Final Report to Cradle Coast Authority:

Defining and mapping habitat requirements to support the survival of King Island threatened birds. Contract No. RLP-KIBIRDS-BMA

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Survey team Matt Webb and David James break for lunch in King Island scrubtit habitat (*Melaleuca ericifolia* swamp forest), Colliers Swamp, King Island.

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Disclaimer

The opinions expressed in this document are made by the author and do not necessarily reflect those of the Cradle Coast Authority NRM, the Tasmanian Forest Practices Authority, the Tasmanian Department of Natural Resources and Environment or the Australian Government Department of Climate Change, Energy, Environment and Water

Cover Photo

King Island Brown Thornbill, Photo by Barry Baker

Executive Summary

- The King Island Biodiversity Management Plan prepared in 2012 states that 'King Island is treasured by residents and visitors alike for its valuable natural assets and way of life - the natural assets underpinning the Island's main industries and leisure activities.' Further, 'It is important to manage these valuable natural assets that make King Island special to ensure their future. The management of biodiversity, including threatened species, is a crucial part of protecting the environment. This does not necessarily mean dramatically changing existing land use practices, but instead developing better approaches within them.'
- Since permanent European settlement of King Island in 1888 about two thirds of the Island has been cleared to support a prosperous beef and dairy industry. Several fauna and flora species (notably Glossy Black-cockatoo, Gang-gang Cockatoo, Forty-spotted Pardalote, Spotted-tailed Quoll, Wombat, Southern Elephant Seal and Coast Banksia) have become locally extinct, and one species (King Island Emu), globally extinct since settlement of the Island. Other species, particularly little-known invertebrate species, may have also become extinct.
- Approximately 14% of King Island is on publicly managed land. The current native vegetation cover is approximately 33%, of which 22% is on private land. If narrow native tree lines and roadside vegetation are discounted from this estimate, the cover of native vegetation on the Island is likely to be less than 30%.
- Much of the remnant native vegetation on King Island, particularly the swamp forests and wet forests, has been impacted by frequent and intense fires since European settlement. A wildfire in 2007 burnt 90% of the swamp paperbark forest of Nook Swamps in the northeast of the Island. Outside formal reserves, most remnant native forests and wet scrubs on King Island show signs of degradation from grazing and trampling by cattle and browsing by native and introduced mammals. Weed invasion has also become an important issue on the Island and affects many of the native vegetation communities.
- Habitat loss is the overwhelming reason for population declines in many species on King Island. Extensive clearing for agriculture has resulted in widespread loss and fragmentation of habitat, particularly for several of the Island's threatened endemic birds. Further, not all the remaining potential habitat is suitable for these birds at the current time. Conservation actions need to be undertaken to prevent these species becoming extinct, and the extensive loss of habitat on the Island dictates that the protection of the remaining habitat should be a high priority in land management decision making.
- King Island Scrubtit and King Island Brown Thornbill are amongst the top three bird species in Australia considered most likely to become extinct. The reasons for loss of their habitat includes land clearing, fires, agricultural draining and herbivore browsing. Given the extensive loss of native vegetation on King Island and the highly threatened status of the King Island Scrubtit and the King Island Brown Thornbill it is likely that, in the absence of recovery actions, these subspecies are likely to become extinct in the wild in the near future.

- Land clearing on King Island has continued over recent decades, albeit subtle for the most part. However, there has been an upturn in the demand for land clearing since 2017 to support a thriving agricultural industry. While the clearance of forest communities, including threatened ones, is regulated under the Forest Practices System, the clearance of non-threatened non-forest vegetation communities is not regulated or monitored in Tasmania. Indeed, the Island's scrub communities, some of which are likely to be the precursors of later stage forests, may well not reach the notice of environmental regulators in Tasmania. Even a moderate amount of land clearance, draining or increased fire in native vegetation on King Island has the potential to limit the recovery of the highly threatened King Island Brown Thornbill and King Island Scrubtit.
- The issue of habitat loss for King Island Brown Thornbill and King Island Scrubtit is further compounded by a lack of knowledge of the potential and important habitats for these species. The King Island Biodiversity Management Plan, adopted as the national recovery plan for these subspecies, recognises a key threat to their survival is the ongoing clearance of potential habitat. Key actions for maintenance and recovery of King Island Brown Thornbill and King Island Scrubtit identified in the Plan includes continuing to strengthen current measures for retention and rehabilitation of remaining wet forest and swamp forest vegetation on the Island, and developing management guidelines in consultation with landowners for protecting remaining habitat from land clearance and drainage.
- In 2021 the Cradle Coast Authority NRM initiated the King Island Threatened Birds Project (the Project) with funding from the Australian Government's National Landcare Program and in kind and collaborative support from the Tasmanian Government's Forest Practices Authority and Department of Natural Resources and Environment.
- The aim of the Project was to define and map the habitat requirements of King Island Brown Thornbill and King Island Scrubtit to inform the development of conservation actions and strategies for the survival of these subspecies.
- The Project undertook surveys for the King Island Brown Thornbill and King Island Scrubtit in March-April and September-October 2021 and in September-October 2022. Additional visits were made to the Island in July 2021 and May 2022 for landowner liaison and vegetation surveys to support the Project.
- The Project combines and reports on data collected during systematic and incidental surveys conducted for the King Island Brown Thornbill and King Island Scrubtit between January 2019 and December 2022. Key surveys for these subspecies are reported in Baker and Holdsworth (2019), Holdsworth (2019), Webb and Crates (2019) and Webb and Bell (2020).
- The distribution of King Island Brown Thornbill is now known to extend north to Lake Martha Lavinia, west to Pegarah, and south to Colliers Swamp, Seal River and Macks Creek. The distribution of detections in both large contiguous vegetation patches and isolated vegetation remnants in farmland suggests a strong capacity for dispersal across unsuitable habitats, including agricultural landscapes. Based on the location of historical and recent detections it is likely the subspecies once occurred in suitable vegetation across the entire Island.

- Additional locations and detections of King Island Brown Thornbill during the present Project is not considered to warrant a review of the estimated number of mature individuals of 100 (Range 50-200) reported by Holdsworth *et al.* (2021) in *The Action Plan for Australian Birds* 2020. Although the subspecies was detected at several new sites during the Project, most were considered to support only a few birds.
- TASVEG mapping units most likely to contain habitat critical to the survival of King Island Brown Thornbill include Wet *Eucalyptus brookeriana* forest (WBR), *Eucalyptus globulus* King Island forest (WGK), Plantations for Silviculture – hardwood (FPH), *Acacia melanoxylon* swamp forest (NAF), *Melaleuca ericifolia* swamp forest (NME), King Island eucalypt woodland (DKW) and Scrub complex on King Island (SSK). In general terms, habitat critical to the survival of the King Island Brown Thornbill is considered to include all the forgoing TASVEG mapping units that currently support mature eucalypts (as an immediate priority for protection and conservation management) or support regrowth eucalypts with the potential to reach maturity in any of these TASVEG mapping units (as a secondary priority for protection and conservation management) i.e., future potential habitat.
- The use and importance of SSK as a habitat for King Island Brown Thornbill remains poorly understood. Nonetheless, dominant flora species that characterise SSK often form a component of the understorey tree layer at sites where King Island Brown Thornbill has been detected. Notwithstanding the lack of detections in SSK, there is little doubt this vegetation community forms part of the matrix of the subspecies' habitat, and buffers habitat from the adverse impacts of land clearing, browsing and trampling by domestic stock, exotic and native mammal browsing, weeds, windthrow and other potential threats. A precautionary approach to the conservation of King Island Brown Thornbill would therefore require protection of SSK where it occurs in contiguous native vegetation patches known to support the subspecies.
- In isolation, Coastal scrub on alkaline sands (SCA) is not likely to contain habitat critical to the survival of the King Island Brown Thornbill. However, where SCA occurs in contiguous native vegetation patches known to support the subspecies and/or native vegetation communities supporting eucalypts, it does form part of the matrix of this subspecies' habitat and provides a buffer from the variety of threats acting on known and future potential habitat.
- *Eucalyptus brookeriana* wet forests (WBR) and *Eucalyptus globulus* King Island forest (WGK) show a very strong association with the subspecies' detection sites. The very high prevalence of detections in Plantations for Silviculture – hardwood (FPH) likely reflects the suitability of *E. obliqua* plantation for the subspecies. However, the high prevalence of detections in FPH may reflect an influence from mature native wet eucalypt forests along drainage lines and other native forest remnants within Pegarah State Forest.
- The overwhelming association between the presence of eucalypts in the forest tree canopy and the detection of King Island Brown Thornbills is qualified by the relationship with the diameter at breast height of eucalypts at survey sites. Modelling of the habitat data suggests the subspecies is strongly associated with mature eucalypt forests, or of individual eucalypt trees, and a high tree canopy cover.
- The distribution of King Island Scrubtit is now known to extend north to Lavinia State Reserve, between Lake Martha Lavinia and Granite Lagoon.

Based on current detections of the subspecies, the Extent of Occurrence and Area of Occupancy may warrant review.

- Additional locations and detections of King Island Scrubtit during the current Project is not considered to warrant a review of the estimated number of mature individuals of the subspecies, beyond the estimate of 50 (Range 30-70) by Holdsworth *et al.* (2021) in *The Action Plan for Australian Birds 2020*. Indeed, there is some concern for the viability of birds in isolated patches of mature *Melaleuca ericifolia* swamp forest in Nook Swamps which did not burn during the 2007 fire. Further, substantial windthrow has also been observed in remnant mature *M. ericifolia* forest in both Nook Swamps and Colliers Swamp, which requires ongoing monitoring.
- TASVEG mapping units most likely to contain habitat critical to the survival of King Island Scrubtit include *Melaleuca ericifolia* swamp forest (NME), Plantations for Silviculture – hardwood (FPH), *Acacia melanoxylon* swamp forest (NAF), Wet *Eucalyptus brookeriana* forest (WBR), Coastal scrub on alkaline sands (SCA) and Scrub complex on King Island (SSK). In general terms, habitat critical to the survival of the King Island Scrubtit is considered to include all the forgoing TASVEG mapping units that currently support mature *M. ericifolia* (as an immediate priority for protection and conservation management) or support regrowth *M. ericifolia* with the potential to reach maturity in any of these TASVEG mapping units (as a secondary priority for protection and conservation management) i.e., future potential habitat.
- The use and importance of Scrub complex on King Island (SSK) and Coastal scrub on alkaline sands (SCA) as a habitat for King Island Scrubtit remains poorly understood. Nonetheless, in isolation, neither SSK or SCA, is likely to contain habitat critical to the survival of the subspecies due to the dense structure, and lack of understorey and ground layer complexity in these communities. The role of SSK and SCA is more likely to assist in dispersal and act as a habitat buffer from the array of potential threats to the King Island Scrubtit. A precautionary approach to conservation of King Island Scrubtit would, as a minimum, require protection of SSK and SCA where these communities occur in contiguous native vegetation patches known to support the subspecies.
- Results of modelling of King Island Scrubtit habitat data reinforces associations identified in previous surveys of the subspecies. The presence of mature *Melaleuca ericifolia* is overwhelmingly the strongest predictor of the presence of King Island Scrubtit. Seventy-eight percent of detections were in *Melaleuca ericifolia* swamp forest (NME). The most common dominant tree canopy species and most common dominant understorey tree species at detection sites was *M. ericifolia*. The species is positively correlated with the cover of ground layer vegetation reflecting the often-high cover of ferns at detection sites. The cover of coarse woody debris is a strong predictor of presence and no doubt reflects the subspecies' preference for habitats with high structural complexity in the understorey, including fallen trees and logs.
- Although there are some strong associations of site-level covariates with detections of King Island Brown Thornbills and King Island Scrubtits, habitat suitability is likely to be strongly linked to vegetation age, patch size, fragmentation and connectivity. The addition of a spatial component into modelling of habitat is likely to provide strong predictors of the presence of King Island Brown Thornbill and the King Island Scrubtit and additional guidance in the development of conservation actions for both subspecies.

- The Project has made considerable progress in identifying the current distribution and habitat of the King Island Brown Thornbill and the King Island Scrubtit. Nonetheless, targeted research is now required including standardised population monitoring and studies of demography, functional habitats and movements, to better understand the subspecies' conservation ecology and inform management actions for their recovery.

Recommendations

King Island Brown Thornbill

Monitoring

- Establish a set of discrete monitoring sites at known locations of King Island Brown Thornbill to measure the success of conservation actions and inform research objectives.

Research

- Determine the size, trend and genetic structure of the population.
- Investigate demography of the population.
- Investigate movements and the role of habitat connectivity in dispersal.

Conservation Actions

- Identify fire management and fire emergency response strategies and implement conservation actions at known locations of King Island Brown Thornbill. Fire is an imminent threat to the viability of the subspecies.
- Protect habitat and supporting vegetation at known locations of King Island Brown Thornbill from land clearing.
- Protect future potential habitat and supporting vegetation of King Island Brown Thornbill from land clearing.
- Prioritise threats at known locations of King Island Brown Thornbill (e.g. fire, weeds, cattle grazing and trampling, native and feral mammal browsing, pasture edge effects) and implement conservation actions.
- Identify all known locations of King Island Brown Thornbill in NC Act reserves on public land and in NC Act conservation covenants on private land as priority sites for conservation actions.
- Seek formal management arrangements, NC Act reserve status and/or NC Act conservation covenants for known locations of King Island Brown Thornbill on currently unreserved public land or unreserved private land.

King Island Scrubtit

Monitoring

- Establish a set of discrete monitoring sites at known locations of King Island Scrubtit to measure the success of conservation actions and inform research objectives.

Research

- Determine the size, trend and genetic viability of the population.
- Investigate demography of the population.
- Investigate movement and dispersal including the role of habitat patch size and connectivity.
- Investigate the feasibility of translocation to apparently suitable but unoccupied habitat.
- Investigate poorly understood potential threats to habitat including mammal browsing and acid sulphate soil.

Conservation Actions

- Identify fire management and fire emergency response strategies and implement conservation actions at known locations of King Island Scrubtit. Fire is an imminent threat to the viability of the subspecies.
- Protect habitat and supporting vegetation at known locations of King Island Scrubtit from land clearing.
- Protect future potential habitat and supporting vegetation of King Island Scrubtit from land clearing.
- Prioritise threats at known locations of King Island Scrubtit (e.g. fire, weeds, cattle grazing and trampling, native and feral mammal browsing, pasture edge effects) and implement conservation actions.
- Identify all known locations of King Island Scrubtit in NC Act reserves on public land and in NC Act conservation covenants on private land as priority sites for conservation actions.
- Seek formal management arrangements, NC Act reserve status and/or NC Act conservation covenants for known locations of King Island Scrubtit on currently unreserved public land or unreserved private land.

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Background

Native vegetation of King Island

The following quotes from the King Island Biodiversity Management Plan (KI BMP), provide an insight to the pre-European vegetation of the Island. French zoologist Francis Péron visited King Island in 1802 describing the vegetation in the area they explored as 'strong and vigorous':

'… in various places the trees and shrubs are so close to the surface of the ground and their debris is so plentiful everywhere, that it is almost impossible to penetrate into the middle of the forests; but, in general, the plants which make up these forests do not show the gigantic proportions that we admired in those of Van Diemen's Land; yet they belong to the same species as these last.....The fern-families, the mosses and the fungi have a great number of species as beautiful as they are vigorous' (in Finzel 2004, p. 17).

A visit by the Field Naturalists' Club of Victoria to the Island in November 1887, commented that they:

'…had considerable difficulty traversing the Island, owing to the fact that it's northern half was covered with dense scrub and its southern part with impenetrable forest' (Campbell 1888).

King Island was first named by John Black who arrived on the Harbinger in 1801, though the island was not settled permanently until nearly a century later in 1888, when it was sectioned off for farming (Donaghey 2003). King Island's history of settlement, farming and associated burning regimes, have all played an important role in influencing the biodiversity of the Island (TSS 2012).

King Island's low relief and geographic isolation has led to vegetation that is relatively low in structure and floristic diversity. The key influences on the distribution of vegetation are soil fertility, drainage, exposure to marine influences and fire history (Barnes *et al.* 2002).

About two-thirds of King Island's vegetation has been cleared for agricultural production since European settlement (Barnes *et al.* 2002). In the early twentieth century, a number of significant lagoons and swamp forests in the Island's north were drained impacting in particular on *Melaleuca ericifolia* swamp forest and *Acacia melanoxylon* swamp forest. Much of the dune system that fringes the Island's west coast has also been cleared for rough grazing, with the loss of extensive tracts of coastal scrub, while extensive *Eucalyptus globulus* forests on the Island's 'plateau' have also been decimated, their demise being aided by a series of major fires in the late 19th and early 20th century (Finzel 2004). Frequent and intense fires over King Island's European history have eliminated most rainforest and wet forest associated flora and fauna from areas of the island (Barnes *et al.* 2002). In recent times, fires in 2001 and 2007 have burnt extensive tracts of the island's remaining native vegetation, in particular within Lavinia State Reserve. The remaining remnant native vegetation is scattered throughout a rural landscape and most patches are small, fragmented and isolated - at least 8% occur in narrow bands and as small remnants (Barnes et al. 2002). Most patches of vegetation are separated by pasture, with limited or no connectivity, particularly for native species with low mobility, such as snails (TSS 2012).

As King Island is a small island with relatively little and highly fragmented native vegetation, some species are more susceptible to local ('island') extinction than they would be in areas of comparable size on the Tasmanian mainland where larger

patches of native vegetation remain (Barnes *et al.* 2002). Fragmentation of the remnant vegetation also makes it more susceptible to further degradation, by creating conditions that encourage damage, such as invasion by weeds (TSS 2012). Outside of formal reserves, most remnant native forests and scrubs on King Island show signs of degradation from grazing and trampling by cattle, and browsing by native and introduced mammals (TSS 2012).

King Island has a total area of approximately 113,918 ha of which 73,835 ha has been cleared for agricultural and other purposes [Calculation of clearance includes: Improved pasture with native tree canopy (FAC); Agricultural Land (FAG); Permanent easements (FPE); Plantation for silviculture – softwood (FPS); Unverified plantations for silviculture (FPU); Extra urban miscellaneous (FUM); Urban areas (FUR) and Weed infestation (FWU), but does not include: *Pteridium esculentum* fernland (FPF); Plantations for silviculture – hardwood (FPH) and Regenerating cleared land (FRG)]. The remaining native vegetation on the island accounts for 39,352 ha [Calculation of native vegetation includes 'Wet eucalypt forest and woodland', 'Dry eucalypt forest and woodland', 'Non-eucalypt forest and woodland', 'Scrub, heathland and coastal complexes', 'Native grassland', 'Saltmarsh and wetland', FPF, FPH and FRG, but does not include: Water, sea (OAQ), Lichen lithosere (ORO) and Sand, mud (OSM)]

King Island is made up of 39 TASVEG Mapping Units, 29 of which are native vegetation communities (Table 1).

Table 1. TASVEG Mapping Units for King Island [Figures accessed from TASVEG Live (NRET) as at February 10, 2022. For the purposes of this report (FPH) Plantations for silviculture – hardwood is treated as a native vegetation type rather than 'Modified land' on the basis that it is native in structure and floristics except for the dominant eucalypts (*E. obliqua* or *E. nitida*) and is suitable habitat for King Island Brown Thornbill and used by King Island Scrubtit]

TASVEG Mapping Unit	Code	Area (Ha)
(AHF) Fresh water aquatic herbland	AHF	240.1
(AHL) Lacustrine herbland	AHL	171.9
(ARS) Saline sedgeland/rushland	ARS	45.8
(ASF) Freshwater aquatic sedgeland and rushland	ASF	6.7
(ASS) Succulent saline herbland	ASS	38.9
(AWU) Wetland (undifferentiated)	AWU	335.3
(DKW) King Island eucalypt woodland	DKW	2,793.6
(DOV) *Eucalyptus ovata* forest and woodland	DOV	601.0
(FAG) Agricultural land	FAG	70,396.9
(FPF) *Pteridium esculentum* fernland	FPF	252.8
(FPH) Plantations for silviculture – hardwood	FPH	281.8
(FPS) Plantations for silviculture – softwood	FPS	207.9
(FPU) Unverified plantations for silviculture	FPU	0.6
(FRG) Regenerating cleared land	FRG	1,064.5
(FUM) Extra-urban miscellaneous	FUM	315.2
(FUR) Urban areas	FUR	206.3

TASVEG Mapping Unit	Code	Area (Ha)
(FWU) Weed infestation	FWU	87.3
(GHC) Coastal grass and herbfield	GHC	564.9
(GSL) Lowland grassy sedgeland	GSL	1.4
(NAF) *Acacia melanoxylon* swamp forest	NAF	136.8
(NAR) *Acacia melanoxylon* forest on rises	NAR	426.1
(NLE) *Leptospermum* forest	NLE	162.7
(NME) *Melaleuca ericifolia* swamp forest	NME	3,661.4
(OAQ) Water, sea	OAQ	273.9
(ORO) Lichen lithosere	ORO	17.2
(OSM) Sand, mud	OSM	438.4
(SAL) *Acacia longifolia* coastal scrub	SAL	370.3
(SCA) Coastal scrub on alkaline sands	SCA	4,471.1
(SCH) Coastal heathland	SCH	262.6
(SLG) *L. glaucescens* heathland and scrub	SLG	68.8
(SLL) *Leptospermum lanigerum* scrub	SLL	21.7
(SLS) *Leptospermum scoparium* heathland and scrub	SLS	1,447.5
(SMR) *Melaleuca squarrosa* scrub	SMR	1,887.7
(SRH) Rookery halophytic herbland	SRH	93.4
(SSC) Coastal scrub	SSC	220.4
(SSK) Scrub complex on King Island	SSK	15,119.2
(SSZ) Spray zone coastal complex	SSZ	245.6
(WBR) *Eucalyptus brookeriana* wet forest	WBR	2,080.1
(WGK) *Eucalyptus globulus* King Island forest	WGK	1,928.4
Grand Total		**113,918.1**

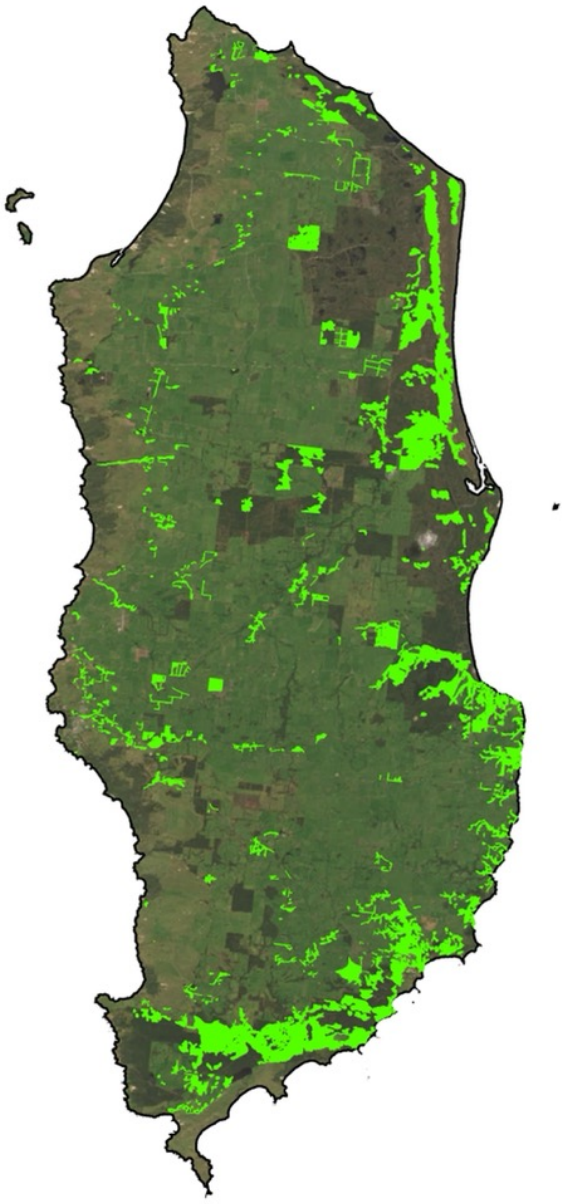
Threatened forest vegetation communities

Five of the seven forest vegetation communities recorded on the Island are listed as threatened under Schedule 3a of the Tasmanian, *Nature Conservation Act 2002* (NC Act) including: *Eucalyptus brookeriana* wet forest (WBR), *Eucalyptus ovata* forest and woodland (DOV), *Eucalyptus globulus* King Island forest (WGK), King Island eucalypt woodland (DKW) and *Melaleuca ericifolia* swamp forest (NME). Both WBR and DOV vegetation communities are also likely to fit the description of the threatened ecological community (TEC) listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), i.e., 'Tasmanian Forests and Woodlands dominated by black gum or Brookers gum (*Eucalyptus ovata* / *E. brookeriana*)'.

Eucalypt forests make up 18.8% of the remaining vegetation on King Island, dry eucalypt forests 8.6% and wet eucalypt forest 10.2%. Of the wet eucalypt forest communities WBR makes up 5.3% and WGK makes up 4.9% of the remaining native

vegetation on the Island. NME makes up 9.3% of the remaining vegetation on the Island though most of the patches of this vegetation community are small, fragmented and isolated from large contiguous patches of native forest. All forest vegetations communities account for 30% of the remaining vegetation on King Island (Figure 1).

Figure 1. *Distribution of forest (eucalypt and non-eucalypt) vegetation communities on King Island according to Tasveg Live (NRET) as at February 10, 2022.*
[Distribution overlaid on recent satellite image]



Non-threatened forest vegetation communities

Acacia melanoxylon swamp forest (NAF) and *Acacia melanoxylon* forest on rises (NAR) may have originally occupied a substantial area of the Island prior to settlement but are now distributed over many small fragmented patches, often associated with significant drainage lines. Combined with *Leptospermum* forest

(NLE) these non-threatened forest communities have an extent of 426 ha and only 1% of King Island's remaining native vegetation.

Scrub vegetation communities

Scrub communities are the most common vegetation type on King Island and make up about 60% of the remaining native vegetation on the Island. Scrubs are usually made up of a mixture of shrubs, generally less than 8 m in height. However, those occurring on more fertile substrates dominated by *Melaleuca* or *Leptospermum* are often seral stages in the succession to forest communities (Barnes *et al.* 2002; Kitchener and Harris 2021).

Scrubs, heathlands and the diverse complexes that they may form are, with a few notable exceptions, dominated by scleromorphic species. The canopy structure of the woody plants in these communities varies from 30 to 100% solid crown cover and are usually 5 m or less in height. While this height is the arbitrary divide between forest (including woodland) and scrub (Specht 1970), taller vegetation is included in these mapping units when it maintains a dense scrubby structure and/or a floristic composition indistinguishable from communities typically 5 m or less in height (Kitchener and Harris 2021)

Some of the scrub communities contain species that have the potential to reach >5 m in height and so, in the absence of disturbance such as fire, can be considered tree species for the purposes of the *Forest Practices Act 1985* and may require an FPP if subject to clearing.

Melaleuca squarrosa scrub (SMR) generally occurs on poorly drained peat or sandy peat soils and is usually dominated by *M. squarrosa* on King Island. *Banksia marginata* and *Acacia mucronata* can be common. *Melaleuca squarrosa* scrub is considered, in the absence of fire, an early succession pathway to *Leptospermum lanigerum – Melaleuca squarrosa* swamp forest (NLM) and is usually distinguished from NLM as being less than 5 m in height (Kitchener and Harris 2021).

Leptospermum scoparium heathland and scrub (SLS) includes dry heathlands and scrub up to 5 m tall, commonly dominated by *L. scoparium*. Other common species include *Allocasuarina monilifera*, *Monotoca glauca* or *Pultenaea daphnoides*. Patches of SLS resulting from land clearance may over time progress to woodland or forest if eucalypt seedlings are present. In the absence of eucalypts this community may succeed to *Leptospermum* forest (NLE) or *Leptospermum scoparium-Acacia mucronata* forest (Kitchener and Harris 2021).

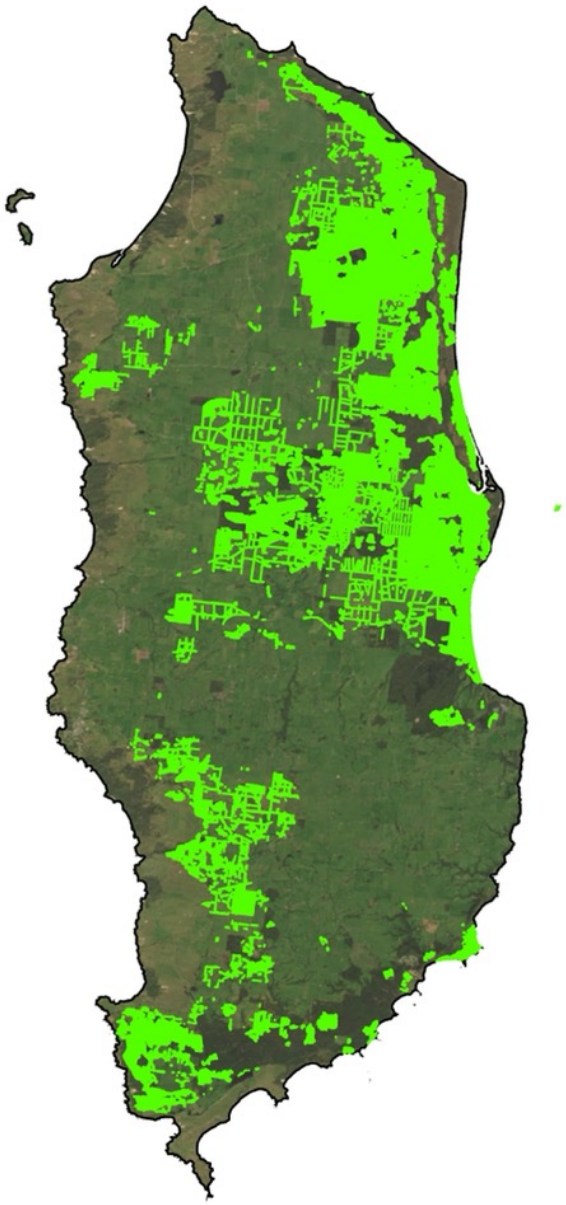
Leptospermum lanigerum scrub (SLL) is dominated by *L. lanigerum* with height generally 2-8 m tall. While little of this community has been mapped on King Island it is likely to occur within other mapping units on the Island. The species diversity in SLL is usually low. The community is often maintained by frequent disturbance, both as a result of fire, and also clearing. On King Island small patches of SLL are included in Scrub complex on King Island (SSK) (Kitchener and Harris 2021).

Scrub complex on King Island (SSK) is endemic to King Island and comprises a successional series of vegetation communities from sedgeland through heathland and onto scrub. It is by far the most extensive vegetation community mapped on the Island making up about 63% of the scrub vegetation and 38% of the Island's extant vegetation (Figure 2). SSK typically occurs on acidic sandy soils in the Eldorado Land system and other undulating flats on the Island.

The sedgelands are dominated by graminoids often with emergent shrubs such as *Melaleuca* and *Leptospermum* present while the heathlands are dominated by *Leptospermum* and *Melaleuca* with heath species from the families Fabaceae (pea family) and Epacridaceae (epacrids) being common.

Figure 2. *Distribution of the scrub vegetation community 'Scrub complex on King Island' (SSK), according to Tasveg Live (NRET) as at February 10, 2022.*

[Distribution overlaid on recent satellite image]



The scrub component is typically dominated by *Melaleuca squarrosa*, *Leptospermum scoparium*, *Acacia mucronata*, *Banksia marginata* and/or *Allocasuarina monilifera*, and often in wetter sites the canopy can be dense, shading out the heath species. *Eucalyptus viminalis* and *E. brookeriana* can be emergent above the tall shrubs. Succession to woodland and forest vegetation occurs, albeit slowly and is determined by soil fertility, waterlogging and fire frequency (Barnes *et al.* 2002).

