of larval feeding damage was found there. There were no large sites (>500 *Adriana* plants). North is at top of page. Base map obtained using Google Earth software.

BBB Distribution on the Fleurieu Peninsula

We were able to confirm presence of BBB at previously recorded locations of Goolwa, Hindmarsh Island and Newland Head (Figure 17). Interestingly the Goolwa site was a street planting of *Adriana*. One of the most notable discoveries of our survey was the BBB colony existing in the dunes at Normanville. This is the most isolated colony we know in the survey area with the nearest known colony at Newland Head ≈25km southwest. The next colony north of Normanville is ≈80km away on the Le Fevre Peninsula. It is assumed that this BBB colony is remnant although we cannot rule out that it is due to a recent human-induced translocation. We regard the risk to this colony as High due to the small number of plants and high chance of ongoing disturbance. It is possible that there are a larger number of *Adriana* in the Normanville dunes than we are aware of. We only searched the southern end of the dunes and there are previous records from elsewhere in the dunes (Milne 2016).

The only other *A. quadripartita* found on the FP were <10 plants in a revegetated strip along a walking trail around the Port Stanvac desalination plant. Other areas in this region which we did not search but could contain *A. quadripartita* include:

- areas inside the Port Stanvac oil refinery and desalination plant confines
- Aldinga Scrub where there are historical records of *A. quadripartita* from 1969
- Onkaparinga River Valley; there is a record of *A. quadripartita from* "bogs along the Onkaparinga River below Clarendon" as late as 1972 (latitude -35.111389°, longitude 138.627778°)
- coastline, reserves and industrial land around Noarlunga
- vegetated clifftop sites such as Hallet Cove Conservation Park
- revegetated area between east of Cape Jervis from Land's End to Fishery Beach (apparently revegetation from remnant plants was performed here and seedlings are recruiting "particularly near Fishery Beach; Margaret Lee; pers. comm. 17 June 2017)

BBB Distribution on Kangaroo Island

KI has a series of large BBB colonies on the east end of the island and all of them are at Low risk due to the size of the populations and low likelihood of broad-scale loss through clearance. The only sites at Medium risk were small sites in roadside vegetation in the vicinity of larger BBB sites. These kind of sites are numerous on the east end of the island due to past and ongoing disturbance associated with land and road management. Remarkably BBB appears to be restricted to the east end of the island even though there are many historical records of *Adriana* in the west, and a very large patch still exists at the old apiary site in Flinders Chase. Despite good conditions and numerous male flowering plants, we could find no evidence of BBB at the site or at other western sites such as Vivonne Bay. The north coast of KI is an area that requires further surveying.

Specifically, other KI sites that should be surveyed, include:

- Smith Bay
- Stokes Bay
- track to Strepera Falls
- Kelly Hill Caves
- large patch of *Adriana* on private land south of Sandhurst Track on the Dudley Peninsula (pers. comm., David Ball, 2017).
- Cape Saint Albans area

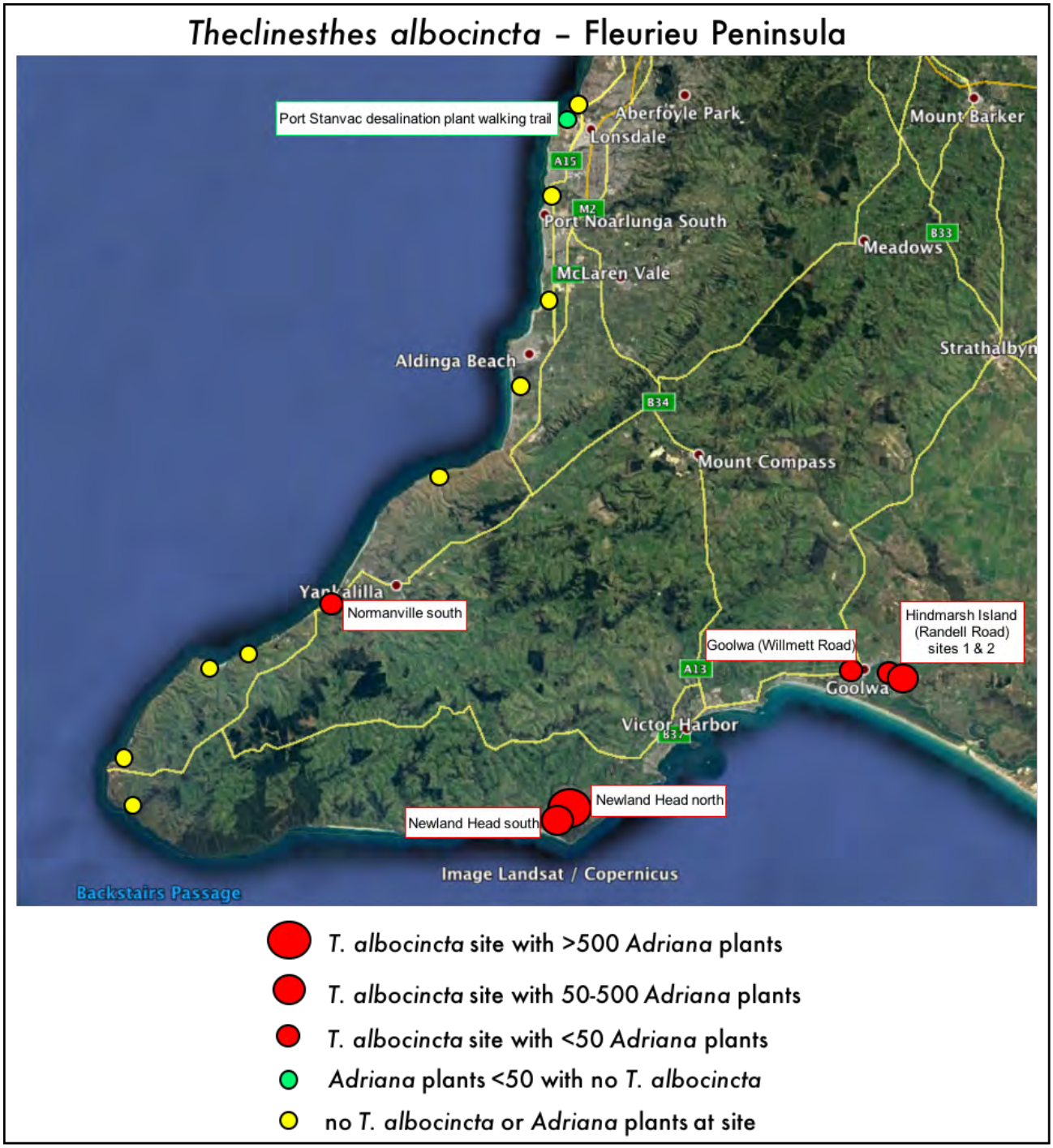


Figure 17. Map of sites surveyed for presence of *Adriana quadripartita* and *Theclinesthes albocincta* on the Fleurieu Peninsula during summer and autumn 2017. Sites where *T. albocincta* was found are shown with red circles (site names in red boxes) with their size representing the size of the supporting population of *Adriana*. One small patch of revegetated *Adriana* was found with no evidence of *T. albocincta* (green circle; site name in green box). Yellow circles indicate survey sites where *Adriana* was not found. The small colony shown at Normanville is newly discovered. North is at top of page. Base map obtained using Google Earth software.

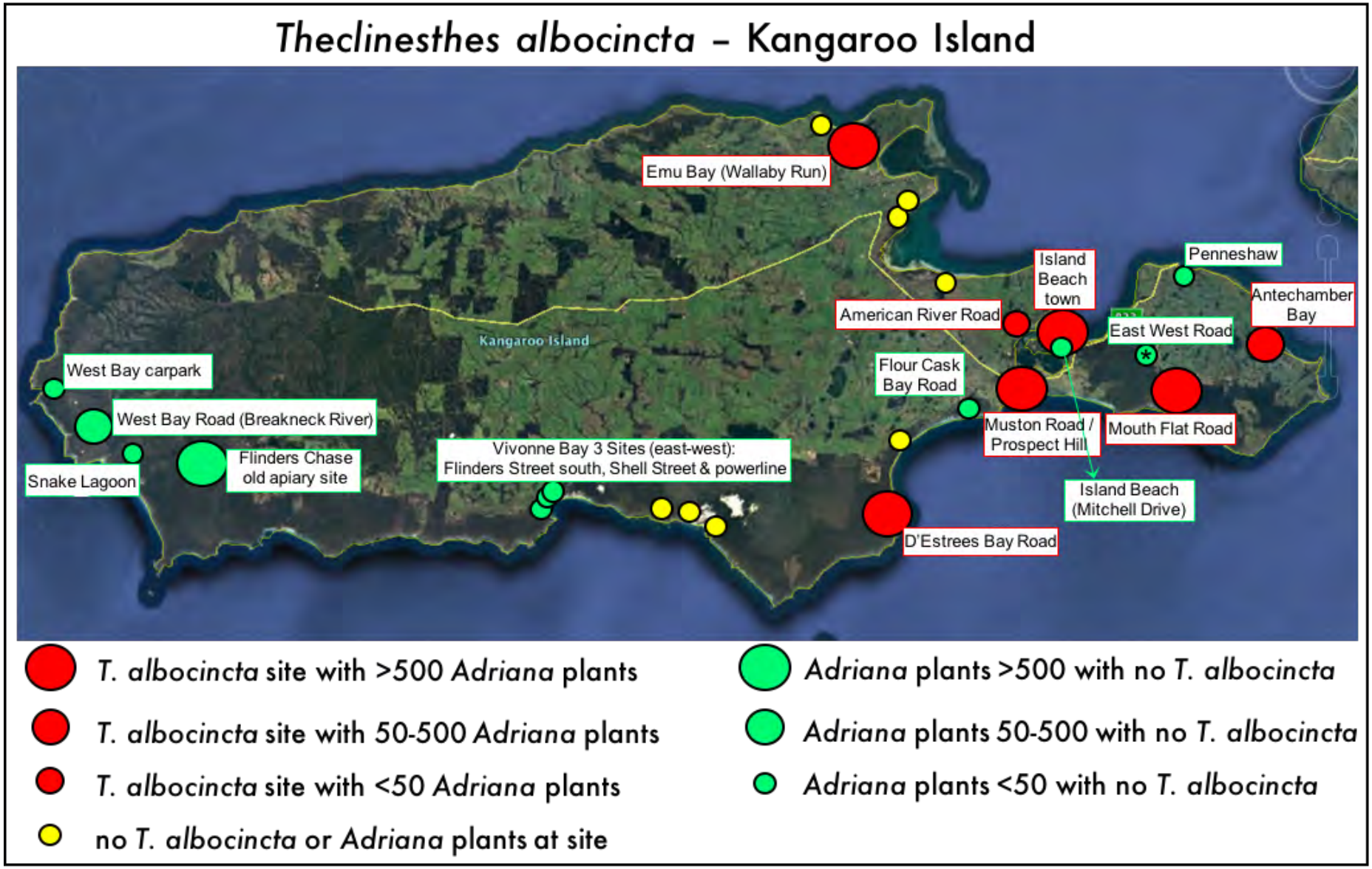


Figure 18. Map of sites surveyed for presence of *Adriana quadripartita* and *Theclinesthes albocincta* on Kangaroo Island between spring 2016 and autumn 2017. Sites where *T. albocincta* was found are shown with red circles (site names in red boxes) with their size representing the size of the supporting population of *Adriana*. The presence of *T. albocincta* at the medium sized site at Antechamber Bay is listed as "suspected". At several sites, small patches of revegetated *Adriana* were found with no evidence of *T. albocincta* (green circles; site name in green boxes). At one of these sites (green circle with *) we are unsure about the presence of *T. albocincta*. Yellow circles indicate survey sites where *Adriana* was not found. Five new *T. albocincta* sites were found. Three of these were large colonies at Mouth Flat Road, D'Estrees Bay and Emu Bay. The other two new sites are the suspected colony at Antechamber Bay and a small site on the American River Road. North is at top of page. Base map obtained using Google Earth software.

