Yarr's Flat Wildlife Reserve & Yarr's Lagoon: An assessment of fauna present to guide future restoration and conservation of native species

by

Mike Bowie & Mitch Hutson

Lincoln University Wildlife Management Report No. 58

Department of Ecology
Faculty of Agriculture and Life Sciences

Lincoln University
Te Whare Wānaka o Aoraki
CHRISTCHURCH·NEW ZEALAND

New Zealand's specialist land-based university

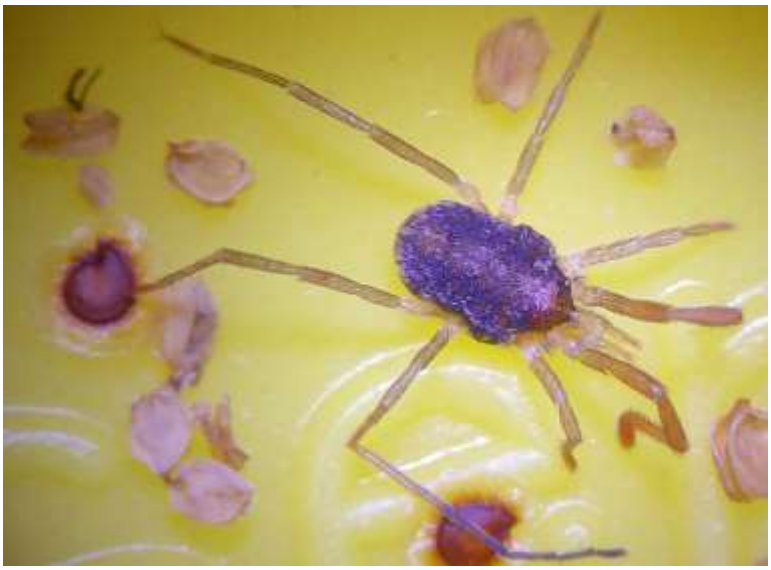
ISSN: 1177-6242 (Print)

ISSN: 1179-7738 (Digital)

ISBN 978-0-86476-414-0 (Digital)

Lincoln University Wildlife Management Report No. 58

Yarr's Flat Wildlife Reserve & Yarr's Lagoon: An assessment of fauna present to guide future restoration and conservation of native species



by

Mike Bowie & Mitch Hutson

Department of Ecology, Lincoln University, PO Box 85084, Lincoln 7647
Email: mike.bowie@lincoln.ac.nz

Prepared for:

Living Water

July 2016

Yarr's Lagoon & Yarr's Flat Wildlife Reserve: An assessment of fauna present to guide future restoration and conservation of native species

Mike Bowie and Mitch Hutson
Ecology Department
Faculty of Agriculture and Life Sciences
Lincoln University
Mike.bowie@lincoln.ac.nz

Abstract

Two sites of ecological interest, Yarr's Lagoon and Yarr's Flat Wildlife Reserve along the LII or Araiara River in Selwyn District, Canterbury were surveyed for terrestrial fauna of interest. A variety of standard methods including pitfall traps, Malaise traps and light traps (for invertebrates), tracking tunnels (for lizards and mammals), five minute bird counts (for birds) were used to assess the fauna present. A higher diversity of ground beetles were found in willow habitats than native habitats at both Yarr's Flat and Yarr's Lagoon. Native moth larva, weevils and mites were found on glasswort at Yarr's Flat. Eleven and seven native birds were found at Yarr's Lagoon and Yarr's Flat respectively. Of interest was a probable sighting of sandpiper curlew at Yarr's Flat and secretive marsh crake at Yarr's Lagoon. Lizards found included the common skink at Yarr's Flat and an unknown skink at Yarr's Lagoon. Tracking tunnels found prints from possum, mice, hedgehog, rats and mustelid at Yarrs Flat and only possum and mice from Yarr's Lagoon. Ecological restoration of the two areas are discussed and recommendations for the management of the native biodiversity is given.

1. Introduction

New Zealand's native lowland ecosystems have been dramatically modified since human occupation due to fire, forest clearance, wetland drainage and the intensive development of agriculture over the past 50 years (MfE, 1997; Norton and Miller, 2000). The largest proportion (30%) of threatened and uncommon native plants in New Zealand are in lowland habitats (de Lange et al. 2009). The Canterbury Plains is one of the worst affected areas with <1% of its original native cover remaining (Ecroyd and Brockerhoff 2005) and Canterbury has the highest number (223 species) of "Threatened" and "At Risk" plants (de Lange et al. 2009). Degradation of New Zealand's wetland areas to about 10% of its original are considered one of the worst in the world (Peters and Clarkson, 2010).

Lake Ellesmere (Te Waihora) as the fifth largest lake in New Zealand and has been internationally recognised as an important wetland. Its ecosystem supports over 166 species of birds of which 133 are native species, as well as many other native faunal species ("Living Water," 2016; Gough & Ward, 1996). It also has been nationally recognised with its own National Water Conservation Order (Reeves, 1990).

One of the rivers that feeds into Lake Ellesmere is the LII (Araiara) which provides an aquatic habitat for birds, aquatic invertebrates including the native fresh water crayfish (Koura), and both rainbow trout (*Oncorhynchus* mykiss) and brown trout (*Salmo trutta*) are common.

Living Water (2016), a partnership between Fonterra and Department of Conservation (DOC) have identified these two ecological areas, Yarr's lagoon and Yarr's Flat adjacent to the LII (Figure 1) within the Te Waihora catchment that would benefit from ecological restoration. The fauna of Yarr's Lagoon ranges from species of both native and exotic birds, insects and mammals. Bird species include swamp birds, waterfowl and forest birds including pukeko (*Porphyrio porphyrio melanotus*), fantail (*Rhipidura fuliginosa*), grey warbler (*Gerygone igata*), shoveler (*Anas rhynchotis*), swans (*Cygnus atratus*), and mallard duck (*Anas platyrhynchos*) (Parker & Grove, 2013).

Biodiversity at Yarr's Flat and Yarr's Lagoon currently is not very well documented and may well have some species of conservation interest. Both of these areas come under the Selwyn catchment which has had some research done nearby such as on Lake Ellesmere (Gough and Ward, 1996). Agriculture, specifically dairy farming is causing significant damage to the waterways (Gough and Ward, 1996; Di and Cameron 2002; Houlbrooke et al. 2004; MacLeod & Moller 2006) and is assumed to be the case in the lower reaches of this catchment.

Restoration efforts (e.g. new planting at Yarr's Flat and willow control in Yarr's Lagoon) are important contributions for improving the quality of these two areas. This report will document the biodiversity found at both Yarr's Lagoon and Yarr's Flat. The baseline data collected from monitoring fauna in the two sites will allow future comparisons in a replicated scientific way so trends over time can be observed. Based on the findings, recommendations will be made on how to improve and manage the biodiversity of these two sites.

Figure 1: Location of Yarr's Flat and Yarr's Lagoon (Image: Google Earth)

1.1 Yarr's Lagoon

Yarr's Lagoon is a Selwyn District Council reserve (Parker & Grove, 2013), approximately 76.9 hectares in area (Blake-Manson, 2011) and is dominated by Grey and Crack willow (*Salix cinerea* & *Salix fragilis*) which are both highly tolerant to saturated soils such as Yarr's Lagoon (Wilkinson, 1999). Scattered through the willow invasion there are native species including one of the largest remnants of manuka (*Leptospermum scoparium*) on the Canterbury Plains (Parker & Grove, 2013). Some *Coprosma* species are also present as well as other common native and exotic plants. Gorse (*Ulex europaeus*) is scattered throughout the whole of Yarr's lagoon in small clumped populations as well as some other less common but worrying weeds such as Spanish heath (*Erica lusitanica*), blackberry (*Rubus fruticosus*) and convolvulus (*Convolvulus verecundus).*

1.2 Yarr's Flat

Yarr's Flat is an open flat on the shores of Lake Ellesmere and has been regarded as wildlife habitat of national and international importance with some of the highest bird diversity in New Zealand (Hughey & Taylor, 2009; O'Donnell, 1985). It is approximately 286 hectares in total area (Department of Conservation, n.d.) however, some of this area is sometimes submerged due to lake levels fluctuating (Wilks, 2010). There virtually no large trees with the exception of some willow around the edges and a mature *Pinus radiata* shelter belt that used to shelter the hut that was once there. The dominant native vegetation is the saltmarsh ribbonwood (*Plagianthus divaricatus*) with exotic grasses (usually

twitch, *Elymus repens*) being a dominant weed in the area. The area also holds small but stabilised monocultures of raupo (*Typha orientalis*) (O'Donnell, 1985) and native wetland stinging nettle (*Urtica linearifolia*). Both of these species are considered locally rare and at risk on the threat ranking system (Butt, 2015). In spring of 2015 native plants were established Yarr's Flat based on Lincoln University Landscape Department plans. Sampling of this restored area will test how the native fauna in the area respond over time.

An understanding of biodiversity in an area is crucial to the ecological values that are present (Brown et al. 2015). Depending on the specific plant species present, they may also provide ecosystem services invaluable to humans such as phytoremediation. This report will assess the faunal biodiversity both of these areas including birds, mammals and invertebrates.

2. Methodology

Monitoring methods used followed as close as possible to Department of Conservation protocols. Biodiversity monitoring for this project was based mainly on fauna including; Invertebrates, birds, mammals and lizards.

2.1 Invertebrate Monitoring

Invertebrates were monitored using a mixed method approach in selected plots.

2.1.1 Pitfall traps

In both study locations pitfall traps were put out in lots of four in the different habitats existing in both research areas. In Yarr's Lagoon there were three monitoring sites where pitfall traps were set, consisting of 12 pitfall traps. One in manuka, one in native rushland and one in willow (see Figure 2 for location).

Pitfall traps were put in the ground using a pitfall corer and placed level with the top of the ground. They were then filled with approximately 50-100 ml of glycol and a lid was placed over them so no rain got into them. On the 16th and 17th of December they were made active by having their lids removed, and left out for a month between December and January. This was consistent for all of 32 pitfall traps at both sites. Locations of each pitfall trap were marked as a waypoint on a GPS for ease of replication and to help locate for retrieval in areas where it would be hard to find them again. For some of the locations where it was more open tussock land/grass land, there was a middle point marked and from there. Pitfalls were placed in north, south, east and west locations at each site respectively from the GPS position.

Yarr's Lagoon pitfall traps were placed in three broad habitat types (Figure 2):

PM1 = Four pitfalls with individual way points throughout the manuka patch

PR1 = Four pitfall traps in the native rush land site placed as close as possible to native vegetation

PFW3 = Four pitfall traps under some willow trees where there was also some native revegetation

Figure 2: Locations of pitfall traps at Yarr's Lagoon

Yarr's Flat had six monitoring sites (Figure 3) consisting of 24 pitfall traps in total. There were two sites in the salt-marsh ribbonwood (*Plagianthus divaricatus*), two sites in the new native planting sites, one site where native planting is proposed in 2016, and one site in the willow trees which has been identified as an area where kahikatea could be planted in the future.

PF1 = Four pitfall traps in an area where it has not been planted but will be planted after my research. This area has been sprayed with herbicide so all grass is either dying, dead or growing back slowly.

PF2 = Four pitfall traps in an area recently planted with native plants.

PFR3 = Four pitfall traps in an area with lots of salt-marsh ribbonwood. They were placed under or very close to the plants and because of this all have an individual waypoint as they are difficult to locate.

PF4 = Four pitfall traps adjacent to some salt-marsh ribbonwood plants

PF5 = Four pitfalls in an area where it is currently overgrown willow but planned for future Kahikatea trees

Figure 3. Locations of pitfall traps at Yarr's Flat

2.1.2 Light Trapping

Light trapping was also employed to sample the nocturnal invertebrate life. A 160W mercury vapour light trap with capture box beneath was used to collect moths. Moths were also hand collected as some moth species do not come close to light. Yarr's Lagoon was light trapped in the native rush habitat where some manure still survive (S43 41.020 E172 27.007). The Yarr's Flat light-trapping was undertaken in track next to glasswort and close to salt-marsh ribbonwood patches (S43 43.115 E172 27.681). Captured moths were frozen until curated. Although numbers of moths were recorded the data is presented in terms of presence and absence (see Appendix).

2.1.3 Malaise Traps

A Malaise trap placed at both research sites in locations were out of sight of humans, open for flying insects and easy to access.