Prior to European settlement Scrub complex on King Island (SSK) was thought to occupy most of the undulating plains on King Island but much of it has been cleared for pasture. Analysis of current and modelled pre-1750 distribution suggests that up to 60% of its original distribution may have been lost (Rod Knight pers. comm. 2021). While some large blocks of this vegetation type occur, over 1000 ha of the

community occurs in patches less than 10 ha in size and is also subject to gradual deterioration and continuing decline.

Comparison of TASVEG 3 with TASVEG Live in 2018, indicated that considerable clearing of native vegetation types has occurred on King Island since the introduction of the Tasmanian Forest Practices System in 1985, with SSK continuing to be cleared and further fragmented, mainly prior to 2000.

The mapping of SSK is difficult with current aerial and satellite imagery and it is likely that areas of other vegetation communities are found within the current mapped extent. *Eucalyptus globulus* King Island forest (WGK), King Island eucalypt woodland (DKW) and *Melaleuca ericifolia* swamp forest (NME) also occur on acid sands and frequently grade into SSK suggesting that the actual extent of SSK is substantially less than is currently thought.

The Tasmanian Vegetation Mapping Program (NRET) recommends that 'Areas of scrub, heath or sedgeland on King Island, especially in the Eldorado Land System, should be mapped as SSK unless they are sufficiently large and temporally stable vegetation matching another scrub or heathland unit' (Kitchener and Harris 2021).

Other non-forest vegetation communities

In recent surveys, King Island Brown Thornbill has been recorded in the TASVEG mapping units Scrub complex on King Island (SSK) and Coastal scrub on alkaline sands (SCA). Further, vegetation patches on King Island can typically contain a mosaic of forest and non-forest vegetation types. Therefore, it is pertinent to include some background information and discussion on the extent and conservation status of all non-forest vegetation types on King Island, irrespective of their potential to support King Island Brown Thornbill or King Island Scrubtit.

Freshwater aquatic herbland (AHF), Lacustrine herbland (AHL), Saline sedgeland/rushland (ARS), Freshwater aquatic sedgeland and rushland (ASF), Succulent saline herbland (ASS) and Wetland undifferentiated (AWU) are wetland and saltmarsh communities with an aerial extent of 839 ha on King Island. The freshwater components of wetland vegetation communities are threatened under the NC Act while the saltmarsh communities are listed as Vulnerable under the EPBC Act i.e., 'Subtropical and Temperate Coastal Saltmarsh'. Rookery halophytic herbland (SRH) and Spray zone coastal complex (SSZ) are threatened under the NC Act, with a combined aerial extent of 339 ha.

Other native non-forest vegetation communities on King Island are non-threatened and include Coastal scrub (SSC), *Leptospermum glaucescens* heathland and scrub (SLG), Coastal heathland (SCH), *Acacia longifolia* coastal scrub (SAL), Coastal grass and herbfield (GHC), Coastal scrub on alkaline sands (SCA) and *Pteridium esculentum* fernland (FPF). They occupy a combined aerial extent of 5957 ha.

Native Flora of King Island

The flora of King Island contains elements with affinities to both mainland Tasmania and Victoria. Some species that are listed as threatened under the TSP Act are also present in Victoria but do not occur on the Tasmanian mainland such as Austral Mulberry *Hedycarya angustifolia*, Blueberry Ash *Elaeocarpus reticulatus* and Bootlace Bush *Pimelea axiflora* subsp*. axiflora*. Several species of flora have become extinct on King Island since European settlement including Celerytop Pine *Phyllocladus aspleniifolius*, Coast Banksia *Banksia integrifolia* subsp. *integrifolia* and Sticky Longheads *Podotheca angustifolia*.

Of about 470 vascular flora species recorded on King Island, 46 are listed as threatened under the TSP Act and/or the EPBC Act (Table 2).

Table 2. Threatened flora species on King Island

Scientific name	Common name	TSP Act status	EPBC Act status
Australina pusilla subsp. *muelleri*	shade nettle	rare	
Austrocynoglossum latifolium	forest houndstongue	rare	
Banksia integrifolia subsp. *integrifolia*	coast banksia	presumed extinct	
Caladenia pusilla	tiny caladenia	rare	
Callitriche sonderi	matted waterstarwort	rare	
Centipeda cunninghamii	common sneezeweed	rare	
Cotula vulgaris var. *australasica*	slender buttons	rare	
Cyathea cunninghamii	slender treefern	endangered	
Cyathea x *marcescens*	skirted treefern	endangered	
Cyrtostylis robusta	large gnat-orchid	rare	
Elaeocarpus reticulatus	blueberry ash	rare	
Gratiola pubescens	hairy brooklime	rare	
Haloragis myriocarpa	prickly raspwort	rare	
Hedycarya angustifolia	Australian mulberry	rare	
Hypolepis distans	scrambling groundfern	endangered	Endangered
Hypolepis muelleri	harsh groundfern	rare	
Juncus vaginatus	clustered rush	rare	
Lepilaena patentifolia	spreading watermat	rare	
Leucopogon lanceolatus var. *lanceolatus*	lance beardheath	rare	
Myriophyllum muelleri	hooded watermilfoil	rare	
Orthoceras strictum	horned orchid	rare	
Parietaria debilis	shade pellitory	rare	
Persicaria decipiens	slender knotweed	vulnerable	
Phyllangium distylis	tiny miterwort	rare	
Phylloglossum drummondii	pigmy clubmoss	rare	
Pimelea axiflora subsp*. axiflora*	bootlace bush	endangered	
Pneumatopteris pennigera	lime fern	endangered	
Poa halmaturina	dune tussockgrass	rare	
Podotheca angustifolia	sticky longheads	presumed extinct	
Pomaderris paniculosa subsp. *paralia*	shining dogwood	rare	
Pterostylis cucullata subsp. *cucullata*	leafy greenhood	endangered	Vulnerable
Pterostylis sanguinea	banded greenhood	rare	

Scientific name	Common name	TSP Act status	EPBC Act status
Schoenoplectus tabernaemontani	river clubsedge	rare	
Senecio psilocarpus	swamp fireweed	endangered	Vulnerable
Solanum opacum	greenberry nightshade	endangered	
Stuckenia pectinata	fennel pondweed	rare	
Stylidium beaugleholei	fan triggerplant	rare	
Stylidium despectum	small triggerplant	rare	
Stylidium perpusillum	tiny triggerplant	rare	
Taraxacum cygnorum	coast dandelion		Vulnerable
Thelymitra holmesii	bluestar sun-orchid	rare	
Thelymitra malvina	mauve tufted sun-orchid	endangered	
Tmesipteris parva	small forkfern	vulnerable	
Triglochin minutissimum	tiny arrowgrass	rare	
Trithuria submersa	submerged watertuft	rare	
Utricularia tenella	pink bladderwort	rare	

Native Fauna of King Island

A number of animal species have been lost from King Island since European settlement. The first extinction recorded from the island was the King Island Emu *Dromaius ater* which was the result of commercial sealers hunting the bird for food. The Grey Goshawk *Accipiter novaehollandiae* was recorded by the Field Naturalists Club of Victoria after their visit in 1887 but there was no further reporting following the shooting of two birds which were killing young turkeys in 1912 (Donaghey 2003).

Glossy Black-cockatoo *Calyptorhynchus lathami* once occurred on the Island but disappeared around 1920 after extensive fires. Gang-gang Cockatoos *Callocephalon fimbriatum* were also once abundant on the island when large areas of eucalypt forest occurred. Forty-spotted pardalote *Pardalotus quadragintus* was recorded during the Victorian Field Naturalists visit of 1887 but has not been recorded since (Donaghey 2003). Yellow-tailed Black Cockatoo *Zanda funerea* and Sulphur-crested Cockatoo *Cacatua galerita* face the threat of local extinction on King Island due to the long-term demise of large old *Eucalyptus globulus* trees supporting large hollows.

Many mammal extinctions have occurred on King Island since European settlement including the Southern Elephant Seal *Mirounga leonina*, Spotted-tailed Quoll *Dasyurus maculatus* and Wombat *Vombatus ursinus* (Donaghey 2003). Native mammals that appear to now be quite rare with restricted distributions on the Island include the Swamp Antechinus *Antichinus minimus*, Eastern Pigmy Possum *Cercartetus nanus* and Long-nosed Potoroo *Potorous tridactylus* (Donaghey 2003).

King Island is home to a number of threatened species in addition to those that have become extinct. This includes two species of migratory parrot (Orange-bellied Parrot *Neophema chrysogaster* and Swift Parrot *Lathamus discolor*) as well as a number of subspecies of birds that are only found on the Island, which have conspecifics found on mainland Tasmania. These are the King Island Green Rosella *Platycercus caledonicus brownie*, King Island Scrubtit *Acanthornis magna greeniana*, King Island Brown Thornbill *Acanthiza pusilla archibaldi* and King Island Black Currawong *Strepera fuliginosa colei*. Eight of King Island's vertebrate species are listed as threatened under the TSP Act and/or the EPBC Act (Table 3)

Table 3. Threatened vertebrates on King Island

Scientific name	Common name	TSP Act status	EPBC Act status
Acanthiza pusilla archibaldi	King Island Brown Thornbill	endangered	Endangered
Acanthornis magna greeniana	King Island Scrubtit	endangered	Critically endangered
Austrochloritis victoriae	Southern Hairy Red Snail	vulnerable	
Haliaeetus leucogaster	White-bellied Sea Eagle	vulnerable	
Limnodynastes peronii	Striped Marsh Frog	endangered	
Litoria raniformis	Green and Gold Frog	vulnerable	Vulnerable
Neophema chrysogaster	Orange-bellied Parrot	endangered	Critically endangered
Platycercus caledonicus brownii	King Island Green Rosella	vulnerable	
Prototroctes maraena	Australian Grayling	vulnerable	Vulnerable
Botaurus poiciloptilus	Australasian Bittern		Endangered
Sternula albifrons sinensis	Little Tern	endangered	Migratory
Sternula nereis nereis	Fairy Tern	vulnerable	Vulnerable

A number of insects are also likely to have become locally extinct since European settlement but specific information is lacking (TSS 2012). The Southern Hairy Red

Snail, listed as vulnerable in Tasmania, was rediscovered in wet forest near the east coast in 1996 (Donaghey 2003).

The loss of structural and floristic diversity and the low mean age class of forest vegetation communities has had a dramatic impact on the fauna that forest vegetation supports. Many species that rely on old growth elements of forests such as tree hollows or coarse woody debris have become uncommon or threatened (Barnes *et al.* 2002; TSS 2012).

Two of the Island's threatened birds, King Island Scrubtit and King Island Brown Thornbill, are amongst the top three bird species in Australia, estimated through an expert elicitation process, to be most likely to become extinct in the next 20 years. The Orange-bellied Parrot (a passage migrant on King Island) is also in the top three most imperilled bird species in Australia. The Swift Parrot is regularly sighted on King Island and likely to have bred on King Island prior to the loss of the extensive mature *Eucalyptus globulus* and *E. brookeriana* forests in the Island. The Swift Parrot ranks at number 13 of the bird species most imperilled in Australia (Geyle *et al.* 2018).

The King Island Black Currawong was listed as Vulnerable under the EPBC Act in 2015 but did not require the making of a recovery plan as recovery actions were considered to be adequately covered by the King Island Biodiversity Management Plan (TSSC 2015).

King Island Scrubtit

The King Island Scrubtit is listed as Endangered on the Tasmanian, *Threatened Species Protection Act 1995* (TSP Act) and Critically Endangered on the Commonwealth, *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

King Island Scrubtit (Photo by Mark Holdsworth)

The King Island Biodiversity Management Plan (KI BMP) was prepared under the provisions of the EPBC Act 1999 and was adopted by the Australian Government as the national recovery plan for the King Island Scrubtit in 2012. The KI BMP recognises that a substantial area of King Island had been cleared for agriculture and drained since European settlement and that the main threat to the subspecies is habitat loss through land clearance and fire (TSS 2012).

Key management objectives of the KI BMP include, to maintain and improve the extent of vegetation, including quality, connectivity and functionality for priority species on King Island and to stop the decline and retain presence of King Island Scrubtit at known sites. Key actions for maintenance and recovery of King Island Scrubtit includes, among other actions, to continue to strengthen current measures for retention and rehabilitation of remaining wet forest and swamp forest vegetation on King Island and to develop management guidelines in consultation with landowners for protecting remaining habitat from land clearance and drainage (TSS 2012).

The KI BMP identifies habitat critical for the survival of King Island Scrubtit as including the sites with known subpopulations (Nook Swamps and Colliers Swamp), and all patches of wet sclerophyll forest and swamp forest.

In 2018, an Australian scientific forum involving an expert elicitation process ranked King Island Scrubtit as the third most likely Australian avian extinction to occur within the next 20 years, with an estimated extinction probability of 83% (Geyle *et al.* 2018).

The very high probability of extinction of the King Island Scrubtit led to priority status for the subspecies for recovery actions by the Australian Government. The Minister for Environment and Water released the Threatened Species Action Plan: Towards Zero Extinctions in October 2022. The plan sets out a pathway for threatened species conservation and recovery over the next 10 years and includes preventing any new extinctions of plants and animals. The plan includes an Australian wide priority list of 110 threatened species.

King Island Scrubtit habitat in Nook Swamps, Lavinia State Reserve

The King Island scrubtit was historically known to occur at the Pass River, Yellow Rock and Yarra Creek (Green and McGarvie 1971) but is thought to have disappeared from these locations during the 1990's (Donaghey 2011). Surveys by Webb et al. (2016) failed to detect the King Island Scrubtit at these locations and reported remaining vegetation as being highly degraded or unsuitable for the subspecies.

A dedicated survey by Webb and Crates (2019), involving repeat surveys at over 200 sites, extended the distribution of the King Island Scrubtit within Pegarah State Forest (previously only recorded on the Fraser River), to include linear patches of habitat along several other drainage lines. Webb and Crates (2019) recognised other parts of the Island had not been surveyed in detail or at all and that it was probable small pockets of currently suitable, and possibly occupied habitat for the King Island Scrubtit may exist. Subsequent surveys (e.g. Webb and Bell 2020; Holdsworth 2019; Baker and Holdsworth 2019) did not identify new locations for the King Island Scrubtit.

Webb and Crates (2019) found that where King Island Scrubtits were detected *M. ericifolia* was present in the canopy at 80% of sites, the canopy cover was >30% at all sites, only 46% of sites supported a notable midstorey with >20% cover and 88% of sites supported an understorey with >30% cover.

Webb *et al.* (2016) recognised common habitat features at known sites of King Island Scrubtit to include *M. ericifolia* forest or other forest communities where *M. ericifolia* is subdominant, the presence of at least some relatively mature *M. ericifolia* trees and the presence of a complex understorey and/or forest debris (eg. fallen trees and branches). Webb and Crates (2019) noted that at a proportion of sites where King Island Scrubtit was detected at Pegarah State Forest, *M. ericifolia* was absent or not a canopy species. Nonetheless, *M. ericifolia* was usually present nearby to these sites.

Webb and Crates (2019) noted the apparent ability of the King Island Scrubtit to persist in small remnant patches of habitat for well over a decade. They made several observations of what were presumed to be family groups (i.e. >2 individuals) suggesting that successful breeding may have been occurring. Such small patches are unlikely to be viable over longer time frames. Though, with appropriate management actions a viable population might be maintained over the time frame required to increase habitat availability, area of occupancy and ultimately, population size.

Holdsworth *et al.* (2021) reconfirmed the assessment of a small population size of the King Island Scrubtit (i.e., not likely to exceed 50 individuals), and a continuing decline assumed on a precautionary basis given the pressures on the subspecies. The ecology of King Island Scrubtit is little studied (Holdsworth *et al.* 2021).

King Island Brown Thornbill

The King Island Brown Thornbill is listed as Endangered on both the Tasmanian, *Threatened Species Protection Act 1995* (TSP Act) and the Commonwealth, *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

King Island Brown Thornbill (Photo by Barry Baker)

The King Island Biodiversity Management Plan (KI BMP) was prepared under the provisions of the EPBC Act 1999 and was adopted by the Australian Government as the national recovery plan for the King Island Brown Thornbill in 2012. The KI BMP recognises that a substantial area of King Island had been cleared for agriculture and drained since European settlement and that the main threat to the subspecies is habitat loss through land clearance and fire (TSS 2012).

Key management objectives of the KI BMP include, to maintain and improve the extent of vegetation (including quality, connectivity and functionality) for priority species including the King Island Brown Thornbill, and to stop the decline and retain presence of the subspecies at known sites. Key actions for maintenance and recovery of King Island Brown Thornbill includes, among other actions, to continue to strengthen current measures for retention and rehabilitation of remaining wet forest and swamp forest vegetation on King Island and to develop management guidelines in consultation with landowners for protecting remaining habitat from land clearance and drainage (TSS 2012).

The KI BMP identifies habitat which is critical to the survival of King Island Brown Thornbill to include all remaining patches of potential habitat, including wet forest and wet scrub.

In 2018, an Australian scientific forum involving an expert elicitation process ranked King Island Brown Thornbill as the most likely Australian avian extinction to occur within the next 20 years, with an estimated extinction probability of 94% (Geyle *et al.* 2018).

The very high probability of extinction of the King Island Brown Thornbill led to priority status for the subspecies for recovery actions by the Australian Government. The Minister for Environment and Water released the Threatened Species Action Plan: Towards Zero Extinctions in October 2022. The plan sets out a pathway for threatened species conservation and recovery over the next 10 years and includes preventing any new extinctions of plants and animals. The plan includes an Australian wide priority list of 110 threatened species.

King Island Brown Thornbill habitat, private land, Bold Head Road

King Island Brown Thornbill abundance has been described as ‘extraordinarily scarce’ with only a dozen or so confirmed records prior to 2019. After being recorded in Pegarah State Forest in 1968 and Loorana in 1971 (Green and McGarvie 1971; McGarvie and Templeton 1974), the King Island Brown Thornbill was considered to be ‘possibly extinct’ until being sighted in Pegarah State Forest in 2002. Since 2002, only a handful of sightings have been reported, all of which have been in Pegarah State Forest (Webb & Crates 2019).

Surveys in 2019 found King Island Brown Thornbill at 35 sites in Pegarah State Forest and several small forest remnants to the west, near Counsel Hill in the north and at several sites in the south of the Island including Gentle Annie Conservation Area, Yarra Creek, Seal River Reserve, Kentford Forest Conservation Area and Grassy Harbour (Baker and Holdsworth 2019, Holdsworth 2019; Webb and Crates 2019; Webb and Bell 2020).

Very little is known about the ecology of King Island Brown Thornbills. They likely feed mainly on insects and have been observed foraging on hanging bark and crevices of eucalypts, and foraging up and down young Swamp Paperbark *Melaleuca ericifolia* trunks (Webb and Crates 2019; Webb and Bell 2020).

No breeding information currently exists for the King Island subspecies. However, breeding is likely similar to Brown Thornbills on mainland Tasmania, which breed from August to January. Nests are a small dome, usually placed on or near the ground, and usually in or below low shrubs, sedges, or ferns (Higgins & Peter 2002).

McGarvie and Templeton (1971) netted two King Island Brown Thornbills at Loorana in 1971. They described the location as open farmland crossed by hedges of boxthorn with small stands of paperbarks.

Green and McGarvie (1971) recorded King Island Brown Thornbill in Pegarah State Forest in wet forest dominated by Blue Gum *Eucalyptus globulus*, with an understorey of *Melaleuca ericifolia*, Common Dogwood *Pomaderris apetala* and Goldey Wood *Monotoca glauca* (DCCEEW 2022).

Observations of King Island Brown Thornbill in the Pegarah State Forest in 1971 described the subspecies' habitat as dense mixed scrub about 10 m tall, comprising mostly *Eucalyptus* regrowth, Prickly Moses *Acacia verticillata*, Caterpillar Wattle *Acacia mucronata*, Blackwood *Acacia melanoxylon*, Silver Banksia *Banksia marginata*, Satinwood *Nematolepis squamea*, Common Teatree *Leptospermum scoparium*, Pink Beard-heath *Leucopogon ericoides*, Tree Broom-heath *Monotoca elliptica* and Bracken *Pteridium esculentum* (Green and McGarvie 1971).

Eucalypts (including *Eucalyptus brookeriana*, *E. viminalis*, *E. globulus*, *E. obliqua*) were present at all sites the King Island Brown Thornbill were detected by Webb and Crates (2019), either dominating the canopy or occurring as a subdominant component of the canopy. Midstorey and understorey cover varied from zero to >50% cover. Foraging was observed in *Melaleuca ericifolia* and *Banksia marginata* (Webb and Crates 2019).

Webb and Bell (2020) revisited some sites at Pegarah State Forest where King Island Brown Thornbill were detected by Webb and Crates (2019) and collected detailed site-level vegetation/habitat information. Sites where habitat characteristics were described for the King Island Brown Thornbill in Pegarah State Forest, were in either *Eucalyptus brookeriana*, *E. viminalis* and/or *E. globulus* dominated forest, and *E. obliqua* plantation. Sites were characterised by:

- Eucalypt forest structure with a dominant canopy cover between 30-80%
- Average height of dominant eucalypt strata between 20-35 m
- High stem density of eucalypts in the dominant strata with mean DBH between 20-50 cm (individual trees ranging from 10-70 cm)
- Complex understorey/midstorey strata of trees and shrubs
- Damp to wet eucalypt forest understorey species with *Monotoca glauca* present at 100% of sites and *Nematolepis squamea*, *Elaeocarpus reticulatus* and *Melaleuca ericifolia* present at >50% of sites
- Ground layer dominated by *Gahnia grandis* and/or *Pteridium esculentum* between 5-80% cover
- Ground more or less 100% cover of eucalypt leaf litter and fine woody debris
- Adjacent vegetation types ranged from similar eucalypt forest (including *E. obliqua* plantation) to dense tall, closed scrub (dominated by *Leptospermum scoparium*, *Acacia mucronata* and/or *Melaleuca squarrosa*), to *Pinus radiata* plantation.

Based on previous studies including Green and McGarvie (1971), Donaghey (2003), Webb and Crates (2019) and Webb and Bell (2020), there is little doubt that eucalypts comprise an important component of King Island Brown Thornbill habitat with many observations of the species foraging in hanging bark and other crevices in eucalypts. Nonetheless, observations of foraging by the subspecies in *Melaleuca*

ericifolia, *Banksia marginata* and other trees and shrubs highlight the limited understanding of the subspecies' ecology (Webb and Bell 2020).

Methods

Survey sites

The King Island Brown Thornbill and King Island Scrubtit survey design aimed to stratify sampling across forest and scrub TASVEG mapping units, tenures, properties, regions, and patch sizes and shapes. The actual survey design was determined by time, logistics and access to private land.

Survey sites from recent studies were incorporated into the current Project, including survey sites established by Baker and Holdsworth (2019), Holdsworth (2019), Webb and Crates (2019) and Webb and Bell (2020).

Interrogation of TASVEG (The Digital Vegetation Map of Tasmania) was undertaken to determine the general distribution of forest and scrub vegetation communities and inform the preliminary scope and design for the survey. TASVEG was supplemented by available satellite imagery to determine the likely maturity of the vegetation. Nonetheless, the selection of survey locations and sites was ultimately determined by landowner consent and feasibility of access.

Recent surveys (e.g., Webb and Crates 2019; Webb and Bell 2020) detected King Island Brown Thornbill in Scrub complex on King Island (SSK), so this vegetation community was targeted for inclusion in the survey. Not only can SSK occur in a mosaic with eucalypt and *Melaleuca ericifolia* dominated forest but *M. ericifolia* and/or eucalypt species are often components of the broader concept of SSK. Coastal scrub on alkaline sands (SCA) was also targeted for inclusion in the survey. SCA can exceed 5 m in height and can support localised occurrences of *M. ericifolia* and/or eucalypt forest within the broader concept of SCA, particularly in deep dune swales.

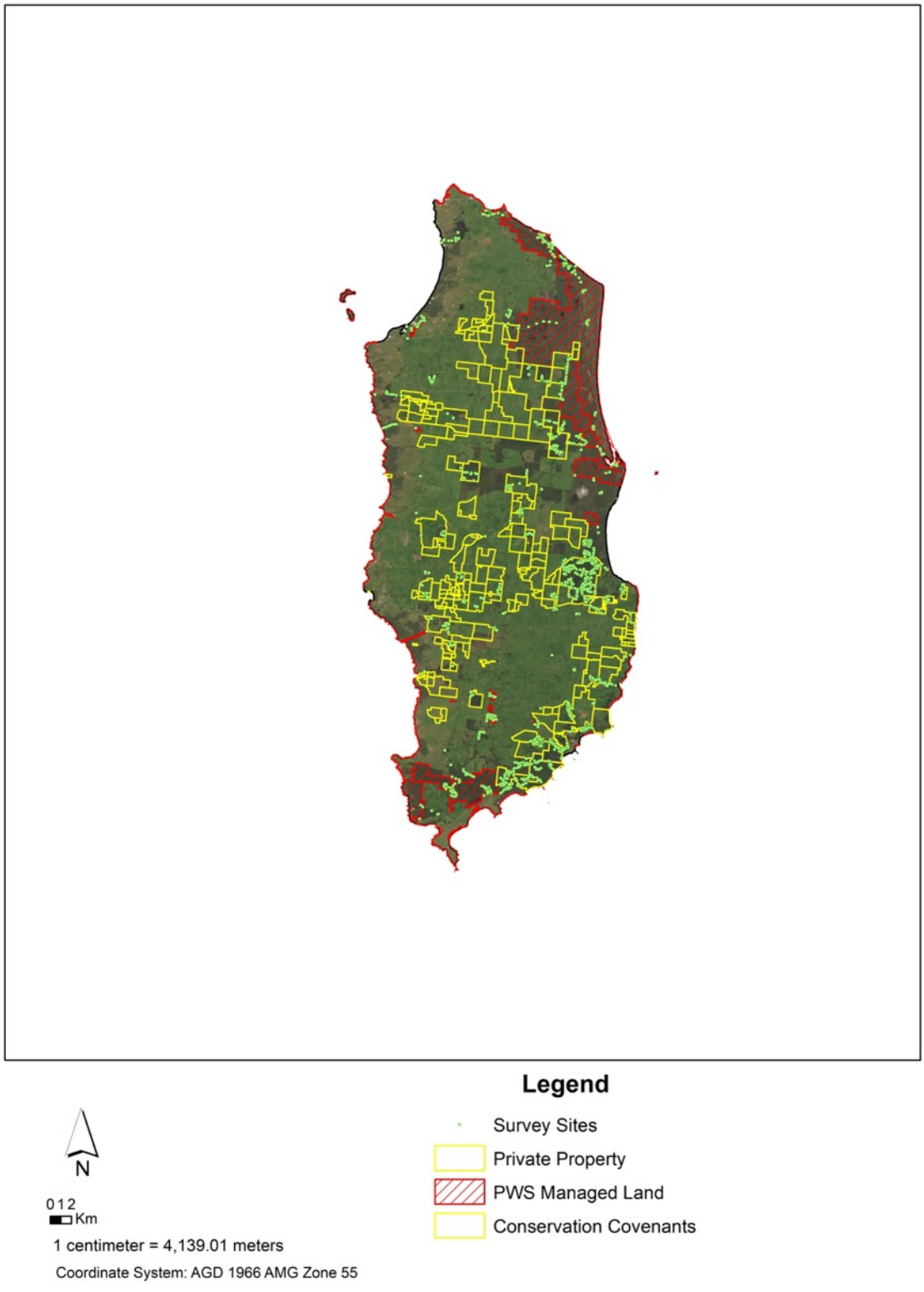
The importance of vegetation communities containing eucalypts for King Island Brown Thornbill and vegetation communities containing *Melaleuca ericifolia* for King Island Scrubtit has been well established by previous studies (e.g., Webb and Crates; Webb and Bell 2020). Consequently, the survey targeted the range of forest vegetation communities on King Island known to support eucalypts and/or *M. ericifolia*, including *M. ericifolia* swamp forest (NME), *Leptospermum* forest (NLE), *Acacia melanoxylon* swamp forest (NAF) *A. melanoxylon* forest on rises (NAR), *Eucalyptus brookeriana* wet forest (WBR), *E. globulus* King Island forest (WGK), King Island eucalypt woodland (DKW) and *E. ovata* forest and woodland.

Ultimately the survey attempted to maximise the spatial coverage of forest and scrub vegetation across the Island. Figure 3 shows the distribution of public land, conservation covenants and other private land where consent was provided to the Project to undertake bird surveys.

Vegetation/habitat assessment

The TASVEG vegetation community and other habitat covariates were recorded at survey sites. The most basic habitat covariate recorded at survey sites was TASVEG vegetation community. More detailed descriptions of habitat covariates were recorded at many survey sites. Detailed habitat assessment included recording up to 53 habitat covariates (Table 4), within a 30 m radius of the centre each survey site.

Figure 3. *Location of public land, private land parcels and private land conservation covenants where consent was provided to the Project to undertake bird surveys.* [Land parcels overlaid on recent satellite image]



A scientific permit to collect fauna and flora material for identification purposes was in place however, there was no threatened species material, or non-threatened flora material collected from reserved land (Fauna Permit No.: TFA 21056; Flora Permit No.: DA21016)

Table 4. Habitat covariates recorded at survey sites where detailed habitat descriptions were conducted

Habitat variable	Measurement/Category
TASVEG vegetation mapping unit	Code
Dominant tree canopy height	m
Dominant tree canopy cover	%
Dominant tree canopy species occupying >50% of the cover	Species name
Dominant tree canopy species occupying <50% of the cover 1	Species name
Dominant tree canopy species occupying <50% of the cover 2	Species name
Dominant tree canopy species occupying <50% of the cover 3	Species name
Dominant tree canopy species occupying <50% of the cover 4	Species name
Dominant tree canopy species occupying <50% of the cover 6	Species name
Dominant canopy eucalypt mean diameter at breast height	cm
Dominant canopy eucalypt low range diameter at breast height	cm
Dominant canopy eucalypt high range diameter at breast height	cm
Tree canopy *Acacia melanoxylon* high range diameter at breast height	cm
Tree canopy *Melaleuca ericifolia* low range diameter at breast height	cm
Tree canopy *Melaleuca ericifolia* low range diameter at breast height	cm
Understorey tree height	m
Understorey tree cover	m
Understorey tree species occupying >50% of the cover	Species name
Understorey tree species occupying <50% of the cover 1	Species name
Understorey tree species occupying <50% of the cover 2	Species name
Understorey tree species occupying <50% of the cover 3	Species name
Understorey tree species occupying <50% of the cover 4	Species name
Understorey tree species occupying <50% of the cover 5	Species name
Shrub layer low range height	m
Shrub layer high range height	m
Shrub layer cover	%
Shrub layer species occupying >50% of the cover	Species name
Shrub layer species occupying <50% of the cover 1	Species name

Habitat variable	Measurement/Category
Shrub layer species occupying <50% of the cover 2	Species name
Shrub layer species occupying <50% of the cover 3	Species name
Shrub layer species occupying <50% of the cover 4	Species name
Shrub layer species occupying <50% of the cover 5	Species name
Ground layer cover	%
Ground layer species occupying >50% of the cover	Species name
Ground layer species occupying <50% of the cover 1	Species name
Ground layer species occupying <50% of the cover 2	Species name
Ground layer species occupying <50% of the cover 3	Species name
Ground layer species occupying <50% of the cover 4	Species name
Ground layer species occupying <50% of the cover 5	Species name
Ground cover 'litter'	%
Ground cover 'herbs'	%
Ground cover 'moss'	%
Ground cover 'grass'	%
Ground cover 'coarse woody debris'	%
Ground cover 'fine woody debris'	%
Ground cover 'bare ground'	%
Ground cover species 1	Species name
Ground cover species 2	Species name
Ground cover species 3	Species name
Ground cover species 4	Species name

Bird surveys

At each survey site the latitude and longitude in decimal degrees was recorded using a hand-held Garmin GPS.

We typically used a rapid call-playback survey protocol for detection of King Island Brown Thornbill and King Island Scrubtit at survey sites. This protocol was similar to that developed by Webb *et al.* (2016).