Reduced-colour Forms of BBB

Adult BBB with much reduced suffusion of blue on the upper surface of the wings and which appeared to match the figures and descriptions of inland forms in Braby (2000a & 2000b), were raised from a number of our coastal survey sites (Tables 6 & 7). There was at least one of these types found in each of the four broad survey regions and overall these individuals accounted for 20% of the 90 adults vouchered from the survey. At three sites on the FP where small numbers of vouchers were taken, colour-reduced forms accounted for the majority of vouchered specimens (Normanville, Newland Head south, Hindmarsh Island Randell Road 1) (Table 7).

Mostly, our reduced-colour adults appeared to be closest to the inland winter form although several individuals with blue suffusion only at the extreme wing bases were similar to the inland summer form described and pictured in Braby (2000b). It must be noted that there is significant variation in the brightness and degree of blue suffusion in both adults that appear to be of coastal and inland forms. The delimitation of defined types within our material is impossible without a much larger sample size. In our specimens, there appears to be more of a continuum of variation of the occurrence and brightness of the blue suffusion. KI had the least proportion of inland forms, however, our sample sizes are too small and temporally disjunct to allow a comparison of the occurrence of inland types between sites or regions.

The only note of caution regarding our reduced-colour specimens being representative of what occurs naturally, is that 17 of the 18 individuals were raised indoors on excised plant material. This might be a concern because environmental conditions have been linked to the distribution of forms (e.g. winter vs summer forms). However, this was highly variable between sites and so is unlikely to be a result of the rearing method alone. The only reduced-colour individual caught in the field was from KI; none of the 16 specimens from KI were raised. On mainland SA, 63 of the 74 specimens were raised with 17 reduced-colour individuals all raised. As mentioned, there was variation between sites with regard to the proportion of reduced-colour individuals occurring in raised cohorts. For example, from Normanville all four specimens were raised producing 3 reduced-colour individuals, from Port Gawler all 16 specimens were raised of which were 6 reduced-colour, and from Parham only one reduced-colour individual was raised out of 22 raised in total.

Ant Attendance

There was a great deal of variability between sites in the overall level of ant activity on *Adriana* plants. Ants of many genera appeared to be attracted to the extrafloral nectaries, particularly on male inflorescences where the nectaries are abundant. There were many occasions where ants appeared to ignore BBB larvae that were close to them. However, we did observe direct interactions between BBB larvae and ants at a small number of sites (Tables 6 & 7).

It should be noted that we only scored direct interactions between ants and larvae whereas the most recent and detailed study of these interactions (Collier 2007) only assessed co-occurrence of larvae and eggs and not direct interactions. We found co-occurrence of ants and BBB to be common and direct interactions much less common. In the NAP region, *Crematogaster*, *Tapinoma* and two *Iridomyrmex* spp. were observed tending BBB larvae. On KI, *Camponotus, Notoncus* and three *Iridomyrmex* spp. were observed tending BBB larvae (Figure 11). Anecdotally, under the conditions occurring when we were present, the attendant ants appeared to be a subset of those foraging on the plant as a whole, rather than foraging specifically on the BBB larvae.

There were only two sites where we observed multiple ant species interacting directly with BBB larvae. At Parham, we observed *Iridomyrmex* and *Tapinoma* tending BBB (one species on each of two visits to the site). At Emu Bay (Wallaby Run) on KI, we observed *Camponotus* and *Notoncus* tending BBB on several small adjacent *Adriana* on January 25th. On February 6th, we returned to the site and observed *Iridomyrmex* tending BBB on a different group of plants at the site.

General Field Observations

Adriana invariably grew in sandy areas where previous disturbance was apparent. These areas were generally infested with grassy weeds, had an open vegetation structure, had undergone partial clearance and were largely unmanaged (see examples in Figure 4). One obvious risk from the abundant dry grass usually associated with *Adriana* is fire; a management tactic to lower the fire risk to small *Adriana* patches may be to control grass through killing it or slashing when dry. The only significant *Adriana* sites that were not greatly impacted by grass were on KI at D'Estrees Bay, Mouth Flat Road, Island Beach and in Flinders Chase National Park (where BBB was not found).

Although we made a brief assessment of weed invasion at most of ours sites, there was no correlations with BBB presence or abundance (which we didn't assess in detail). *Adriana* inherently has a patchy habitat and a relatively dynamic distribution within it. Overall, *Adriana* appeared to be resilient with small patches able to persist across the landscape where habitat occurs, and an ability to handle grass invasion and respond to disturbance. The two primary causes of loss of *Adriana* are conversion of land to farming or housing. This is best evidenced on the metropolitan coast where the secondary dunes that comprised the former *Adriana* habitat have been almost entirely removed. Normanville is another example.

In periods where there were low adult numbers or low activity, we found that observing adults was a relatively poor way to assess presence of BBB. There were numerous cases where eggs and early larval damage were the only evidence we could find of BBB. Eggs were usually relatively quick and easy to find due to their concentration on young male inflorescences. This was true of several sites on KI early in the season and also at Normanville.

In the survey area, there were no other butterfly species laying eggs on *A. quadripartita*. The only other eggs that were observed on the *Adriana* foliage were heteropteran and appeared quite different. There were several other insects that caused feeding damage on leaves and fruits (e.g. Chrysomelidae), however, the highly defined linear feeding tracks made on one side of the leaf, and presence of multiple holes in the side of unopened male flower buds, were characteristic of BBB larval damage.

At small sites where we know BBB exists, there were times where it was very hard to find evidence of their existence, likely due to overall numbers of adults or that the generations are more discrete in small populations leading to gap in adult presence. For example, on the Le Fevre Peninsula at Biodiversity Park we were able to find ample evidence of BBB (larvae) on 1st February but were unable to find clear evidence on a return visit on 7th March (an adult emerged on 8th March from a larva collected on the first visit). Normanville was another site where adults were not observed and there was only a small amount of putative larval damage, yet BBB adults must have been present around the time survey was conducted.

There was a marked concentration of adult and larval activity around male plants in flower. At several sites on KI which were visited numerous times, it was noted that adult activity was concentrated at different parts of large *Adriana* patches at different times. For example, at Emu Bay, plants that had a lot of BBB activity early in the season had little activity later and adults had moved to elsewhere in the patch to plants with new male flowers, which is also where eggs and larvae were concentrated.

Two species of moth were also noted to be utilising *A. quadripartita*. One species is from the superfamily Gelechioidea and its larvae have a "leaf-tying" habit such that they live and feed within plant foliage that they knit around themselves. The larva of this species is much more elongate than BBB larvae and do not become as large; when they are disturbed from within their shelter they move very quickly as a defensive mechanism, unlike BBB larvae. At Torrens Island, we also observed what is likely to be a species of the Cosmopterigidae associated with leaf-blister mines (larvae feed internally in leaves).

One point of interest is that we did not record any egg or larval parasitoids of BBB. This is despite raising more than 50 BBB adults from field collected larvae from a broad geographical range, and making *ad hoc* observations of field-collected eggs. In our experience, lepidopteran parasitoids are usually wasps and/or flies, and are essily obtained. Parasitoids reduce populations of their hosts and it is useful to understand the parasitoid suite associated with a host for conservation purposes. Further targeted surveying would be useful to characterise the suite of parasitoids associated with BBB because it is known that they do occur.

Other Butterflies Recorded During the Survey

Other lycaenid or hesperiid butterflies were recorded opportunistically during the survey (Tables 2-5). Of most note were old larval shelters of *Antipodia atralba* (Black and white skipper) that we found on *Gahnia lanigera* growing atop a small coastal hillock to the north of the Port Stanvac desalination plant (latitude -35.093237°, longitude 138.484102°; Figure 19). This species was one of six butterflies listed as being of conservation concern by the MANCAP (2009). Nearby, at the same site we saw numerous individuals of *Candalides heathi* (Rayed blue) primarily around blossoming *Myoporum parviflorum* in a grassy area on the northern fenceline of the desalination plant (Figure 19). *Candalides heathi* is widespread in SA but not observed very commonly.

Ogyris otanes (Small eastern bronze azure) was seen at West Bay on KI. This species' larvae live in nests of the ant, *Camponotus terebrans*, and feed nocturnally on foliage of *Choretrum* spp. This butterfly is primarily a mallee-associated species that is reasonably common on KI but is now rarely seen on mainland SA. Several other lycaenids appeared widespread and relatively abundant. These were *Zizina labradus* (Common grass blue), *Nacaduba biocellata* (Double-spotted line-blue) and *Theclinesthes serpentata* (Saltbush blue).