At Yarr's Lagoon a malaise trap was placed in the open native rushland site (Figure 4; S43 41.020 E172 27.007).

Figure 4: Location of the Malaise trap in the rushland site at Yarr's Lagoon

The Malaise trap at Yarr's Flat was placed in some of the more mature salt-marsh ribbonwood (Figure 5; S43 43.101 E172 27.722).

Figure 5: Location of the Malaise trap at Yarr's Flat

2.1.4 Wooden Discs

Wooden discs (Bowie and Frampton, 2004) were used at both study sites as a non-destructive monitoring method. Each disc was placed on exposed soil by clearing all of the grass away. This was so

the vegetation did not rot underneath them. They were left in the field for future monitoring. Ten wooden discs were placed throughout two different locations of Yarr's Lagoon (Figure 6). Sites included in the native rushland habitat (WD11-WD15) and under the willow trees amongst the native understory (WD16-WD20).

Figure 6: Locations of wooden discs at Yarr's Lagoon

Wooden discs at Yarr's Flat were placed trying to cover a variety of habitats (Figure 7) including: natural native vegetation (saltmarsh ribbonwood) (WDR1 & WDR2), native planted areas (WD3 & WD4), proposed native plant out area (WD5), and exotic vegetation (willow trees) (WD6). In total there were nine discs put out in Yarr's Flat. Two discs were placed at WDR1, WDR2 and WD6 as they were next to each other. The others all had a single disc at each waypoint.

Figure 7. Locations of wooden discs at Yarr's Flat

2.1.5 Weta Motels

Weta motels were also placed permanently at both sites. Ten were placed at each site and all of them were marked on the GPS so they can be evaluated each year for an assessment of biodiversity. These were all placed approximately at a height of ~1-1.5 so it is easier to assess and safe from ground predators.

At Yarr's Lagoon weta motels were placed among the native rushland site and the native manuka site (Figure 8). They were all placed on tree trunks that were large enough to hold the weta motel.

Figure 8: Locations of weta motels at Yarr's Lagoon

At Yarr's Flat motels were all attached to salt-marsh ribbonwood (Figure 9).

Figure 9: Locations of weta motels at Yarr's Flat: overview (left) & layout in ribbonwood (right)

2.1.6 Litter extraction

Leaf litter collected from under manuka patch at the eastern end of Yarr's Lagoon on 14 January 2016 was placed on a Berlese Funnel for seven days and specimens collected into 70% ethanol and curated for identification.

2.2 Mammal and lizard tracking tunnels

Both mammals and lizards were monitored using the mixed monitoring approach which uses the same tracking tunnel lines for all species. These tracking tunnel lines were put out according to DOC protocol as best as they could be. There was one tracking line put in at Yarr's Lagoon and two lines at Yarr's Flat. Each tracking line had 10 tunnels spaced at 50 m intervals. At Yarr's Lagoon the tracking line was the north side of the lagoon (Figure 10) for ease of access and to try and accommodate for the whole area as well as following DOC protocols. At Yarr's Flat one line was setup beside the LII and the other was to the north-east side of the site (Figure 11). When the lizard tunnel cards were being collected in they were replaced for rodent monitoring using peanut butter bait and then left out for one fine night following DOC's protocol (Gillies and Williams, 2013). The weather was good for the first night they were out so they were collected in the following day (2/2/2016). The bait used was kangaroo pet food fresh meat. These were left out for two fine nights according to DOC protocol as well. They were collected in on the 4th of February 2016. While the lizard tunnel cards were being collected in they were replaced for rodent monitoring.

2.2.1 Lizards

Lizards were monitored first by placing an inked footprint card into each tunnel with a small amount canned peaches as lure. These lines were then left for two nights and then collected in. As they were being collected in, a new tracking card was placed and lure was changed.

2.2.2 Rodents

Rodents were monitored by replacing the tracking card and lure. Peanut butter was used as lure for rodents. These were left out for one fine night and then collected in. On collection (2/2/16) the tracking card was changed as well as the lure.

2.2.3 Mustelids

Mustelids were monitored by replacing the tracking card from rodents with a brand new card and then fresh lure. The meat lure used was a mix between rabbit and hares. These were left out for two fine nights and then collected in on 4 February 2016.

Figure 10: Locations of tracking tunnels at Yarr's Lagoon

Figure 11: Locations of tracking tunnels at Yarr's Flat

2.3 Birds

Birds were monitored in both study locations. They were monitored with five minute bird counts and all species were recorded if they were heard or seen and identified. Each plot was 150 m apart so that when the birds were counted, there was no overlap or double counting. When the birds were counted, a visual 50 m was estimated and all birds that were within the 50 m in the 5 minutes of bird counting were counted. There were also transects done throughout Yarr's Lagoon along the main track in between the five minute bird counts. This method was used better represent and cover of the area since most of the lagoon was inaccessible.

2.3.1 Yarr's Lagoon bird monitoring

At Yarr's Lagoon there was five monitoring locations for 5 minute bird counts as well as four transect lines running through the lagoon usually between the 5 MBC locations (Figure 12). The five locations were chosen to comprise of different habitats which were >150 m apart to be independent. Bird counts were undertaken between 9.30am and midday on 18 December 2015, 12 January and 2 February 2016.

YLB1: Riparian site

This site was right next to a foot bridge installed by neighbouring farmers and had a fork in the drain native as well as exotic plants surrounding it. It also had the drain which allowed for aquatic birds to live on, this had aquatic plants in the drain too.

YLB2: Gate Site

This gate site was on the fence line of neighbouring farmers land. It was predominantly willow trees with scattered native and exotic shrubs and trees and pasture for stock.

YLB3: Fork Site

This site was selected as it was where the track forked down to the main LII River. It was open with pasture and exotic grasslands then on the edge had willow dominated swamplands and two drains at the fork of the track both of which provided habitat for birds and aquatic plants.

YLB4: LII River site

This site was on the LII River margin and was dominated by willow trees with open exotic grasslands.

YLB5: Manuka wetland site

This is the western-most site amongst manuka, ferns, willow and some open water.

Transect 1:

This transect line was from the gate on Goodericks Rd, at the start of the paper road and the end point was at YLB1. The habitat on this transect line ranged from pasture, to croplands, to exotic weeds and then it also followed a small drain.

Transect 2:

This transect started at YLB1 and ended at YLB2. It had a dominant vegetation of willow trees and pasture on either side. It also had a drain that ran adjacent with the transect line.

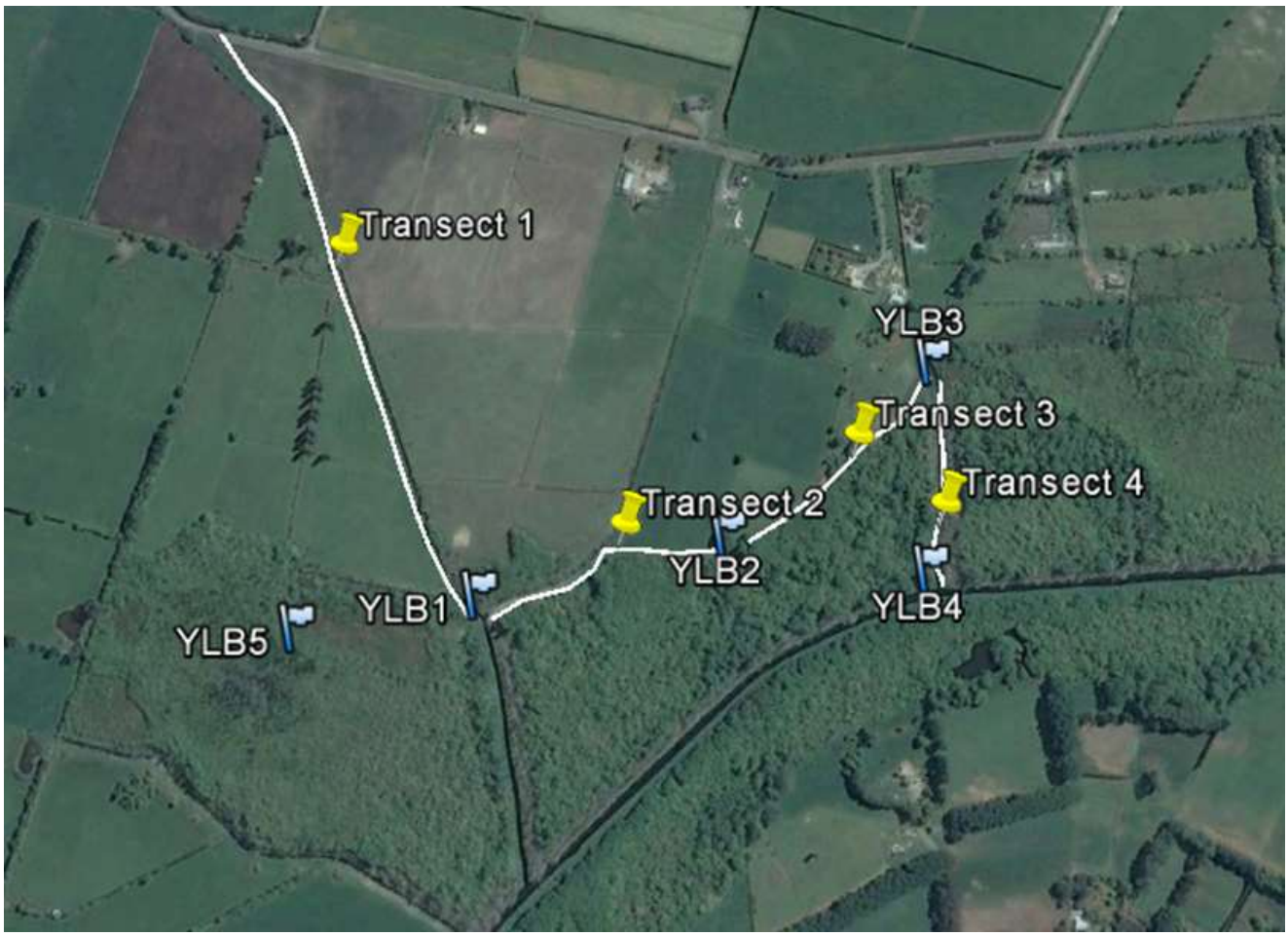
Transect 3:

This transect ran from YLB2 to YLB3. It followed the neighbouring farmer's fence and had pasture with scattered willows and some occasional native throughout the line on one side with willow trees on the other.

Transect 4:

This transect ran from YLB3 to YLB4. The habitat was dead willow trees with regenerating native grasses as well as willow and scattered native on the other side.

Figure 12. map of five minute bird count and transect line locations at Yarr's Lagoon



2.3.2 Yarr's Flat bird monitoring

At Yarr's Flat there were four different bird count sites. These were following standard protocol for 5 minute bird counts. This meant that all count sites were 150 m apart from one another. At each plot they were trying to encompass all different habitat types available to birds at Yarr's Flat (Figure 13). Bird counts were undertaken between 9.30am and midday on 10 December 2015, 12 January and 4 February 2016.The habitat types that were covered were:

Bird count plot 1: The lake edge

The lake edge was selected because it had habitat for both aquatic birds as well as terrestrial birds. The main vegetation there was salt-marsh ribbonwood with some open exotic grasslands surrounding this.

Bird count plot 2: The Maimai

This position of the maimai location was selected because it included a small piece of the LII river mouth in it as well as a small margin of the lake. It also included some exotic grassland and some salt-marsh ribbonwood.

Bird count plot 3: Native planting site

The native planting site was chosen in anticipation of finding out what effect the native planting that has been planted there would have on the birds over time. This was a baseline monitoring regime so it gathered the baseline of current bird diversity in the area. Hopefully overtime, more bird counts can be done and we will see over time what impact the native planting has had on avifauna. The area where they have planned and planted out was originally sprayed with herbicide to kill off exotic grass.

Bird count plot 4: The mixed plot

This site had a mixture of exotic and native plants and grasses. It ranged from mature *Pinus* trees to salt-marsh ribbonwood to exotic grassland.