Extended survey time was used at many sites as a substitute for repeat surveys, particularly where repeat surveys were not feasible. Low detectability of King Island Brown Thornbill and King Island Scrubtit using the rapid call-playback survey protocol constrains the implementation of an ideal (comprehensive and representative) sampling design. Both subspecies have an estimated detection probability (given presence) of about 0.3. There are trade-offs between the accessibility of sites and the number of repeat surveys that can be undertaken. Clearly, if birds are detected early in a repeat survey protocol then less resources are required to confirm presence. However, in presumably unsuitable habitats, several repeat surveys may be necessary to provide a high level of confidence of species absence. Many sites remain effectively inaccessible due to lack of vehicular access or occur in extensive

tracts of dense forest and scrub. In many cases there is little option but to extend survey effort during a single visit rather that revisit a site.

We used King Island Brown Thornbill and King Island Scrubtit song recordings to increase detectability of both birds during their respective surveys by broadcasting calls using portable speakers approximately every 20-30 seconds. [Animal Ethics Committee, DPIPWE advised on 29 January 2021 that ethics approval was not required for the survey protocol.]

Presence-absence and estimated abundance of King Island Brown Thornbills and King Island Scrubtits was recorded at each survey site. When we detected birds, we recorded the detection type as visual or audible.

We typically surveyed each site using two observers, each visually surveying approximately about half of the site area. We attempted to avoid surveying in rain or during periods when local wind speeds exceeded ~20 km per hour.

Matt Webb and David James conducting a 5-minute site survey for King Island Brown Thornbill and King Island Scrubtit in *Melaleuca ericifolia* swamp forest at Macks Creek, Colliers Swamp Conservation Area.

Drone aerial imagery

An unmanned aerial vehicle (UAV) and associated photogrammetry was used in September 2022 to provide detailed 2-3 cm aerial imagery of several King Island Brown Thornbill-present and King Island Scrubtit-present locations. Collection of this imagery was intended to inform more detailed TASVEG vegetation community mapping of King Island Brown Thornbill and King Island Scrubtit habitat and to develop 3D mapping for ongoing habitat analyses and condition monitoring.

The aerial survey acquisition dates were 16 September – 2 October 2022. There was no ground control used. Imagery was processed in DroneDeploy. The output pixel size was in the order of 3 cm.

Modelling approach

Modelling was performed using a machine learning approach called Bayesian additive regression trees (BART). BART is a classification tree method defined by a prior distribution and a likelihood for returning occurrence predictions, that enables the quantification of uncertainty around the predictions and the estimation of the marginal effects of the covariates (Chipman *et al.* 2010; Tan and Roy 2019). BART iteratively generates sets of trees based on a set of priors about tree structure and nodes, and builds a posterior distribution of estimated classification probabilities. To estimate the probability of a binary outcome (e.g., detection / non-detection), BART starts by generating and fitting a sum-of-trees model and then using Bayesian "backfitting" with a Markov chain Monte Carlo (MCMC) algorithm to create a posterior draw. BART models were run using 200 trees and 1000 back-fitting MCMC iterations, discarding 20% as burn-ins. After dropping the burn-in samples, the full set of sum-of-trees models across all samples from the Markov chain is treated as a posterior distribution and used to generate the posterior distribution of predictions. BART brings the conceptual familiarity and strengths of classification tree methods, but adds a relatively simple Bayesian component that inherently and intuitively handles model uncertainty (Yen *et al.* 2011; Carlson 2020, Baquero *et al.* 2021; Kougiomoutzis *et al.* 2021). The Bayesian structure of BART captures uncertainty within a single model with no need of bootstrapping (Carson 2020).

Model fitting performance was evaluated using the following measures: (i) RMSE, (ii) the area under the receiver operating characteristic curve (AUC), (iii) the classification accuracy, (iv) sensitivity, and (v) specificity. RMSE needs to be minimised, while the other metrics need to be maximised. In general, AUC values of ≥0.5 indicate better than random performance, ≥0.7 indicate adequate performance, and ≥0.8 indicate excellent performance (Hosmer 2000). To compute the classification accuracy, sensitivity and specificity, predictions were converted to binary predictions using TSS-maximisation thresholds (Scherrer *et al.* 2018; Zurell *et al.* 2020). The covariate importance was also estimated by measuring the proportion of total branches used for a given covariate.

A standardised and automated stepwise covariate selection was used to reduce their number. The algorithm starts with the full covariate set, fits a model, measures its root mean square error and discards the covariate with the lowest importance to fit a new model. Covariates are iteratively eliminated until there are only three covariates left. The final set of covariates is selected by minimising the root-mean squared error (RMSE).

Partial dependence plots show the response curves of an individual variable in the sum-of-trees models. The main line is the average of partial dependence plots for each posterior draw of sum-of-trees models, while the envelope shows the true Bayesian credible intervals (95% width).

Results

Distribution of survey sites

Figure 4 and 5 show the distribution of survey sites for King Island Brown Thornbill and King Island Scrubtit combining all surveys conducted between 2019 and 2022. The distribution of >1500 survey sites is considered to provide a good spatial coverage of suitable habitat for both these subspecies on King Island. Most surveys were conducted in forest and scrub vegetation along the north, east and south coast of the Island. Few surveys were conducted in the dune vegetation along the west coast, comprising mainly Coastal scrub on alkaline sands (SCA), though sufficient surveys were conducted to confirm general low suitability of this vegetation community for either King Island Brown Thornbill or King Island Scrubtit.

Figure 6 shows the locations where King Island Brown Thornbills were detected between 2019 and 2022. The subspecies was detected at 102 sites in total (combining data from Webb and Crates (2019), Holdsworth and Baker (2019), Webb and Bell (2020) and the current Project). No attempt has been made to assess the independence of these sampling sites.

For management purposes, King Island Brown Thornbill detection sites have been grouped into 16 locations. Location boundaries are arbitrary, but in most cases, locations are grouped detection sites that are within 2 km of each other (Figure 7).

1 ***Lake Martha Lavinia*** - includes 2 detections on the northeast shore of Lake Martha Lavinia in Lavinia State Reserve.

2 ***Counsel Hill North*** - a single detection on private land at Saltwater Creek adjacent to Lavinia State Reserve.

3 ***Counsel Hill South*** - includes detections on private land including 1 conservation covenant.

4 ***Pegarah State Forest*** - includes detections in Pegarah State Forest and on private land to the south including 1 conservation covenant.

5 ***Pegarah West*** - includes detections in 3 native forest remnants on private land west of Pegarah.

6 ***Pegarah East*** - includes detections in 1 native forest remnant on private land southwest of Pegarah State Forest.

7 ***Naracoopa*** - a single detection on private land at Bronzewing Creek.

8 ***Yarra Creek*** - includes detections on private land on Yarra Creek and a native forest remnant on Bold Head Road.

9 ***Gentle Annie*** - 1 detection in Gentle Annie Conservation Area.

10 ***Grassy Harbour*** - includes detections in Parer Creek west of Grassy Harbour Road on private land.

11 ***Kentford Forest*** - includes detections in Kentford Forest Conservation Area and Kentford Forest Nature Reserve.

12 ***Red Hut Road East*** - includes detections on private property east of Red Hut Road.

13 ***Red Hut Road South*** - includes detections on a private land conservation covenant near Crown Creek.

14 ***Colliers Swamp East*** - a detection on eastern boundary of Colliers Swamp Conservation Area.

15 ***Seal River*** - includes detections on private land on Seal River northwest of Colliers Swamp.

16 ***South Road*** - includes detections east and west of South Road near Macks Creek in Seal Rocks Conservation Area and Colliers Swamp Conservation Area.

Figure 8 shows the locations where King Island Scrubtits were detected between 2019 and 2022. The subspecies was detected at 81 sites in total (combining data from Webb and Crates (2019), Holdsworth and Baker (2019), Webb and Bell (2020) and the current Project). No attempt has been made to assess the independence of these sampling sites.

For management purposes, King Island Scrubtit detection sites have been grouped into 5 locations. Location boundaries are arbitrary, but in most cases, locations are grouped detection sites that are within 2 km of each other (Figure 9).

1 ***Granite Lagoon*** - includes detections from northeast of Granite Lagoon to Lake Martha Lavinia in Lavinia State Reserve and on private land.

2 ***Nook Swamps North*** - includes detections in the northern portion of Nook Swamps in Lavinia State Reserve.

3 ***Nook Swamps South*** - includes detections in the southern portion of Nook Swamps in Lavinia State Reserve.

4 ***Pegarah State Forest*** - includes detections in Pegarah State Forest and near the Fraser River on private land.

5 ***Colliers Swamp*** - includes detections in Colliers Swamp, and associated with the Seal River and Mt Stanley Creek in Colliers Swamp Conservation Area, and associated with Mt Stanley Creek in a private land conservation covenant.

Figure 10 shows the distribution of King Island Brown Thornbill and King Island Scrubtit detections in relation to Nature Conservation Act 2002 reserves and conservation covenants. Figures 11-16, show detail of the location of survey sites and detections of King Island Brown Thornbills and King Island Scrubtits in relation to NCA Act reserves and private land conservation covenants.

Figure 4. *Location of King Island Brown Thornbill and King Island Scrubtit survey sites, 2019 – 2022.*
[sites overlaid on recent satellite image of King Island; 1678 sites in total, combining data from Webb and Crates (2019), Holdsworth and Baker (2019), Webb and Bell (2020) and the current KITB Project; sites are not necessarily independent]

Figure 5. *Location of King Island Brown Thornbill and King Island Scrubtit survey sites, 2019 – 2022.*
[sites overlaid on TASMAP topographic map; 1678 sites in total, combining data from Webb and Crates (2019), Holdsworth and Baker (2019), Webb and Bell (2020) and the current KITB Project; sites are not necessarily independent]

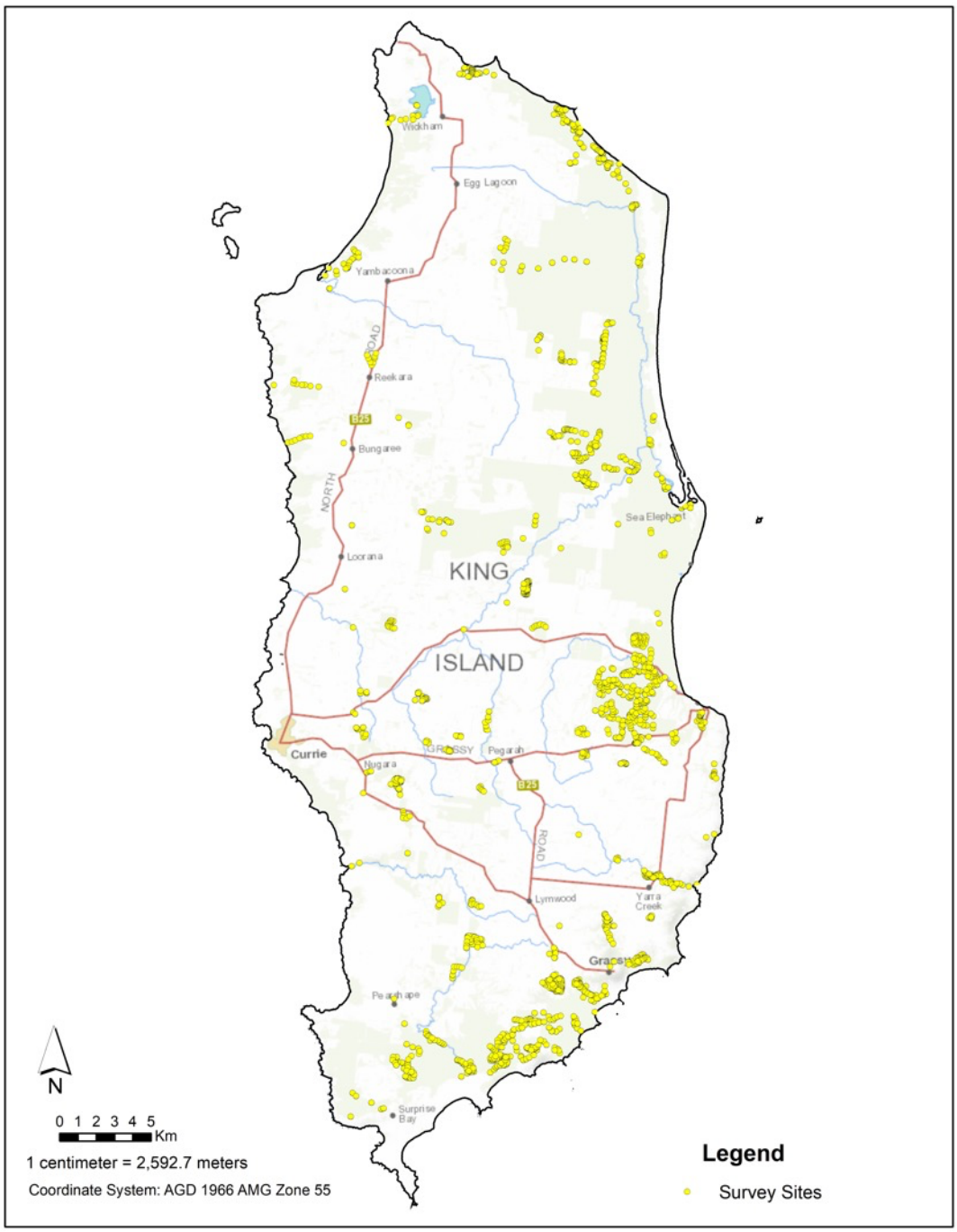


Figure 6. *Location of survey sites where King Island Brown Thornbills were detected, 2019 – 2022.*
[sites overlaid on recent satellite image; 102 sites in total, combining data from Webb & Crates (2019), Holdsworth & Baker (2019), Webb & Bell (2020) and the current KITB Project; sites are not necessarily independent]

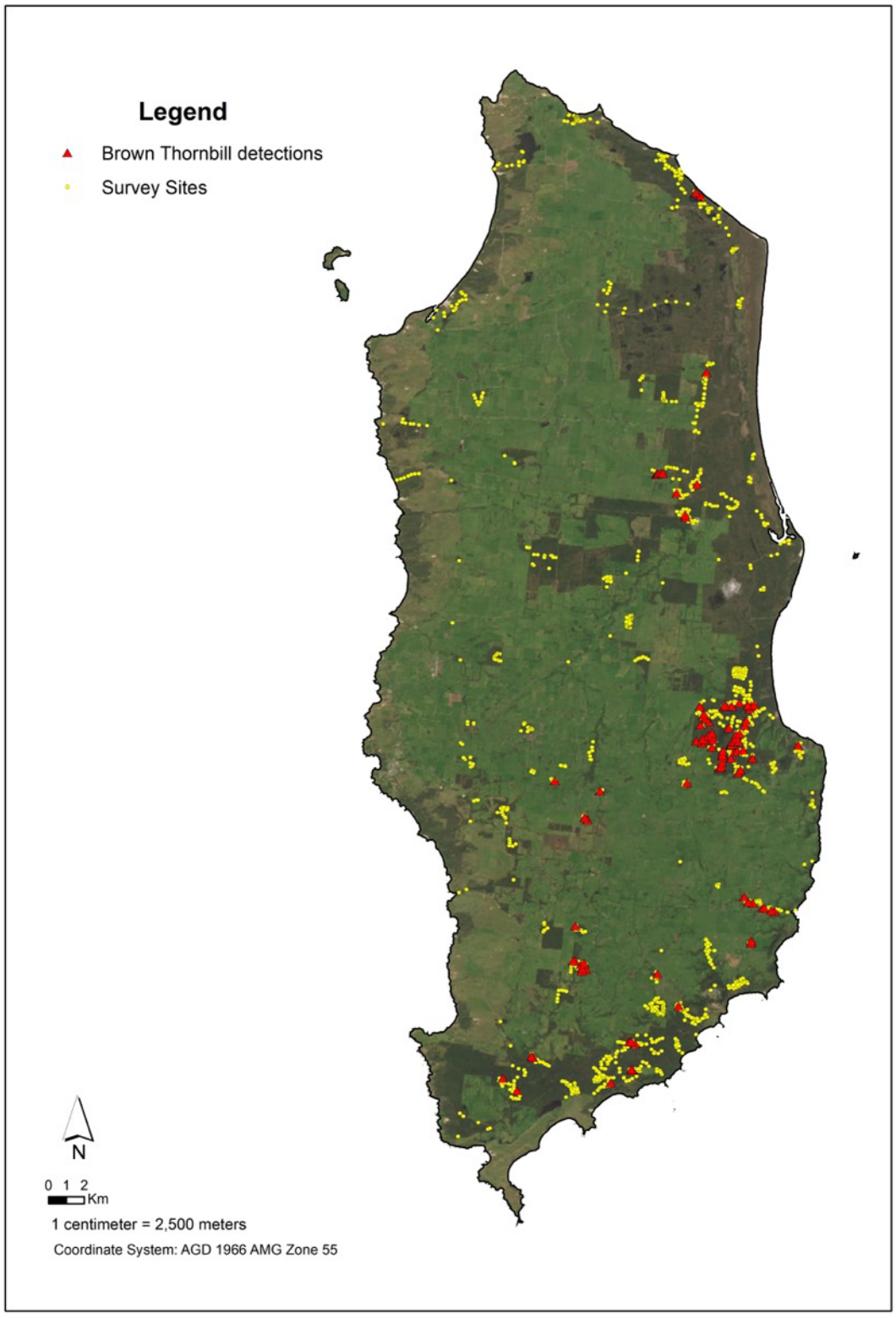


Figure 7. Locations of King Island Brown Thornbill detection sites (i.e. grouping detection sites into spatial clusters where for the most part detection sites within the same cluster are within approximately 2 km of each other).

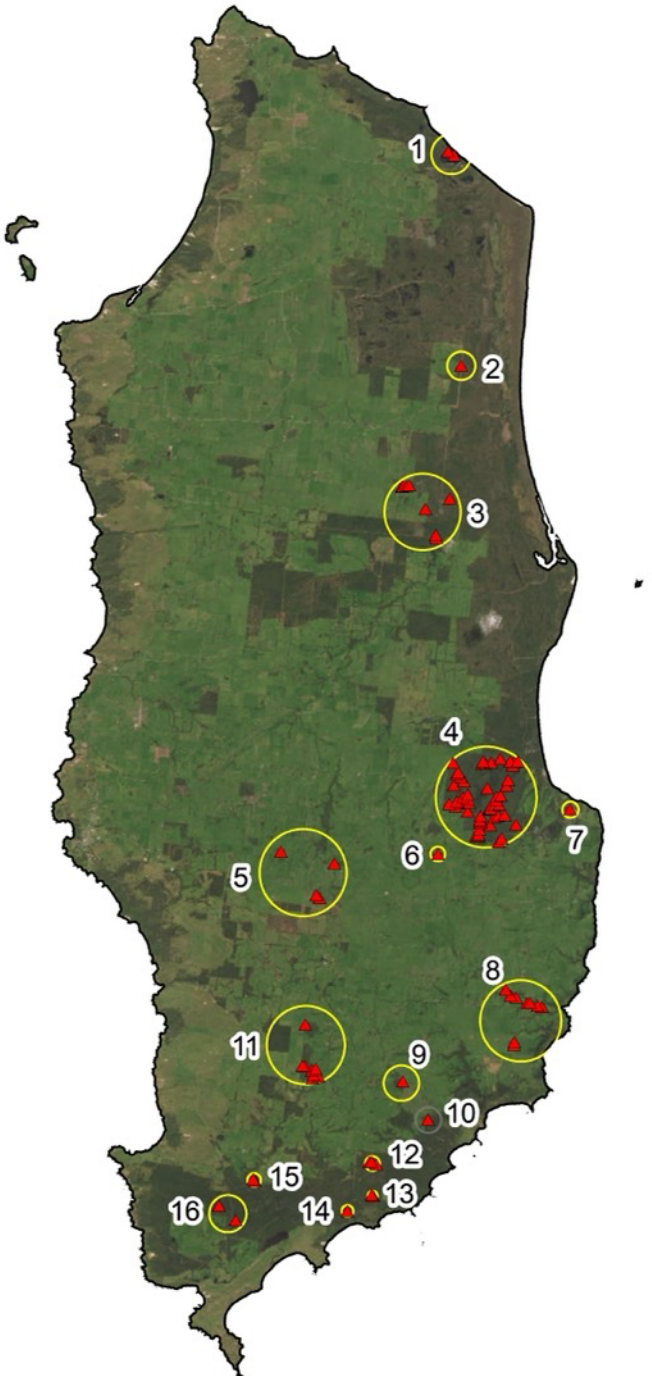


Figure 8. *Location of survey sites where King Island Scrubtits were detected, 2019 – 2022.*
[sites overlaid on recent satellite image; 81 sites in total, combining data from Webb and Crates (2019), Holdsworth and Baker (2019), Webb and Bell (2020) and the current KITB Project; sites are not necessarily independent]

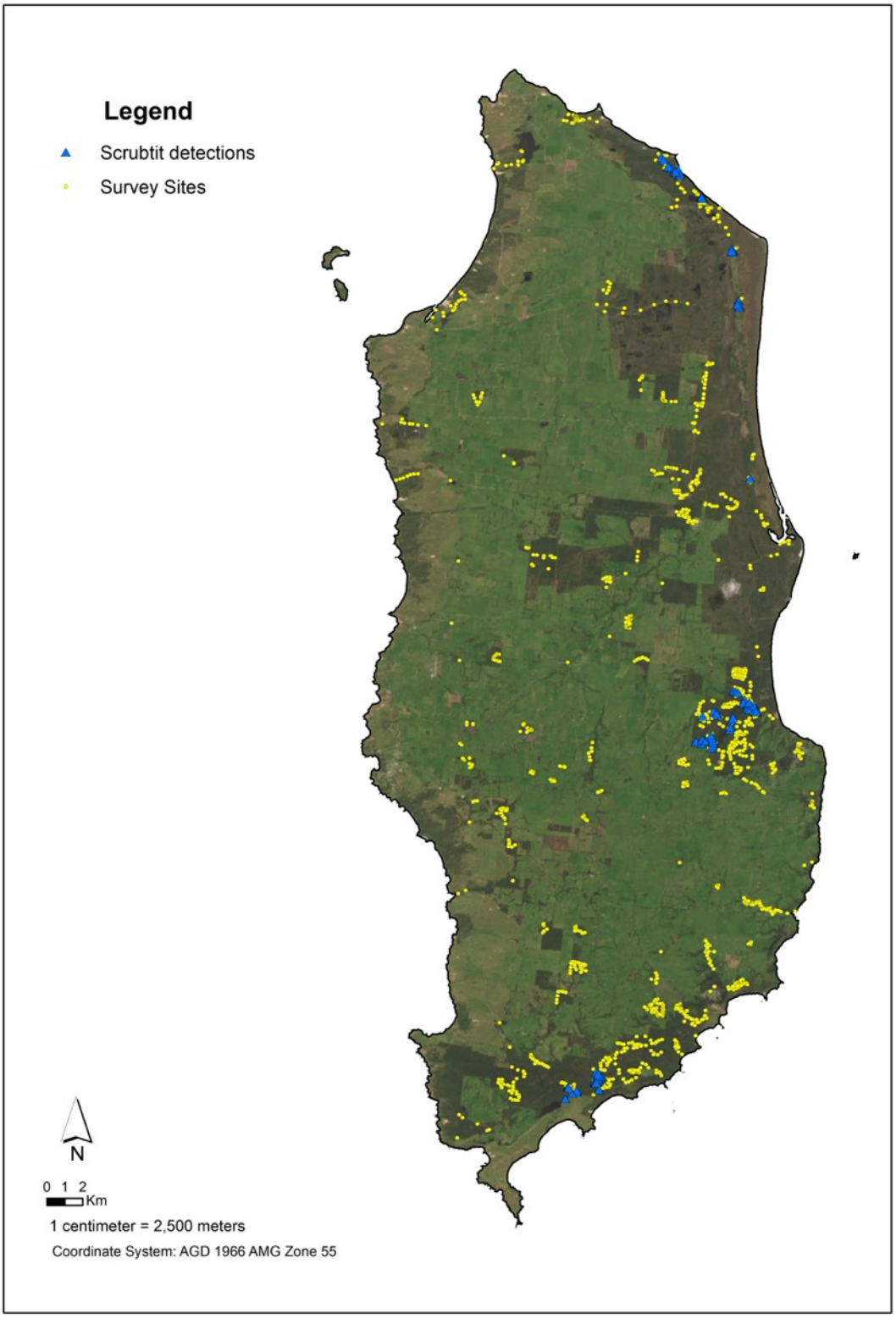


Figure 9. Locations of King Island Scrubtit detection sites (i.e. grouping detection sites into spatial clusters where for the most part detection sites within the same cluster are within approximately 2 km of each other).

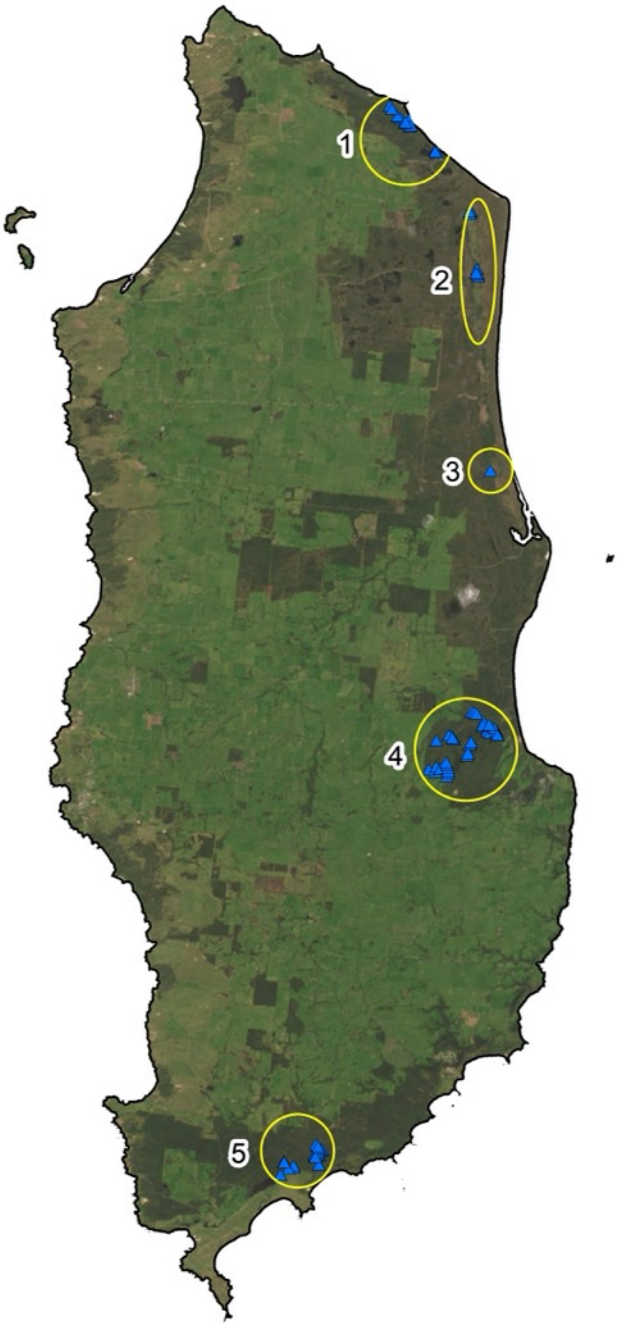


Figure 10. *Distribution of survey sites and detections of King Island Brown Thornbills and King Island Scrubtits, 2019 – 2022 in relation to Nature Conservation Act 2002 reserves and conservation covenants.*

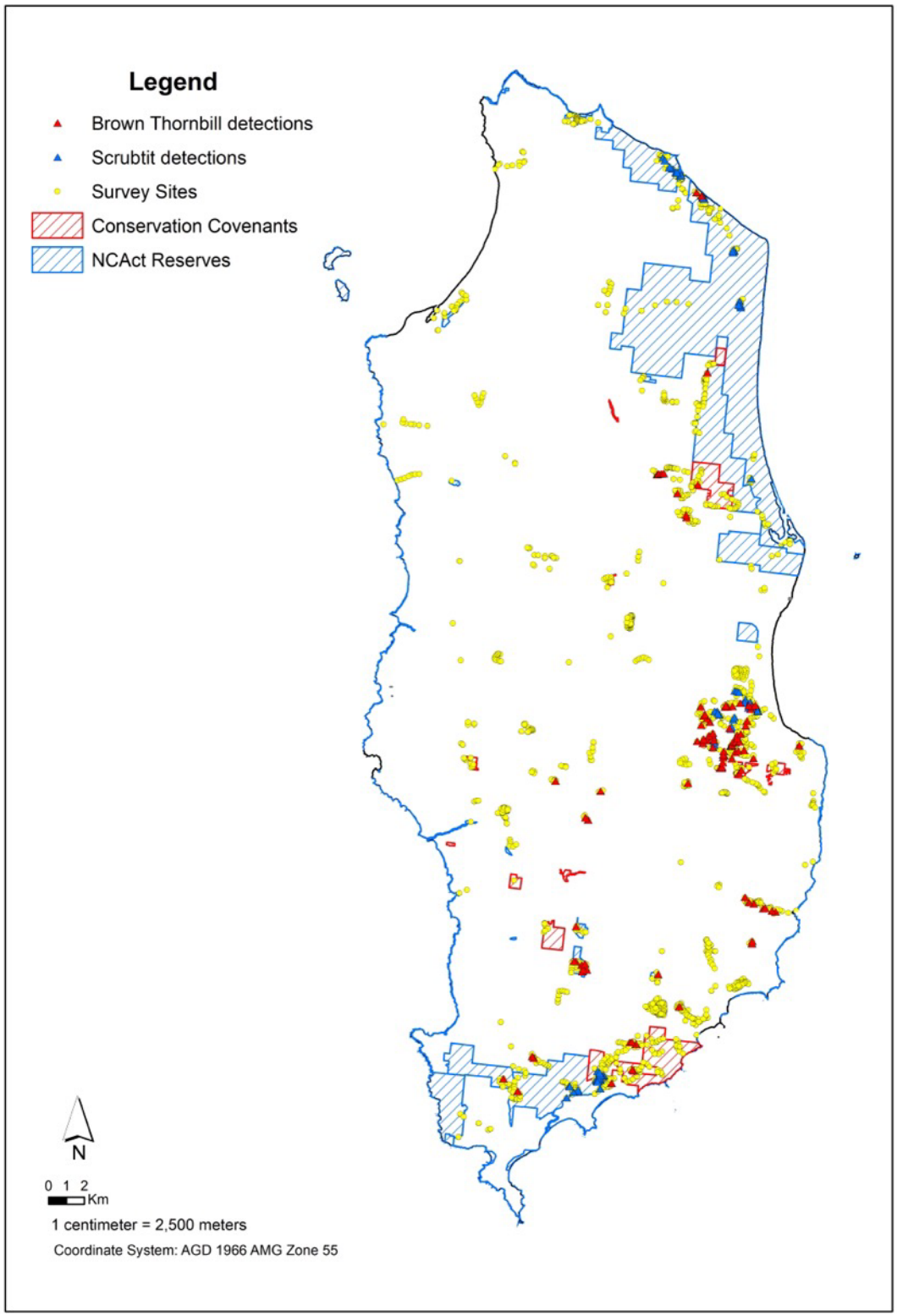


Figure 11. *Location of survey sites and detections of King Island Brown Thornbills and King Island Scrubtits, 2019 – 2022: detail of the north and northeast coast between Disappointment Bay in the west and the northern section of Nook Swamps in the east.*
[sites overlaid on recent satellite image]