Figure 19. Jessica Marsh and Andy Young examine old shelters of the Black and white skipper (*Antipodia atralba*) constructed on *Gahnia lanigera*. The *Gahnia* were growing on a small coastal hillock to the north of the Port Stanvac desalination plant (seen in background). Location: latitude -35.093237°, longitude 138.484102°. *Candalides heathi* (Rayed blue) was seen in the grassy area on the fenceline near the top left. (Photograph, Richard Glatz)

Sea-level Rise Risk Analysis

Almost all of the known BBB sites are in relatively low lying locations within 500m of the coast and therefore face real threats associated with sea-level rise over the next century. Recent inundation mapping is available online (CoastAdapt 2016). Currently, mapping is confined to areas around Adelaide and maps were able to be obtained for an area spanning from just south of Light Beach on the NAP coastline, south to approximately West Beach (covering the entire Metro region of our study) (Figures 20-23). As discussed in the methods, these maps show the predicted extent of flooding associated with 2.2˚C of warming by 2100 and an associated sea-level rise of 0.48m. The flood areas shown on these maps are the current (dark blue) and predicted (light blue) maximum flooding extents, which are associated with HAT conditions (Siebentritt 2016).

Within the NAP region, only the southern-most four of the known BBB sites are covered by the inundation mapping. Figure 20 shows a closer view of this area (from Buckland Park to north of Middle Beach) and Figure 21 shows the whole region (Buckland Park to Parham) including areas not covered by the mapping. It is intuitive that the effect of sea-rise on different sites will vary depending on site characteristics, and this is indicated by the mapping. For example, the Port Gawler sites (which are part of the same larger population which we suspect extends north for several kilometres) appear to be differently impacted. Whereas the Port Gawler south site is predicted to be inundated, the Port Gawler north site appears to be reduced and fragmented but still with significant habitat. The Middle Beach site (and township) is currently an island in a larger, tidally inundated area which will be heavily impacted. The Buckland Park habitat is predicted to become a small island akin to the current Middle Beach site and may continue to support *Adriana*. Therefore, we have assessed the sea-rise risk to Port Gawler south and Middle Beach as High and to Port Gawler north and Buckland Park as Medium. Risk-ratings associated with sea-rise for all known BBB sites on the mainland, are listed in Table 8 along with considerations used in the assessment. Impact of sea-rise on KI was not assessed. Four of the eight NAP sites (and all of the FP sites) occur in areas not covered by the inundation maps. Therefore, the sea-rise risk-rating for these sites was extrapolated using their altitude, proximity to the coast and other site details (see Table 8).

The inundation maps of the Metro area (Figures 22 & 23) provide useful information both at a site level (to inform conservation of current populations) and at a region level (to inform reintroduction efforts in the Metro region). Firstly, the mapping predicts that the Torrens Island grassland and Biodiversity Park sites will only be subject to a minor impact and will not reduce significantly in size, whereas the Mutton Cove north site is already marginal and would be lost. Secondly, the area between Grange and Semaphore (including West Lakes) would be significantly impacted by inundation (in the absence of engineering solutions) whereas the areas north and south of this would be impacted to a much lesser degree.

The only currently known FP site that is at High risk of sea-rise is the small, newly discovered colony at Normanville dunes. This is because most of the known *Adriana* at Normanville exist in low lying areas immediately behind the main dune although a few plants were higher up on the road verge. The other FP sites are all above the 0.6m altitude required to prevent flood probability increasing (NCCARF 2016a).

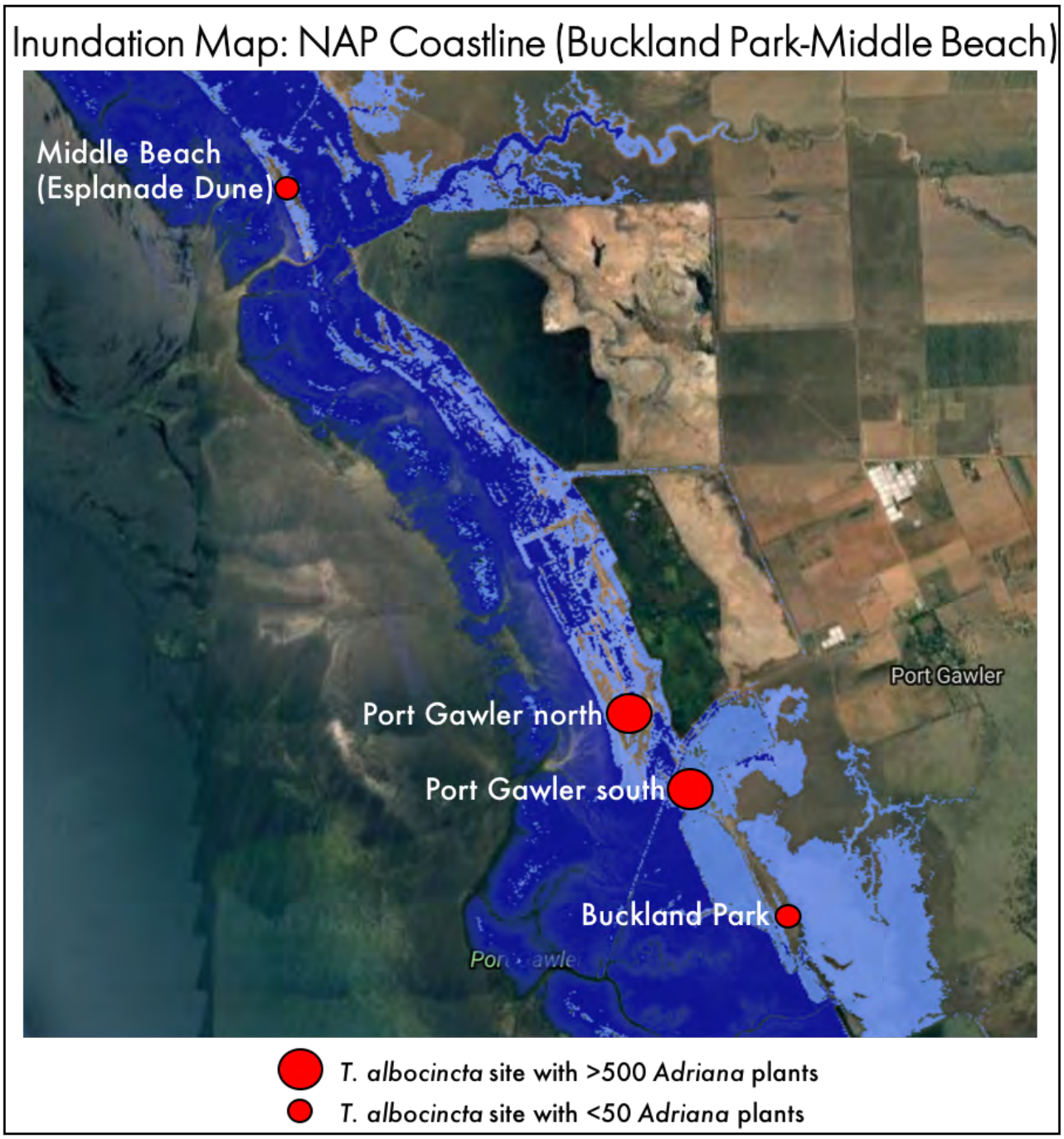


Figure 20. Inundation mapping for part of the NAP coastline from Buckland Park to just north of Middle Beach. Known BBB colonies are shown with red dots with their size representing the number of *Adriana* at the site. The current maximum extent of flooding due to HAT conditions (ICSM 2011; Siebentritt 2016) is shown in dark blue shading and *Adriana* patches are located at the margin of this area. Light blue shading represents the maximum flooding predicted under a High RCP scenario (+2.2°C warming, 0.48m sea-level rise by 2100; NCCARF (2017b)). All of the known BBB sites are impacted to some degree. Buckland Park and Port Gawler north sites are likely to remain viable to some degree, whereas Port Gawler south and Middle Beach sites are expected to be lost. At 2100, the Buckland Park site appears similar to the current Middle Beach site (an island in a larger, potentially inundated area). Note that the Port Gawler sites are part of one large population which extends to just south of Middle Beach in areas that are not shaded or are light blue. North is at top of page. Inundation map obtained from CoastAdapt (2016) and modified.

Figure 21. Map of the NAP region with BBB colonies (red dots) and currently available inundation data. The current maximum extent of flooding due to HAT conditions (ICSM 2011; Siebentritt 2016) is shown in dark blue shading and *Adriana* patches are located at the margin of this area. Light blue shading represents the maximum flooding predicted under a High RCP scenario (+2.2°C warming, 0.48m sea-level rise by 2100; NCCARF (2017b)). All of the known BBB sites are impacted to some degree. It is likely that BBB colonies at Light Beach, Thompson Beach and perhaps Webb Beach will be impacted to some degree, with the larger Light Beach population likely to have the best chance of surviving due to its size. The *Adriana* at Parham are a bit further inland and cover a large area and therefore are likely to remain viable for BBB. North is at top of page. Inundation map obtained from CoastAdapt (2016) and modified.