Figure 13: Locations of five minute bird count sites at Yarr's Flat

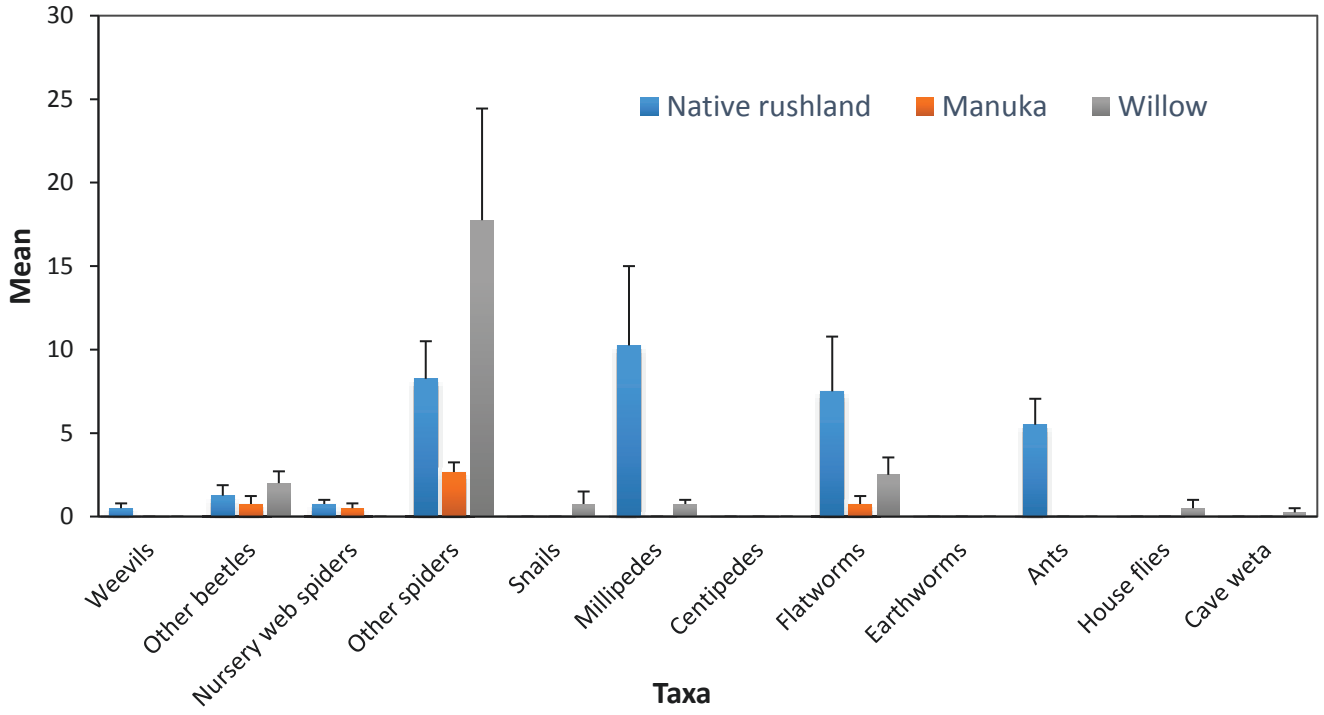
3. Results

3.1.1 Pitfall traps

3.1.1.1 Yarr's Lagoon pitfalls

Native rushland dominated in most taxa apart from spiders which were very abundant in the willows (Figure 14).

Figure 14: Mean Number of all species found in all habitat types at Yarr's Lagoon collected in pitfall traps



Total of eight carabid species were collected from Yarr's Lagoon with the majority of them (7 species) being found in the willow habitat (Table 1). Carabid species included *Bembidion rotundicolle*, *Clivina vagans*, *Dichrochile atrata*, *Holcaspis elongella*, *Mecylcothoroax rotundicollis*, *Megadromus enysi*, *Notagonum feredayi* and an unidentified species.

Table 1. Carabid diversity from pitfall traps in three habitats at Yarr's Lagoon

Site	Species diversity	Shannon Diversity Index	Standard Deviation
Willows	7	1.25	0.14
Manuka	1	0	0
Rushland	1	0	0

Figure 15: Mean number of other beetle species collected from all sample sites at Yarr's Lagoon site using pitfall traps.

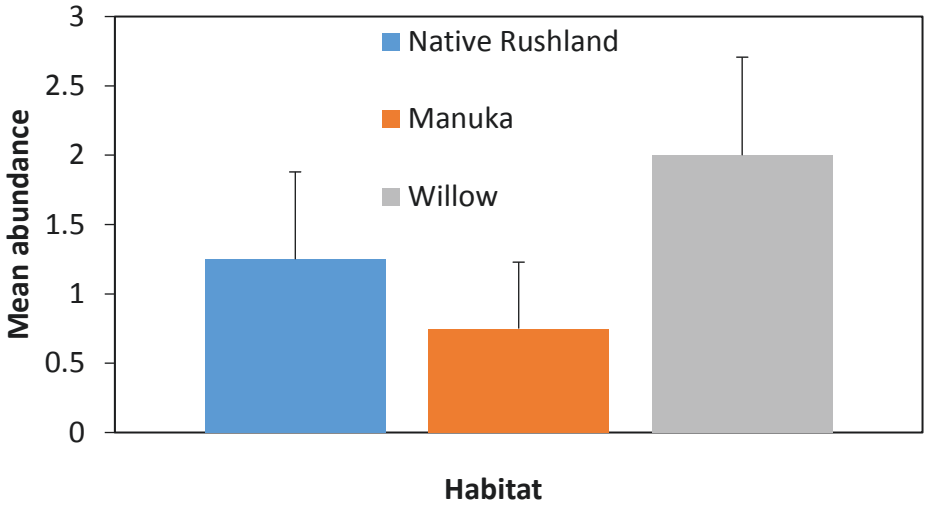


Figure 1: Mean number of spiders found in all habitats sampled in Yarr's Lagoon from pitfall traps

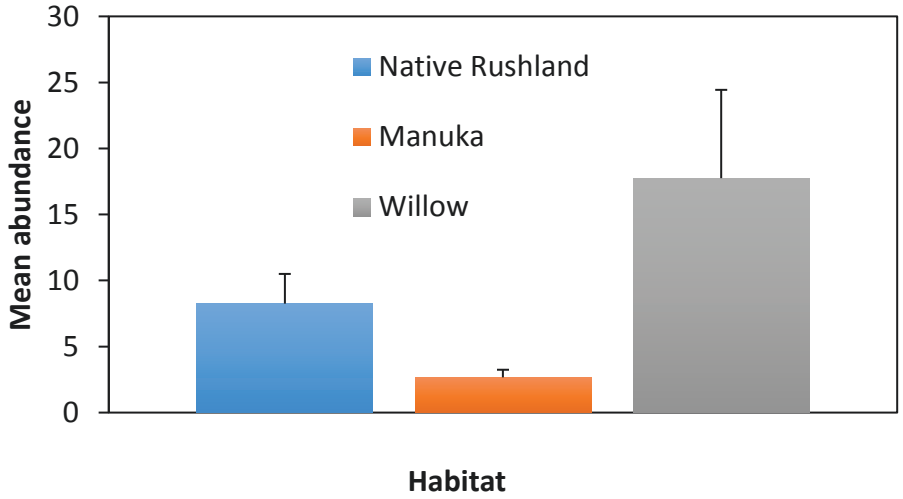
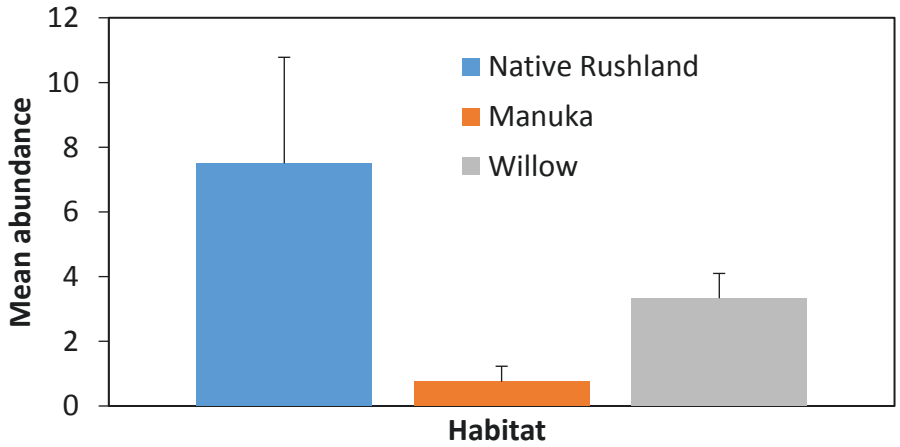


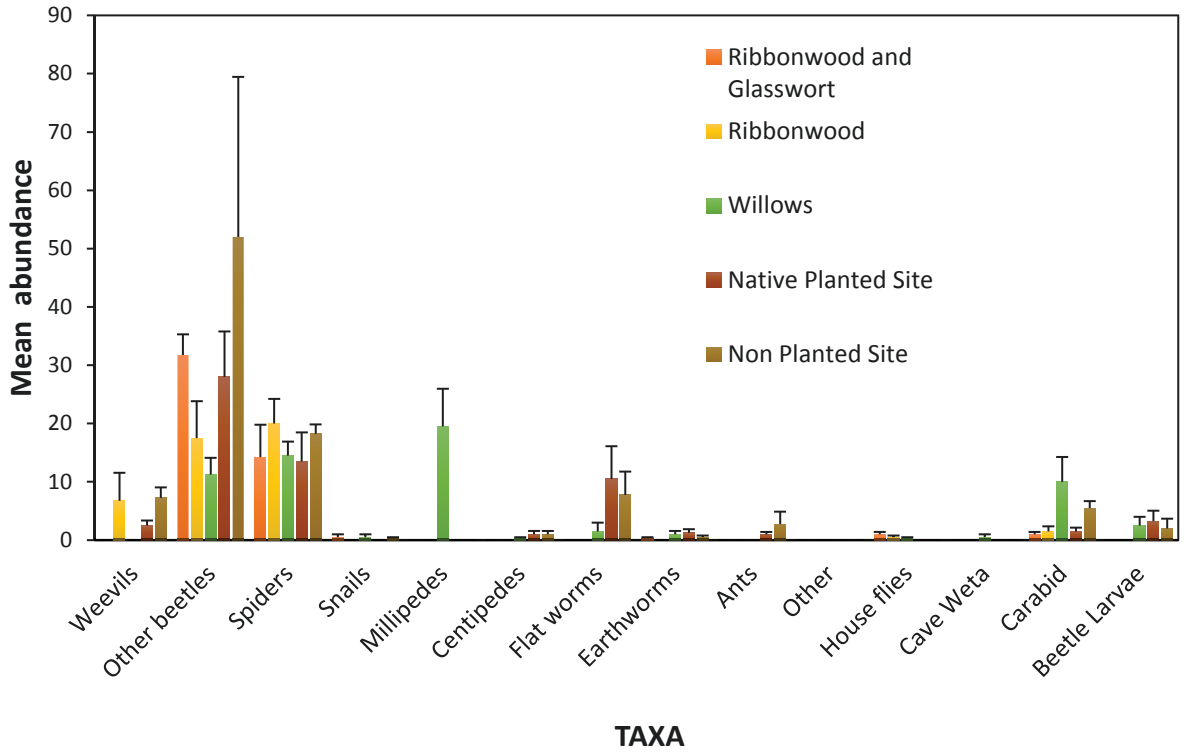
Figure 2: Mean number of flatworms found at all habitat sites sampled in Yarr's Lagoon from pitfall traps.



3.1.1.2 Yarr's Flat pitfalls

Beetles and spiders were the most conspicuous taxa caught at Yarr's Flat in terms of abundance in pitfall traps (Figure 18).

Figure 3: Mean number of all species found at all sample sites at Yarr's Flat in pitfall traps



Ground beetles (carabids) were significantly higher in pitfall traps under willow than in other sites other than non-planted (herbicide) plots (Figure 19). Eight species of carabid (all endemic) were in total were identified: *Metaglymma monoliferum*, *Anisodactylus binotatus*, *Lecanomerus latimanus*, *Notogonum feredayi*, *Clivina vagans*, *Mecylcothorax rotundicollis, Bembidium rotundicolle*, and *Megadromus antarcticus.* Traps under the willows caught significantly higher diversity of carabids than the other habitats with five species (Table 2).

Figure 19: Mean number of carabids at each sample site collected in pitfall traps at Yarr's Flat.