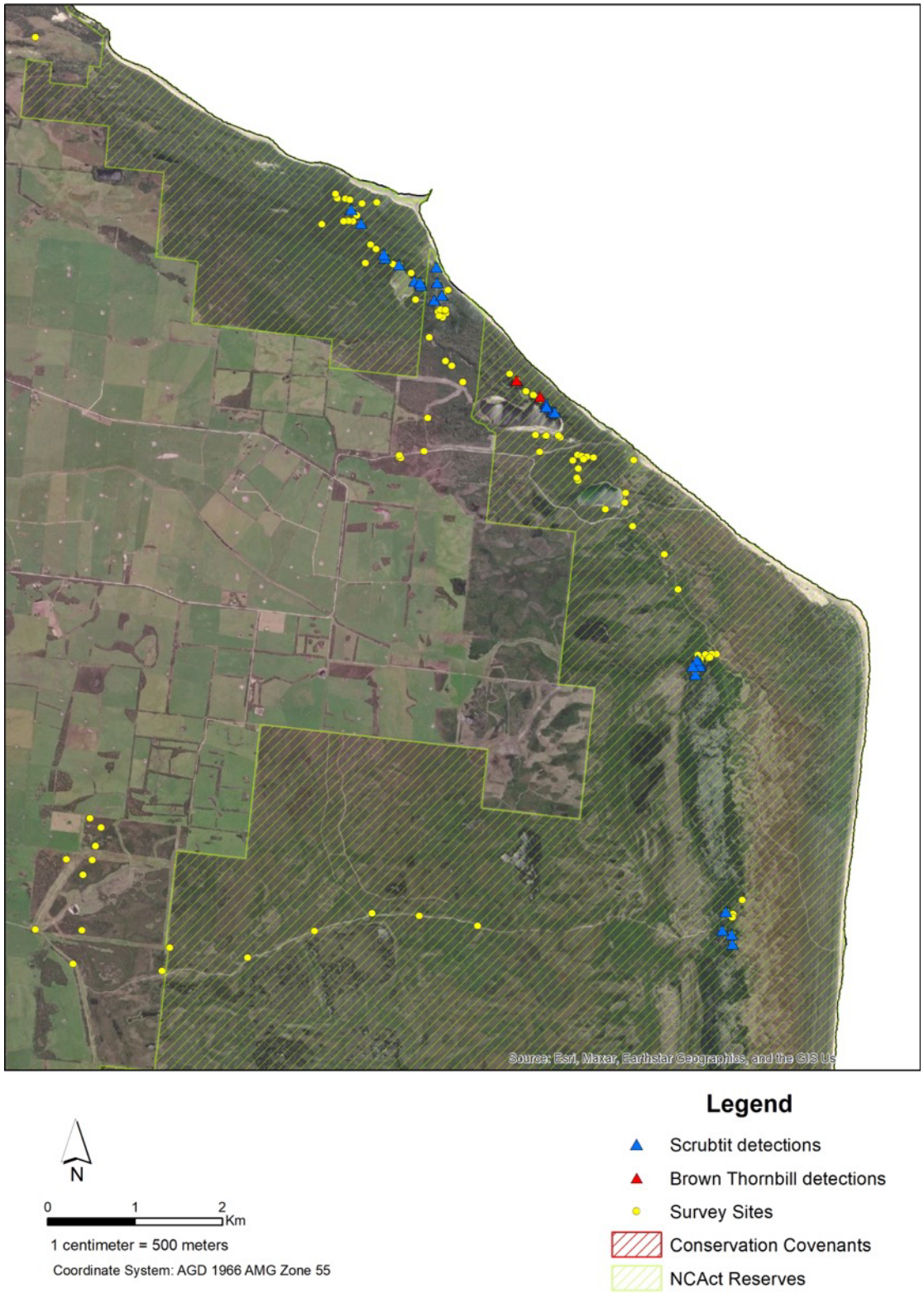


Figure 12. *Location of survey sites and detections of King Island Brown Thornbills and King Island Scrubtits, 2019 – 2022: detail along the northeast coast including the southern section of the Nook Swamps, extending south to the Sea Elephant River estuary.*
[sites overlaid on recent satellite image]

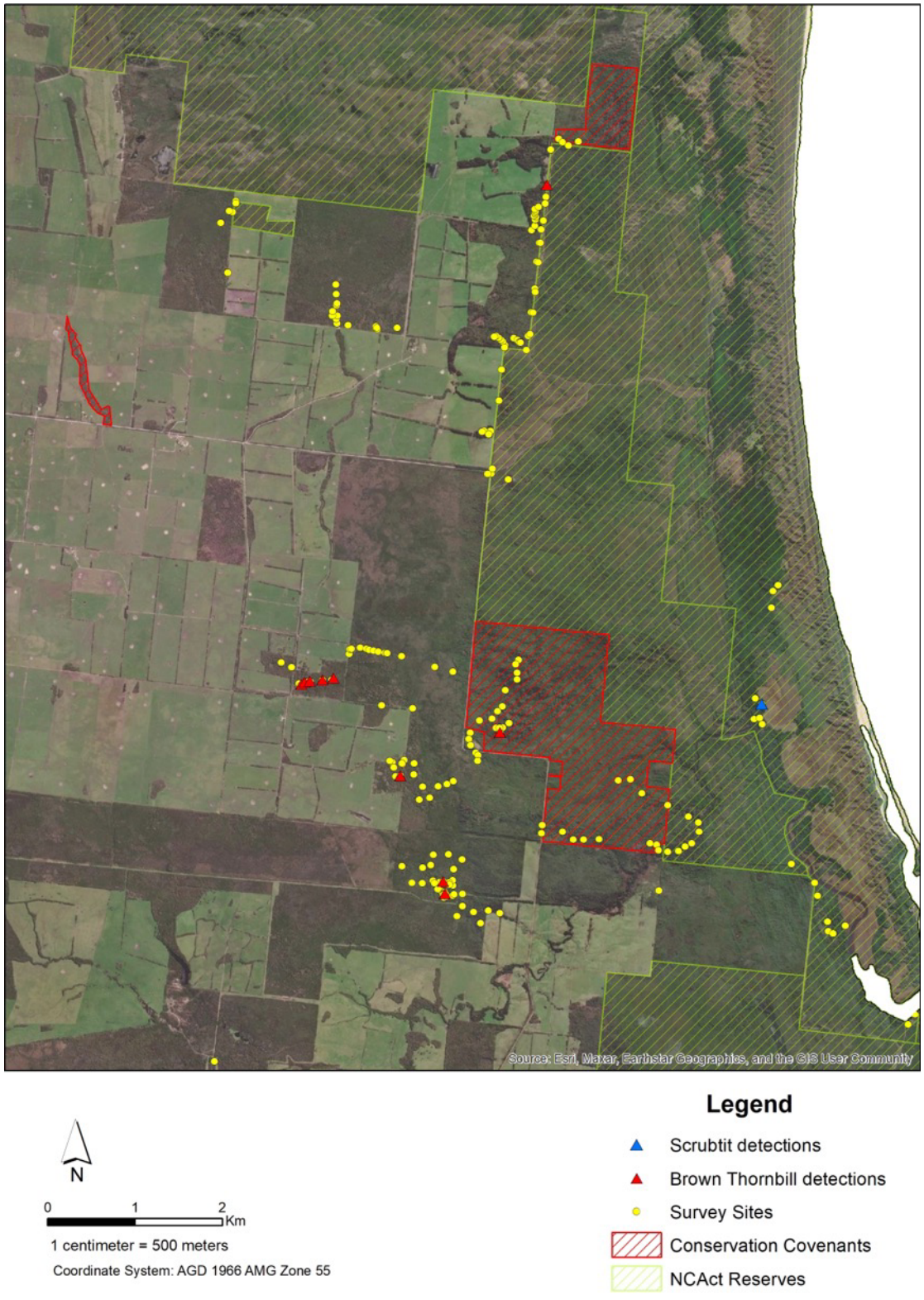


Figure 13. *Location of survey sites and detections of King Island Brown Thornbills and King Island Scrubtits, 2019 – 2022: detail along the east coast and centred on Pegarah State Forest, west of Naracoopa.*
[sites overlaid on recent satellite image]

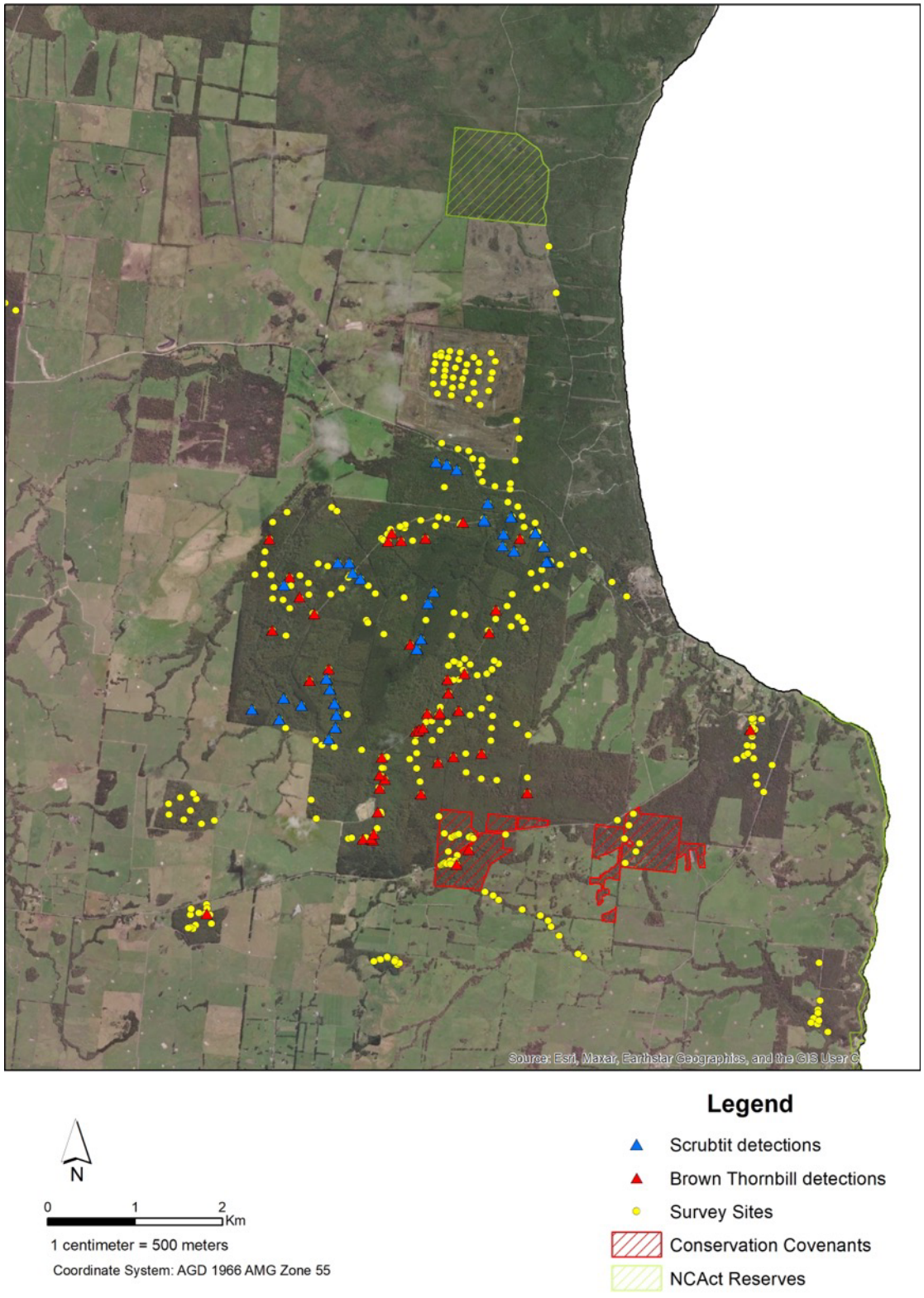


Figure 14. *Location of survey sites and detections of King Island Brown Thornbills and King Island Scrubtits, 2019 – 2022: detail west of Pegarah State Forest across agricultural land to the southwestern reaches of the Sea Elephant River.*
[sites overlaid on recent satellite image]

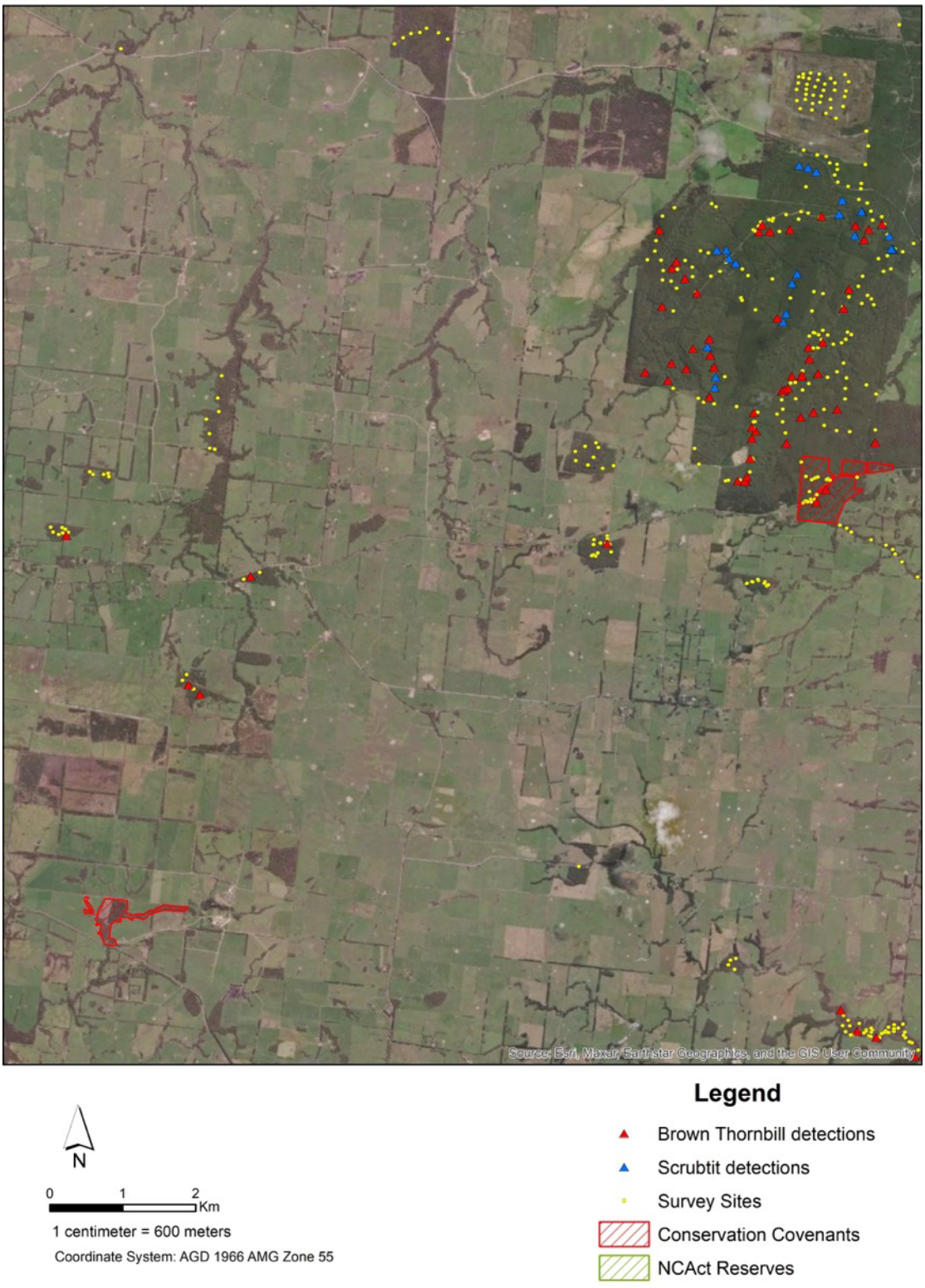


Figure 15. *Location of survey sites and detections of King Island Brown Thornbills and King Island Scrubtits, 2019 – 2022: detail along the east coast between Barrier Creek in the north and Grassy in the south.*
[sites overlaid on recent satellite image]

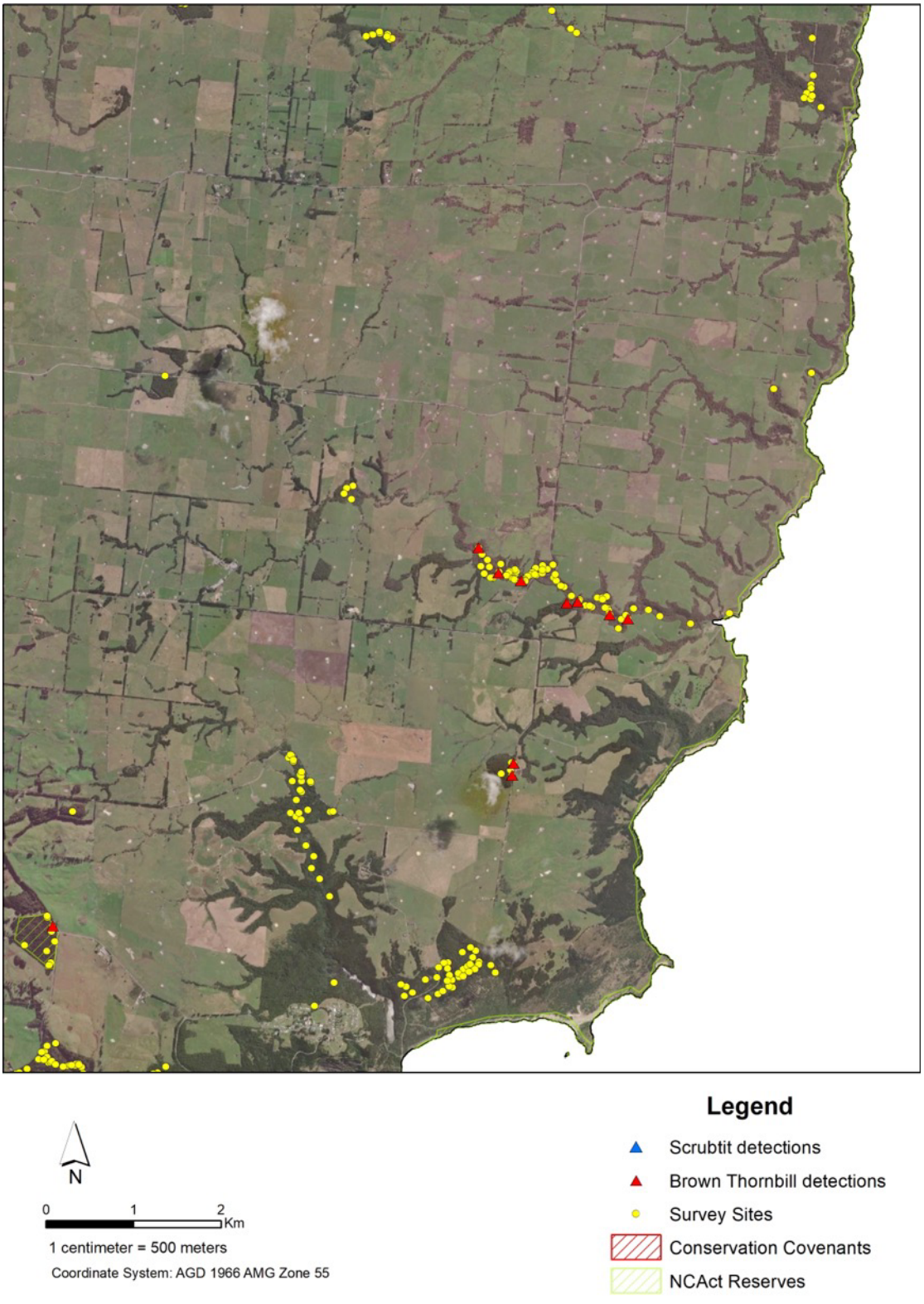
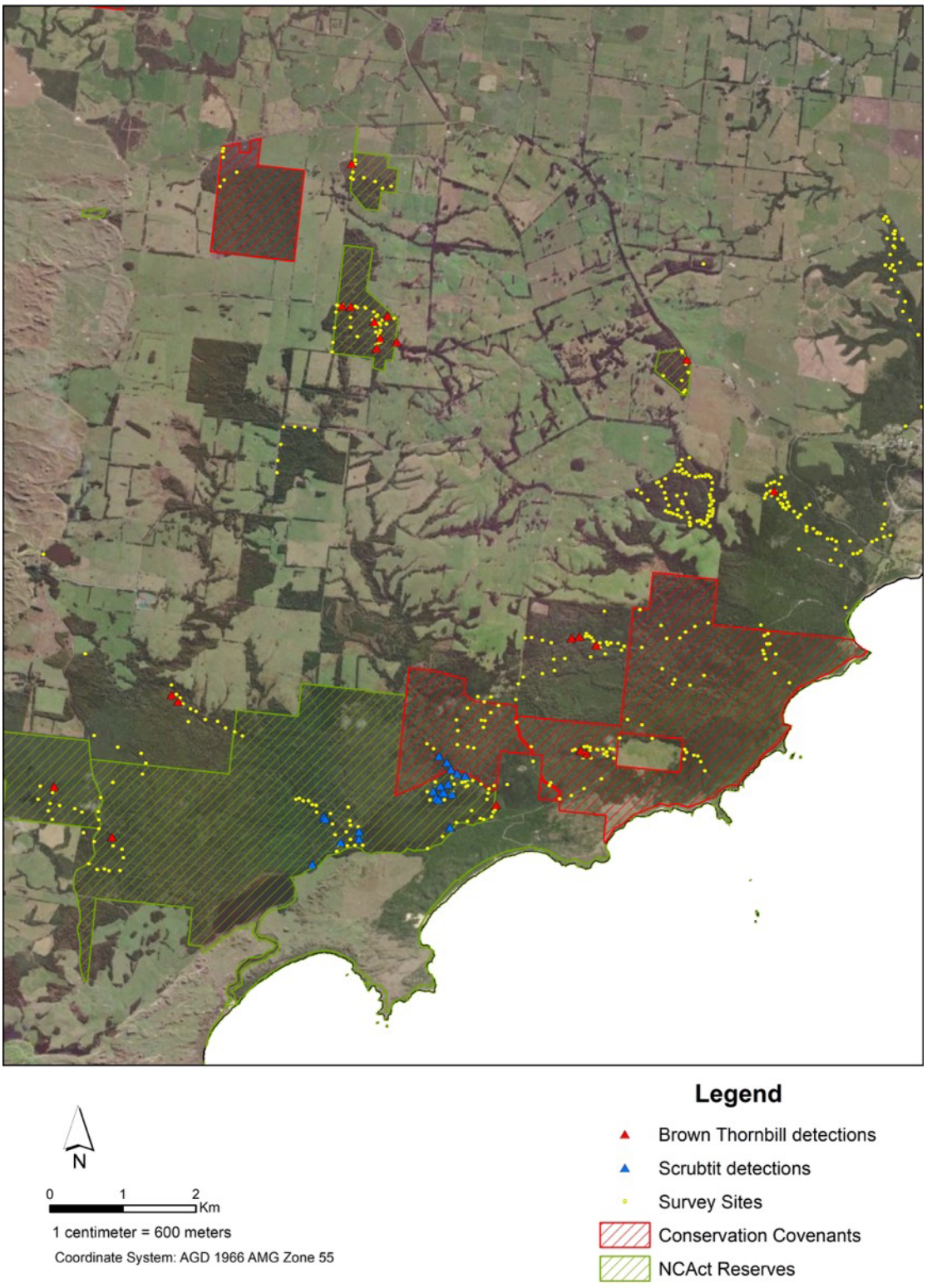


Figure 16. *Location of survey sites and detections of King Island Brown Thornbills and King Island Scrubtits, 2019 – 2022: detail along the southeast coast between Grassy River in the east and Seal River in the west.*
[sites overlaid on recent satellite image]



Habitat at survey sites

Habitat data, where it includes a minimum record of TASVEG vegetation community, was collected at approximately 1000 survey sites. Detailed habitat data including information on up to 53 covariates was collected at approximately 500 survey sites.

Table 5 shows the prevalence of King Island Brown Thornbill and King Island Scrubtit detections by Tasmanian native vegetation community (i.e., TASVEG mapping unit).

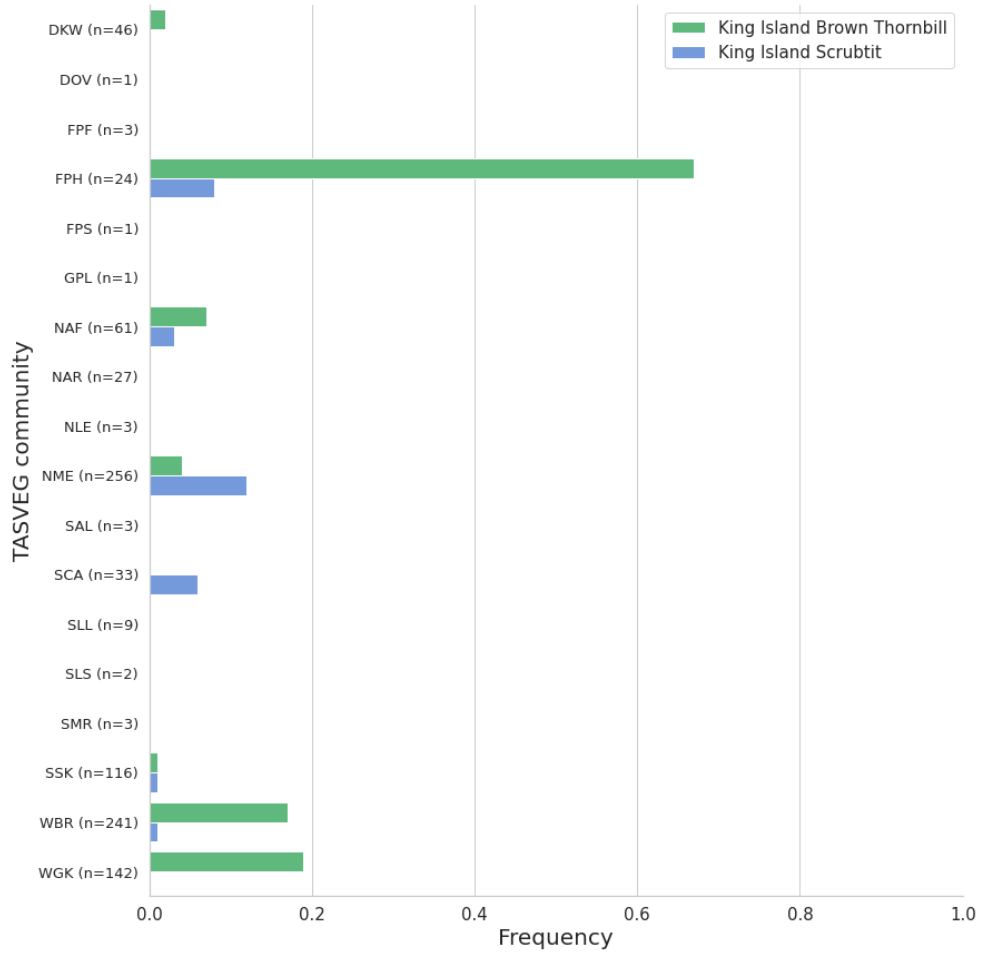
Most detections of King Island Brown Thornbill were in wet eucalypt forests including Wet *Eucalyptus brookeriana* forest (WBR), *Eucalyptus globulus* King Island forest (WGK), Plantations for Silviculture – hardwood (FPH) (i.e., *E. obliqua* dominated forest within Pegarah State Forest), *Melaleuca ericifolia* swamp forest (NME) and *Acacia melanoxylon* swamp forest (NAF). Only single detections were made in King Island eucalypt woodland (DKW) and Scrub complex on King Island (SSK). Prevalence of detections more or less reflected the number of detections in TASVEG communities however, the prevalence of detections of the subspecies in FPH in Pegarah State Forest was extremely high (i.e., 0.67) (Table 5, Figure 17).

Most detections of King Island Scrubtit were in *Melaleuca ericifolia* swamp forest (NLE), with only a few detections in Wet *Eucalyptus brookeriana* forest (WBR), Plantations for Silviculture – hardwood (FPH) (i.e., *E. obliqua* dominated forest within Pegarah State Forest), *Acacia melanoxylon* swamp forest (NAF) and Coastal scrub on alkaline sands (SCA). A single detection was made in Scrub complex on King Island (SSK) (Table 5, Figure 17).

Table 5. The prevalence of detections of King Island Brown Thornbill and King Island Scrubtit by Tasmanian native vegetation community (TASVEG mapping unit)

TASVEG mapping unit		King Island Brown Thornbill		King Island Scrubtit	
Name	**No. of sites**	**No. of detections**	**Prevalence of detections**	**No. of detections**	**Prevalence of detections**
DKW	46	1	0.02	0	0
DOV	1	0	0	0	0
FPF	3	0	0	0	0
FPH	24	16	0.67	2	0.08
FPS	1	0	0	0	0
GPL	1	0	0	0	0
NAF	61	4	0.07	2	0.03
NAR	27	0	0	0	0
NLE	3	0	0	0	0
NME	256	10	0.04	31	0.12
SAL	3	0	0	0	0
SCA	33	0	0	2	0.06
SLL	9	0	0	0	0
SLS	2	0	0	0	0
SMR	3	0	0	0	0
SSK	116	1	0.01	1	0.01
WBR	241	40	0.17	2	0.01
WGK	142	27	0.19	0	0

Figure 17. The prevalence of detections of King Island Brown Thornbill and King Island Scrubtit by Tasmanian native vegetation community (TASVEG mapping unit)



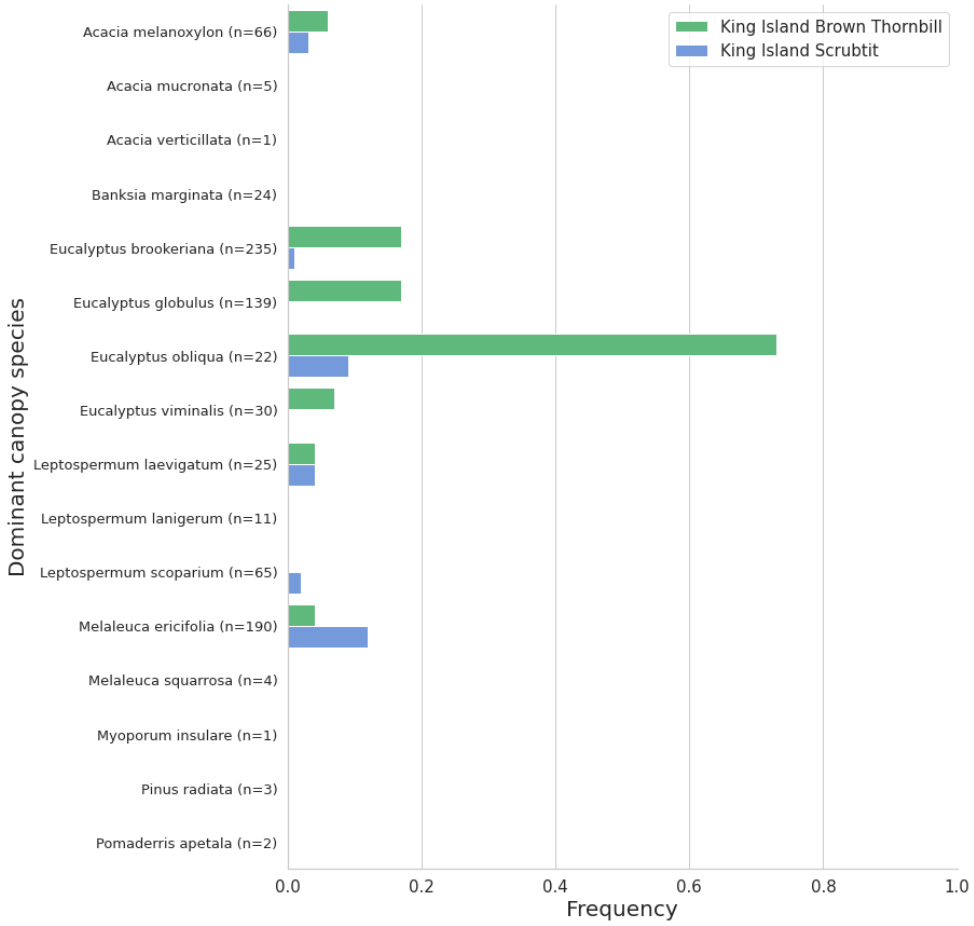
The dominant tree canopy species most common at King Island Brown Thornbill detection sites was *E. brookeriana*, *E. globulus* or *Eucalyptus obliqua* (*E. obliqua* was only present within Pegarah State Forest). *Melaleuca ericifolia* and *Acacia melanoxylon* were less common dominant canopy tree species. Dominant canopy tree species (i.e., species contributing to >50% of the tree canopy cover), in decreasing order of prevalence was *E. obliqua*, *E. globulus*, *E. brookeriana*, *E. viminalis*, *A. melanoxylon*, *M. ericifolia* and *Leptospermum laevigatum* (Table 6, Figure 18). Clearly, dominance of the canopy by eucalypts is a fundamental component of the subspecies' habitat. As the allocation of forest vegetation communities to TASVEG forest mapping units most often reflects the dominant tree canopy species, 'TASVEG community' and 'Dominant canopy tree species' is expected to be highly correlated. *Leptospermum laevigatum* was recorded at only one of 25 sites, a location where Coastal scrub on alkaline sands (SCA) was associated with a highly localised occurrence of eucalypts and *M. ericifolia*.