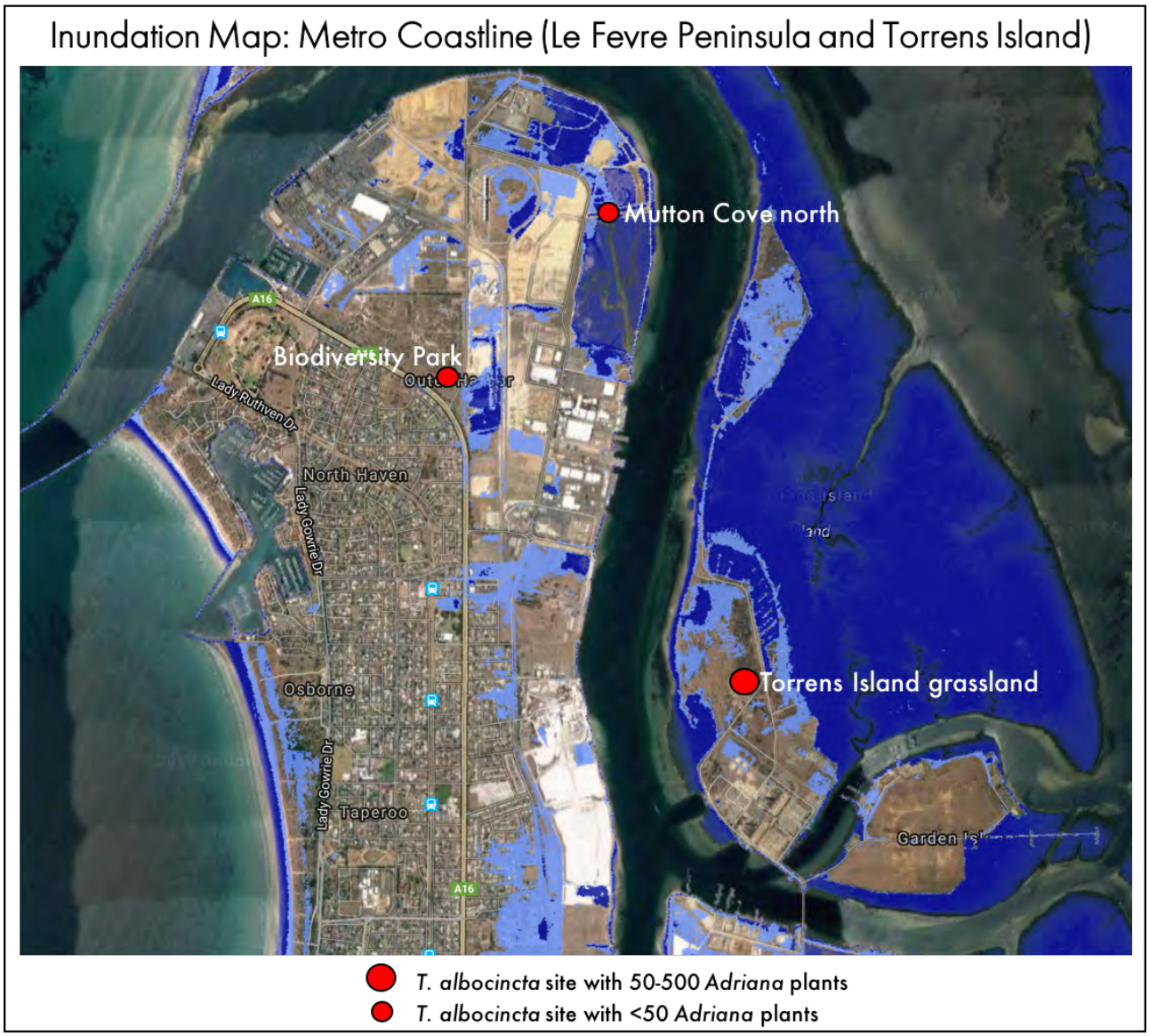


Figure 22. Inundation mapping for Le Fevre Peninsula and Torrens Island where the only known BBB colonies (red dots) in the Metro region occur. The current maximum extent of flooding due to HAT conditions (ICSM 2011; Siebentritt 2016) is shown in dark blue shading and *Adriana* patches are located at the margin of this area. Light blue shading represents the maximum flooding predicted under a High RCP scenario (+2.2˚C warming, 0.48m sea-level rise by 2100; NCCARF (2017b)). The Mutton Cove north site is already marginal and will likely be lost by 2100. However, the increase in flooding is minimal at the Torrens Island and Biodiversity Park sites and these are expected to remain viable with respect to sea-level rise. Similarly, much of the Le Fevre Peninsula appears to be at low risk of flooding, particularly its western half. North is at top of page. Inundation map obtained from CoastAdapt (2016) and modified.

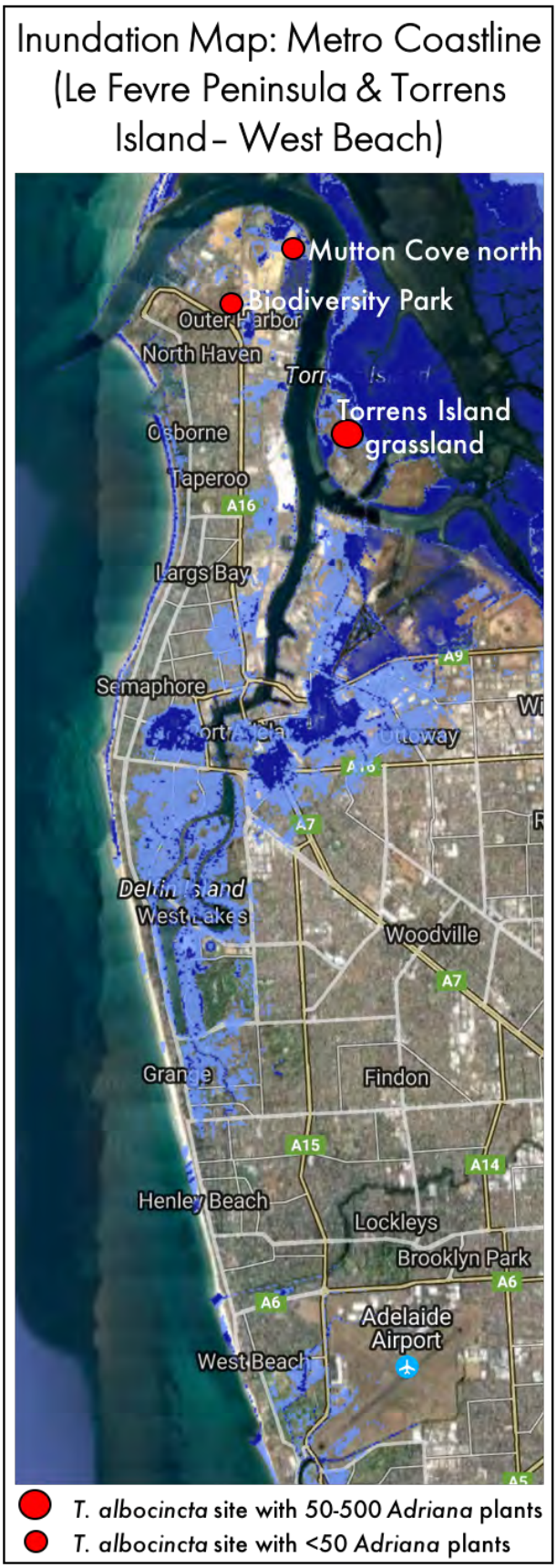


Figure 23. Inundation mapping for Metro coastline where BBB is now almost extinct. The only known BBB colonies (red dots) occur at the northern margin of the region in areas where residential development has not occurred. The current maximum extent of flooding due to HAT conditions (ICSM 2011; Siebentritt 2016) is shown in dark blue shading, whereas light blue shading represents the maximum flooding predicted under a High RCP scenario (+2.2°C warming, 0.48m sea-level rise by 2100; NCCARF (2017b)). This suggests that in the long-term, potential habitat will become increasingly inundated between about Semaphore and Grange (assuming no engineering solutions are applied), while the areas to the north and south should remain suitable for *Adriana* and BBB. North is at top of page. Inundation map obtained from CoastAdapt (2016) and modified.

Table 8: Degree of long-term risk of inundation or damage to known BBB colonies due to sea-level rise, in mainland areas of this survey. Comments are provided to give some detail on the factors contributing to the Risk Level. Potential for inundation was determined by overlaying BBB sites onto HAT inundation maps based on expected sea-level rise of 0.48m by 2100, and associated with 2.2°C warming over the same period (Figures 20-23; High RCP scenario; ICSM 2011; CoastAdapt 2016; NCCARF 2016b; Siebentritt 2016). Note that only sites in an area between Middle Beach (NAP region) and West Beach (Metro region) were covered by inundation mapping and the inundation risk for other sites (denoted by ^ superscript) has been extrapolated using site characteristics.

Site	Sea-rise Risk Level	Comments
Northern Adelaide Plains		
Parham Social Club & township^	Low	Large, extended colony that is slightly inland (behind township) and generally higher than 60cm altitude
Webb Beach (George Street)*^	High	Small colony close to current inundation
Thompson Beach (Herron Crescent)*^	High	Small colony in behind first row of houses at beach
Light Beach*^	Medium-High	Large, extended site with some area above 60cm altitude
Middle Beach (Esplanade dune)*	High	Available habitat likely to become inundated or significantly reduced
Port Gawler north	Medium	Expect reduction of habitat area but still with potential for significant *Adriana* to persist
Port Gawler south	High	Likely to become inundated
Buckland Park*	High	Likely to become an island in a large area of potential inundation. May persist but high risk of loss or reduction
Metropolitan Area		
Mutton Cove north*#	High	Likely to be inundated
Torrens Island grassland	Low	Not a significant flood risk at site
Biodiversity Park*	Low	Not a significant flood risk at site
Fleurieu Peninsula		
Normanville south*^	High	Small number of plants in low lying area just behind primary dune system (some *Adriana* near roadside might persist)
Goolwa (Willmett Road)^	Low	Sufficient altitude; likely escape flooding (street planting)
Hindmarsh Island (Randell Road 1)^	Low	Sufficient altitude; likely escape flooding
Hindmarsh Island (Randell Road 2)^	Low	Sufficient altitude; likely escape flooding
Newland Head north^	Low	Sufficient altitude; will escape flooding
Newland Head south^	Low	Sufficient altitude; will escape flooding

*believed to be newly recorded sites for *Theclinesthes albocincta* discovered during this survey
#*T. albocinc*ta occurrence suspected only
^inundation mapping not available so risk extrapolated based on relevant site characteristics

Discussion of Findings and Management Options

Occurrence of *A. quadripartita* and BBB Across the Landscape

As mentioned earlier, *Adriana* almost invariably occurs in areas where previous disturbance has occurred and the natural vegetation has been degraded. Usually, it occurs in non-managed land infested with grassy weeds (Figure 4). *Adriana* displayed an ability to be a dominant plant where it occurs as large populations but also to persist in small patches and respond to disturbance.

In large patches of *Adriana,* BBB populations appeared robust at present. The only medium-large *Adriana* population (> 50 plants) that we are concerned about is at Torrens Island. This is because the plants are generally old and there is little regeneration, the site is very heavily infested with grass and at risk of fire, and anecdotally there appeared much less evidence of BBB activity than other similar sites. On the day of the visit to Torrens Island and the following day, we found ample evidence (including adults) of BBB at the large sites at Port Gawler and Parham but also at numerous small sites (Biodiversity Park, Buckland Park (Figure 26), and Middle Beach (Figure 24)).

These small sites (and others at Thompson Beach (Figures 5 top left and 25) and Normanville) demonstrated a remarkable capacity for BBB to occupy small, often isolated, niches in the landscape. The small patches in the NAP region were associated with isolated sand dunes in small housing subdivisions on recently unmanaged land (Buckland Park (Figure 26) and Le Fevre Peninsula). The other small patch of note is in the highly isolated, degraded dunes at Normanville. We consider the small sites in housing developments, and at Normanville, to be at High risk with others at Medium risk (Tables 6 & 7).

These small *Adriana* patches seemed to be remnants of bigger patches because they occupied only a small proportion of the available habitat in which they still occur (Figures 24-26). This made the patches difficult to find and illustrate the care needed to find them. Figures 24-26 show the overall search paths and the small *Adriana* patches found at Middle Beach, Thompson Beach and Buckland Park, respectively. Vacant house blocks and roadsides were where *Adriana* occurred in the subdivisions (Figures 5 top left, 24 & 25) and therefore the risk to these plants is High.