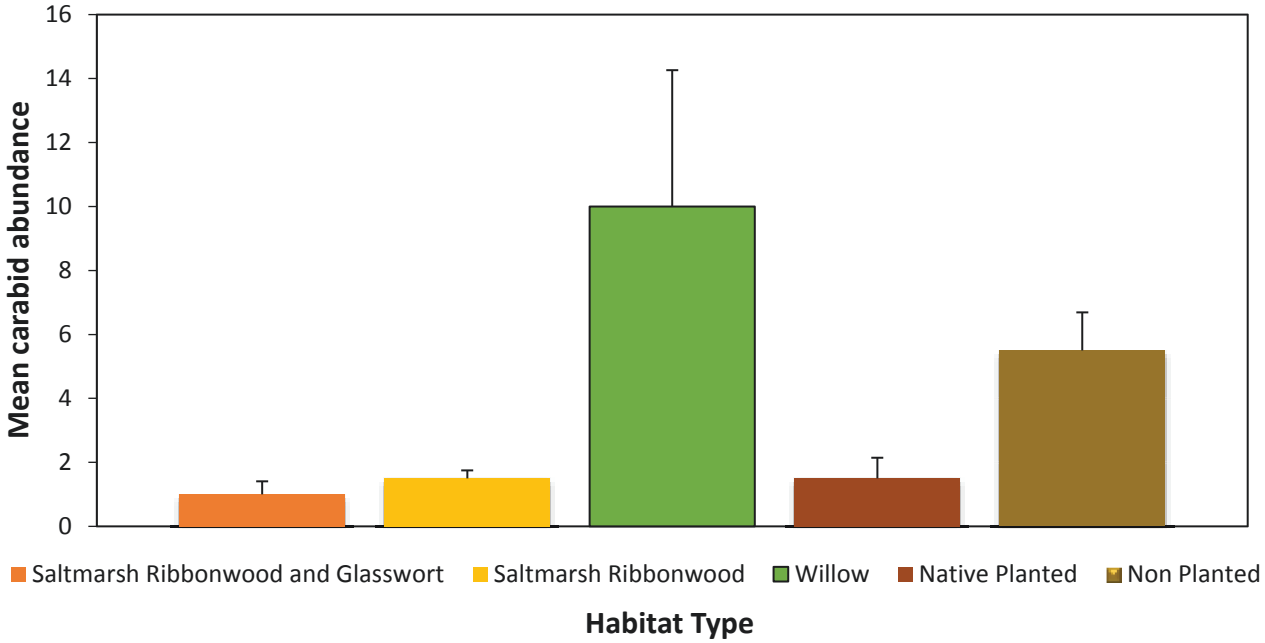
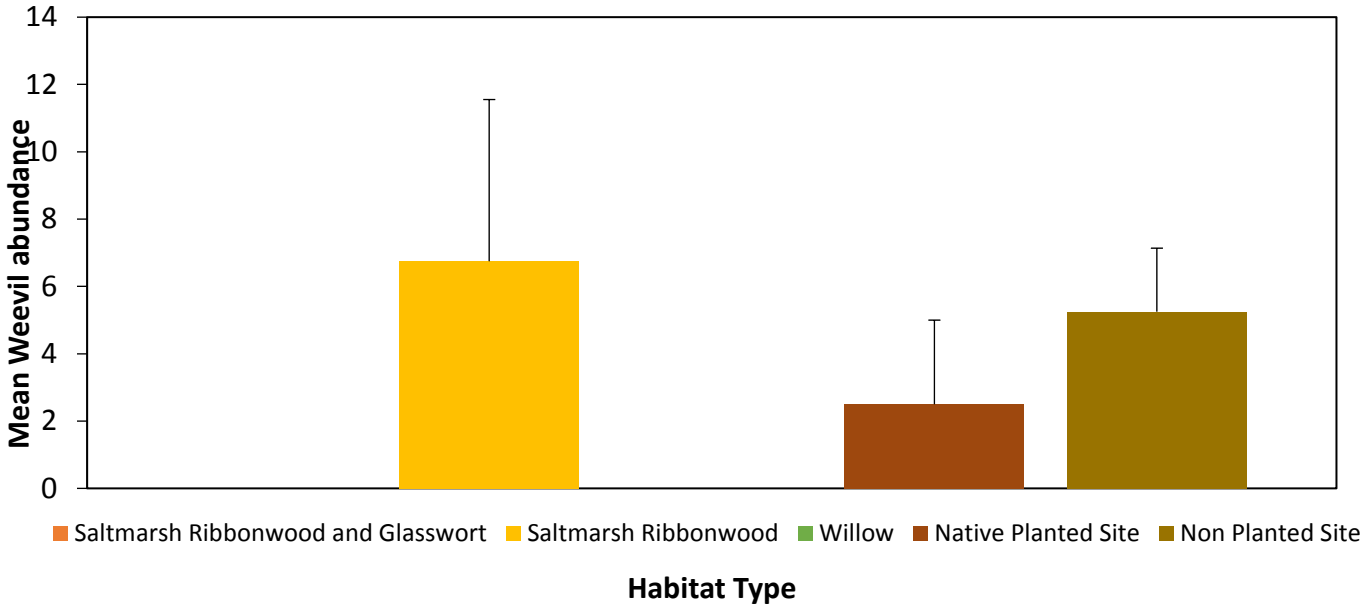


Table 2: Carabid species diversity found in pitfall traps from four habitats at Yarr's Flat.

Habitat sampled	Species diversity	Shannon Diversity Index	Standard Deviation
Willow grove	5	1.32	0.12
Salt-marsh Ribbonwood	2	0.69	0
Unplanted/Herbicided	2	0.69	0
Native plantings	1	0	0

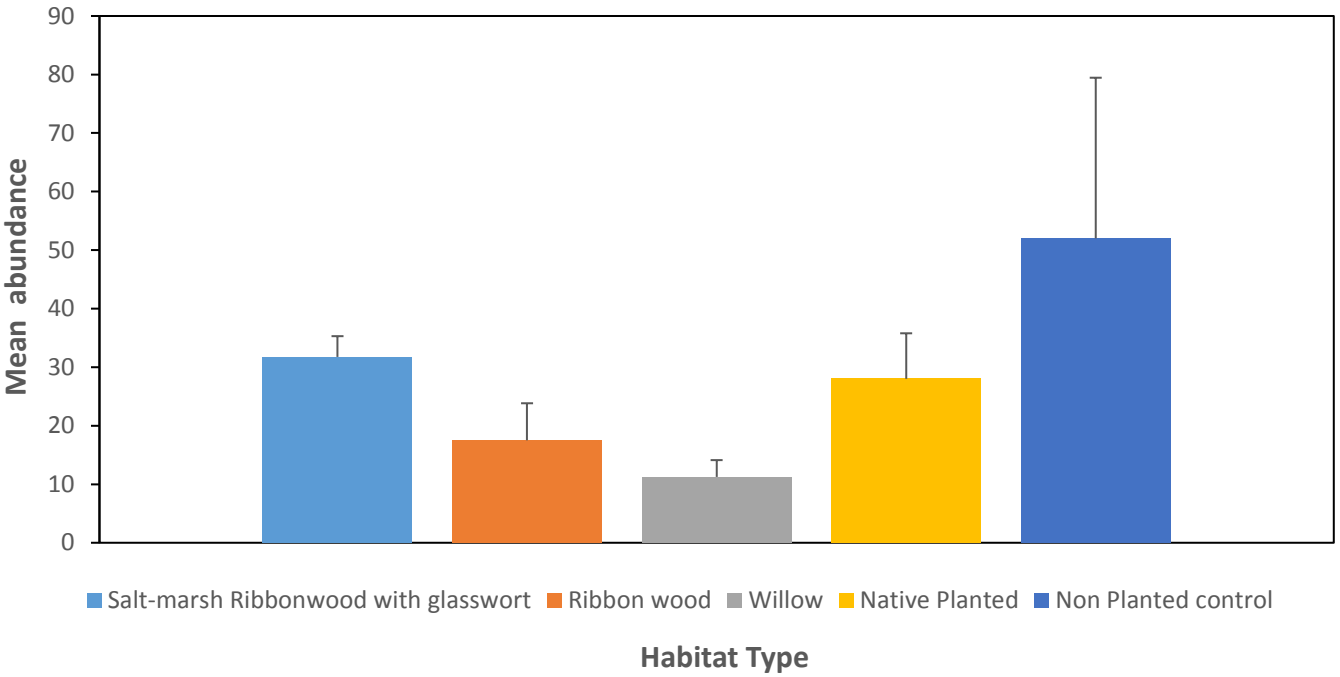
Weevils trapped in salt-marsh ribbonwood, native planted sites and non-planted sites all had similar abundance with none being found in pitfalls set under willows and in the ribbonwood/glasswort habitat (Figure 15).

Figure 20: Mean number of weevils for each habitat type sampled at Yarr's Flat



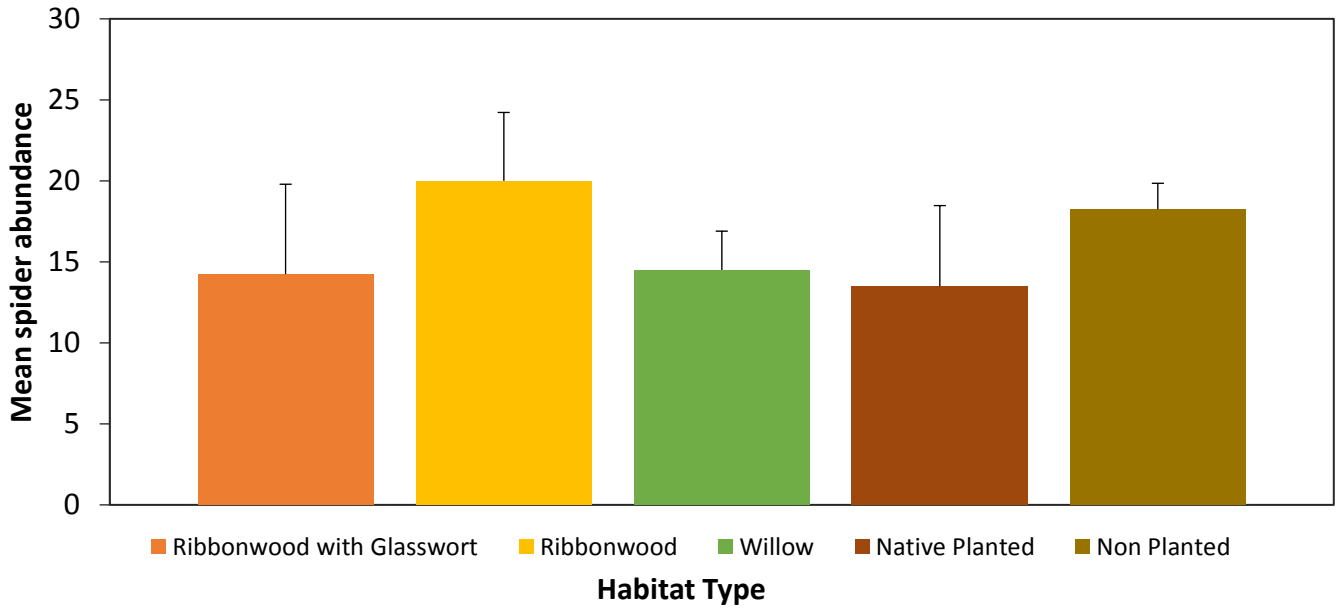
Of the remaining beetle species, dominated by scarabs (*Costelytra* sp.), Elaterids (click beetles) and staphylinids (rove beetles), the unplanted (herbicided) site had the highest mean abundance, while the willow site had the least (Figure 21).

Figure 21: Mean number of beetles (excluding carabids and weevils) found at all sites sampled at Yarr's Flat in pitfall traps.



A high abundance of spiders were collected from all the pitfall sites with no significant differences between them (Figure 22).

Figure 22: Mean abundance of spiders found at Yarr's Flat at all sample sites using pitfall traps.



3.1.2 Light trapping

Moths were the main taxa collected however three caddisflies species (Trichoptera) were also collected at both sites. Sixty-three species of moths were collected from both sites with Yarr's Lagoon the most diverse with 51 species and Yarr's Flat with 31 species (see Appendix). Other species such as

nursery web spiders (*Dolomedes minor*) are very easy to see at night with their reflective eyes and were common at both sites.

3.1.3 Malaise trap

A large number of beetle and wasp species have been collected from traps at both locations and are listed in Appendix.