The dominant tree canopy species most common at King Island Scrubtit detection sites was *Melaleuca ericifolia*, with *E. brookeriana* present at three sites, *Eucalyptus obliqua* and *Acacia melanoxylon* present at two sites each and *Leptospermum scoparium* and *L. laevigatum* present at one site each (Table 6, Figure 18).

Table 6. The prevalence of detections of King Island Brown Thornbill and King Island Scrubtit by dominant canopy species

Dominant canopy species		King Island Brown Thornbill		King Island Scrubtit	
Species	**No. of sites**	**No. of detections**	**Prevalence of detections**	**No. of detections**	**Prevalence of detections**
Acacia mucronata	5	0	0	0	0
Acacia verticillata	1	0	0	0	0
Acacia melanoxylon	66	4	0.06	2	0.03
Banksia marginata	24	0	0	0	0
Eucalyptus brookeriana	235	39	0.17	3	0.01
Eucalyptus globulus	139	24	0.17	0	0
Eucalyptus obliqua	22	16	0.73	2	0.09
Eucalyptus viminalis	30	2	0.07	0	0
Leptospermum laevigatum	25	1	0.04	1	0.04
Leptospermum lanigerum	11	0	0	0	0
Leptospermum scoparium	65	0	0	1	0.02
Melaleuca ericifolia	190	8	0.04	23	0.12
Melaleuca squarrosa	4	0	0	0	0
Myoporum insulare	1	0	0	0	0
Pinus radiata	3	0	0	0	0
Pomaderris apetala	2	0	0	0	0

Figure 18. The prevalence of detections of King Island Brown Thornbill and King Island Scrubtit by dominant canopy species.



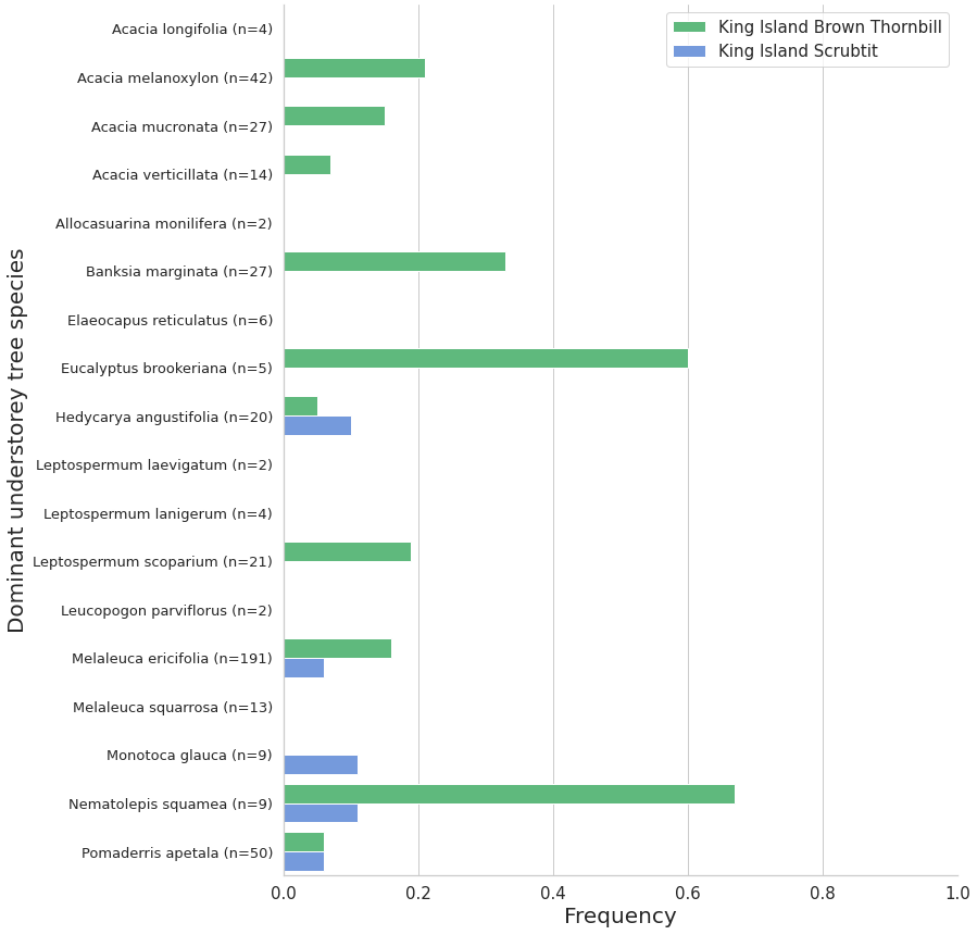
Dominant understorey tree species (i.e., species contributing the most to the understorey tree layer cover), most common at King Island Brown Thornbill detection sites included *Melaleuca ericifolia, Banksia marginata, Acacia melanoxylon,* 'the absence of an understorey tree layer' and *Nematolepis squamea.* Less commonly, the understorey tree species was *Acacia mucronata*, *Leptospermum scoparium*, *Eucalyptus brookeriana* and *Pomaderris apetala*. Dominant understorey tree species, in decreasing order of prevalence included *N. squamea*, *B. marginata*, *A. melanoxylon*, *L. scoparium*, *M. ericifolia*, *A. mucronata*, *E. brookeriana*, *A. verticillata*, *P. apetala* and *Hedycarya angustifolia* (Table 7, Figure 19). The common dominant understorey tree species at detection sites are typical components of wet eucalypt forest on King Island (e.g., *N. squamea*, *M. ericifolia*, *A. melanoxylon*) but also key dominant tree species in Scrub complex on King Island (SSK) (e.g., *B. marginata*, *A. mucronata*, *L. scoparium*).

Dominant understorey tree species most common at King Island Scrubtit detection sites was *Melaleuca ericifolia*. A number of sites did not have an understorey tree layer. *Pomaderris apetala* was dominant at three sites, *Hedycarya angustifolia* at two sites and *Monotoca glauca* and *Nematolepis squamea* dominant at one site each (Table 7, Figure 19).

Table 7. The prevalence of detections of King Island Brown Thornbill and King Island Scrubtit by dominant understorey species

Dominant understorey species		King Island Brown Thornbill		King Island Scrubtit	
Species	**No. of sites**	**No. of detections**	**Prevalence of detections**	**No. of detections**	**Prevalence of detections**
Acacia longifolia	4	0	0	0	0
Acacia mucronata	27	4	0.15	0	0
Acacia verticillata	14	1	0.07	0	0
Acacia melanoxylon	42	9	0.21	0	0
Allocasuarina monilifera	2	0	0	0	0
Banksia marginata	27	9	0.33	0	0
Elaeocarpus reticulatus	6	0	0	0	0
Eucalyptus brookeriana	5	3	0.6	0	0
Hedycarya angustifolia	20	1	0.05	2	0.1
Leptospermum laevigatum	2	0	0	0	0
Leptospermum lanigerum	4	0	0	0	0
Leptospermum scoparium	21	4	0.19	0	0
Leucopogon parviflorus	4	0	0	0	0
Melaleuca ericifolia	191	31	0.16	11	0.06
Melaleuca squarrosa	13	0	0	0	0
Monotoca glauca	9	0	0	1	0.11
No understorey species	140	6	0.04	7	0.05
Nematolepis squamea	9	6	0.67	1	0.11
Pomaderris apetala	50	3	0.06	3	0.06

Figure 19. The prevalence of detections of King Island Brown Thornbill and King Island Scrubtit by dominant understorey species.



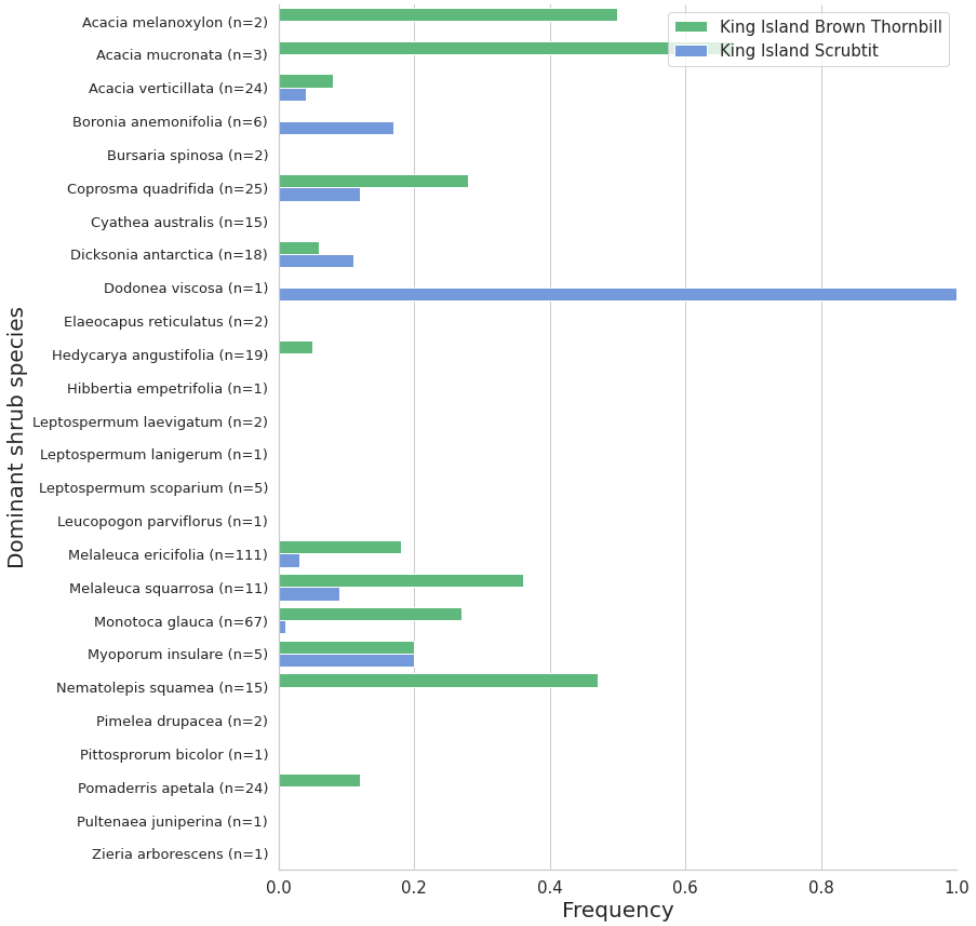
Dominant shrub layer species (i.e., species contributing to most of the shrub layer cover), most common at King Island Brown Thornbill detection sites included *Melaleuca ericifolia*, *Monotoca glauca, Coprosma quadrifida* and *Nematolepis squamea.* Less commonly the dominant shrub layer species was *Melaleuca squarrosa*, *Pomaderris apetala*, 'the absence of a shrub layer', *Acacia mucronata* or *A. verticillata*. *Acacia melanoxylon*, *Dicksonia antarctica*, *Hedycarya angustifolia* and *Myoporum insulare* were dominant at only single sites. Dominant shrub species, in decreasing order of prevalence included *A. mucronata, A. melanoxylon, N. squamea, M. squarrosa, C. quadrifida, M. glauca, M. insulare* and *M. ericifolia*. Those with a prevalence of less than 0.1 included *A. verticillata*, *D. antarctica*, *H. angustifolia* and 'the absence of a shrub layer' (Table 8, Figure 20).

Dominant shrub layer species most common at King Island Scrubtit detection sites was 'No shrub species present'. *Melaleuca ericifolia* and *Coprosma quadrifida* were dominant at three sites each and *Dicksonia antarctica* was dominant at two sites (Table 8, Figure 20).

Table 8. The prevalence of detections of King Island Brown Thornbill and King Island Scrubtit by dominant shrub species

Dominant shrub species		King Island Brown Thornbill		King Island Scrubtit	
Species	**No. of sites**	**No. of detections**	**Prevalence of detections**	**No. of detections**	**Prevalence of detections**
Acacia mucronata	3	2	0.67	0	0
Acacia verticillata	24	2	0.08	1	0.04
Acacia melanoxylon	2	1	0.5	0	0
Boronia anemonifolia	6	0	0	1	0.2
Bursaria spinosa	2	0	0	0	0
Coprosma quadrifida	25	7	0.28	3	0.12
Cyathea australis	15	0	0	0	0
Dicksonia antarctica	18	1	0.06	2	0.11
Dodonea viscosa	1	0	0	1	1
Elaeocarpus reticulatus	2	0	0	0	0
Hedycarya angustifolia	19	1	0.05	0	0
Hibbertia empetrifolia	1	0	0	0	0
Leptospermum laevigatum	2	0	0	0	0
Leptospermum lanigerum	1	0	0	0	0
Leptospermum scoparium	5	0	0	0	0
Leucopogon parviflorus	1	0	0	0	0
Melaleuca ericifolia	111	20	0.18	3	0.03
Melaleuca squarrosa	11	4	0.36	1	0.09
Monotoca glauca	67	18	0.27	1	0.01
Myoporum insulare	5	1	0.2	1	0.2
No shrub species	101	3	0.03	10	0.1
Nematolepis squamea	15	7	0.47	0	0
Pimelea drupacea	2	0	0	0	0
Pittosprorum bicolor	1	0	0	0	0
Pomaderris apetala	24	3	0.12	0	0
Pultenaea juniperina	1	0	0	0	0
Zieria arborescens	1	0	0	0	0

Figure 20. The prevalence of detections of King Island Brown Thornbill and King Island Scrubtit by dominant shrub species.



Dominant ground layer species (i.e., species contributing to most of the ground layer cover), most common at King Island Brown Thornbill detection sites included *Gahnia grandis* and *Pteridium esculentum. Melaleuca ericifolia* was dominant at three sites, *Carex appressa* at two sites and *Blechnum nudum*, *Blechnum* sp., *Coprosma quadrifida*, *Dianella tasmanica*, *Hypolepis rugosula*, *Pimelea drupacea* and 'the absence of a ground layer' at single detection sites. *Asparagus scandens* is an introduced weed with an expanding distribution on King Island. It was the dominant ground layer species at one King Island Brown Thornbill detection site. Dominant shrub species, in decreasing order of prevalence included *A. mucronata, A. melanoxylon, N. squamea, M. squarrosa, C. quadrifida, M. glauca, M. insulare* and *M. ericifolia*. Those with a prevalence of less than 0.1 included *A. verticillata*, *D. antarctica*, *H. angustifolia* and 'the absence of a shrub layer' (Table 9, Figure 21).

Dominant ground layer species most common at King Island Scrubtit detection sites included *Pteridium esculentum*, *Gahnia grandis*, *Blechnum nudum*, and *Melaleuca ericifolia* (Table 9, Figure 21).

Table 9. The prevalence of detections of King Island Brown Thornbill and King Island Scrubtit by dominant ground species

Dominant ground species		King Island Brown Thornbill		King Island Scrubtit	
Species	**No. of sites**	**No. of detections**	**Prevalence of detections**	**No. of detections**	**Prevalence of detections**
Acacia verticillata	1	0	0	0	0
Asparagus scandens	3	1	0.33	0	0
Bauera rubioides	1	0	0	0	0
Blechnum nudum	8	1	0.12	4	0.5
Blechnum species	2	1	0.5	2	1
Boronia anemonifolia	4	0	0	1	0.25
Carex appressa	23	2	0.09	0	0
Coprosma quadrifida	2	1	0.5	0	0
Dianella tasmanica	3	1	0.33	0	0
Dicksonia antarctica	5	0	0	1	0.2
Elaeocarpus reticulatus	2	0	0	0	0
Empodisma minus	2	0	0	0	0
Epacris impressa	1	0	0	0	0
Gahnia grandis	232	39	0.17	5	0.02
Grass species	19	0	0	0	0
Histiopteris incisa	5	0	0	0	0
Hypolepis rugosula	1	1	1	0	0
Juncus species	5	0	0	0	0
Lepidosperma concavum	2	0	0	0	0
Lepidosperma gladiatum	2	0	0	2	1
Leptecophylla juniperina	1	0	0	1	1
Melaleuca ericifolia	19	3	0.16	3	0.16
Monotoca glauca	1	0	0	0	0
No ground species	35	1	0.03	2	0.06
Olearia glutinosa	1	0	0	0	0
Pimelea axiflora	1	0	0	0	0
Pimelea drupacea	2	1	0.5	0	0
Poa tenera	3	0	0	0	0
Polystichum proliferum	1	0	0	0	0
Pteridium esculentum	202	33	0.16	8	0.04
Pteris tremula	1	0	0	0	0
Sambucus gaudichaudiana	1	0	0	0	0

Dominant ground species		King Island Brown Thornbill		King Island Scrubtit	
Species	**No. of sites**	**No. of detections**	**Prevalence of detections**	**No. of detections**	**Prevalence of detections**
Sedge species	4	0	0	1	0.25
Senecio species	1	0	0	0	0
Tetragonia implexicoma	5	0	0	0	0
Todea barbara	1	0	0	0	0

Figure 21. The prevalence of detections of King Island Brown Thornbill and King Island Scrubtit by dominant ground species.

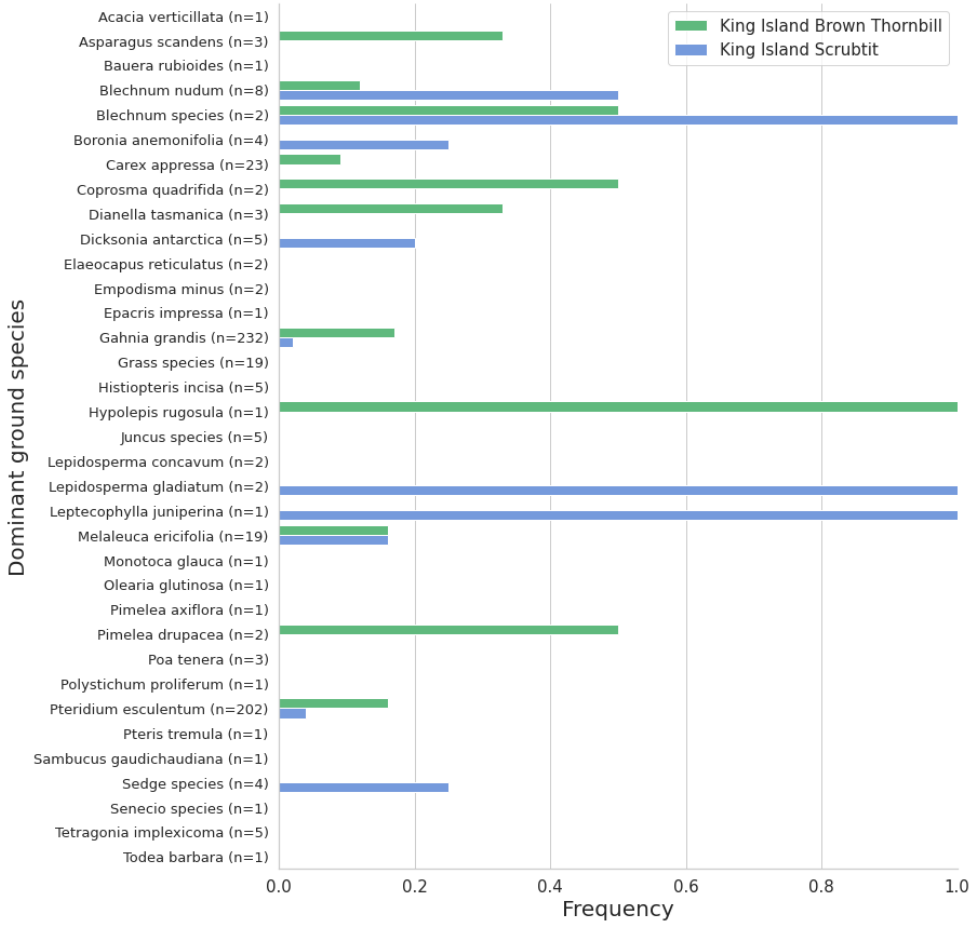


Figure 22 shows the comparison of distributions of percentage ground layer cover data (i.e., total aerial cover of the ground layer vegetation between the height range 0.3-1.5 m) recorded at King Island Brown Thornbill and King Island Scrubtit detection and non-detection sites. Comparison of the data distributions suggest a negative relationship between King Island Brown Thornbill detections and percentage ground layer cover i.e., the subspecies appears to be more prevalent at sites with low percentage ground layer cover. In contrast the King Island Scrubtit appears to be positively correlated with the percentage ground layer cover.

Figure 22. Distribution of percentage ground layer cover data recorded at King Island Brown Thornbill and King Island Scrubtit detection and non-detection sites.

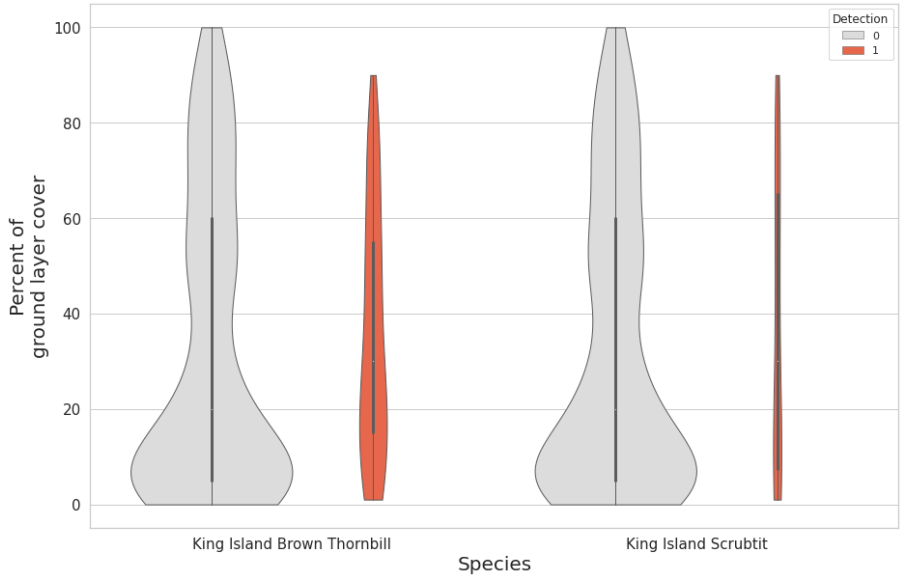


Figure 23 shows the comparison of distributions of percentage cover of fine woody debris data (i.e., the percentage cover of woody debris >10 cm in diameter) recorded at King Island Brown Thornbill and King Island Scrubtit detection and non-detection sites. Comparison of the data distributions suggest a positive relationship between King Island Brown Thornbill detections and percentage of fine woody debris i.e., the subspecies appears to be more prevalent at sites with a high percentage ground layer cover. In contrast the King Island Scrubtit appears to be more prevalent at sites with a low percentage ground layer cover.

Figure 23. Distribution of percentage fine woody debris cover data recorded at King Island Brown Thornbill and King Island Scrubtit detection and non-detection sites.

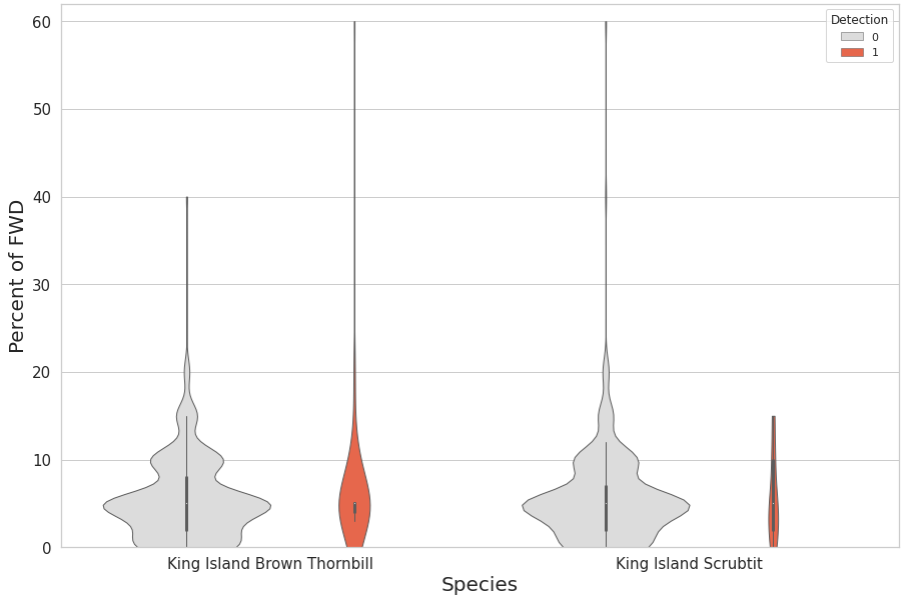


Figure 24 shows the comparison of distributions of percentage cover of coarse woody debris (i.e., the percentage cover of coarse woody debris >10 cm in diameter) recorded at King Island Brown Thornbill and King Island Scrubtit detection and non-detection sites. The distribution of the data suggest a possible positive relationship between King Island Brown Thornbill detections and percentage of coarse woody

debris i.e., the subspecies appears to be more prevalent at sites with a high percentage cover of coarse woody debris. The King Island Scrubtit appears to be considerably more prevalent at sites with a high percentage cover of coarse woody debris.

Figure 24. Distribution of percentage coarse woody debris cover data recorded at King Island Brown Thornbill and King Island Scrubtit detection and non-detection sites.

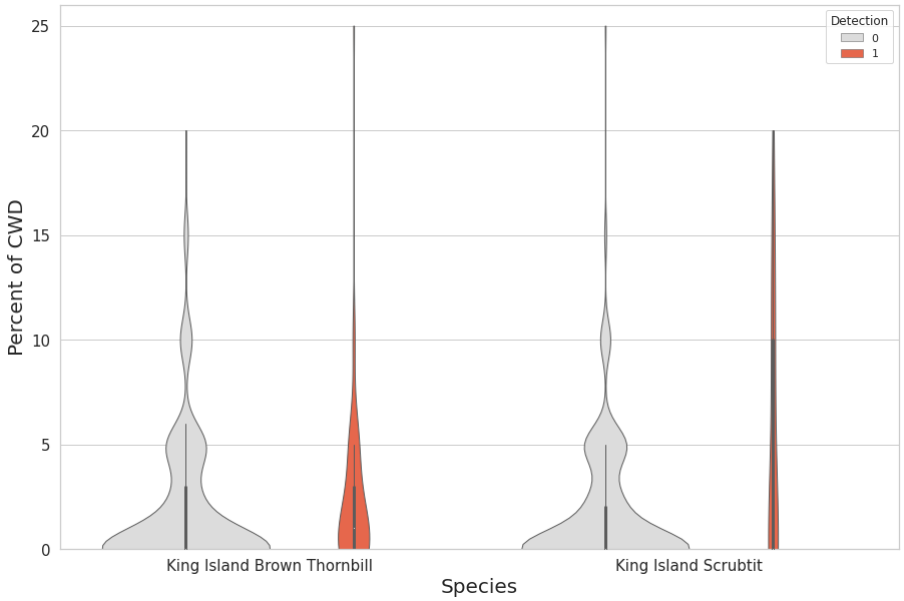


Figure 25 shows the comparison of distributions of *Melaleuca ericifolia* DBH-High data (i.e., the high range of diameter at breast height of *Melaleuca ericifolia*) recorded at King Island Brown Thornbills and King Island Scrubtit detection and non-detection sites. Comparison of the data distributions do not suggest an association between King Island Brown Thornbill detections and the DBH of *M. ericifolia*. In contract there appears to be a very strong positive relationship between DBH of *M. ericifolia* and detections of King Island Scrubtit.

Figure 25. Distribution of *Melaleuca ericifolia* DBH-High data recorded at King Island Brown Thornbill and King Island Scrubtit detection and non-detection sites.

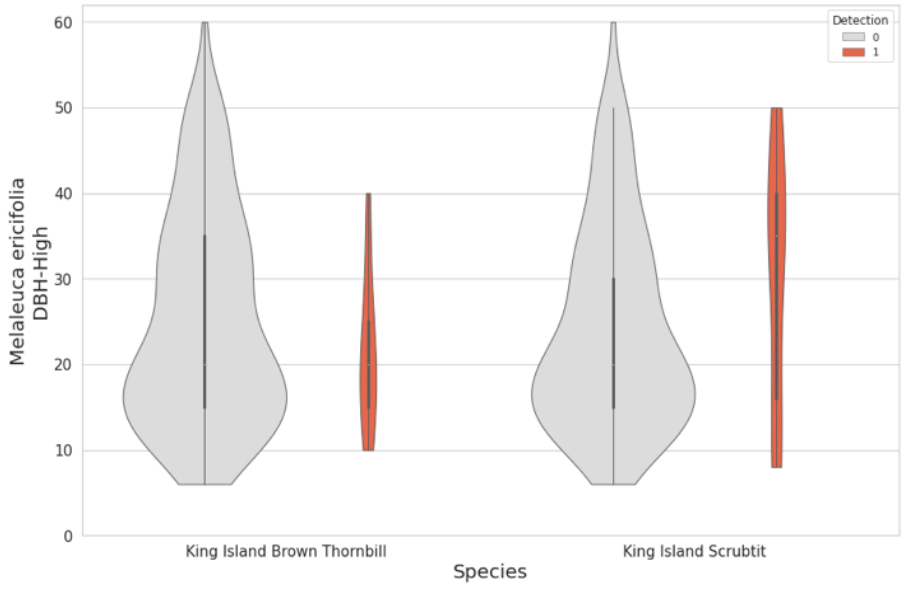


Figure 26 shows the comparison of distributions of eucalypt DBH-High data (i.e., the high range of diameter at breast height of eucalypts) recorded at King Island Brown Thornbills and King Island Scrubtit detection and non-detection sites. Comparison of the data distributions suggest a positive relationship between King Island Brown Thornbill detections and the DBH of eucalypts i.e., the subspecies appears to be more prevalent at sites with a eucalypt DBH of at least 40 cm. Eucalypts were absent from King Island Scrubtit detection sites.

Figure 26. Distribution of eucalypt DBH-High data recorded at King Island Brown Thornbill and King Island Scrubtit detection and non-detection sites.