The ability for BBB to persist on small patches of *Adriana* means it is a high chance that revegetation or regeneration could make a significant impact on the size and distribution of BBB colonies, either through:

- increasing the size of existing small colonies
- reducing the risk to existing small colonies by strategic establishment of *Adriana* in in positions where they are less likely to be removed
- establishing new colonies in areas where BBB has become extinct or that link isolated colonies

An interesting outcome of inundation mapping is that it demonstrates that the BBB sites (i.e. *Adriana* patches) are invariably located at the margins of the current maximum flood range at the highest tides (dark blue; Figures 20-23). In the case of Middle Beach, the current sand dune habitat of BBB (on which the housing subdivision) is placed, is effectively a small island in a large area of potential inundation (Figures 20 & 21). If the coastline remains relatively low energy as it is today, then current *Adriana* populations will likely be able to persist on sites that abut tidally-inundated land. Therefore, **current sites that are largely above about 0.6m altitude will probably remain viable for *Adriana*** to varying degrees (see Figure 13 "height allowance" trend-line).

Increasing and Linking BBB Populations

The repeated occurrence of BBB on small, isolated *Adriana* patches raises the question as to whether these BBB populations are true remnants, or more recent colonisations as a result of dispersal events or a mixture of both. It is also very difficult to determine with confidence if *Adriana* has always persisted at the sites where small patches are still found, or if they were absent for a time and then reintroduced by disturbance. There is no data on dispersal in BBB and it is assumed that it generally does not move large distances. It is also possible that human-induced movement of BBB has occurred although we have no evidence of that. This is important because it speaks to whether part of the management strategy should be to link these patches.

Figure 24. Search path (red) and small *Adriana* patch (green) for Middle Beach where BBB was found. At left is the total search area and at right is a higher magnification view of the area containing the *Adriana* patch. Almost all plants were in the roadside or vacant/abandoned house blocks, and occupied only a small part of the potential habitat. The dune comprising the search area was isolated from other *Adriana* patches (at the northern extent of the Port Gawler site) by at least 2km and perhaps more. North is at top of page. Base map obtained using Google Earth software.

Figure 25. Search path (red) and small *Adriana* patch (green) for Thompson Beach where BBB was found. At left is the total search area and at right is a higher magnification view of the area containing the *Adriana* patch. Almost all plants were in the roadside or vacant house blocks, and occupied only a small part of the potential habitat. This BBB colony is isolated from other *Adriana* patches by at least 5km and perhaps more. North is at top of page. Base map obtained using Google Earth software.

Figure 26. Search path (red) and small *Adriana* patch (green) for Buckland Park where BBB was found. *Adriana* plants occupied only a small part of the potential habitat. This BBB colony is isolated from other *Adriana* patches (at the northern extent of the Port Gawler site) by at least 2km and perhaps more. North is at top of page. Base map obtained using Google Earth software.

There is some evidence that the Port Gawler, Torrens Island and Newland Head populations of BBB have reduced genetic diversity compared to populations in southeast SA and Yorke Peninsula (Collier 2007, Collier *et al.* 2010). It was postulated that this is because they are fragments of previously larger populations. However, the model of BBB and *Adriana* occurrence used to develop the sampling and statistical comparisons, was far simpler than what we found. As examples, the size of several sites was highly underestimated (and hence limited spatial coverage of samples was achieved) and the existence other large and small colonies was not known and are possibly linked to some degree. Further, the barriers between the large and putatively isolated colonies on the NAP coast (Port Gawler, Light Beach and Parham) appear natural (due to tidal inundation) although clearance inland causing farmland to abut inundated regions, may have disrupted links between them. The initial disturbance that occurred at these sites has also likely increased the *Adriana* populations there. It is arguable that the Yorke Peninsula populations have actually been fragmented more, keeping in mind that *Adriana* occurrence is inherently patchy due to the limited niche it occupies and its ability to respond to disturbance.

Regardless of the actual degree of fragmentation of the NAP and northern Metro populations, the data presented by Collier et al (2010) suggests that BBB is not able to disperse between Torrens Island and Port Gawler which are about 14km apart. However, it may be possible that BBB can move hundreds of metres to several kilometres, such as between Le Fevre Peninsula and Torrens Island. Population genetic studies of small isolated BBB populations would help to answer this question and better inform the maximum spatial separation (i.e. cost efficiency) of *Adriana* plantings needed to allow BBB dispersal between them.

The NAP inundation map shows **there will be increasing areas of tidally inundated land directly abutting farmland which means that establishment of *Adriana* in more inland areas will increasingly require the use of private land including farmland.** It would therefore be wise to establish mechanisms to engage private landholders in biodiversity management programs.

The exact degree of eventual sea-rise is obviously hard to predict, however, it is clear that a certain amount of sea-rise has occurred and is "locked-in" for the period of the climate scenario modelling (to 2100). Furthermore, the flood mapping of a given predicted sea-height is likely to be accurate because the altitude of the landscape is known, and the current effect of the highest tides is well characterised in term of raising "background" sea height.

The current level of uncertainty associated with sea-rise predictions, and the delayed nature of the associated threats, means that sea-rise management recommendations are secondary to those dealing with shorter-term threats, will likely be funded by other funding sources, and will be informed by future data. Therefore, the risk level associated with shorter-term threats to BBB sites (Tables 6 & 7) are determined separately from that associated with sea-rise (Table 8). This also means that **management recommendations for the next few years are simplified in that they can ignore the longer-term issues, and the sea-rise risk analysis can be used to slowly skew management resources towards the sites that are predicted to be impacted least**, and/or strategic inland and higher altitude areas, as climate models are refined.

Use of Eggs and Larval Damage to Detect BBB Populations

We found that inspection of suitable male *Adriana* inflorescences for presence of eggs and early larval damage was a very sensitive way to detect BBB when there were low adult numbers or low activity. This was due to the significant concentration of egg laying and adult activity around suitable male plants. At several sites on KI, this method was used to preempt easily observable adults in very short time periods, in some cases after significant surveying for adults in good conditions. This method also led to detection at Normanville where we did not observe adults, and others have tried unsuccessfully to locate BBB there previously.

Perhaps the most useful use of BBB eggs is for determining and monitoring BBB population sizes. Currently this is performed by counting adults (as per (Collier *et al.* 2008). However, there are several disadvantages to that method that counting eggs may overcome. These include adult counts being effected by multiple-counting of individuals, need to capture and release, level of adult activity can be low due to weather, season or low numbers of flowering male plants. Also, BBB often occurs with other small blue butterflies and is hard for inexperienced observers to distinguish (particularly in flight).

It is likely that counts of utilised male inflorescences and/or egg number itself could each be used to determine BBB population at the time of surveying, and of future populations, by determining the mathematical relationship between them. The "egg method" would largely overcome the disadvantages mentioned above and is useful when adult numbers are low for detection or counts.

Reduced-colour Forms of BBB

Amongst the 90 specimens obtained during this survey is displayed the entire diversity of all described *T. albocincta* forms. The reduced-colour forms we obtained occurred across a wide range of the sites and made up the majority of material from the FP. This casts doubt on the geographic basis for the occurrence of these forms, however, we have not examined other material designated as inland forms to assess whether our reduced-colour forms are the same. In our material, both the colour intensity and placement appeared to be quantitative traits that form a continuum of phenotypes. This is not a management issue so much as a taxonomic problem.

Conservation Status and Management Priorities by Region

Northern Adelaide Plains

The three large BBB populations on the NAP coastline are currently robust and do not require active management. Apart from their coastal position and potential long-term risk from rising sea-level, the only current threat is large scale clearance which is subject to the Native Vegetation Act (DEH 1991). **However, the four isolated colonies occurring on small *Adriana* patches are all at High or Medium risk and would benefit from revegetation and perhaps other management activities.** These colonies are at Webb Beach, Thompson Beach, Middle Beach and Buckland Park. All of these colonies occur in larger areas of habitat that could be utilised and would support *Adriana* (see examples in Figures 24-26). Three small colonies occur in housing subdivisions and would gain significant benefit from residents and council maintaining and increasing *Adriana* plantings on private land and roadsides. Thus, a mixture of revegetation and regeneration within housing sub-divisions and in surrounding vegetation could be used to increase the size and stability of these small BBB populations. **As an initial aim, increasing these *Adriana* patches to 100 plants or more would protect the associated BBB colonies in the short-term, could be assessed for impact, and provide a springboard for future efforts.** This would require the establishment of about 500 new *Adriana* plants across the five small sites. This could be undertaken in conjunction with publicity and supply of *Adriana* seedlings to interested members of the public. Education of the public and council in areas where *Adriana* occurs might also lead to retaining more *Adriana* seedlings that emerge due to disturbance etc. but are then removed as weeds.

Over a longer-term it would be wise to:

- locate new patches of *Adriana* for augmentation management
- once current sites are stabilised:
    - begin to skew resources towards sites at lowest risk from sea-rise
    - locate new areas of potential *Adriana* habitat, particularly in inland or elevated positions, where they are at less risk from sea-level rise
- examine strategic areas of habitat to provide corridors between isolated populations

Metropolitan area

The beaches of the Metropolitan area represent the longest unbroken stretch of former BBB habitat as they are associated with secondary dune systems that is typical habitat for *A. quadripartita*. Figure 27 shows the extent of this habitat running from West Beach to Outer Harbour. BBB is now extinct from this area except for the northern tip containing Torrens Island and Le Fevre Peninsula. However, this entire coastline would be suitable for establishment of *A. quadripartita* and reintroduction of BBB.

There are three broad management goals for BBB in this region:

- **Strengthen the foothold of BBB on the Le Fevre Peninsula.** This could be achieved by revegetating or regenerating *Adriana* at the Biodiversity Park and Mutton Cove sites, as well as identifying other sites for establishment or augmentation of *Adriana* patches on the peninsula. The Mutton Cove site is marginal and at High Risk of future inundation and so should only be seen as a source population for nearby colonies over the next decade, after which resources should be shifted to sites of Low or no inundation risk.

- Reintroduction of BBB along the entire metropolitan coast through establishment and maintenance of *Adriana* patches on public and private land. Over the longer term, skew resources towards areas predicted to have only low impact from rising sea-levels (south of Grange and north of Semaphore).
- Improvement of Torrens Island site. We rate this site as at Medium Risk because of the low level of BBB activity detected (given the size of the site), and the heavy grass infestation preventing natural recruitment of new *Adriana* and increasing risk of fire. The Torrens Island site would require ongoing weed management to improve the *Adriana* there and would be a potential site to test management options such as burning or disturbing soil around existing *Adriana*. *Adriana* at Torrens Island are on industrial land and therefore any management would require negotiation with the owners and an ongoing arrangement would be required to facilitate management and reduce the risk of any investment. The disadvantages of this site make it a lower priority for short-term conservation funding compared to activities on the Le Fevre Peninsula, however, the fact it will only have minor impact from predicted sea-rise means it may be worth protecting this site over the long-term.