3.1.4 Wooden discs

Native species included carabids, earthworms (*Maorodrilus* sp.), Tenebrionid *Zeadelium zelandicum*, flat worm, leaf-vein slug and snails were collected under discs at Yarr's Lagoon. On 27 July 2016 four large skinks were found overwintering under one disc in the rushland site of Yarr's Lagoon. Very little of interest was collected under discs at Yarr's Flat.

3.1.5 Weta motels

Motels at Yarr's Flat were dominated by spiders dominated by Theriidae and many with spiderlings. In motels at Yarr's Lagoon manuka site motels contained many Tenebrionidae (*Artystona* species) and large spiders (*Cambridgea* species).

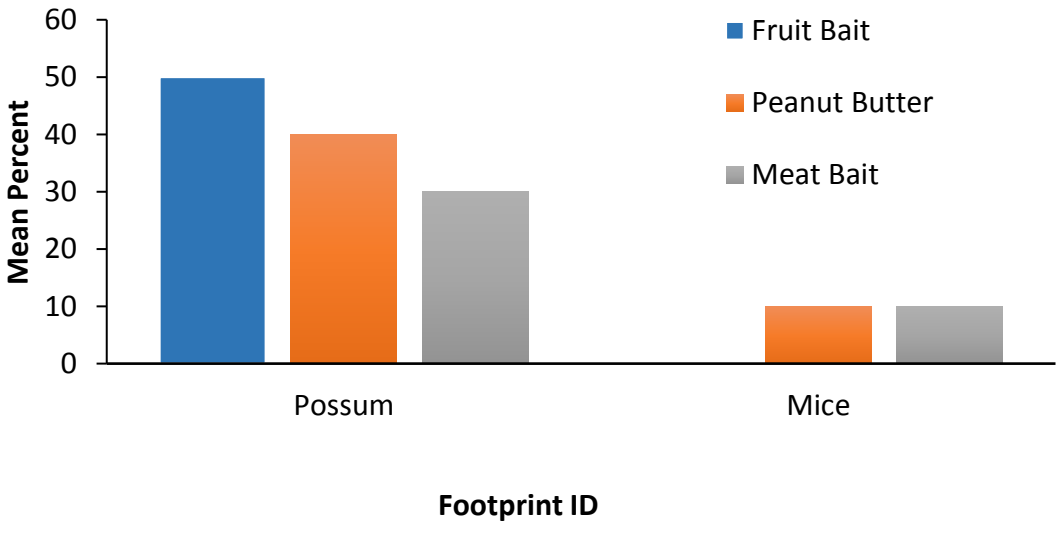
3.1.6 Litter invertebrates

Leaf litter from Yarr's Lagoon beneath manuka was dominated by small beetles (see Appendix for species).

3.2.1 Tracking tunnels at Yarr's Lagoon

At Yarr's Lagoon only possum and mice tracks detected with the former being relatively high at 50% and 40% tracking with fruit and peanut butter bait respectively (Figure 23).

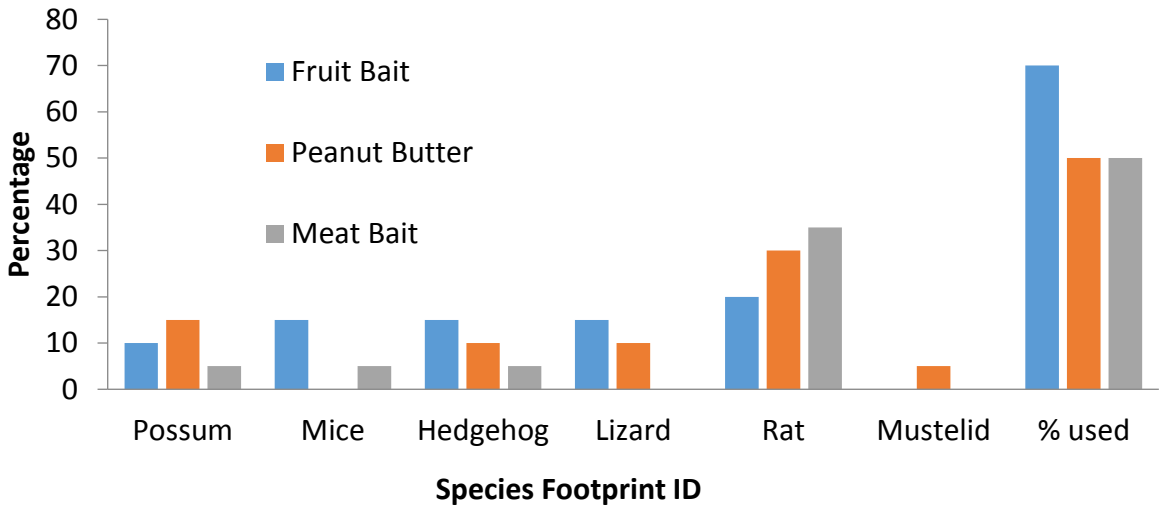
Figure 23: Graph showing tracking tunnel line at Yarr's Lagoon with percentage of species using the tunnels correlated with bait type.



3.2.2 Tracking tunnels at Yarr's Flat

Skinks were often observed on warmer days at Yarr's Flat and this was reflected in the presence of their prints on 15% of cards with fruit bait and 10% on cards with peanut butter bait. However the concern is the presence of rats and hedgehogs as shown by the tracking results (Figure 24). Possum, mice and mustelids were also detected at Yarr's Flat.

Figure 24: Tracking tunnel lines at Yarr's Flat showing percentage of tracking tunnels used, correlated with bait type



3.3 Birds

Eleven and seven native bird species were observed at Yarr's Lagoon and Yarr's Flat respectively. While 13 and nine introduced bird species were observed at Yarr's Lagoon and Yarr's Flat respectively. At Yarr's Lagoon the silvereyes and goldfinches were the most common native and introduced bird respectively. While at Yarr's Flat pied stilts and skylarks were the most abundant native and introduced species respectively. No real surprises with the species found apart from observing a marsh crake at Yarr's Lagoon approximately halfway along paper road to the lagoon proper. Nice to see a sandpiper (possibly *Calidris ferruginea*) at Yarr's Flat in the "maimai" site near the mouth of the LII. A bellbird was also heard at Yarr's Flat but none were recorded from Yarr's Lagoon. Five minute bird counts and transect monitoring and Yarr's Lagoon yielded very similar results in terms of bird numbers and diversity. The highlight was the sighting of the cryptic and shy marsh crake along the paper road (track) which leads from the gate at Goodericks Rd to the lagoon proper.

Table 3: Checklist of birds recorded and Yarr's Flat and Yarr's Lagoon

*Observed outside of the official bird counts

Native birds	**Yarr's Flat**	**Yarr's Lagoon**
Bellbird	✔	
Black-backed Gull	✔	
Fantail		✔
Grey Warbler		✔
Harrier Hawk	✔	✔
Kingfisher		✔
Marsh Crake*		✔
Pied Oystercatcher		✔
Pied Stilt	✔	
Pukeko		✔
Sandpiper	✔	
Shag (unidentified)		✔
Silvereye		✔
Spur-wing plover	✔	✔
Welcome Swallow	✔	
White-faced heron		✔

Introduced birds	**Yarr's Flat**	**Yarr's Lagoon**
Blackbird		✔
Chaffinch	✔	✔
Goldfinch		✔
Greenfinch	✔	✔
Hedge sparrow	✔	✔
House sparrow	✔	✔
Magpie	✔	✔
Mallard	✔	✔
Pheasant		✔
Redpoll		✔
Rock Pigeon	✔	
Starling	✔	✔
Thrush		✔
Yellowhammer	✔	✔

Figure 25: Mean bird abundance in transects at Yarr's Lagoon with standard errors (N=3)

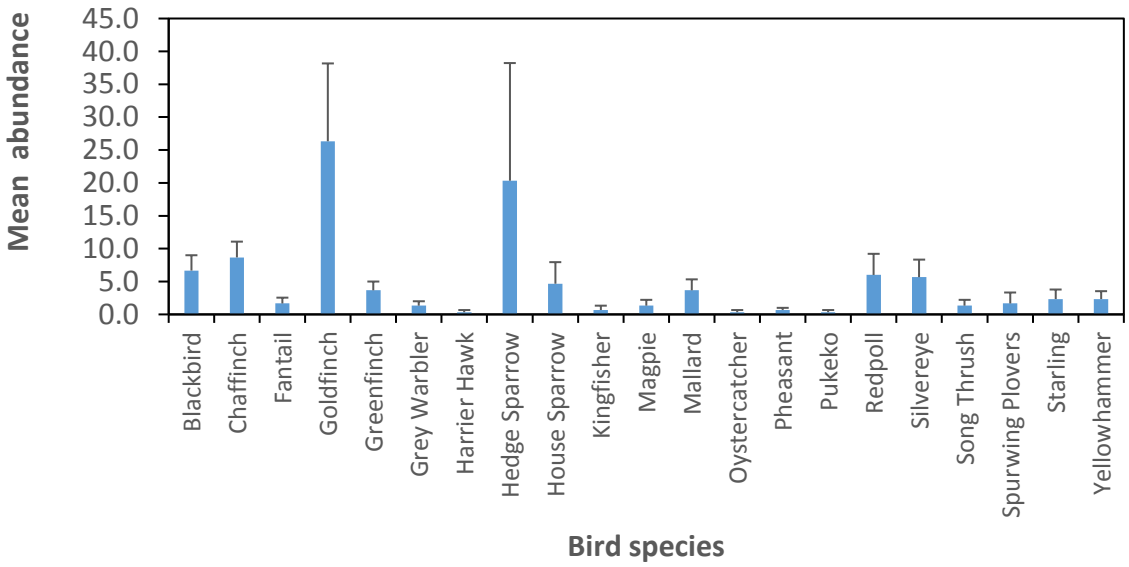


Figure 26: Mean abundance of species from five minute bird counts at Yarr's Lagoon (N=3)

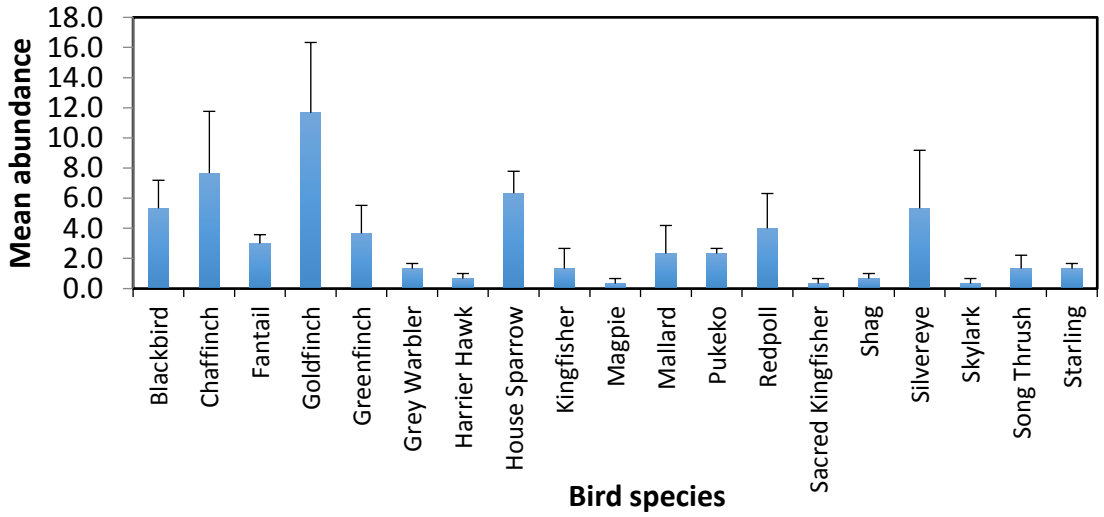
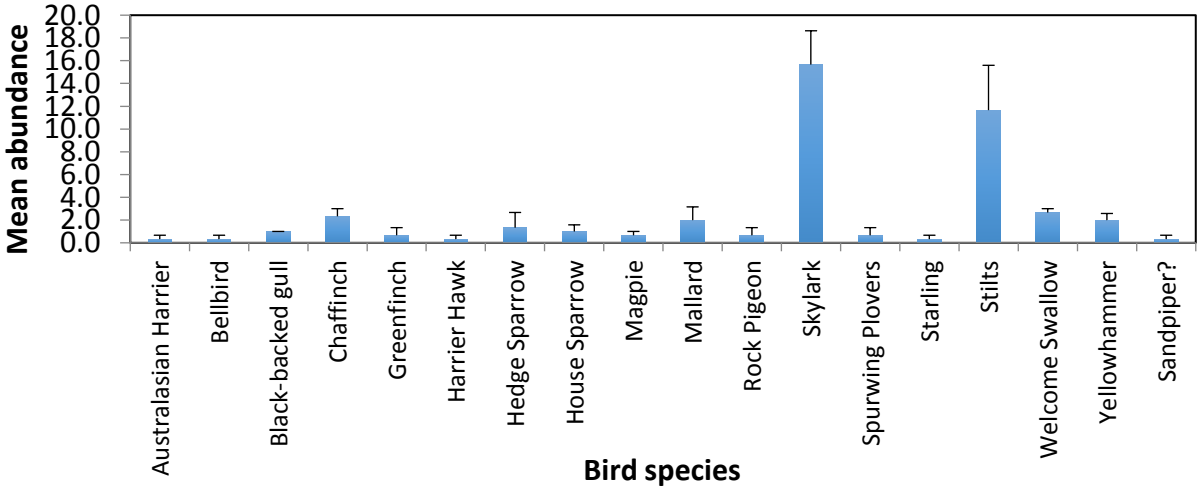