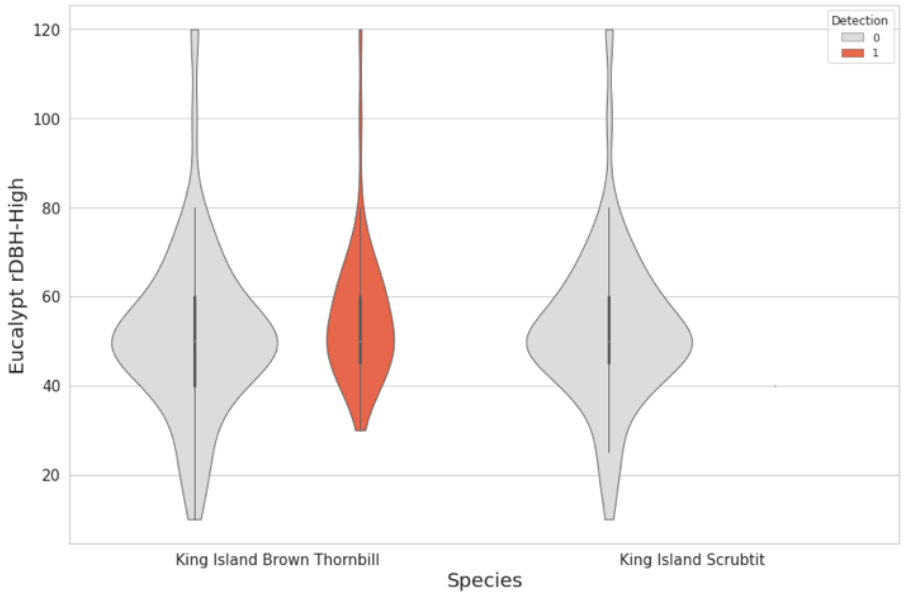
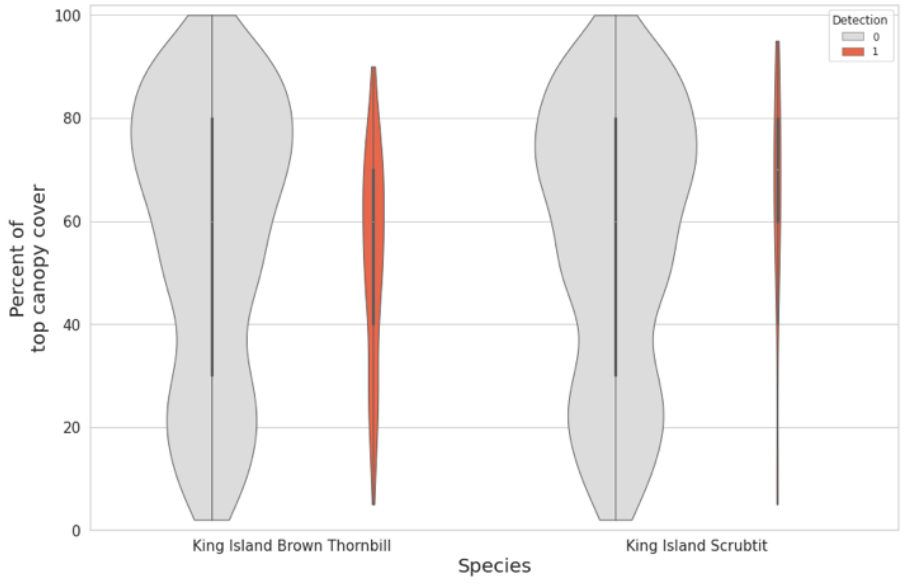


Figure 27 shows the comparison of distributions of top canopy cover data (i.e., the aerial cover of the dominant tree layer) recorded at King Island Brown Thornbills and King Island Scrubtit detection and non-detection sites. Comparison of the data distributions suggests little relationship between detections and aerial cover of the top tree canopy for either King Island Brown Thornbill or King Island Scrubtit.

Figure 27. Distribution of percent of top canopy cover data recorded at King Island Brown Thornbill and King Island Scrubtit detection and non-detection sites.



Model outputs

King Island Brown Thornbill and King Island Scrubtit based on TASVEG mapping units.

Covariates: n_{site}=972

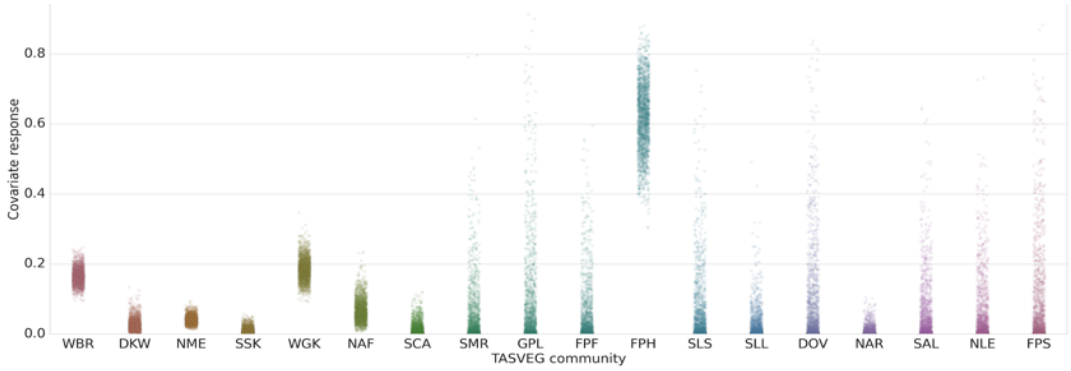
- TASVEG community (categorical)

Model fitting performance:

Species	RMSE	AUC	Accuracy	Sensitivity	Specificity
King Island Brown Thornbill	0.59	0.78	0.65	0.97	0.2
King Island Scrubtit	0.54	0.82	0.71	0.99	0.11

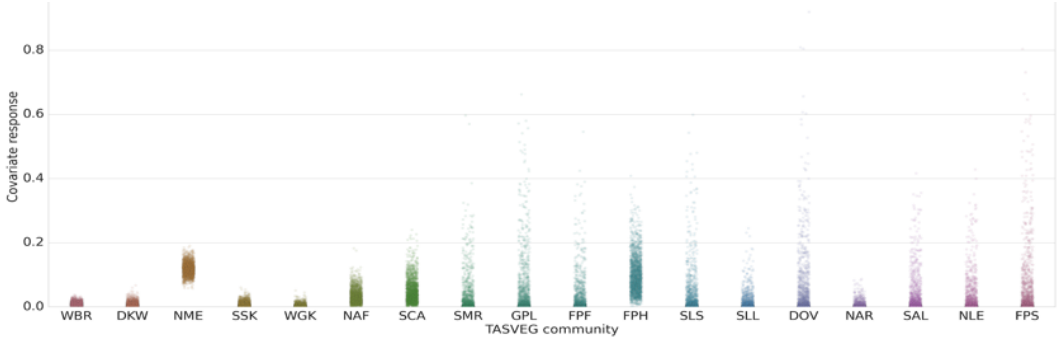
The TASVEG vegetation communities model performs well for the King Island Brown Thornbill, with the responses of *Eucalyptus brookeriana* wet forests (WBR) and *Eucalyptus globulus* King Island forest (WGK) showing a strong association with the subspecies' detection sites. The response of *E. obliqua* plantation (FPH) is considerably more dispersed which may be explained by the influence of mature native wet eucalypt forests along drainage lines and other remnants within the Pegarah State Forest block (Figure 28).

Figure 28. Covariate response: King Island Brown Thornbill



The TASVEG vegetation communities model performs well for the King Island Scrubtit, with the responses of *Melaleuca ericifolia* swamp forest (NME) showing an outstandingly strong association with the subspecies' detection sites (Figure 29).

Figure 29. Covariate response: King Island Scrubtit



King Island Brown Thornbill and King Island Scrubtit model based on key site-level covariates.

Covariates**:** n_{site}=233

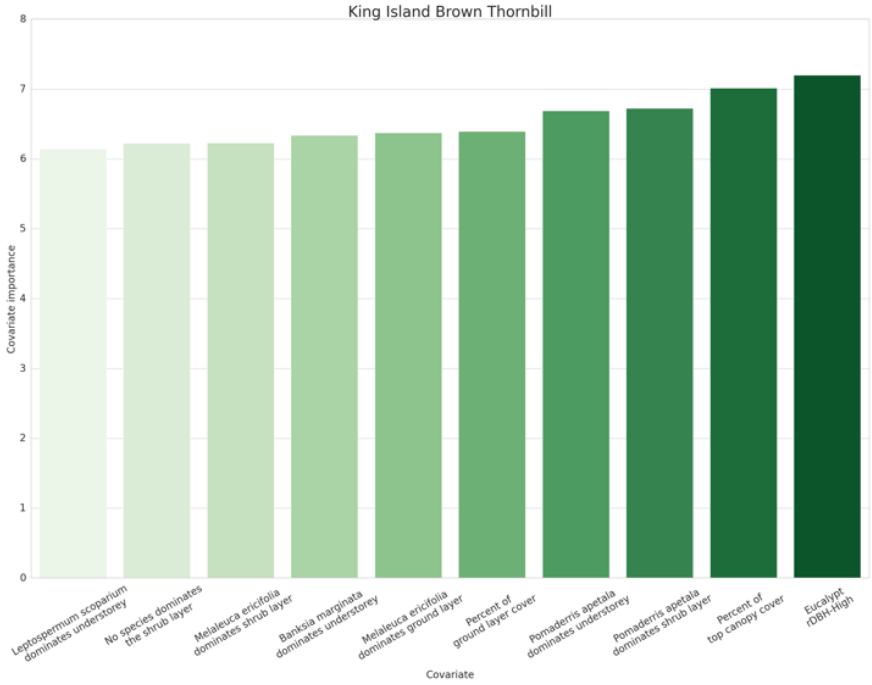
- Percentage cover of dominant canopy tree
- Dominant canopy tree species (categorical)
- Dominant canopy eucalypt high DBH
- Dominant canopy *Melaleuca ericifolia* high DBH
- Percentage cover of understorey tree layer
- Dominant understorey tree species (categorical)
- Percentage cover of ground layer
- Dominant ground layer species (categorical)
- Percentage cover of shrub layer
- Dominant shrub layer species (categorical)
- Percentage cover of coarse woody debris
- Percentage cover of coarse woody debris

Model fitting performance:

Species	**RMSE**	**AUC**	**Accuracy**	**Sensitivity**	**Specificity**
King Island Brown Thornbill	0.27	0.93	0.88	0.97	0.53
King Island Scrubtit	0.18	0.96	0.96	0.98	0.67

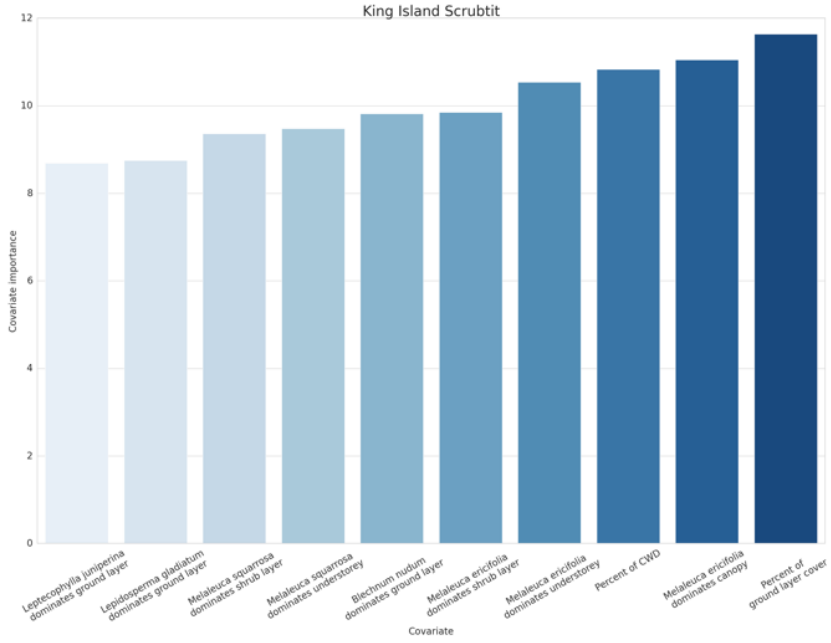
Important covariates at King Island Brown Thornbill detection sites include DBH of the dominant eucalypt, the percentage cover of the tree canopy, *Pomaderris apetala* dominant in the shrub layer and *P. apetala* dominant in the understorey (Figure 30).

Figure 30. The importance of key covariates at King Island Brown Thornbill detection sites.



Important covariates at King Island Scrubtit detection sites include the percentage ground layer vegetation cover, *Melaleuca ericifolia* dominant in the tree canopy layer, percentage cover of coarse woody debris and *M. ericifolia* dominant in the understorey layer (Figure 31).

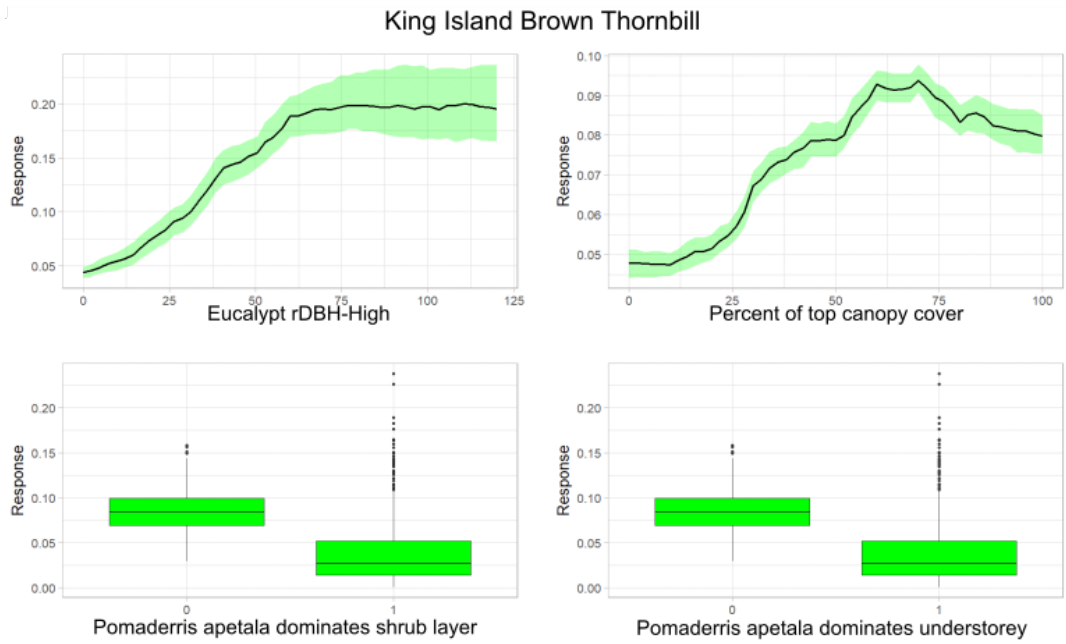
Figure 31. The importance of key covariates at King Island Scrubtit detection sites.



Partial dependence plots provide some insight into the relationship between habitat covariates and King Island Brown Thornbill detections (Figure 32A). Clearly the importance of DBH reflects the association of King Island Brown Thornbills with mature eucalypts. The response of eucalypt DBH rises rapidly to a DBH of about 60 cm after which the curve plateaus and the confidence interval increases. This likely reflects the association of King Island Brown Thornbills with mature eucalypts (i.e., at least about 60 cm DBH). Beyond 60 cm DBH there is no increased likelihood of detection as maturity has already been established.

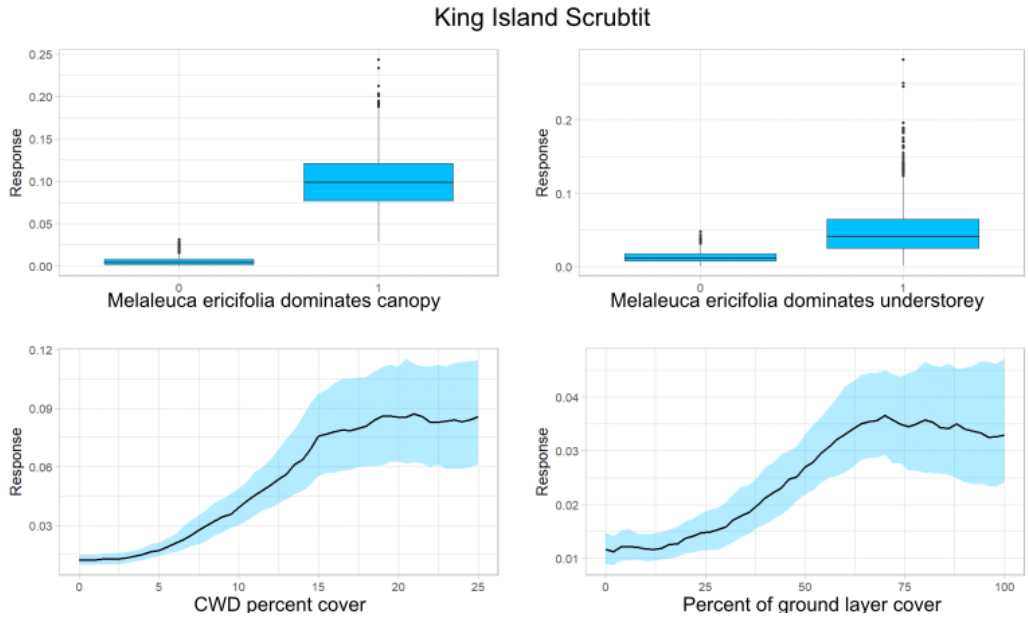
The response of percentage cover of the dominant tree canopy appears to be most favourable between 50% and 75% after which a closed canopy appears less suitable for the subspecies. The relationship between the presence of *Pomaderris apetala* in the shrub layer and/or the understorey layer is negative i.e., King Island Brown Thornbills are less likely to be detected when *P. apetala* is present. The reason for this relationship is not obvious however, it is common when *P. apetala* dominates the understorey in *E. brookeriana* wet forest (WBR) and/or *Eucalyptus globulus* King Island forest (WGK) it often occurs at a very dense cover, and is usually associated with low understorey species diversity.

Figure 32A. Partial dependence plots for covariates associated with King Island Brown Thornbill detections



Partial dependence plots provide some insight into the relationship between habitat covariates and King Island Scrubtit detections (Figure 32B). The importance of *Melaleuca ericifolia* as the dominant tree canopy species at detection sites is overwhelming. Without doubt this reflects the association of King Island Scrubtits with mature *M. ericifolia*. It is not surprising then, that there is also a strong relationship between *M. ericifolia* dominating the understorey tree layer and King Island Scrubtit detections. The response curve of the percentage cover of coarse woody debris rises sharply to 15%, after which the response plateaus and the confidence interval increases. This likely reflects the association of King Island Scrubtits with a complex understorey including fallen trees and logs for foraging. A similar response curve is seen for the percentage cover of ground layer vegetation, whereby there is a sharp rise in the covariate response to about 60% cover, following which the response plateaus and the confidence interval increases. It was noteworthy that King Island Scrubtit detections are often associated with a high ground layer cover of ferns, particularly *Blechnum*, *Dicksonia* and *Polystichum*.

Figure 32B. Partial dependence plots for covariates associated with King Island Scrubtit detections



Drone Aerial Imagery

Figures 33-38 show examples of drone aerial imagery (~2-3 cm pixel size) at detection sites for King Island Brown Thornbill and King Island Scrubtit. Figure 33 is a King Island Brown Thornbill detection site on private land west of Counsel Hill, located in *Eucalyptus brookeriana* wet forest (WBR) over a dense understorey of *Melaleuca ericifolia*. Figure 34 is a detection site at Kentford Forest Nature Reserve, also WBR, but with a more open understorey that includes *M. ericifolia*.

Figure 35 and 36 are King Island Scrubtit detection sites at Colliers Swamp Conservation Area and at the Nook Swamps in Lavinia State Reserve. Both sites are *Melaleuca ericifolia* swamp forest and support a dense canopy cover of *M. ericifolia*.

Figure 37 and 38 both show neighbouring King Island Brown Thornbill and King Island Scrubtit detection sites. Figure 37 is located at Lake Martha Lavinia. The King Island Brown Thornbill detection is associated with a localised occurrence of

Eucalyptus globulus and mature *M. ericifolia*. The Scrubtit detections are associated with mature *M. ericifolia* with localised dominance located in a sheltered flat adjacent to Lake Martha Lavinia. The vegetation rapidly shifts to Coastal scrub on alkaline sands (SCA) dominated by *Leptospermum laevigatum* as it rises sharply to the northeast on a large sand dune. Figure 38 is located within Pegarah State Forest with the King Island Brown Thornbill detections associated with *E. obliqua* plantation (FPH). The King Island Scrubtit detections are associated with intact native vegetation along a drainage line, dominated by *M. ericifolia*.

Figure 33. King Island Brown Thornbill habitat – Private land west of Counsel Hill (drone aerial imagery; approximate scale 1:400)

Figure 34. King Island Brown Thornbill detection site at Kentford Forest Nature Reserve (drone aerial imagery; approximate scale 1:400)

Figure 35. King Island Scrubtit detection site at Colliers Swamp Conservation Area (drone aerial imagery; approximate scale 1:500)

Figure 36. King Island Scrubtit detection site at Nook Swamps, Lavinia State Reserve (drone aerial imagery; approximate scale 1:500)

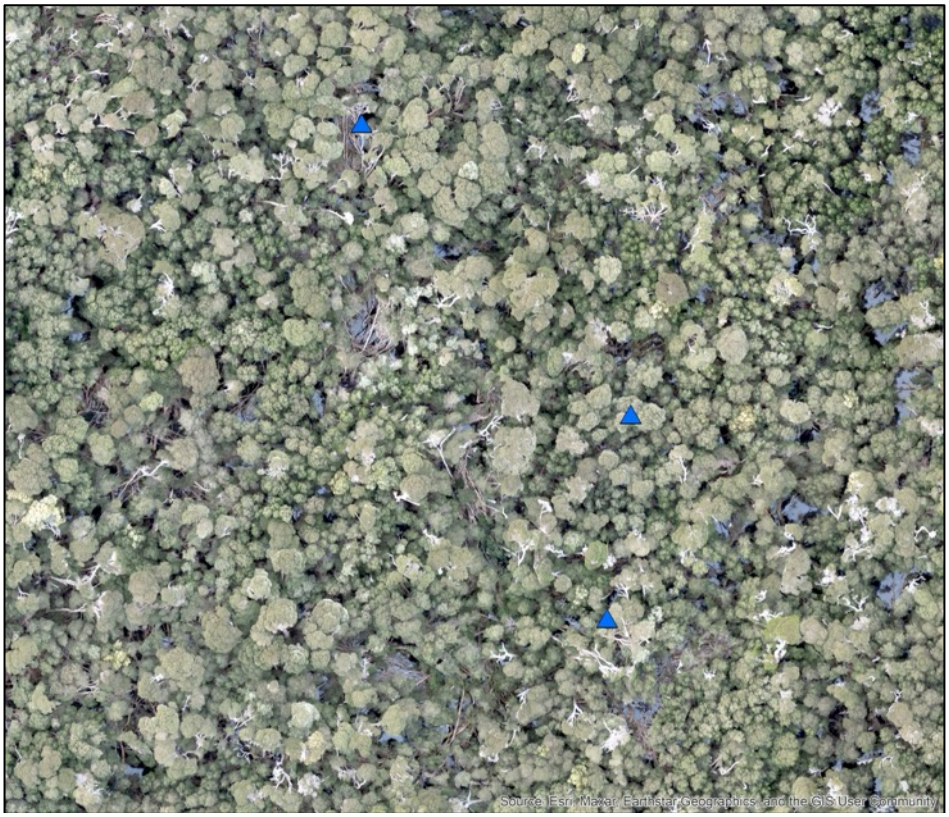
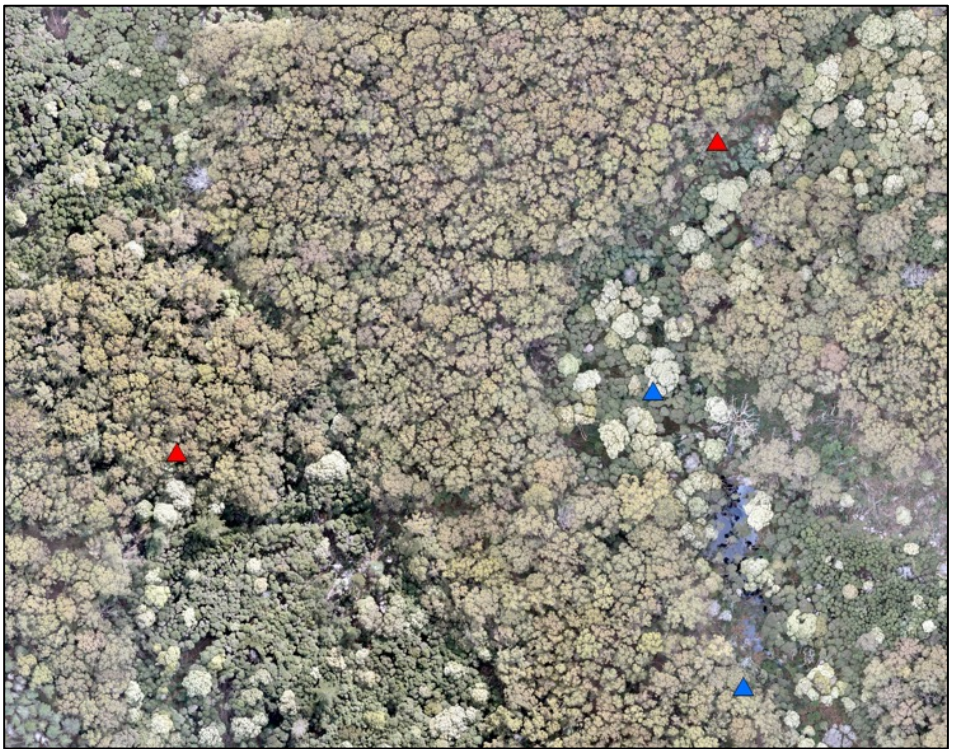


Figure 37. Neighbouring King Island Brown Thornbill and King Island Scrubtit detection sites at Lake Martha Lavinia, Lavinia State Reserve (aerial imagery; approximate scale 1:500)

Figure 38. Neighbouring King Island Brown Thornbill and King Island Scrubtit detection sites at Pegarah State Forest (aerial imagery; approximate scale 1:500)



Threatened flora observations

Incidental observations of several threatened flora species were made during bird surveys. Many of the observations represent additional locations for threatened flora and several new and substantial populations were identified for *Pimelea axiflora* and *Hypolepis distans*.

Blueberry Ash *Elaeocarpus reticulatus* (r, TSP Act) typically occurs in wet forests. In Tasmania *E. reticulatus* occurs only on King Island and Flinders Island. On King Island the species is threatened by fire, land clearance and cattle. Many observations were made of *E. reticulatus* during bird surveys, particularly on private land in remnant wet vegetation types (Figure 39).

Austral Mulberry *Hedycarya angustifolia* (r, TSP Act) typically occurs in wet forests, gullies and riverine habitats. In Tasmania *H. angustifolia* only occurs on King Island. On King Island the species is threatened by fire, land clearance and cattle. Many observations were made of *H. angustifolia* during bird surveys, particularly on private land remnants and deeply incised drainage lines (Figure 40).

Bootlace Bush *Pimelea axiflora subsp. axiflora* (e, TSP Act) typically occurs in wet forests. In Tasmania, *P. axiflora* only occurs on King Island. The species is threatened by fire, land clearance and cattle. Incidental observations of *P. axiflora* were made during bird surveys, including a significant and extensive additional subpopulation on Mt Stanley Road (Figure 41, 44).

Scrambling Groundfern *Hypolepis distans* (e, TSP Act; E, EPBC Act) typically occurs in wet forests and scrubs, and swamp forests. In Tasmania, *H. distans* occurs in far northwest Tasmania and on King Island. The species is threatened mainly by fire, land clearance and cattle. Incidental observations of *H. distans* during bird surveys has added three subpopulations to the five subpopulations previously known on the Island, including a substantial subpopulation carpeting an area in excess of 0.5 ha in the east of Colliers Swamp (Figure 42, 43).

Figure 39. *Locations of observation records of Blueberry Ash* Elaeocarpus reticulatus *made during the KITB Project (TSP Act = r).*
[sites overlaid on observation records of *Elaeocarpus reticulatus* in the Tasmanian, Natural Values Atlas (NRET), extracted November 2022; all sites overlaid on recent satellite image]

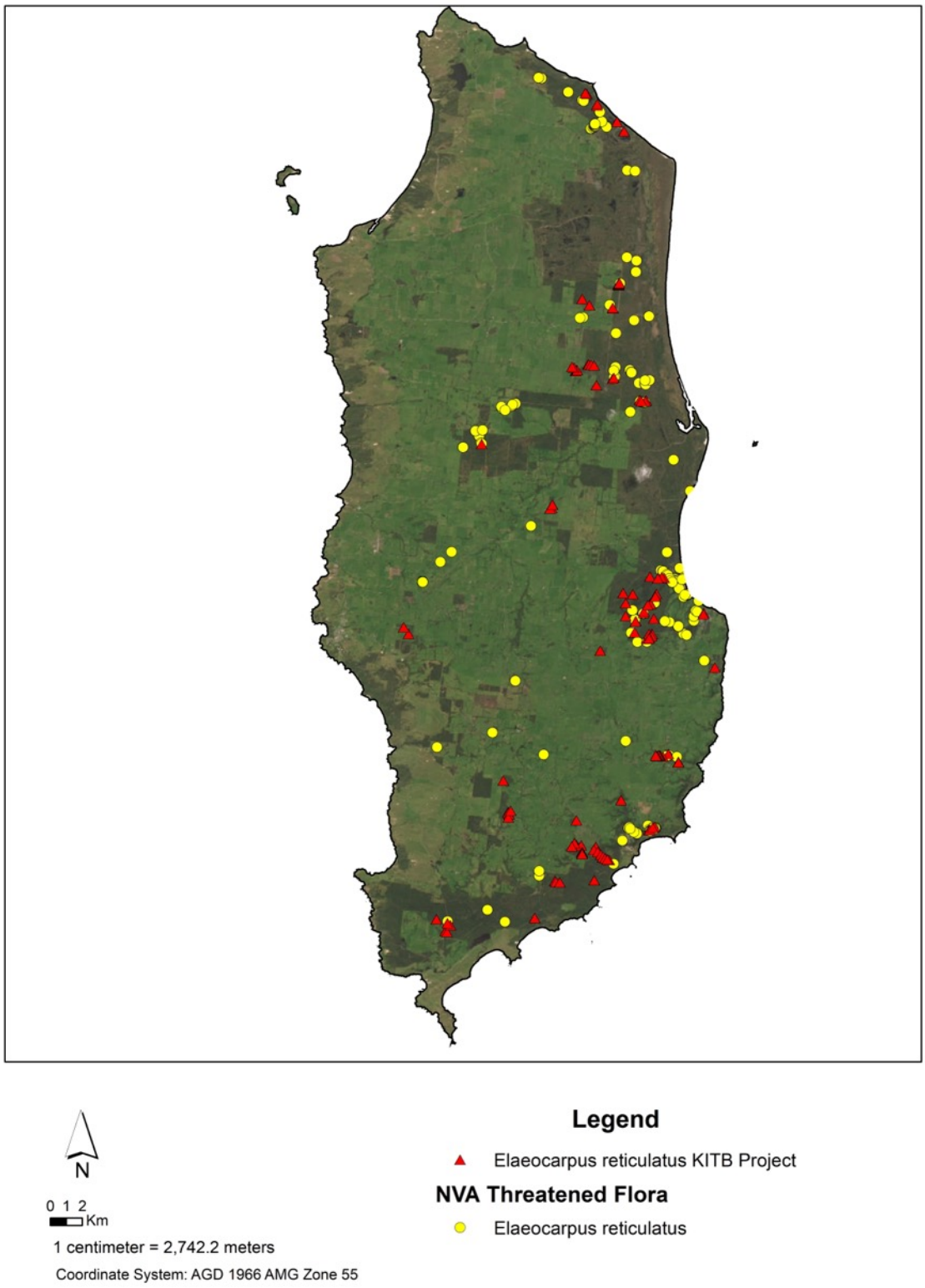


Figure 40. *Locations of observation records of Austral Mulberry* Hedycarya angustifolia *made during the KITB Project (TSP Act = r).*
[sites overlaid on observation records of *Hedycarya angustifolia* in the Tasmanian, Natural Values Atlas (NRET), extracted November 2022; all sites overlaid on recent satellite image]