There are a range of options for sites to establish *Adriana* and BBB along the metro coast that fall into four broad categories:

- private gardens in residential areas
- public spaces and council land
- industrial/commercial land
- schools

Combined, these areas provide a multitude of sites of varying size which are spread right across the metro area. For example, Figure 28 shows areas from the extremity of the Metro region and the public parks and green spaces in the area, which could be used to establish *Adriana* and thereby reintroduce BBB along the Metro coast. Industrial and commercial sites show a lot of promise because they are large and generally not disturbed once established (e.g. Torrens Island grassland, West Beach Treatment Works and Caravan Park etc.). By targeting these areas such that small *Adriana* patches are spread along the coastal fringe, BBB could be reintroduced to much of this former habitat.

In city areas, the public and schools could be engaged to play a role by:

- establishing *Adriana* in their gardens
- working with councils to establish *Adriana* in public spaces and street plantings
- establishing BBB colonies on *Adriana* plants

Industrial areas could be utilised by negotiating with owners to establish plantings in areas that provide amenity benefits for the site, or non-utilised areas that do not interfere with operations. Councils can be engaged to incorporate *Adriana* into their normal plantings or allowing the conservation workers to revegetate council land.

To engage the public, a range of options could include:

- supply of *Adriana* seedlings with growing and maintenance instructions
- supply of a BBB information pack or other promotion to garner interest in re-establishing BBB
- engage strategic members of the public or schools to reintroduce, manage and monitor BBB on their properties. Could be part of a "citizen science" project

To achieve an aim of spreading BBB along the Metro coast it would be advantageous to establish a series of medium *Adriana* sites (>50 plants) in public areas spread fairly evenly along the coast. BBB could then be introduced to these sites while the public is engaged to establish a larger number of smaller intervening sites to fill in gaps along the coast.

Fleurieu Peninsula

Except for the southern areas where BBB is doing well, BBB is largely absent from areas where its habitat used to exist on the FP (Figure 29). There are two key management goals for BBB on the FP:

- strengthening of the newly discovered, isolated BBB colony at Normanville Dunes
- reintroduction of BBB to the coastal areas around the southern suburbs of Adelaide such as at Port Stanvac, Aldinga and Noarlunga

Figure 29 shows current BBB colonies on the FP and their relationship to areas of former dune habitat. With regard to Normanville, revegetation could be used to strengthen *Adriana* in the dunes and public spaces. The public in Normanville could also be engaged to grow *Adriana* privately. The coastline of the southern suburbs of Adelaide could be managed as for the remainder of the Metro coast, by utilising public spaces, industrial land (e.g. Port Stanvac refinery and desalination plant) and private gardens.

The *Adriana* on Hindmarsh Island appear to be robust for now. Although some occur in roadside vegetation and may be at risk from roadworks, there are also plants on adjacent properties. Additionally, minor roadworks in that area would likely stimulate germination of new *Adriana*.

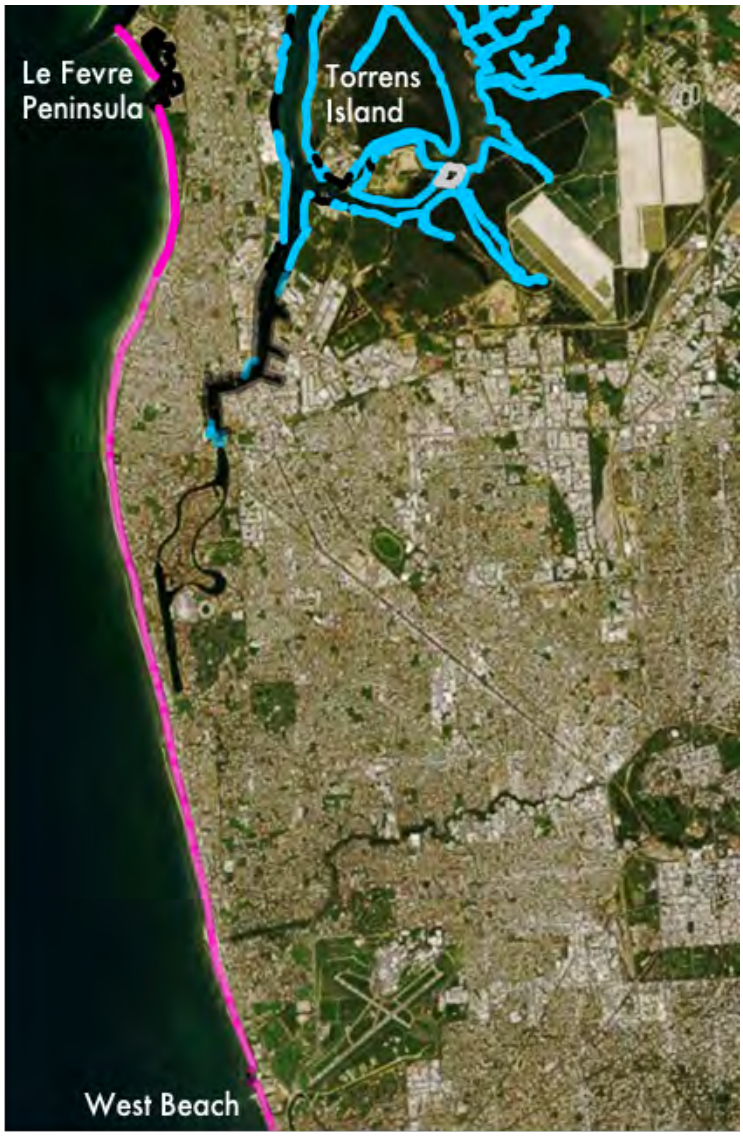


Figure 27. Adelaide metropolitan coastline showing sandy shores associated with dune systems (pink) in which *Adriana quadripartita* grew. At top is the Le Fevre Peninsula and Torrens Island where BBB still occurs. BBB is extinct from the remainder of its former habitat which used to stretch south to West Beach (at the bottom of the picture) and beyond. This area is a prime target for reintroduction of BBB. North is at top of page. Map obtained from CoastAdapt Shoreline Explorer Portal (accessed online at http://coastadapt.com.au/coastadapt-interactive-map).

Figure 28. Public green areas and parks (marked with green outlines) at northern and southern ends of the Metro coastline. These areas are abundant and widespread enough to facilitate *Adriana* and BBB establishment along the Metro coast. Top: Torrens Island and the Le Fevre Peninsula showing known or suspected BBB colonies (red dots). The north and east areas of the peninsula are largely industrial with abundant space, while the southern and western areas have public spaces and gardens spread throughout. Bottom: West Beach which contains a similar mix of public spaces, residential properties and industrial areas (such as the airport and adjacent treatment works). North is at top of page. Base map and public green areas obtained using Google Earth software.

Figure 29. Fleurieu Peninsula region showing sandy shores associated with dune systems (pink) in which *Adriana quadripartita* grew. Existing BBB colonies are associated with these areas and are shown with red dots. BBB is extinct from much of this former habitat in the southern suburbs of Adelaide such as Aldinga, Noarlunga and Marino. These areas are prime targets for reintroduction of BBB. There is also still a small colony in similar habitat at Normanville which could be strengthened. BBB colonies at Newland Head and further east, are currently stable. North is at top of page. Maps obtained from CoastAdapt Shoreline Explorer Portal (accessed online at http://coastadapt.com.au/coastadapt-interactive-map).

Kangaroo Island

KI is a stronghold for *T. albocincta* and with numerous large sites at Low risk. The apparent lack of BBB on the western half of KI is curious because *Adriana* occurs patchily across the island and there is a very large stand of *Adriana* at the old apiary site in the Flinders Chase National Park. Further, the area from which it is absent on KI is small compared to its overall range along much of the coastline of the peninsulas and south east of SA. The old apiary site is the only significant stand of *Adriana* known where BBB appears absent. It would be possible to translocate BBB to the apiary site although it is not known if it ever occurred in western KI. Currently, *T. albocincta* does not require active management on KI.

Further Research on BBB and *Adriana*

This survey has provided the most comprehensive assessment of BBB in the survey region and led to a range of discoveries. It has also raised a series of knowledge gaps with regard to managing *Adriana*/BBB, and biological points of interest which require further investigation to understand them.

Further areas for BBB research include:

1. The dispersal ability of the butterfly. It is not known if, or how far, BBB can actively disperse. Similarly, it is not known if weather events contribute to BBB dispersal. Population genetic studies may be able to provide an estimate and the newly discovered isolated populations would be useful in this regard. This information might also indicate if current small BBB populations are true remnants or more recent colonisation events.
2. Refining the use of BBB eggs to obtain population counts of BBB for monitoring and research purposes.
3. Incorporating methods to improve revegetation and regeneration of *Adriana*. It would be wise to investigate disturbance (e.g. fire, soil disturbance) as a method of improving current *Adriana* stands because disturbance has a large effect naturally and has the capacity to significantly reduce labour associated with propagation and revegetation. Improving current seed germination methods would improve propagation of *Adriana* and may remove the need to establish cuttings.
4. Undertaking high resolution spatial assessments identifying specific parcels of land that are at higher elevations and/or inland and will facilitate long-term adaptation of *Adriana* and BBB populations. This will likely require negotiation with private landholders and perhaps utilisation of farmland or horticultural areas.
5. Establishing ongoing monitoring sites to assess the response of relevant dune vegetation communities to increased sea-levels to help make decisions about targeting areas as climate refuges, and vulnerable species for management.
6. Development of protocols for individuals to grow/manage *Adriana*, and to introduce/monitor BBB on private land. This would facilitate the strengthening or reintroduction of BBB populations in residential areas and small coastal communities.
7. Characterising the parasitoid suite associated with BBB, and its impact
8. Determining the significance of the reduced-colour (inland) forms of adult BBB found at coastal sites.

Other Conservation Targets for the AMLR NRM Region

An important "side-effect" of the BBB project is that it draws attention to invertebrates and also to specific interactions between organisms, which are crucial for maintaining biodiversity. By conserving *Adriana*, it is likely that other invertebrates will benefit especially if they are specific to *Adriana* as for BBB. Although invertebrates account for ≈95% of the animal species on land, they are rarely considered in conservation and land management programs. Although we understand that many invertebrate species are rare and/or endangered, there is only one listed in SA as Regionally Endangered (Green carpenter bee on KI) and therefore they are not mentioned in biodiversity plans, vegetation assessments, etc. This is a shortcoming because invertebrates are also functionally important (e.g. as pollinators), regulating the dynamics of our ecosystems.