Figure 27: Mean abundance from five minute bird counts at Yarr's Flat



4. Discussion

4.1 Yarr's Lagoon

The invertebrate fauna present at Yarr's Lagoon is fairly typical for a wetland habitat. The discovery of *Megadromus ensyi* in pifall trap under willows was interesting. If the identification is correct then this is the most eastern record from New Zealand entomology museums. This species is usually found up in the foothills or higher with the closest specimen found at Springfield and Kowai Bush (near Springfield) and Type location is believed to be Broken River (Canterbury). DNA analysis of this species to confirm its identity would be useful. Finding skinks in the rushland area under wooden disc was a surprise and may require further investigation (Figure 28). Eight species of carabid was collected at Yarr's Lagoon with willow collecting 36 of the 38 (95%) specimens and seven of the eight species collected. Similar results were found in Waikato wetlands where willow habitat had a higher beetle diversity (Watts et al. 2012). The difference at Yarr's Lagoon is that the majority of the beetles collected in pitfalls were were carabids which are generalist predators, whereas in the Waikato study they were detritophores.

Some thought needs to be given to the how to conserve these carabids when it comes to willow removal. Other areas should be planted out first such as the northern pocket which has already been herbicided. The stream along the eastern side of the access road to the lagoon should be considered for restoration. The neighbour (Hamilton) has recently removed willows and sprayed gorse and is prepared to move fence away from the drain to make way for more planting. The stream looks very clear and stony near its source but after a short distance silting is apparent (Figure 29). Planting with appriopriate natives including *Phormium tenax* and *Carex secta* that will stabilise the banks, shade the water to reduce algal growth, help reduce the silting, provide phytoremediation (Hahner et al. 2014) and provide habitat and food for wildlife (Collins, 2011; Langlands 2014). Along the LII River native plantings may include species such as raupo to provide the habitat for the nationally endangered e.g. Australasian bittern (*Botaurus poiciloptilus*). Species such as this are good indicators of habitat health given they need an ecologically diverse habitat with abundant food including fish, insects, frogs, crayfish, etc. It was hoped that bittern monitoring could be undertaken at the lagoon over the summer scholarship period but on consulting with Peter Langlands (pers. com.) it was obvious that auditory monitoring would not work for bittern at this time of the year.

Weeds such as willows and gorse dominate this site but regardless of this there is native flora surviving and and providing habitat for a diverse invertebrate community. Amongst these three biocontrol agents are present for gorse: the gorse mite, *Tetranychus lintearius*, the seed weevil *Exapion ulicis* and the gorse pod moth *Exapion ulicis*.

This site has a huge potential for recreation activities including kayaking, fishing, bird watching and walking. These can all be possible while maintaining and even enhancing the habitat quality. However, parts of the wetland is difficult to negotiate apart from the grassy strips that are maintained in places. A huge potential exists to create some more tracks and boardwalks to help explore the values of this site. Clearly a loop track or series of loop tracks would improve its attractiveness for recreation. The rushland and manuka sites provide the most ecological interest but the potential to put a boardwalk through these areas so that the access around the site and to the open wetland site would considerably enhance the asthetic and ecological value to public and scientists alike.

Predators such as mustelids and rats are a major threat to birds including bittern, marsh crake and the tracking tunnel monitoring showed a suite of predators at Yarr's Flat, whereas at Yarr's Lagoon only possum and mice prints were found. It is likely that other predators such as feral cats are present but they can be a difficult species to monitor. At the time tracking tunnels became active, the weather was

not ideal for tracking tunnels and the cards got wet. It also disrupted the time schedule for completing some monitoring and meant that at the time of monitoring the lizard presence, they were out for longer than the suggested protocol (one week instead of two nights).

4.2 Yarr's Flat

Ground beetles (Carabidae) are often used as indicator species in restoration monitoring so it was interesting find as many as eight overall, seven which are native species. Five species alone were found under the willows beside the LII, more than the other habitats combined. The willows specifically may not be the specific attraction, rather vegetative cover it provides and the course woody debris (CWD) (Watts 2012) or alternatively the soil conditions and adjacent the bank of the LII. It could be possible that the recently arrived giant willow aphid (Figure 30) which are present at the site in very large numbers are providing a food resource for the ground beetles which are generalist predators. Regardless of the reason thought should be given to replacing the willows with suitable natives over time that will provide overhead cover for the carabids and other invertebrates. Exotic trees do provide shelter for invertebrates, macrocarpa shelterbelts for example a large number of native beetle close by in Lincoln University (Bowie et al. 2014). Wooden discs (Bowie and Frampton, 2004) and CWD from felling the willows should be used to provide valuable habitat on the ground and will help protect invertebrates from the myriad of predators (rodents, hedgehogs, etc) present at the site (Bowie, 2008; Watts et al. 2012). Bowie (2008) found that using wooden discs as CWD as many as 14 ground beetle species (Carabidae) were found using these artificial refuges on Banks Peninsula. Grey willow (*Salix cinerea*) habitat contained a higher beetle diversity and abundance than native vegetation in Waikato wetlands (Watts et al. 2012). Their study found that willow habitats were dominated by detritivores, whereas in native wetland vegetation, herbivores dominated. The beetle composition and endemicity were found to be most similar between native vegetation and restored areas within the wetland indicating that willow removal and restoration plantings should be undertaken to help restore the endemic suite of beetle species.

Figure 28: Skinks found under wooden disc at Yarr's Lagoon rushland site

Figure 29: Stream beside the access paper road/track showing unstable bank and silting

Figure 30: Giant willow aphid (*Tuberolachnus salignus*) at Yarr's Flat beside LII

The glasswort patch on the track was a habitat to a large numbers of weevils which were swept from the plants one evening when light trapping. Weevil species included *Steriphus diversipes lineata* (Figure 31), *Steriphus variabilis* and the Argentine stem weevil *Listronotus bonariensis*. A large pollen eating mite (*Balaustium* sp.) was also collected in large numbers (Figure 32). The ecology of these insect-plant relationships would make an interesting natural history study on this estuarine habitat

Figure 31: *Steriphus diversipes lineata* feeding on flowering glasswort

A total of 63 moth species were recorded from Yarr's Flat and Yarr's Lagoon combined with many having specific native host plant e.g. *Plagianthus*, *Juncus*, *Carex*, *Coprosma*, etc (see Appendix). At Yarr's Flat a species not commonly found was the noctuid *Meterana levis*, a species whose larvae are known to feed on *Plagianthus*. Another uncommon noctuid collected at this location was *Ectopatria aspera.* Only a single specimen was collected using sweep-net on glasswort which is known as its host. Hughey & Taylor (2009) noted that damage to habitat was being caused by vehicles, presumably being destroyed by four wheel drives (Figure 33). This fragments the habitat patches, introducing weeds and making it less habitable to insects. This glasswort habitat is special given the weevil, mite and moth species that have been found living on this, unfortunately the main issue is that the general public do not recognise or value this as a significant habitat (Burrows and Partridge, 2008). Stopping the vehicle use of the track by locking the entrance gate and providing appropriate interpretive signage at the various habitats may help to protect the habitat and educate users. The holes created by the 4WD vehicles could potentially be filled in with the appropriate soil to speed up the rehabilitation process. A walking track to the side of this glasswort patch would also be desirable.

Other insect species will be attracted by more native plantings, but some thought could be given to encouraging rarer species such as those listed in DOC endangered list (McGuinness CA, 2001; Pawson SW and Emberson RM 2000). Yellow admiral was also recorded and may well be encouraged by exotic stinging nettles *Urtica* spp. Part of the restoration program could be dedicated to planting native swamp nettle *Urtica perconfusa* which is 'At risk – declining'. Few studies exist for this area but a study in Kaitorete Spit identified species such as *Muehlenbeckia complexa* as a host plant for three species of copper butterfly (*Lycaena* spp.) and *Bityla difugurata* and *B. sericea.*

Figure 32: Mite (*Balaustium* sp.) collected from glasswort at Yarr's Flat

Figure 33: Vehicle damage to glasswort habitat at Yarr's Flat

Skinks were observed during visits and their footprints were found in the tracking tunnels, but none were found under Onduline lizard lodges placed in the reserve. Mortimer (2015) has documented the presence of the common skink (*Oligosoma nigriplantare polychroma*). Thought should be given to providing some plant species that would survive the damp, saline soil conditions and provide berries for them. Species such as *Coprosma propinqua, Muehlenbeckia astonii, Coprosma crassifolia, Melicytus alpinus and Muehlenbeckia complexa* are known food plants for lizards, however they would need to be in higher zone away from flooding as only *C. propinqua* would withstand wet roots for too long. An area could be set aside, and even raised a little to provide a drier, sunnier, even rockier habitat for lizards. Predator trapping especially for hedgehogs, cats and mustelids would give the lizards and other vulnerable native species a better chance to breed up numbers.

The planting-out at Yarr's Flat with a selection of native plants has introduced indigenous biodiversity along the margins Lake Ellesmere and close to the LII River. This is important for water quality but can also introduce other species including invertebrates which also add to biodiversity value (Collins, 2011). This should encourage bellbirds to species such as the flax. Although some of the initial plantings were limited in their survival, species choice and soil analysis mapping of salinity should help improve plant survival and restoration success. The methods used in this research has found that in the native planted areas, invertebrate diversity is not very high. There are certain species who have a higher representation than other but currently, invertebrate diversity is low. This would be expected to increase over the years following because the plants are only saplings at the moment. Once the planting gain maturity it would be expected that native invertebrate diversity would increase. Another expectation from the native plantings would be that it would attract more native birds to the area for example, tui, fantail, grey warbler etc. Day, (1995) suggests that this is very much a true phenomenon with this exact observation being made a reality in Hamilton urban gardens in New Zealand. It has also been supported by multiple scientific studies not only in New Zealand but worldwide.

There are other services that native planting provides for an ecosystem for example, filtration of nutrients (Day, 1995).

5. Recommendations

As with any restoration, keeping good records of successes and failures can provide valuable lessons for future work either at the same site or similar habitats elsewhere. Photo point monitoring is highly recommended and the use of a drone with GPS reference points is invaluable.

5.1 Yarr's Lagoon

- Implement weed control including willow, gorse, Spanish heath and hawthorn (*Crataegus monogyna*) in particular in the native rushland site at Yarr's Lagoon. There is a population of manuka accompanied by other natives including *Coprosma* species, flax species and *Pittosporum* species that are currently getting outcompeted by the grey and crack willow. Controlling the willow population would allow for the native plants to have more space but may also allow access to other weeds. The advantages of weed removal should outweigh negatives and have potential flow-on effects with the bird and invertebrate diversity.
- Prohibit cows from grazing in the lagoon area and beside the drain as they do pug up area and add unwanted nutrients to wetland.
- Implement bird habitat enhancement for wetland birds (Langlands 2014).
- Bittern (*Botaurus poiciloptilus*) monitoring should be undertaken at the lagoon to supplement the data collected from Yarr's Flat.
- Native planting in dead willow area that has been sprayed and along drain leading in the lagoon beside the paper access road/track.
- Survey the drain/stream along paper road for native fish and invertebrates.
- Identify the skinks found in rushland and a fungal survey may be interesting.
- Continue monitoring of terrestrial invertebrates every 2-5 years.