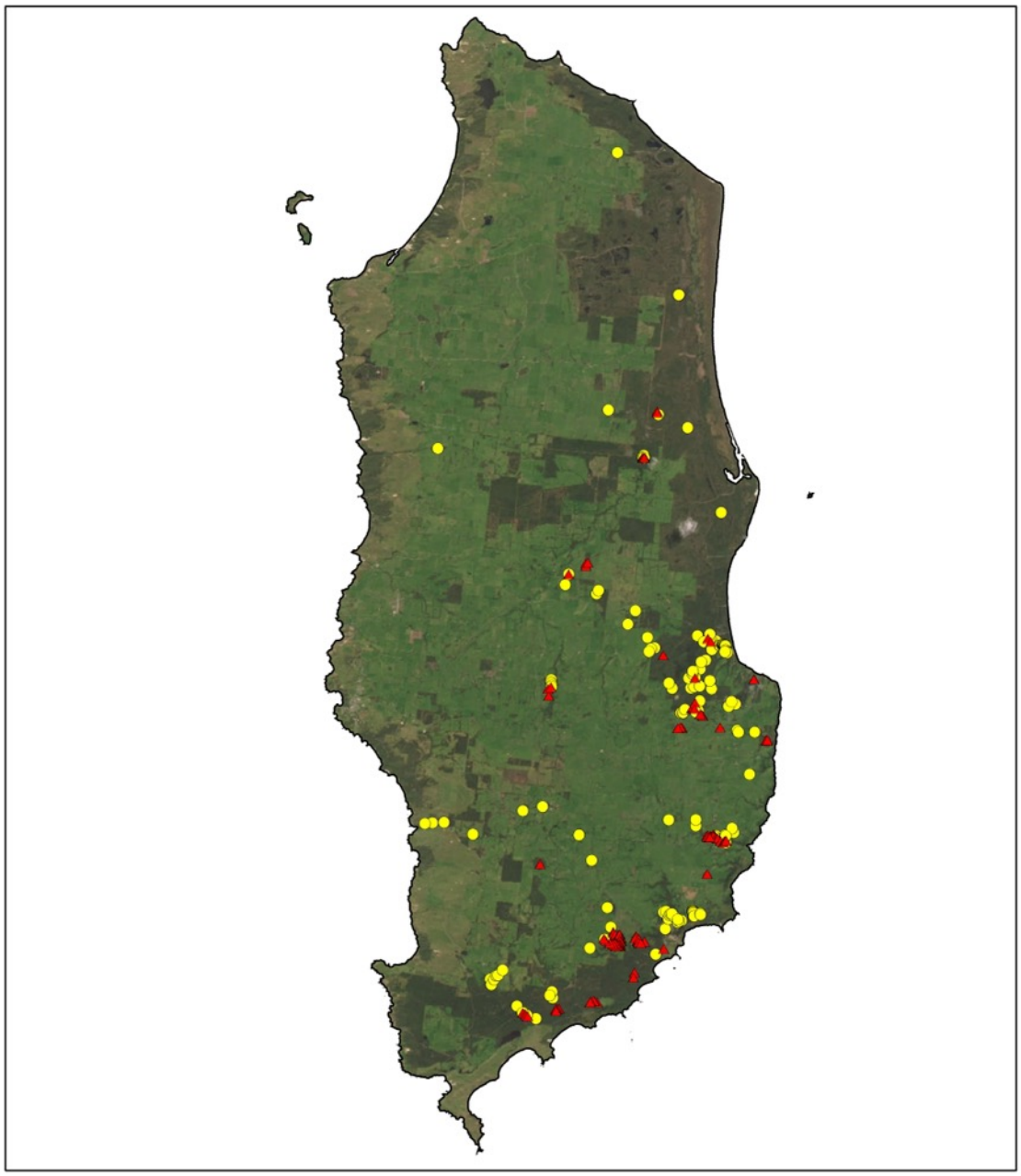


Figure 41. *Locations of observation records of Bootlace Bush* Pimelea axiflora *subsp*. axiflora *made during the KITB Project (TSP Act = e).*
[sites overlaid on observation records of *Pimelea axiflora* subsp. *axiflora* in the Tasmanian, Natural Values Atlas (NRET), extracted November 2022; all sites overlaid on recent satellite image]

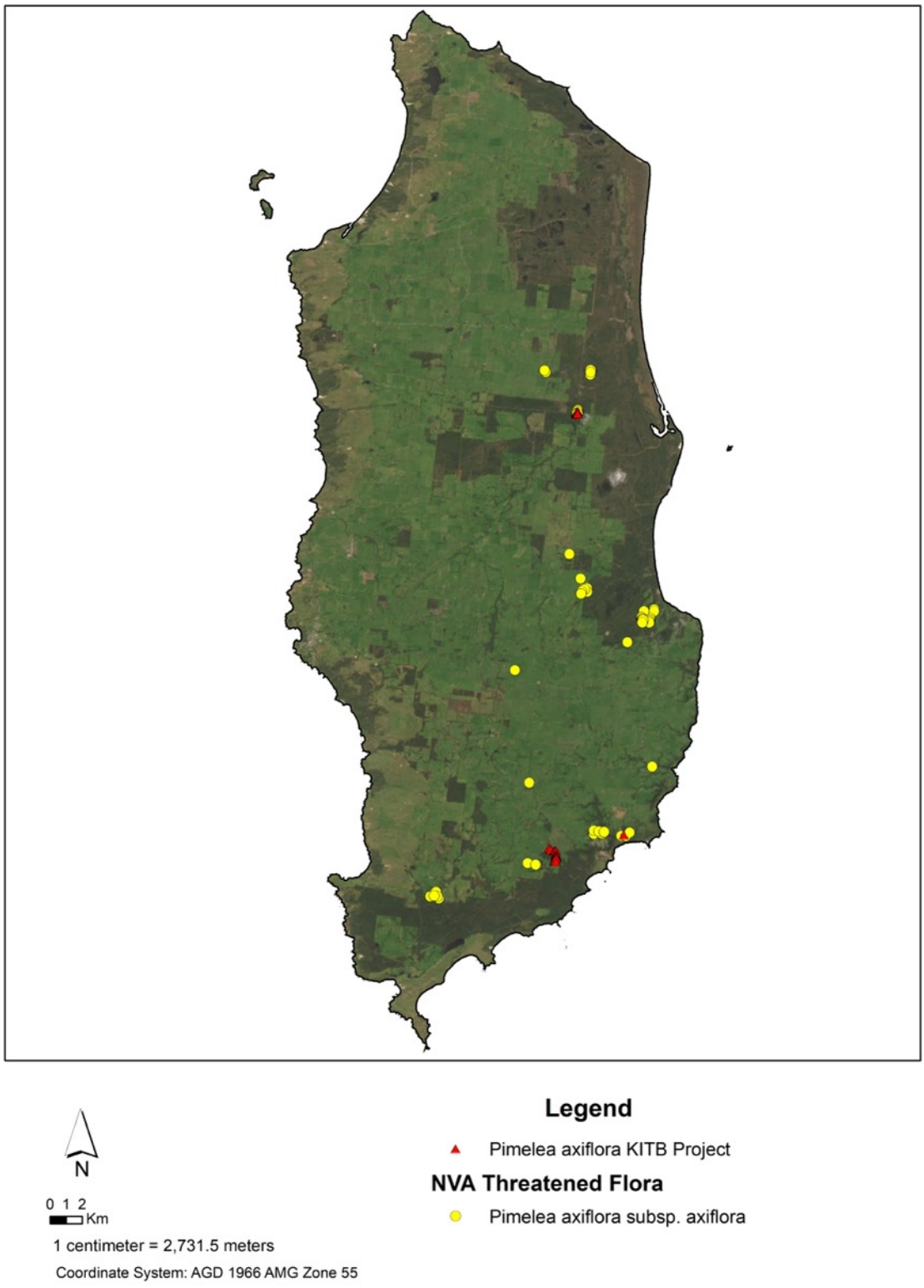


Figure 42. *Locations of observation records of Scrambling Groundfern* Hypolepis distans *made during the KITB Project (TSP Act = e; EPBC Act = E).*
[sites overlaid on observation records of *Hypolepis distans* in the Tasmanian, Natural Values Atlas (NRET), extracted November 2022; all sites overlaid on recent satellite image]

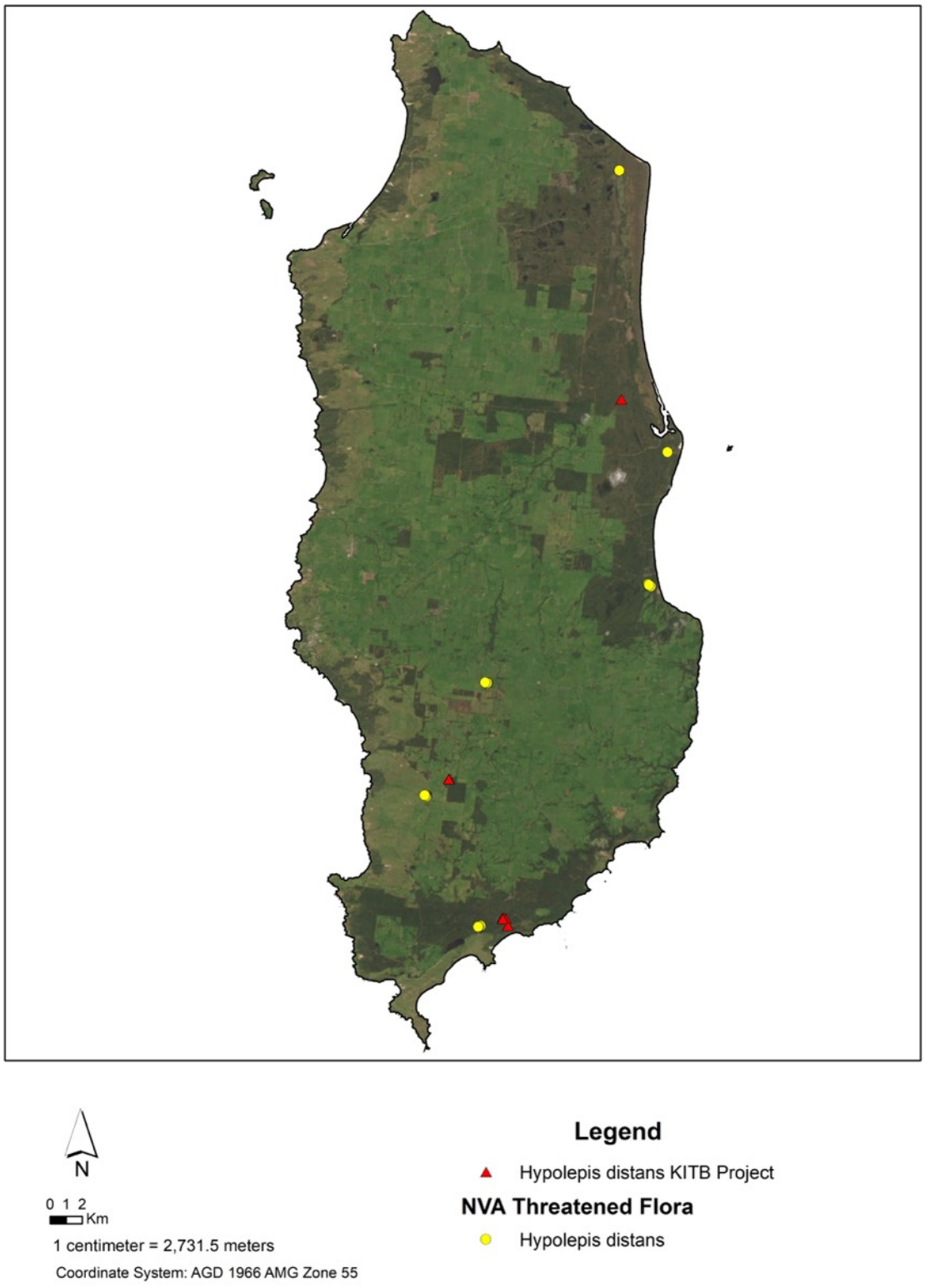


Figure 43. Scrambling Groundfern *Hypolepis distans* (TSP Act = e; EPBC Act = E) carpeting up to 0.5 ha in east Colliers Swamp Conservation Area.

Figure 44. Bootlace Bush *Pimelea axiflora subsp. axiflora* (TSP Act = e) a major shrub layer species on private property on Mt Stanley Road.

Threatened fauna observations

Observations of non-target threatened and near threatened bird species were made during targeted surveys for King Island Brown Thornbill and King Island Scrubtit. There is limited spatial data on the Natural Values Atlas (NVA) for some of King Island's rare birds. As the NVA is used as the key source of information on threatened species by environmental consultants, land use planners and natural resource management practitioners, entering incidental records on the NVA is encouraged. Note that there is likely to be a large number of observation records of King Island's rare birds (particularly threatened and near threatened birds) submitted to other biological databases such as BirdData (BirdLife Australia's online Bird Monitoring Platform). Indeed, our Project team members, Barry Baker and Mark Holdsworth, routinely enter their bird observation records into BirdData, including all observations records made during the current Project. We intend to collate all observation records of rare King Island birds made during the current Project and enter these in the NVA. The following incidental observations were made by one member of the Project team.

The White-bellied sea eagle *Haliaeetus leucogaster* is listed as vulnerable on the TSP Act. Three additional nest records were made during the Project - all known locally on King Island (Figure 45). The nest in Colliers Swamp is impressive (Figure 46).

Figure 47 shows the observation records of King Island Brown Thornbills 2019 – 2022 in comparison to observation records on the NVA made prior to 2019.

Figure 48 shows the observation records of King Island Scrubtits 2019 – 2022 in comparison to observation records on the NVA made prior to 2019.

King Island Green Rosella *Platycercus caledonicus brownii* is listed as vulnerable on the TSP Act. Observations were frequently observed in association with older and mature *Eucalypts globulus* King Island forest (Figure 49).

King Island Yellow Wattlebird *Anthochaera paradoxa kingi* is not listed as threatened but is considered to be a rare species on King Island. Holdsworth *et al.* (2021) in *The Action Plan for Australian Birds 2020* assessed the subspecies to be Endangered based on IUCN Red List criteria, on the basis of a small population that is likely to be declining due to ongoing land clearance (Figure 50).

Observation records of King Island Black Currawong *Strepera fuliginosa colei* are well represented in the NVA from across King Island through the Wings on King project. Wings on King is a project of the King Island Landcare Group and BirdLife Australia in association with Birds of King Island (Figure 51).

Figure 45. *Locations of observation records of White-bellied sea eagle* Haliaeetus leucogaster *nests made during the KITB Project (TSP Act = v).*
[sites overlaid on observation records of *Haliaeetus leucogaster* in the Tasmanian, Natural Values Atlas (NRET), extracted November 2022; all sites overlaid on recent satellite image]

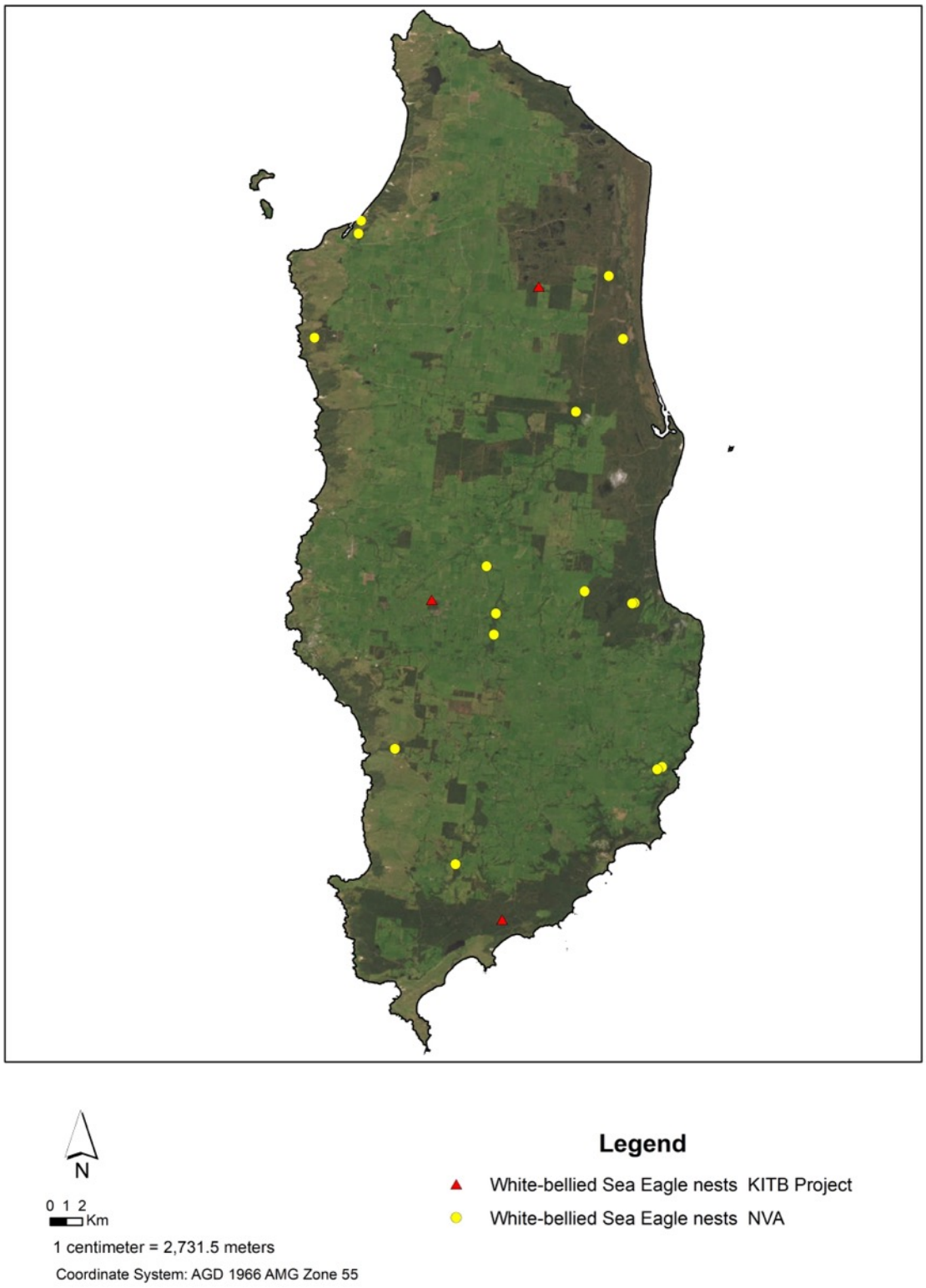


Figure 46. White-bellied sea eagle *Haliaeetus leucogaster* nest located in a mature *Eucalyptus brookeriana* in *E. brookeriana* wet forest WBR, Colliers Swamp

Figure 47. *Location of survey sites where King Island Brown Thornbills were detected, 2019 – 2022 compared to historic records prior to 2019.*
[sites overlaid on observation records made prior to 2019 of King Island Brown Thornbill in the Tasmanian, Natural Values Atlas (NRET), extracted November 2022; all sites overlaid on recent satellite image]

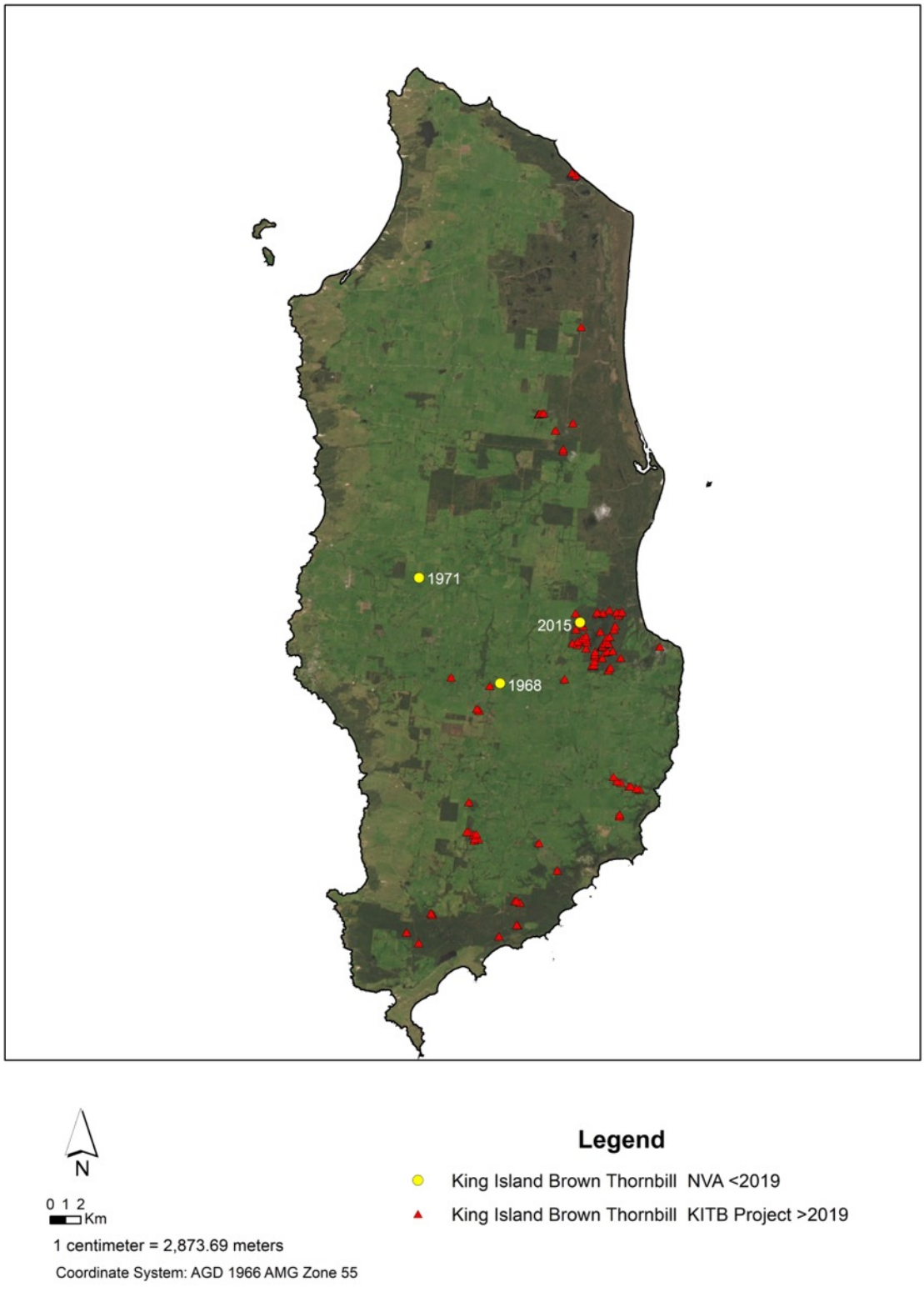


Figure 48. *Location of survey sites where King Island Scrubtits were detected, 2019 – 2022 compared to historic records prior to 2019.*
[sites overlaid on observation records made prior to 2019 of King Island Scrubtits in the Tasmanian, Natural Values Atlas (NRET), extracted November 2022 and re-validated; all sites overlaid on recent satellite image]

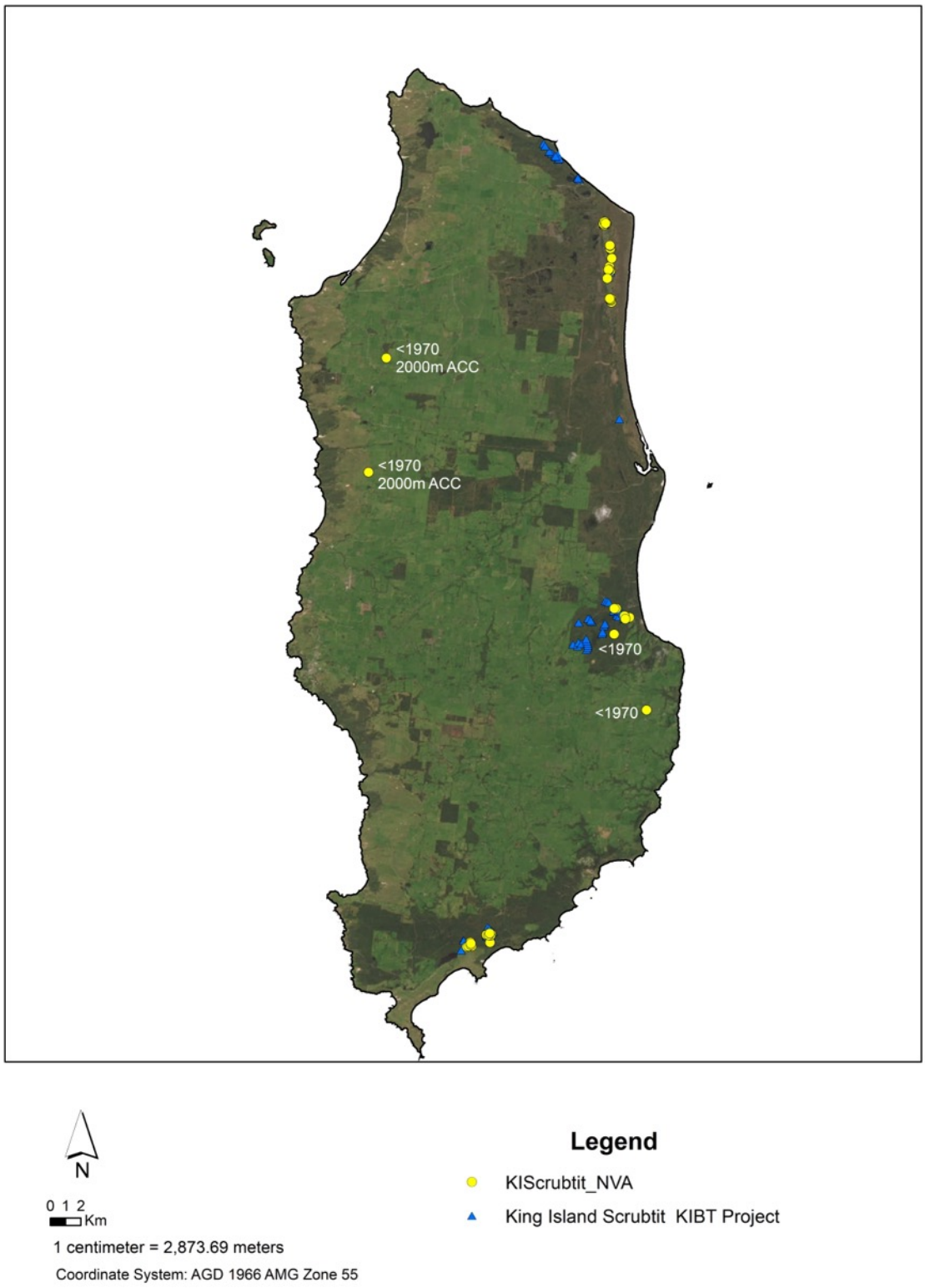


Figure 49. *Locations of observation records of King Island Green Rosella* Platycercus caledonicus brownii *made during the KITB Project (TSP Act = v).* [sites overlaid on observation records of *Platycercus caledonicus brownii* in the Tasmanian, Natural Values Atlas (NRET), extracted November 2022; all sites overlaid on recent satellite image]

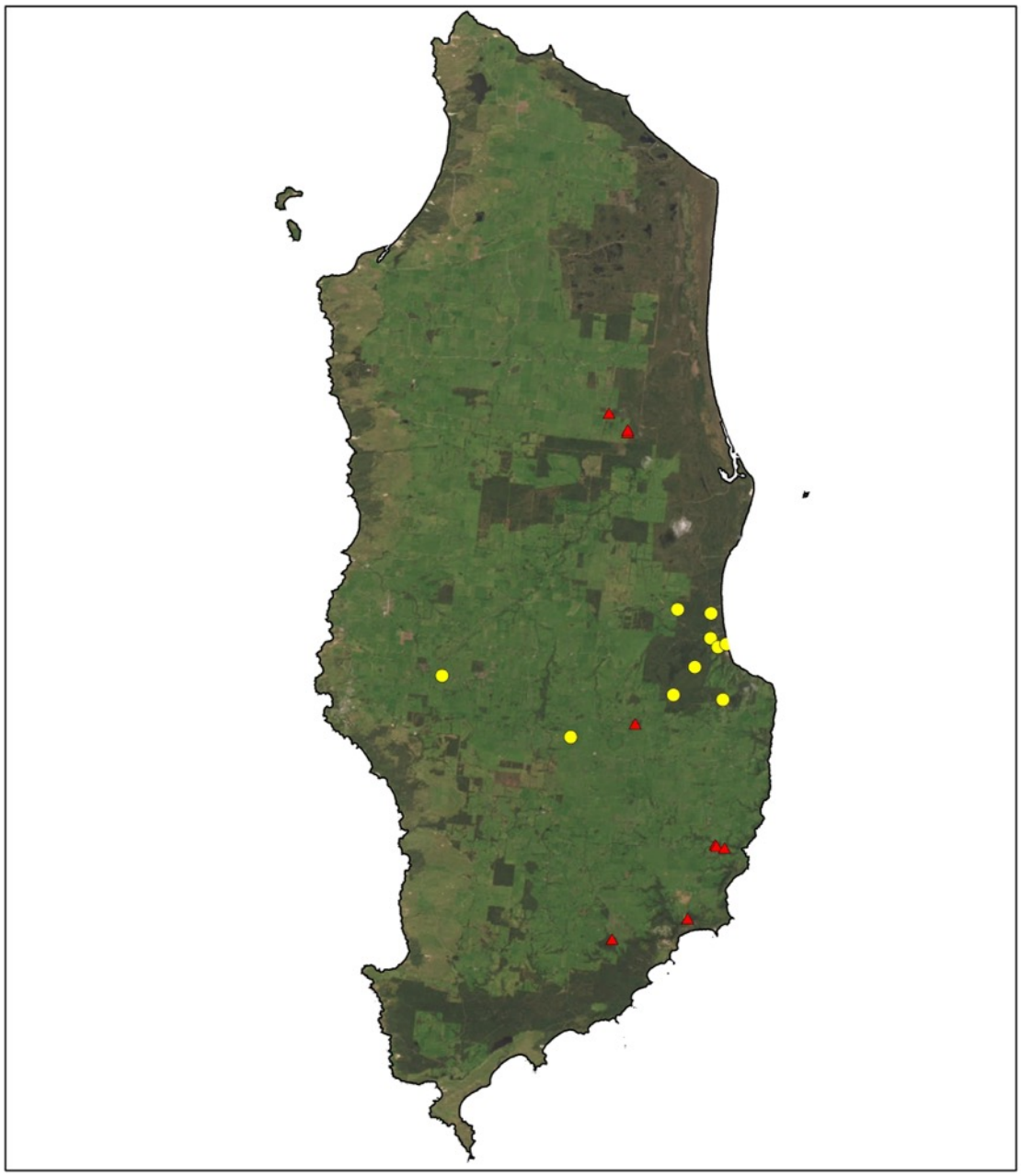


Figure 50. *Locations of observation records of King Island Yellow Wattlebird* Anthochaera paradoxa kingi *made during the KITB Project (not listed).* [sites overlaid on observation records of *Anthochaera paradoxa kingi* in the Tasmanian, Natural Values Atlas (NRET), extracted November 2022; all sites overlaid on recent satellite image]