Butterflies are an exception and they have received some attention because they are large insects that attract human interest. Thus, they are useful as icon species. However, they are not a diverse group in SA and play a limited functional role in ecosystems. The MANCAP (Caton *et al.* 2009) identified six butterflies of concern in the region, of which *T. albocincta* was one (and the only of the six species considered common). Of these, the two skippers (Cynone grass-skipper and Black and white sedge-skipper) are the most obvious choices for future management efforts. Evidence of the latter was observed during this survey near Port Stanvac (Figure 19).

With a view to conserving ecosystem functionality and large proportions of the associated biodiversity, it would be wise to assess important groups of invertebrates as conservation targets or to aid in monitoring. For example, if managing sub-sets of biodiversity, the conservation impact would likely be much greater if an area were managed for a suite of pollinating insects than for an individual vertebrate such as a bird or reptile. Some invertebrate groups that could be assessed include:

- functional groups such as those that pollinate or degrade organic matter
- agricultural pest and beneficial species to facilitate revegetation projects associated with agricultural land (see Glatz 2015)
- invertebrate groups displaying particularly high diversity e.g. true bugs, flies, beetles, moths
- invertebrate suites associated specifically with rare plants
- iconic invertebrates from other taxonomic groups, e.g. bees, ants, wasps, spiders, dragonflies, grasshoppers, beetles, flies, moths

References

Beaumont, K. P., D. A. Mackay and M. A. Whalen (2009). "Combining distances of ballistic and myrmecochorus seed dispersal in *Adriana quadripartita* (Euphorbiaceae)." *Acta Oecologica* **35**: 429-436.

Beaumont, K. P., D. A. Mackay and M. A. Whalen (2016). "Ant defence of a dioecious shrub, *Adriana quadripartita* (Euphorbiaceae), with extrafloral nectaries." *Australian Journal of Botany* **64**: 539-546.

Black, J. (1986). *Flora of South Australia Part II: Leguminosae-Rubiaceae*. Government of South Australia, Adelaide, Australia.

Bonney, N. (2003). *What Seed Is That? A guide to the identification, collection, germination and establishment of native plant species for central southern Australian lanscapes. Revised Edition.* Adelaide, Australia.

Braby, M. F. (2000a). *Butterflies of Australia: Their Identification, Biology and Distribution. Volume II.* CSIRO Publishing, Collingwood, Victoria, Australia.

Braby, M. F. (2000b). *Butterflies of Australia: Their Identification, Biology and Distribution. Volume I.* CSIRO Publishing, Collingwood, Victoria, Australia.

Caton, B., D. Fotheringham, E. Krahnert, J. Pearson, M. Royal and R. Sandercock (2009). Metropolitan Adelaide and Northern Coastal Action Plan 2009. Volume 1: Conservation and Threat Assessment. Prepared for the Adelaide and Mount Lofty Ranges NRM Board and Depertment for Environment and Heritage, Adelaide: 227 pp.

CoastAdapt. (2016). "Sea-level rise and future climate information for coastal councils." Retrieved online 19 June 2017, from https://coastadapt.com.au/sea-level-rise-information-all-australian-coastal-councils.

Collier, N. (2007). *Landscape ecology and conservation of South Australian butterflies*. PhD Thesis, Flinders University.

Collier, N., M. Gardner, M. Adams, C. R. MacMahon, K. Benkendorff and D. A. Mackay (2010). "Contemporary habitat loss reduces genetic diversity in an ecologically speciualized butterfly." *Journal of Biogeography* **37**: 1277-1287.

Collier, N., D. A. Mackay and K. Benkendorff (2008). "Is relative abundance a good indicator of population size? Evidence from fragmented populations of a specialist butterfly (Lepidoptera: Lycaenidae)." *Population Ecology* **50**: 17-23.

DEH (1991). The South Australian Native Vegetation Act, 1991. South Australian Department for Environment and Heritage, Adelaide, South Australia.

Fisher, R. H. (1978). *Butterflies of South Australia*. Government of South Australia, Adelaide, Australia.

Glatz, R. V. (2015). Native Vegetation and Ecosystem Services on Kangaroo Island: landscape resiliece and the triple bottom line. D'Estrees Entomology & Science Services, Kangaroo Island, Australia: 71 pp.

Gross, C. and M. A. Whalen (1996). "A revision of *Adriana* (Euphorbiaceae)." *Australian Systematic Botany* **9**: 749-771.

Grund, R. (1996). "The distribution of *Theclinesthes albocincta* (Waterhouse) and *Theclinesthes hesperia littoralis* (Sibatani & Grund), based on herbarium records of eggs (Lepidoptera: Lycaenidae)." *The Australian Entomologist* **23**(4): 101-110.

Grund, R. and A. Sibatani (1975). "The life histroy of a hitherto unrocognised lycaenid species: *Theclinesthes albocincta* (Waterhouse) from South Australia." *Australian Entomological Magazine* 2: 99-103.

ICSM (2011). *Australian Tides Manual. Special Publication No. 9. Version 4.1*. Canberra, Australia, The Intergovernmental Committee on Surveying and Mapping, Commonwealth of Australia.

Milne, T. (2016). Normanville Dunes Biodiversity Action Plan. T & M Ecologists Pty. Ltd., Mount Barker, Australia: 160 pp.

NCCARF (2016a). Datasets Guidance 2: Sea-level Rise and You. Future climate change and sea-level rise. National Climate Change Adaptation Research Facility, Gold Coast, Australia: 18 pp.

NCCARF (2016b). What are the RCPs? National Climate Change Adaptation Research Facility, Gold Coast, Australia: 1 pp.

SASCC. (2017). "Seeds of South Australia: *Adriana* quadripartita (Euphorbiaceae)." Retrieved online 21 May 2017, from http://saseedbank.com.au/species_information.php?rid=277.

Siebentritt, M. (2016). Understanding sea-level rise and climate change, and associated impacts on the coastal zone. CoastAdapt Information Manual 2, National Climate Change Adaptation Research Facility, Gold Coast, Australia: 28 pp.

Appendix A: TWO PAGE FLYER - Finding and Identifying *Theclinesthes albocincta*

How to look for the Bitterbush blue butterfly (*Theclinesthes albocincta*)


Photo: D.A.Young


Photo: D.A.Young

Females lay on leaves & female flowers but it is much less common than on male flower spikes

Caterpillars of the Bitterbush blue butterfly feed only on the Coastal bitterbush. Butterflies lay eggs only on the bitterbush. So, you need to find some bitterbush!

Bitterbush usually occurs on sand dunes within 500m of the coast. Bushes are usually 1-3m high and have bright glossy leaves which can be serrated.


Photo: R.V.Glatz

Female flowers (often plain green)


Photo: R.V.Glatz

Male flower spike with buds & some opened flowers


Photo: R.V.Glatz

Female laying egg on young male flower spike


Photo: D.A.Young

Bitterbushes have male and female flowers on separate plants. Find young male flower spikes with unopened buds because females lay eggs mainly on them. Butterfly activity and caterpillars are concentrated on and around flowering male plants. Look closely for eggs on young male flower spikes. Eggs are about 1-2mm, green-white and round with a sunken centre.


Eggs and characteristic holes caused by caterpillars

Photo: D.A.Young

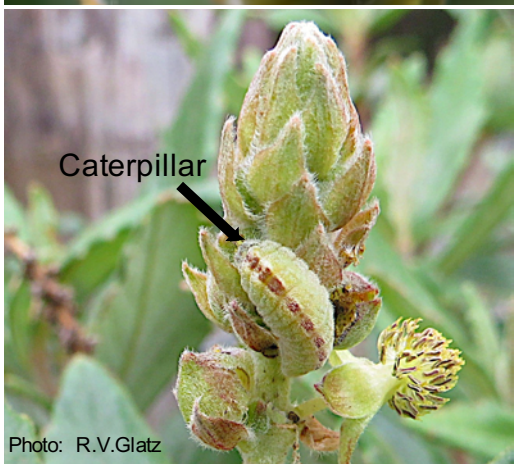

Caterpillar

Photo: R.V.Glatz

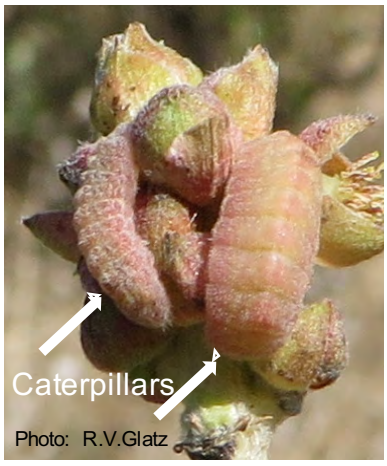

Caterpillars

Photo: R.V.Glatz

Look for caterpillars too. They are up to 1cm, fat, range from pink-green and often have a stripe. Look for damage made by the caterpillars. The make characteristic single holes in the side of male buds and their supporting bracts.