5.2 Yarr's Flat

- Remove vehicular access onto Yarr's Flat. Considerable damage has been caused to glasswort (*Sarcocornia quinqueflora*) which is home to many native insects including an uncommon host-specific moth species. Damage to other small, less obvious species is also likely.
- Establishment of some native riparian plantings along the LII to replace the willow cover that appears to be providing habitat for the carabid community at present.
- Planting of salt-marsh ribbonwood in gaps to make a few contiguous areas. MB collected seeds which were given to the DOC nursery at Motukarara for future restoration.
- Complete a soil analysis on the flat area that is likely to be planted. Knowledge of the salt levels of the area will help with plant species selection and survival. If the soil is being analysed for salinity then assessment of other nutrients may similarly be useful to gauge nutrient deficiencies or excesses (e.g. nitrates, phosphate, lead, iron) which will also guide management and planting. Lincoln University has a Soil Science Centre specifically set up for soil analysis. This could be undertaken as a summer scholar project and could involve using Differential GPS to accurately assess the location, elevation in relation to vegetation and soil nutrients.
- Repeating the invertebrate monitoring every 2-5 years to pick up population trends over time that may be related to management initiatives; add to invertebrate species list; and help understand the insect-plant relationships in the complex estuarine ecosystem.
- Repeating the bird monitoring every 2-5 years to pick up population trends over time that may be related to management initiatives; add to bird species list.
- Hare damage to restoration plantings is still an issue and may need additional ways to control.

Long-jawed orb web spider (*Tetragnatha* sp.) on salt-marsh ribbonwood at Yarr's Flat

6. Acknowledgements

We wish to acknowledge the following people:

- Robin Smith (Living Water) for the funding and support for this Summer Scholarship
- Brian Patrick, Sam Brown, Bruce Marshall and Dr Rowan Emberson for help with identification of specimens
- Julia and Andrew Causer for access on to difficult sections of Yarr's Lagoon

7. References

Blake-Manson H (2011). Selwyn District Land Drainage Schemes. *Selwyn-Waihora Zone Committee, Selwyn District Council.*

Bowie MH, Frampton CM (2004). A new technique for non-destructive monitoring of soil surface invertebrates for ecological restoration programmes. Ecological Restoration and Management 5(1): 34-42.

Bowie MH (2008). Ecological restoration of the invertebrate fauna on Quail Island (Ōtamahua). Proceedings of the Conserv-Vision Conference, University of Waikato, 2-4 July 2007. Edited by: Dr Bruce Clarkson, Dr Priya Kurian, Todd Nachowitz, & Dr Hamish Rennie. The University of Waikato, Private Bag 3105, Hamilton, New Zealand.

Brown MA, Stephens RTT, Peart R, Fedder B (2015). Vanishing Nature facing New Zealand's Biodiversity Crisis: The Story So Far. *New Zealand Law Foundation, EDS*. 2-20.

Burrows CJ, Partridge TR (2008). Vegetation of the coast. Chapter 24, In: *The Natural History of Canterbury* Edited by Winterbourne M, Knox G, Burrows C, Marsden I. Canterbury University Press, 3rd Edition. 923pp.

Butt J (2015). Rapid Ecological Assessment of the Yarr's Flat/LII Area. Wai-Ora Forest Landscapes Ltd.

Clark DA, Caradus JR, Monaghan RM, Sharp P, Thorrold BS (2007). Issues and options for future dairy farming in New Zealand. New Zealand Journal of Agricultural Research. 50 (2): 203-221.

Collins K (2011). *Benefits of riparian planting: A case study of lowland streams in the Lake Ellesmere catchment* (Doctoral dissertation, Lincoln University).

Day TD (1995). Bird species composition and abundance in relation to native plants in urban gardens, Hamilton, New Zealand. Notornis 42(3), 172-186.

de Lange PJ, Norton DA, Courtney SP, Heenan PB, Barkla JW, Cameron EK, Hitchmough R, Townsend AJ (2009). Threatened and uncommon plants of New Zealand. New Zealand Journal of Botany 47(1): 61-96.

Department of Conservation. (n.d.). Yarr's Flat Wildlife Management Reserve. Retrieved from:http://www.doc.govt.nz/documents/about-doc/role/policies-and-plans/m36183_Yarr'sflatwildres.pdf

Di HJ, Cameron KC (2002). Nitrate leaching and pasture production from different nitrogen sources on a shallow stony soil under flood-irrigated dairy pasture. Australian Journal of Soil Research 40: 317–334.

Ecroyd CE, Brockerhoff EG (2005). Floristic changes over 30 years in a Canterbury Plains kanuka forest remnant, and comparison with adjacent vegetation types. New Zealand Journal of Ecology. 29(2): 279-290.

Gillies CA, Williams D (2013). DOC tracking tunnel guide v2.5.2: Using tracking tunnels to monitor rodents and mustelids. Department of Conservation, Science & Capability Group, Hamilton, New Zealand. www.doc.govt.nz

Gough JD, Ward JC (1996). Environmental decision-making and lake management. Journal of Environmental Management 48(1): 1-15.

Hahner JL, Robinson BH, Hong-Tao Z, Dickinson NM (2014). The phytoremediation potential of native plants on New Zealand dairy farms. International Journal of Phytoremediation 16: 719-734.

Head N, Given D (2001). Threatened plants of Canterbury including a revised species list. Journal of Canterbury Botanical Society 35: 5-14.

Houlbrooke DJ, Horne DJ, Hedley MJ, Hanly JA, Snow VO (2004). A review of literature on the land treatment of farm-dairy effluent in New Zealand and its impact on water quality. New Zealand Journal of Agricultural Research 47 (4): 499-511.

Howell CJ (2008). Consolidated list of environmental weeds in New Zealand. *Science & Technical Pub*., Department of Conservation.

Hughey KFD, Taylor KJW (2009). Te Waihora/Lake Ellesmere, State of the Lake and Future Management: Birdlife of the Lake. *EOS Ecology, Christchurch.* 150pp.

Langlands P (2014). A report on the LII and suggested habitat enhancements for birdlife. Report for DOC Maahunui Office. 8pp.

Living Water (2016). Living Water is a partnership between Fonterra and the Department of Conservation. Retrieved from: http://www.livingwater.net.nz/#home. Accessed 21 July 2016.

Macleod CJ, Moller H (2006). Intensification and diversification of New Zealand agriculture since 1960: An Evaluation of current indicators of land use change. Agriculture Ecosystems & Environment 115(1): 201–218.

McGuinness CA (2001). The conservation requirements of New Zealand's Nationally Threatened Invertebrates. Threatened species occasional publication No. 20. Department of Conservation. 658pp.

Ministry for the Environment, (1997). The State of New Zealand's Environment. *Ministry for Environment, Wellington*.

Mortimer J (2015). A lizard survey of North Canterbury – Interim unpublished report. 14pp.

O'Donnell CFJ (1985). Lake Ellesmere: A Wildlife Habitat of International Importance. *Fauna Survey Unit Report No. 40.* N.Z. Wildlife Service, Department of Internal Affairs.

Parker M, Grove P (2013). Tā-rere-kau-tuku (Yarr's Lagoon): Wetland Condition, Threats and Significance Assessment. *Environment Canterbury unpublished report.*

Partridge TR (1989). Botanical survey of the saline lakeshore vegetation of the Hill property. Yarr's Flat, Lake Ellesmere, and various management options. Botany Division Report, DSIR. 14pp.

Pawson SW, Emberson RW (2000). The conservation status of invertebrates in Canterbury. Conservation Advisory Science Notes: 320. Department of Conservation. 66pp.

Peters M, Clarkson B (2010). Wetland restoration. A handbook for New Zealand freshwater systems. Manaaki Whenua Press. 273pp.

Reeves P (1990). National Water Conservation (Lake Ellesmere) Order 1990 (SR 1990/155). http://www.legislation.govt.nz/regulation/public/1990/0155/4.0/DLM138903.html accessed 27 June 2016.

Te Waihora Environmental Restoration Plans. (2011). Te Waihora Environmental Restoration Plans: Araiara/Yarr's Flat. *Whakaora Te Waihora.*

Watts C, Rohan M, Thornburrow D (2012). Beetle community responses to grey willow (*Salix cinerea*) invasion within three New Zealand wetlands. New Zealand Journal of Zoology 39(3): 209-227.

White EG (2002). New Zealand Tussock Grassland Moths: a taxonomic and ecological handbook based on light-trapping studies in Canterbury. Maanaki Whenua Press, Lincoln. 362pp.

Wilkinson AG (1999). Poplars and willows for soil erosion control in New Zealand. Biomass and Bioenergy 16(4): 263-274.

Wilks K (2010). *Response of benthic invertebrate fauna to fluctuating lake levels and salinity concentrations in Lake Ellesmere/Te Waihora*. (Master's thesis, University of Canterbury, 2010).

APPENDICES

Flatworm (*Artioposthia triangulata*)

Flatworm (‘*Australopacifica*’ species)

Hare foraging on flax at Yarr's Flat

Cicada on salt-marsh ribbonwood at Yarr's Flat

Zealaranea crassa on salt-marsh ribbonwood

Leaf-vein slug under wooden disc at Yarr's Lagoon

Harvestman (?*Megalopsalis* sp.) found on manuka tree at Yarrs Lagoon

Tumbling beetle (*Mordella promiscus*) feeding on manuka flower at Yarrs Lagoon

Nurseryweb spider (*Dolomedes minor*) at Yarr's Lagoon (also common at Yarr's Flat)

Orocrambus moth on gorse at Yarr's Lagoon

Colaranea verutum on salt-marsh ribbonwood at Yarr's Flat

Green orb web spider (*Colaranea ?viriditas*) on salt-marsh ribbonwood at Yarr's Flat

Appendix

INVERTEBRATES FROM YARRS FLAT RESERVE & YARRS LAGOON, WAIHORA, CANTERBURY

* exotic species

Host information from White (2002) and Brian Patrick pers. comm.

ORDER/ Family/ species	Yarr's Flat	Yarr's Lagoon	Ecological and biological notes #	Distribution
LEPIDOPTERA			**BUTTERFLIES AND MOTHS**	
Coleophoridae			Case-bearing moths	
**Coleophora trifolii*	X		Introduced clover case-bearer on clovers	
Crambidae			Grass and moss moths	
Eudonia dinodes		X	Unknown	
Eudonia leptalea	X		Larvae sod webworm	
Eudonia minualis		X	Mosses	
Eudonia octophora		X	Larvae in damp grassland/wetland	
Eudonia rakaiaensis	X		Larvae on mosses	
Eudonia sabulosella	X		Larvae sod webworm	Widespread endemic
Eudonia submarginalis	X	X	Sod webworm in pasture on grasses	
Eudonia new species formerly *E. minualis*		X	Larvae on mosses	
Glaucocharis auriscriptella		X	Mosses?	
Glaucocharis lepidella		X	Larvae on mosses	
Hygraula nitens	X	X	Pond moth; aquatic larvae on aquatic plants	Australasian; Widespread
Orocrambus apicellus		X	Larvae on sedges in wetlands	
Orocrambus flexuoselus	X	X	Larvae in grasslands (both native & exotic)	Ubiquitous endemic
Scoparia chalicodes	X		Larvae in dry mosses in grassland	
Scoparia minusculalis		X	Larvae in mosses	
Udea flavidalis		X	Larvae on herbs and lianes - both native and exotic	
Depressariidae				
**Agonopterix alstroemeriana*	X	X	Larvae on hemlock; introduced from Europe	European
Elachistidae			Grass miner moths	
Cosmiotes ombrodoca	X	X	Larvae mine grasses	
Elachista gerasmia		X	Larvae mine grasses	
Erebidae				
Rhapsa scotoscalis		X	Larvae on leaf litter	
Gelechiidae			Twirler Moths	