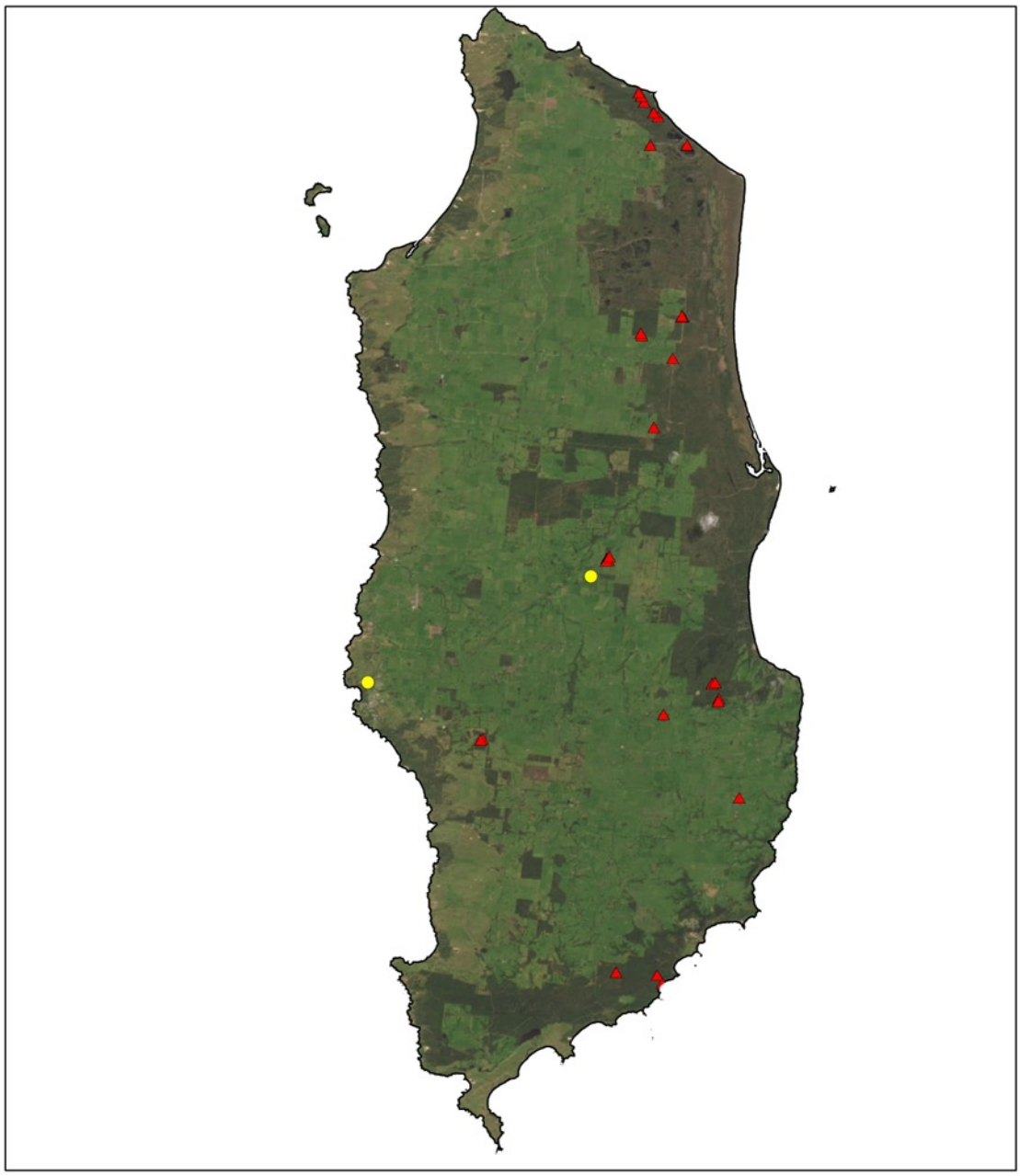


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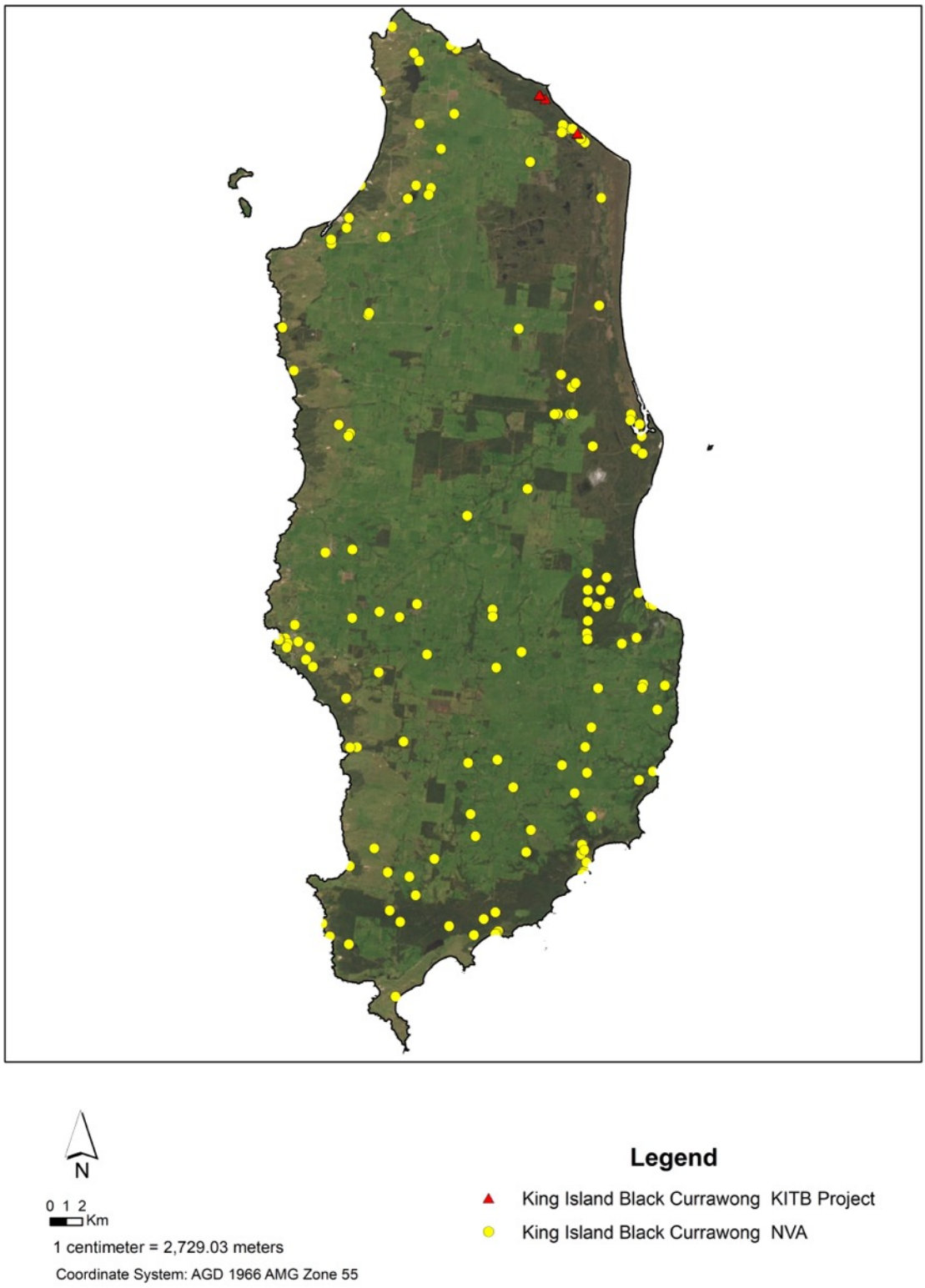
Figure 51. *Locations of observation records of King Island Black Currawong* Strepera fuliginosa colei *made during the KITB Project (V, EPBC Act).*
[sites overlaid on observation records of *Strepera fuliginosa colei* in the Tasmanian, Natural Values Atlas (NRET), extracted November 2022; all sites overlaid on recent satellite image]



TASVEG map of King Island

TASVEG is a Tasmania-wide vegetation map produced by the Tasmanian Vegetation Monitoring and Mapping Program (TVMMP), Department of Natural Resources and Environment Tasmania (NRET) and comprises over 150 mapping units captured at a nominal scale of 1:25,000. TASVEG is continually revised and updated via photographic and satellite image interpretation and is verified in the field where possible.

The inaccuracy of native vegetation mapping on King Island is recognised as a significant impediment to landscape conservation planning and management of biodiversity assets. Indeed, improved forest and scrub vegetation mapping on King Island is critical to the identification and management of King Island Brown Thornbill and King Island Scrubtit, both at the landscape scale and at the landuse planning and approvals scale.

Since the inception of the Project, we have worked closely with the TVMMP to develop protocols and processes for on-ground validation and revision of native vegetation mapping on King Island, focusing on forest and scrub vegetation communities. NRET provided the Project with a range of GIS mapping layers and tools to assist in this activity. Throughout the Project, the TVMMP have contributed, in a collaborative and coordinated manner to on-ground validation and revision of the native vegetation map of King Island.

TASVEG mapping on King Island has been shown to be poorly indicative of forest and scrub vegetation communities on the Island, and to be at its least indicative within the mosaic of forest and scrub that often occurs as *Eucalyptus brookeriana* wet forest (WBR), *Melaleuca ericifolia* swamp forest (MNE) and Scrub complex on King Island (SSK).

The KITB Project has provided the TVMMP with a considerable amount of data from field validation and revision of the TASVEG map of King Island. All data provided up until October 2021 is now incorporated into TASVEG Live. TASVEG Live is a snapshot of the in-production mapping for the official TASVEG dataset. TASVEG Live is an 'as-is' dataset and has not undergone the regular quality assurance checks associated with an official TASVEG release. TASVEG Live mapping is indicative only.

Progress with on-ground validation and revision of the TASVEG map of King Island at 1 January 2023 and data to inform ongoing review and revision collected by the Project is shown in Figure 52. Figure 52 does not show revisions to polygon codes and boundaries, rather the extent of TASVEG 4 polygons impacted by the KITB Project and the locations of vegetation community and habitat point data to assist in a major review of the TASVEG map of King Island by TVMMP in 2023.

Figure 53 shows the extent of drone aerial imagery captured by the Project in September 2022. This imagery has been provided to the TVMMP to assist in a major review of the TASVEG map of King Island in 2023.

The Tasmanian Government’s TVMMP will have access to 10 cm aerial imagery of King Island (flown in Spring 2022) to assist in a major review of the TASVEG map of the Island. The Project will assist the TVMMP towards developing an accurate TASVEG map of King Island that utilises the Project’s TASVEG, and habitat point data to validate aerial photographic interpretation from the new high resolution aerial imagery for King Island. The revised TASVEG map of King Island will then be used to develop a refined habitat map of potential and future potential habitat for the King Island Brown Thornbill and King Island Scrubtit, and habitat critical to the survival of these subspecies.

Figure 52. Progress with on-ground validation and revision of the TASVEG map of King Island at 1 January 2023. Revisions to polygon codes and boundaries are not shown rather, the extent of TASVEG 4 polygons impacted by the KITB Project and the distribution of vegetation community and habitat point data to assist in a major review by TVMMP in 2023.

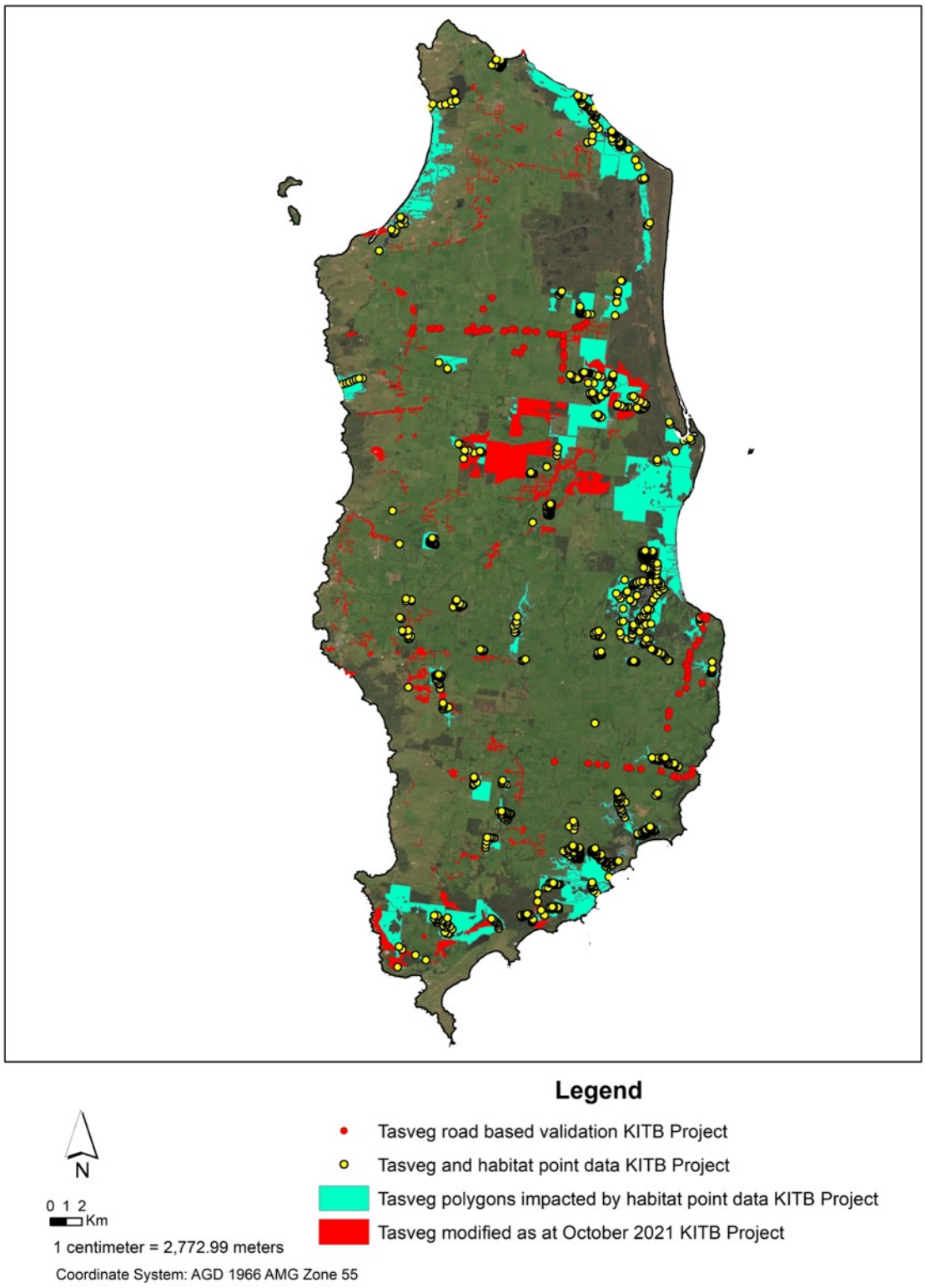
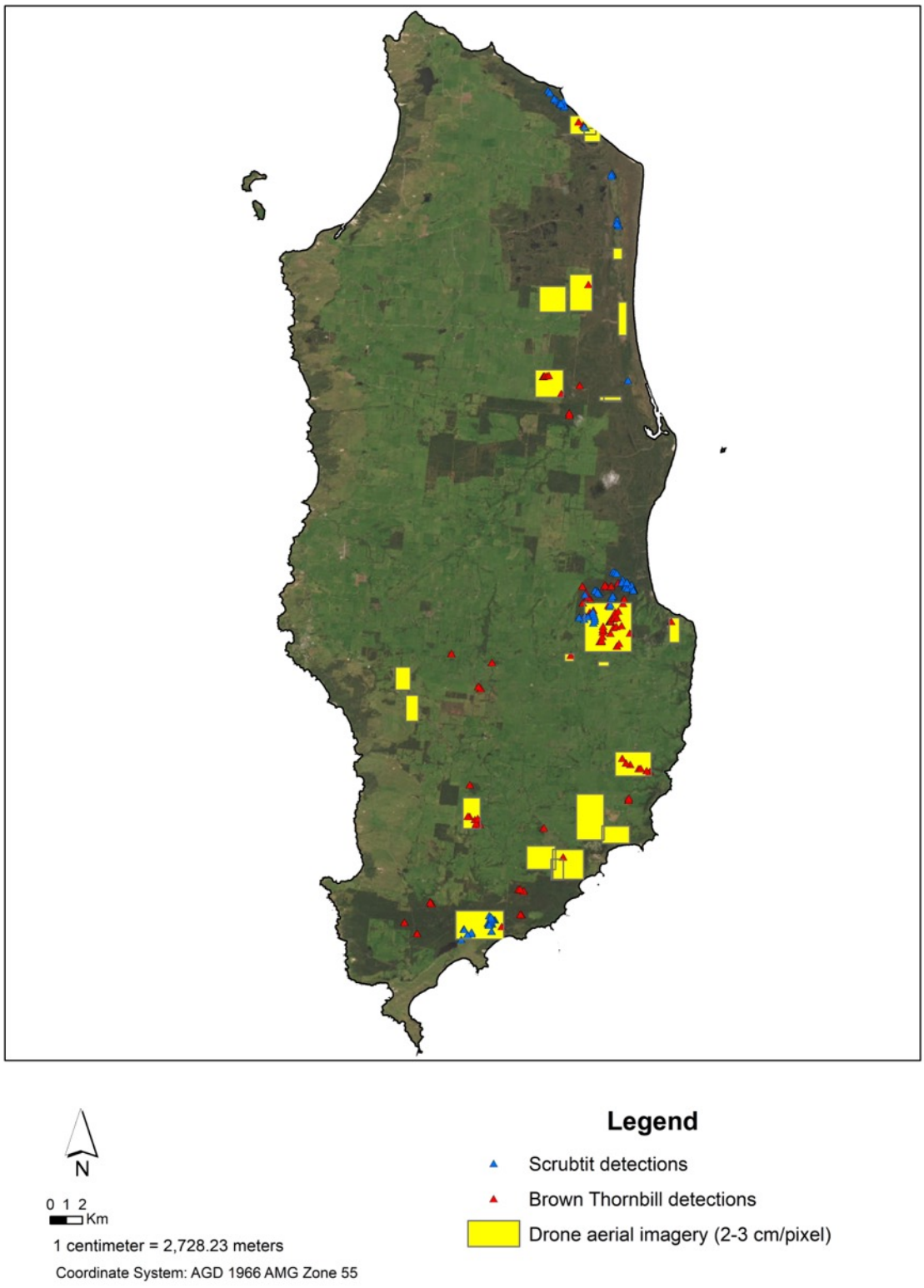


Figure 53. Extent of drone aerial imagery (~2-3 pixel/cm) captured by the Project in September 2022.



Discussion

King Island Brown Thornbill

The distribution of King Island Brown Thornbill is now known to extend north to Lake Martha Lavinia, west to Pegarah, and south to Colliers Swamp, Seal River and Macks Creek. Based on current detections of the subspecies, the Extent of Occurrence is estimated to be 320 km^2. The distribution of detections in both large contiguous vegetation patches and isolated vegetation remnants in farmland suggests a strong capacity for dispersal across unsuitable habitats, including agricultural landscapes. Based on the location of historical and recent detections it is likely the subspecies once occurred in suitable vegetation across the entire Island.

Additional locations and detections of King Island Brown Thornbill during the present Project, including detections at Lake Martha Lavinia, north and south of Counsel Hill, Naracoopa, Grassy Harbour, Seal River, Macks Creek, Kentford Forest north, Red Hut Road and Colliers Swamp, does not warrant a review of the estimated number of mature individuals of 100 (Range 50-200) reported by Holdsworth *et al.* (2021) in *The Action Plan for Australian Birds* 2020. Although the subspecies was detected at several new sites during the current Project most were considered to support only a few birds.

TASVEG mapping units most likely to contain habitat critical to the survival of King Island Brown Thornbill include, in order of prevalence, Plantations for Silviculture – hardwood (FPH) (i.e., *E. obliqua* dominated forest within Pegarah State Forest), Wet *Eucalyptus brookeriana* forest (WBR), *Eucalyptus globulus* King Island forest (WGK), *Acacia melanoxylon* swamp forest (NAF), *Melaleuca ericifolia* swamp forest (NME), King Island eucalypt woodland (DKW) and Scrub complex on King Island (SSK). In general terms, habitat critical to the survival of the King Island Brown Thornbill is considered to include all the forgoing TASVEG mapping units that currently support mature eucalypts (as an immediate priority for protection and conservation management) or support regrowth eucalypts with the potential to reach maturity in any of these TASVEG mapping units (as a secondary priority for protection and conservation management) i.e., future potential habitat.

The use and importance of SSK (which can commonly occur in a mosaic with eucalypt and *Melaleuca ericifolia* dominated forest communities) as a habitat for King Island Brown Thornbill remains poorly understood. Detailed site-level investigations will be required to elucidate the role of this TASVEG mapping unit in the subspecies' ecology, including its role as a functional habitat for breeding, foraging and dispersal. Nonetheless, dominant flora species that characterise SSK, including *Banksia marginata*, *M. ericifolia*, *Leptospermum scoparia*, *Acacia verticillata* and *A. mucronata*, often form a component of the understorey tree layer at sites where King Island Brown Thornbill has been detected. Notwithstanding the lack of detections of King Island Brown Thornbill in SSK, there is little doubt this vegetation community forms part of the matrix of the subspecies' habitat, and buffers habitat from the adverse impacts of land clearing, browsing and trampling by domestic stock, exotic and native mammal browsing, weeds, windthrow and other potential threats. A precautionary approach to the conservation of King Island Brown Thornbill would therefore require protection of SSK where it occurs in contiguous native vegetation patches known to support the subspecies.

In isolation, Coastal scrub on alkaline sands (SCA) is not likely to contain habitat critical to the survival of the King Island Brown Thornbill. However, where SCA occurs in contiguous native vegetation patches known to support the subspecies and/or native vegetation communities supporting eucalypts, it does form part of the

matrix of this subspecies' habitat and provides a buffer from the variety of threats acting on known and future potential habitat.

Little is known of the role of SCA, SSK or other minor scrub vegetation communities in dispersal of the King Island Brown Thornbill, though the detection of the subspecies in small, isolated forest remnants in agricultural land would suggest considerable mobility.

The dominant canopy species where King Island Brown Thornbills were detected, in order of prevalence includes *Eucalyptus obliqua* (i.e., only within Pegarah State Forest), *E. brookeriana*, *E. globulus*, *E. viminalis*, *Acacia melanoxylon*, *Melaleuca ericifolia* and *Leptospermum laevigatum*. Clearly, dominance of the canopy by eucalypts is a fundamental component of the subspecies' habitat. *Leptospermum laevigatum* was recorded at only one of 25 sites, at a location where Coastal scrub on alkaline sands (SCA) was associated with a highly localised dominance by eucalypts and *M. ericifolia*.

A significant amount of habitat data has now been collected at the site-level and strong associations have been identified between King Island Brown Thornbill and habitat covariates. *Eucalyptus brookeriana* wet forests (WBR) and *Eucalyptus globulus* King Island forest (WGK) show a very strong association with the subspecies' detection sites. The very high prevalence of detections of King Island Brown Thornbills in Plantations for Silviculture – hardwood (FPH) likely reflects the suitability of *E. obliqua* plantation (note *E. obliqua* plantation is only present in Pegarah State Forest). However, the modelled response of FPH is more dispersed which may reflect an influence from mature native wet eucalypt forests along drainage lines and other native forest remnants within Pegarah State Forest.

The overwhelming association between the presence of eucalypts in the forest tree canopy and the detection of King Island Brown Thornbills is qualified by the relationship with the diameter at breast height of eucalypts at survey sites. Modelling of the habitat data suggests the subspecies is strongly associated with mature eucalypt forests. The covariate response rises sharply to a DBH of 50-60 cm and then plateaus with a corresponding increase in the confidence intervals, suggesting that once a certain maturity of the eucalypt forest (or of individual eucalypts) is reached there is little additional influence of DBH on the detection of the subspecies. Modelling of habitat data suggests a strong influence of the tree canopy cover with maximum response between 50-70% cover. There is a strong negative relationship with the presence of *Pomaderris apetala* in the shrub layer and/or in the understorey layer which is more difficult to interpret. However, *P. apetala* in the understorey is generally correlated with a dense understorey tree or shrub layer, a high stem density and low flora species diversity.

Although there are some strong associations of site-level covariates with detection of King Island Brown Thornbills, habitat suitability is likely to be strongly linked to vegetation age, patch size, fragmentation and connectivity. Therefore, the addition of a spatial component into modelling of King Island Brown Thornbill habitat is likely to be rewarding. Spatial data in its most basic form (i.e., latitude and longitude of survey sites) will be introduced into habitat models and supplemented with ecologically relevant measures of habitat and vegetation patch size, fragmentation and connectivity. The combination of site-level and spatial factors in the modelling is likely to provide strong predictors of the subspecies presence and more guidance in the development of conservation actions for the King Island Brown Thornbill.

The Project has made considerable progress in identifying the current distribution and habitat of the King Island Brown Thornbill however, targeted research is now required, including standardised population monitoring and studies of demography,

functional habitats and movements to better understand the subspecies' conservation ecology and inform management actions for its recovery.

King Island Scrubtit

The distribution of King Island Scrubtit is now known to extend north to Lavinia State Reserve, between Lake Martha Lavinia and Granite Lagoon. Based on current detections of the subspecies, the Extent of Occurrence and Area of Occupancy may warrant review.

Additional locations and detections of King Island Scrubtit during the current Project, including detections at Lake Martha Lavinia and Granite Lagoon, is not considered to warrant a review of the estimated number of mature individuals of the subspecies, beyond the estimate of 50 (Range 30-70) by Holdsworth *et al.* (2021) in *The Action Plan for Australian Birds* 2020. Indeed, there is some concern for the viability of birds in isolated patches of mature *Melaleuca ericifolia* swamp forest in Nook Swamps which did not burn during the 2007 fire. Further, substantial windthrow has also been observed in remnant mature *M. ericifolia* forest in both Nook Swamps and Colliers Swamp, which requires ongoing monitoring.

TASVEG mapping units most likely to contain habitat critical to the survival of King Island Scrubtit include, in order of prevalence, *Melaleuca ericifolia* swamp forest (NME), Plantations for Silviculture – hardwood (FPH) (i.e., *E. obliqua* dominated forest within Pegarah State Forest), Coastal scrub on alkaline sands (SCA), *Acacia melanoxylon* swamp forest (NAF), Wet *Eucalyptus brookeriana* forest (WBR) and Scrub complex on King Island (SSK). There is little doubt that NME is the most important predictor of the subspecies' presence. In general terms, habitat critical to the survival of the King Island Scrubtit is considered to include all the forgoing TASVEG mapping units that currently support mature *M. ericifolia* (as an immediate priority for protection and conservation management) or support regrowth *M. ericifolia* with the potential to reach maturity in any of these TASVEG mapping units (as a secondary priority for protection and conservation management) i.e., future potential habitat.

The use and importance of scrub vegetation communities such as Scrub complex on King Island (SSK) and Coastal scrub on alkaline sands (SCA) (which can both support localised occurrences of *Melaleuca ericifolia* dominated forest), as a habitat for King Island Scrubtit remains poorly understood. Detailed site-level investigations will be required to elucidate the role of these TASVEG mapping units in the subspecies' ecology. Nonetheless, in isolation, neither SSK or SCA, is likely to contain habitat critical to the survival of the King Island Scrubtit due to the dense structure, and lack of understorey and ground layer complexity in these vegetation communities. The role of SSK and SCA is more likely to assist in dispersal and act as a habitat buffer from the array of potential threats to the subspecies on King Island. A precautionary approach to conservation of King Island Scrubtit would at least require protection of SSK and SCA where these vegetation communities occur in contiguous native vegetation patches known to support the subspecies.

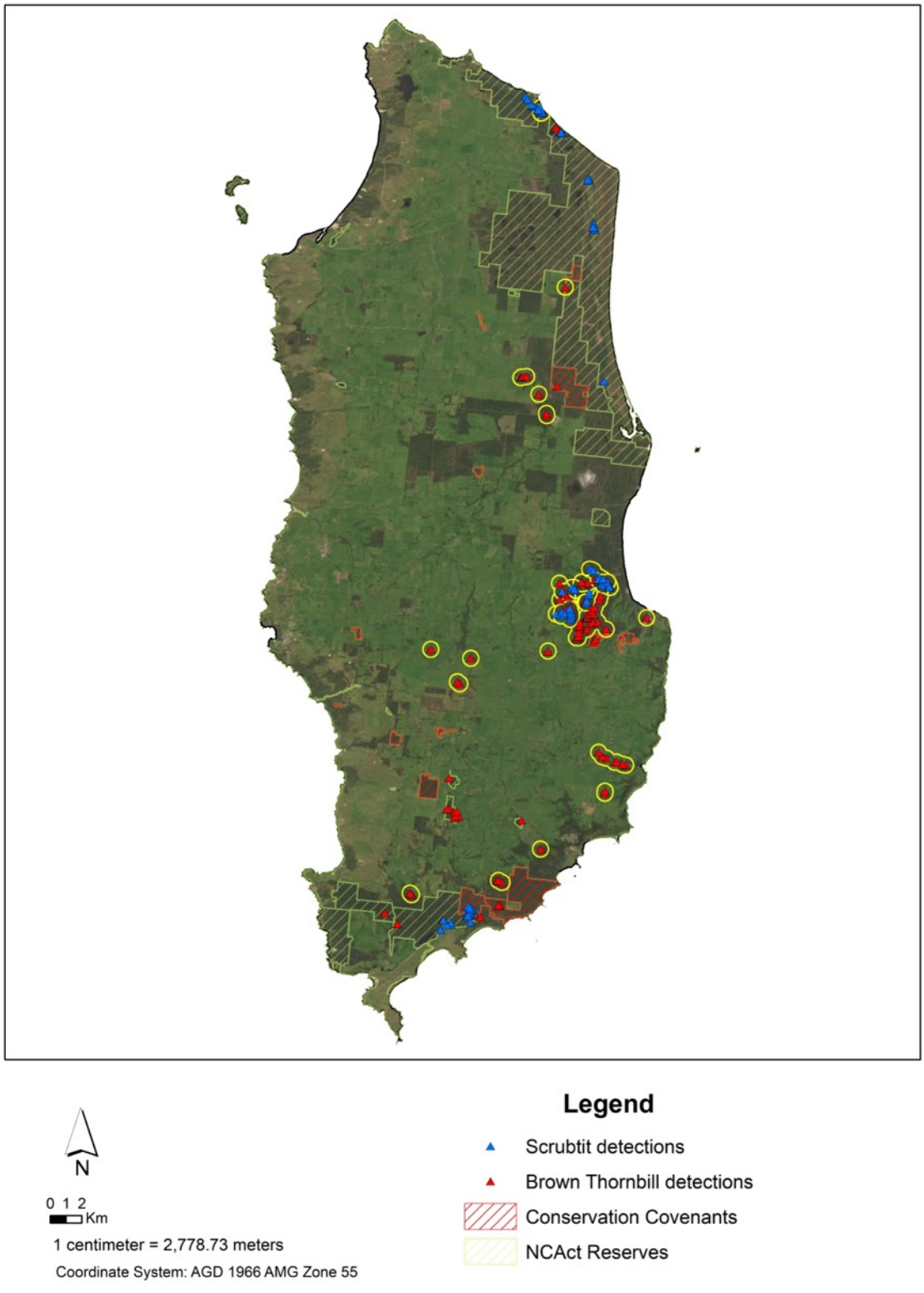
Results of modelling of King Island Scrubtit habitat data reinforces the apparent associations identified in previous surveys of the subspecies by Webb *et al.* (2016), Webb and Crates (2019) and Webb and Bell (2020). The presence of mature *Melaleuca ericifolia* is overwhelmingly the strongest predictor of the presence of King Island Scrubtit. Seventy-eight percent of detections (where TASVEG vegetation community was recorded) were in *Melaleuca ericifolia* swamp forest (NME). It is not surprising that the most common dominant tree canopy species was *M. ericifolia* (i.e., 74% of detection sites) and the most common dominant understorey tree was also *M. ericifolia* (i.e., 61% of detection sites). The species is positively correlated with the cover of ground layer vegetation reflecting the often-high cover of ferns including

Blechnum nudum, *Polystichum proliferum* and *Dicksonia antarctica*. The cover of coarse woody debris is a strong predictor of the presence of the King Island Scrubtit, no doubt reflecting the subspecies' preference for habitats with high structural complexity in the understorey, including fallen trees and logs.

The Project has made considerable progress in identifying the current distribution and habitat of the King Island Scrubtit, but for similar reasons put forward for the King Island Brown Thornbill, targeted research is now required including standardised population monitoring and studies of demography, functional habitats, and movements to better understand the subspecies' conservation ecology and inform management actions for its recovery.

Figure 54 shows the locations of King Island Brown Thornbill and King Island Scrubtit detections on unreserved private and public land in relation to the distribution of NCA Act reserves on private and public land. An assessment of the security of potential habitat at these locations and potential threats to resident birds is a conservation priority.

Figure 54. *Locations of King Island Brown Thornbill and King Island Scrubtit detections (2019 – 2022), on unreserved public and private land.*
[sites overlaid on recent satellite image]



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