D'Estrees ENTOMOLOGY Science Services

birdlife AUSTRALIA

Government of South Australia

Adelaide and Mount Lofty Ranges Natural Resources Management Board

Australian Government

D'Estrees
ENTOMOLOGY
Science Services

birdlife
AUSTRALIA

Government
of South Australia

Adelaide and
Mount Lofty Ranges
Natural Resources
Management Board

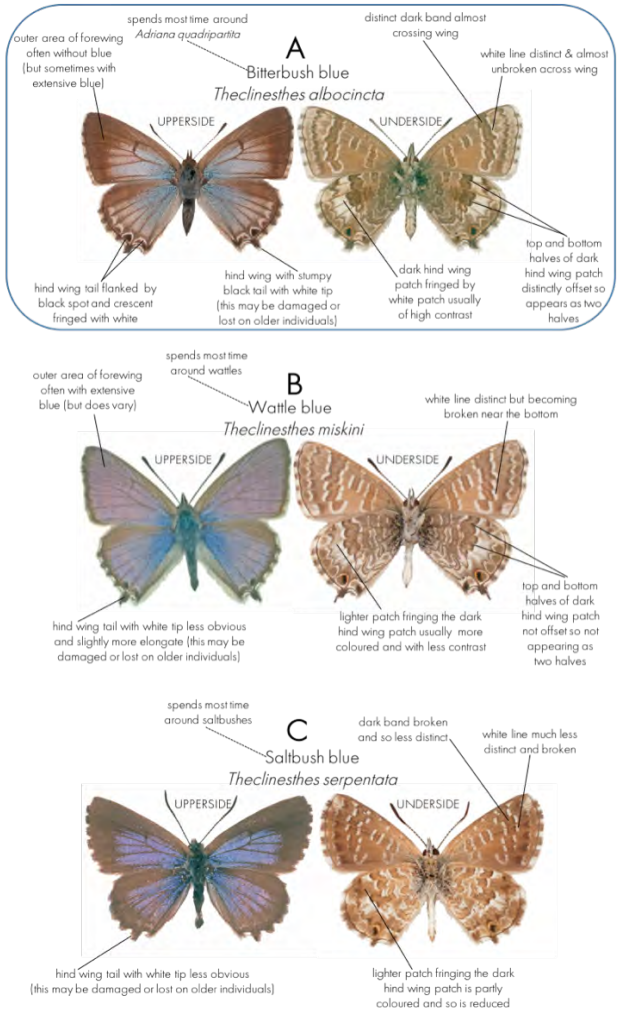
Australian Government

HOW TO USE THIS CHART

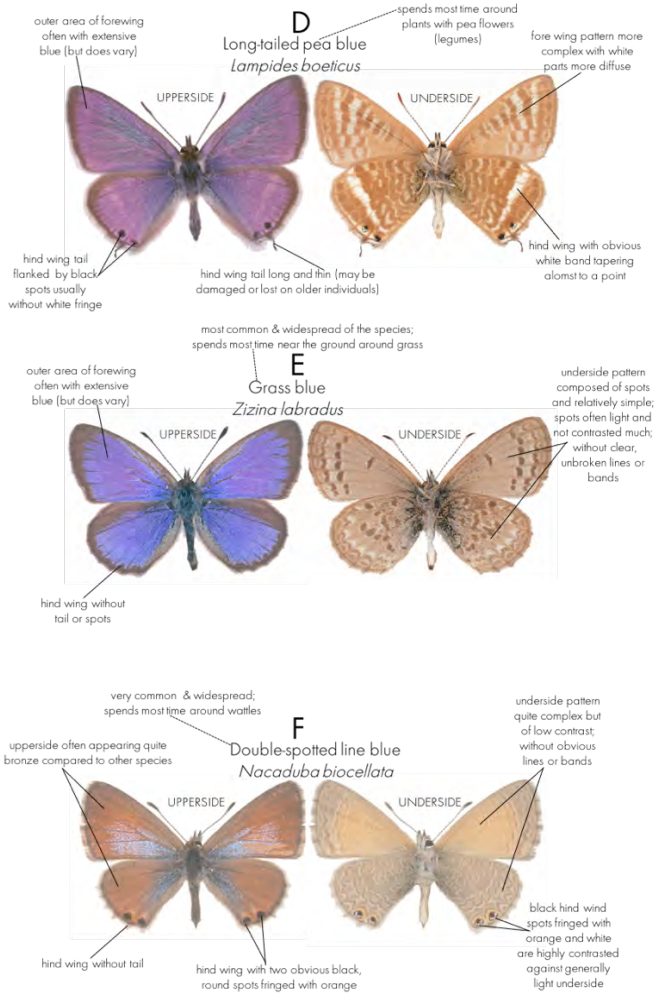
This chart is designed to enable the identification of Bitterbush blue butterfly, *Theclinesthes albocincta* (A) by highlighting features that are different from other small blue butterflies occurring on the Northern Adelaide Plains, Metropolitan coastline and Fleurieu Peninsula. The upperside of each species is shown on the left hand side and the underside of each is shown on the right.

Bitterbush blue butterfly (A) is shown in the blue box along with important features that can be used to tell it from other similar species. The other species (B-F) have features shown that are different to Bitterbush blue. The left hand side shows the three *Theclinesthes* species which are closely related and hardest to tell apart. Generally the best feature to identify the species is the plant that the butterfly spends most time around. On the right are the three other common species of small blue butterfly.

Some features are shared between species and all features shown are naturally variable between individuals, and they also vary with the age and condition of the butterfly. Therefore, as many features should be used as possible (at least 4-5) to identify the butterfly because it is the combination of features that is unique.



Theclinesthes species



Other species

Photographs from Butterfly Conservation SA Inc.
Obtained from http://butterflyconservationsa.net.au/butterflies/identify/online-identification-tool

Appendix B: *Theclinesthes albocincta* Site Survey Form

Survey time, location and weather

Observer Names:
Date (DD-Mon-YYYY):
Survey start time:
Survey end time:
Site Name:
Lat (˚S):
Long (˚E):

Directions and distance from nearest identifiable location:

Weather (brief description of conditions during the survey, including wind and temperature):

Presence and degree of *Adriana quadripartita*

Is *Adriana quadripartita* present?
Estimate of plant number? (can use exact number, approx. value, < or >, range of values)
If *Adriana* present: (tick one of more)
extensive, dense stands of *Adriana*
extensive, more open, spread-out stands of *Adriana*
small, dense stands of *Adriana*
a smaller area with a strong cohort of spread-out *Adriana*
a linear stand of *Adriana* (e.g. along a path, power-line clearance etc.)
a few, scattered examples of *Adriana* distributed over a wide area
a few, scattered examples of *Adriana* distributed over a smaller, discreet area
other (specify)
Potential for on-ground works to increase Adriana at site? ***(comment on land tenure, management of current plants and surrounds, area available for expansion)***

Presence and degree of *Theclinesthes albocincta* and ants

Was adult *Theclinesthes albocincta* voucher-identified, observed or suspected? (tick one or more)
vouchered and observed in considerable numbers (<5)
vouchered and observed in low numbers(>5)
vouchered single specimen
observed in considerable numbers, no voucher
observed in low numbers, no voucher
observed single individual
blue butterfly of undetermined species observed on or over *Adriana*
blue butterflies observed at the site but not identifiably on or over *Adriana*
no blue butterflies observed at the site

Ant activity observed on and around *Adriana **(tick one or more and comment)**
high ant activity on the ground and *Adriana*
moderate ant activity around and on *Adriana*
moderate ant activity but NOT on *Adriana*
low ant activity around and on *Adriana*
very little, or no, ant activity around and on *Adriana*
direct interaction(s) between ant(s) and *Theclinesthes* observed
Notes (number of direct observations, species identifications etc.):

* If ants are found attending a larva or pupa, suspected as being that of *Theclinesthes*, then attempt to photograph the association and take a voucher of the attending ant species and *Theclinesthes* larva/pupa (if more than one species is involved, voucher both to the same vial and make a note of the circumstance). Where possible, capture a voucher sample of any ants found at the site for identification.

Soil, ground litter/debris, urban development and clearance

Soil and vegetation at the site: (tick one or more and/or comment)
stony soil
clay or water-logged soil
bare, mobile sand
bare, consolidated sand
lightly vegetated sand
heavily vegetated sand with a strong component of local native vegetation
heavily vegetated sand with a strong component of introduced/invasive vegetation
none of the above (define as best you can):

Plant litter and other debris: (tick one and comment) (e.g. rocks, dead leaves, snail shells, sticks)
High
Moderate
Low
Specify make up of litter/debris :

Is the site encroached by urban development or has experienced alteration to, or clearance of, native vegetation?
If YES, give details:
If YES, grade this disturbance from 1(low) to 5 (extreme):

Weeds

Is the site affected by invasive weeds?
Is weedy grass a dominant part of the site vegetation?
List of weeds*:
Notes (include estimated % coverage levels of major species or WONS):

*obtain voucher of major weeds if unsure

Timing and type of human or environmental disturbance

Does the direct site appear to have experienced human disturbance? (tick one or more below and comment)*
the last year
the last five years
the last ten years
over ten years previously
unknown
Comment:

*an estimation based on observations such as state of vegetation, of disturbed ground, relative newness of buildings and infrastructure, combining this with local, anecdotal evidence etc., should be used to draw an approximated conclusion to this question.

Does the direct site appear to have experienced environmental disturbance? (e.g. fire, major erosion events etc.) (tick one or more below and comment)*
the last year
the last five years
the last ten years
over ten years
unknown
Notes:

* an estimation based on presence of burn scarring, state of eroded plant matter and discussions with persons who may have lived in or visited the area on a frequent basis, may provide an approximation.

Proximity and linkage to other existing or historical *Theclinesthes* or *Adriana* sites

Is the site near or adjacent to a previously known, recorded or observed colony of *Theclinesthes or Adriana?* (tick one or more and comment on type of nearby site)
Yes: directly adjacent (within 100m)
Yes: adjacent (100m-500m distant)
Yes: nearby (within 2km)
Yes: within 5km of the site
Yes: within 10km of the site
No
Notes (include what is at nearby site(s) and if the nearby record is extant or historical):
Is there a corridor(s) of native vegetation linking the site to the nearby site(s)? (tick one or more and comment):
Yes: several such corridors, or an extensive corridor of good-quality, native vegetation links the sites
Yes: a single corridor of average quality vegetation links the sites
Yes: poor quality or broken vegetation exists, providing a potential link between the sites
No
Two or more urban isolates exist with extant *Adriana*
Two or more isolates clearly exist as remnants of a larger fragmented population
Notes:

Proximity to beaches and further observations

Shortest distance from site to nearest beach (tick one):
within 20m of the inland edge of a beach
within 100m of the inland edge of a beach
within 500m of the inland edge of a beach
within 1km of the inland edge of a beach
over 1km of the inland edge of a beach

Any further observations or thoughts relating to this specific site or its relationship to other sites

Appendix C: Photographs of Sites Supporting *Theclinesthes albocincta*

Photographs of sites supporting *Theclinesthes albocincta* on the Northern Adelaide Plains coastline, during summer and autumn 2017. Top left - Buckland Park sand dune; top right - Light Beach; centre left – Middle Beach; centre right – Parham Social Club and township; bottom left – Port Gawler south; bottom right – Thompson Beach (Herron Crescent).

Photographs of sites supporting *Theclinesthes albocincta* on the metropolitan and Fluerieu Peninsula coasts, during summer and autumn 2017. Top – Torrens Island grassland; centre left – Biodiversity Park; centre right – Normanville dunes; bottom – Newland Head south.

Photographs of sites supporting *Theclinesthes albocincta* on Kangaroo Island from spring 2016 to autumn 2017. Top left – D'Estrees Bay Road; top right – Island Beach township; centre Emu Bay; bottom left – Mouth Flat Road; bottom right – Prospect Hill.