**Phthorimaea operculella*	X		*Solanum* species	Introduced
Geometridae			Geometrid moths	
Asaphodes abrogata	X		Larvae on Plantago - both native and exotic	
Austrocidaria gobiata		X	Larvae on *Coprosma*	
Austrocidaria similata		X	Larvae on *Coprosma*	
Chloroclystis inductata		X	Larvae on flowers - both native and exotic	
Declana floccosa		X	Larvae polyphagous on shrubs and trees - both native and exotic	
Declana leptomera		X	Larvae polyphagous on shrubs and trees - both native and exotic	
Epyaxa rosearia		X	herbs (both native & exotic)	
Homodotis megaspilata		X	Larvae on herbs and leaf litter - both native and exotic	
Hydiomena rixata		X	herbs- both native (*Epilobium* and *Gunnera*) and exotic	
**Phrissogonus filata*		X	Larvae on flowers both native and exotic	Introduced
Pseudocoremia leucelaea	X		Larvae on podocarps	
Pseudocoremia suavis		X	Larvae polyphagous on trees - both native and exotic	
Glyphipterigidae			Sedge moths	
Glyphipterix iocheaera		X	Larvae mine *Juncus*	
Hepialidae			Porina moths	
Wiseana copularis	X	X	Subterranean larvae in grassland	Widespread endemic
Wiseana umbraculata	X	X	Subterranean larvae in damp grassland	Widespread endemic
Noctuidae			Noctuid moths	
Aletia moderata	X		Larvae on herbs both native (*Raoulia* at least) & exotic	
Ectopatria aspera	X		Swept as larva from glass wort at night	
Graphania mutans	X	X	Larvae on herbs (both native & exotic)	Widespread endemic
Graphania ustistriga	X	X	Larvae on tall herbs and most often arboreal on shrubs and trees - both native and exotic	
Graphania plena	X	X	Larvae on herbs	Widespread endemic
Meterana levis	X		Larvae on *Plagianthus* and *Hoheria* species	less common species
**Mythimna separata*		X	Northern armyworm	Widespread - spreading south
Persectania aversa	X		Larvae on grasses	Widespread endemic
Proteuxoa (Rictonis) comma	X	X	Larvae on native & exotic grasses and herbs	
Tmetolophota atristriga	X	X	Larvae on grasses (both native and exotic)	Widespread endemic
Tmetolophota semivittata		X	Larvae on sedges (*Carex* spp.)	
Nymphalidae			Admiral butterflies	
Bassaris itea	X	X	Yellow admiral - larvae on *Urtica* species	
Oecophoridae			Lichen tuft moths	
Barea exarcha		X	Larvae on dead wood	
Hierodoris s-fractum		X	Leaf litter of drylands but has adapted to gorse	
Izatha picarella		X	Larvae on dead wood (lichen moth)	

Leptocroca species lindsayi?	X		Larvae on leaf litter	
Stathmopoda horticola		X	Polyphagous on natives and exotics – flowers/ fruit/ leaf litter	
Psychidae			Bag worms	
Liothula omnivora	X	X	Common bag moth	
Tineidae			Fungus moths	
**Tinea bisselliella*			Introduced – larvae feed on dead insects	Introduced
Tortricidae			Leafrollers	
Capua semiferana		X	Larvae on leaf litter; dry open areas	Widespread endemic
"Cnephasia" jactatana		X	Larvae polyphagous on ferns, fruits and foliage of many species including shrubs	
Ctenopseustis obliquana		X	Polyphagous on shrubs and trees – leafroller	
**Cydia succedana*	X	X	Larvae on gorse flowers; introduced biological control agent	exotic
Epichorista siriana	X		Larvae on grasses – both native and exotic	
Harmologa amplexana		X	Polyphagous on trees and shrubs – leafroller in fruits, perched leaf litter and foliage	
Merophyas leucaniana		X	Grasses and herbs and low-growing shrubs	
**Sperchia intractana*		X	Australian species now well established – host?	Australian
TRICHOPTERA			Caddis flies	
Hydrobiosidae				
Hydrobiosis clavigera		X	Predatory larvae in streams	
Hydroptilidae			Micro-caddis	
Oxyethira albiceps	X	X	Cased larvae in ponds	
Leptoceridae			Long-horned caddis	
Oecetis unicolor	X		Ponds with larvae in case	
Triplectides cepahlotes	X	X	Ponds with larvae in case	
Polycentropodidae			Tube-making caddisflies	
Polyplectropis puerilis		X	Larvae in streams	
COLEOPTERA			**BEETLES**	
Anthribidae				
Euciodes suturalis	X	X		
Sharpius sandageri		X		
Archeocrypticidae				
Archeocrypticus topali	X		Australian species	

Carabidae			Ground beetles	
**Anisadactylus binotatus*	X			
Bembidion rotundicolle	X	X		
Clivina vagans	X	X		
Dichrochile atrata	X	X		
Holcaspis elongella		X		
Lecanomerus latimanus	X			
Mecylcothoroax rotundicollis	X	X		
Megadromus antarcticus	X	X		
Megadromus (enysi) walkeri		X		
Metaglymma moniliferum	X			
Notagonum feredayi	X	X		
Indet. sp.		X		
Cerambycidae			Longhorn beetles	
Liogramma zelandica		X		
Prionoplus reticularis	X		huhu beetle	Widespread endemic
Spilotrogia pulchella	X			
Zorion guttigerum		X	Flower longhorn	
Cleridae			Checkered beetles	
Phymatophaea tracheloglaba		X		
Coccinellidae			Ladybirds	
*Coccinella undecimpunctata	X		Elevenspotted ladybird	
Rhyzobius indet sp. 1		X		
Rhyzobius indet sp. 2		X		
Curculionidae			Weevils	
Eucossonus sp. indet.		X		
**Exapion ulicis*		X	Gorse seed weevil. Ex Malaise trap in rush area of Yarrs Lagoon	
Chalepistes aequalis	X			
Hoherius meinhertzhageni	X		Ex Malaise on saltmarsh ribbonwood	
Irenimus aequalis	X		The description of which is being reviewed	
Listronotus bonariensis	X		Mainly swept off glasswort at night	
Peristoreus durus	X			
Sitona obsoletus	X		Ex Malaise on saltmarsh ribbonwood	
Steriphus ascitus		X		
Steriphus diversipes lineata	X		Mainly swept off glasswort at night	
Steriphus variabilis	X			

Dermestidae			Hide beetles	
Trogoderma sp.				
Dytiscidae			Water beetles	
Rhantus plantaris	X		Predaceous diving beetle - not that common	
Elateridae			Click beetles	
Conoderus exsul	X		Common	
Latridiidae	X		Minute scavenger beetles	
Cortinicara hirtalis	X			
Melyridae			Soft-wing flower beetles	
Indet. sp 1. "larger, blue"	X			
Indet. sp 2. "pronotal basal seta"	X			
Mordellidae			Tumbling flower beetles	
Mordella promiscua		X		
Oedemeridae			False blister beetles	
Selenopalpus aciphyllae	X			
Scarabaeidae			chafers	
Costelytra zealandica	X		grasslands	Widespread endemic
Odontria ?varicolorata		X		
Scirtidae			Marsh Beetles	
Undet. sp. 1 "large"	X	X		
Undet. sp. 2 " dark; pronatal basal seta"	X	X		
Undet. sp. 3 "glabrous"	X			
Undet. sp. 4 "dark suture"	X	X		
Undet. sp. 5 "unkempt"		X		
Undet. sp. 6 "small greenish yellow"		X		
Tenebrionidae			Darkling beetles	
Artystona sp.		X		
Zeadelium zelandicum		X		
Odonata			Dragonflies and damselflies	
Lestidae			Spreadwings	
Austrolestes colensonis	X	X	Blue damselfly	

Coenagrionidae			Pond damselfly
Xanthocnemis zealandica	X	X	Red damselfly
DIPTERA			Flies
Asilidae			Robberflies
Neoitamus ?melonopogoa		X	
Syrphidae			flower flies; hover flies
Melangyna novaezealandiae	X		
Melanostoma fasciatum	X		
HYMENOPTERA			**WASPS, BEES, ANTS**
Apidae			Bees
Bombus sp.		X	Bumble bee
Eumenidae			Potter wasps
Spilotrogia pulchella	X		European tube wasp
Ichneumonidae			Parasitic wasps
Xanthocryptus ? Sp.		X	
Pompilidae			Spider wasps
Indet. sp. 1 "large brown"	X	X	
Indet. sp. 2 "smaller black"	X	X	
ORTHOPTERA			WETA, GRASSHOPPERS
Raphidophoridae			Cave weta
Pleioplectron simplex		X	
HEMIPTERA			**BUGS**
Aphididae			Aphids
**Tuberolachnus salignus*			Giant willow aphid
Cicadidae			Cicidas
Indet. sp. 1 "large green"		X	
Indet. sp. 2 "smaller brown"	X		

ARANEAE			SPIDERS	
Colaranea ?viriditas	X		Green orb-web spider	
Colaranea verutum	X			
Sidymella sp.	X			
Cambridgea sp.	X	X		
Dolomedes minor	X	X	Nursery web spider	Common
Tetragnatha sp.	X		Long-jawed orb web spider	Common
Zealaranea crassa	X			
OPILIONES			HARVESTMENT	
Phalangiidae				
?Megalopsalis sp.		X	Long-legged harvestman	
ACARI			Mites	
Tetranychidae			Spider mites	
**Tetranychus lintearius*		X	Gorse spider mite biocontrol	
Erythraeidae				
Balaustium sp.	X		Feeding on Glasswort pollen	
PSEUDOSCORPIONES			False Scorpions	
Chernetidae				
Indet. genus & species 1	X			
Indet. genus & species 2	X			
MOLLUSCS			**SNAILS, SLUGS**	
Cavellia serpentinula	X			
Charopa pseudocoma	X	X		

APPENDIX -GPS LOCATIONS

GPS code	GPS coordinates	Site	Notes
Moth trapping			
LIGHT-TRAP	S43 43.115 E172 27.681	Yarrs Flat	
LIGHT-TRAP	S43 41.020 E172 27.007	Yarrs Lagoon	
Malaise Traps			
MALAISE TRAP 1	S43 43.101 E172 27.722	Yarrs Flat	
MALAISE TRAP 2	S43 41.020 E172 27.007	Yarrs Lagoon	
Pitfall traps			
PF1	S43 42.941 E172 27.657	Yarrs Flat	herbicided but not planted
PF10	S43 43.221 E172 27.678	Yarrs Flat	
PF11	S43 43.223 E172 27.677	Yarrs Flat	
PF12	S43 43.227 E172 27.678	Yarrs Flat	
PF13	S43 43.219 E172 27.679	Yarrs Flat	
PF2	S43 43.000 E172 27.700	Yarrs Flat	Amongst recent plantings
PF4	S43 43.223 E172 27.665	Yarrs Flat delta	Salt-marsh ribbonwood
PF5	S43 42.727 E172 27.095	Yarrs Flat by LII	Willows
PFR1	S43 43.108 E172 27.724	Yarrs Flat	
PFR2	S43 43.114 E172 27.726	Yarrs Flat	
PFR3	S43 43.117 E172 27.734	Yarrs Flat	
PFR4	S43 43.120 E172 27.718	Yarrs Flat	
PFW3	S43 40.963 E172 27.380	Yarrs Lagoon	Willows
PM1	S43 41.044 E172 26.957	Yarrs Lagoon	Manuka
PM2	S43 41.053 E172 26.952	Yarrs Lagoon	Manuka
PM3	S43 41.050 E172 26.959	Yarrs Lagoon	MOSS MOUND Manuka
PM4	S43 41.045 E172 26.974	Yarrs Lagoon	Manuka
PR1	S43 41.014 E172 27.003	Yarrs Lagoon	Rushland
PR2	S43 41.017 E172 27.005	Yarrs Lagoon	Rushland
PR3	S43 41.018 E172 27.003	Yarrs Lagoon	Rushland
Tracking tunnels			
T1	S43 41.005 E172 27.095	Yarrs Lagoon	
T2	S43 41.011 E172 27.131	Yarrs Lagoon	
T3	S43 41.000 E172 27.171	Yarrs Lagoon	
T4	S43 40.991 E172 27.207	Yarrs Lagoon	
T5	S43 40.974 E172 27.239	Yarrs Lagoon	
T6	S43 40.970 E172 27.274	Yarrs Lagoon	
T7	S43 40.962 E172 27.315	Yarrs Lagoon	
T8	S43 40.968 E172 27.356	Yarrs Lagoon	
T9	S43 40.943 E172 27.382	Yarrs Lagoon	
T10	S43 40.923 E172 27.422	Yarrs Lagoon	
T11	S43 42.723 E172 27.085	Yarrs Flat	
T12	S43 42.749 E172 27.099	Yarrs Flat	
T13	S43 42.775 E172 27.108	Yarrs Flat	
T14	S43 42.801 E172 27.119	Yarrs Flat	
T15	S43 42.829 E172 27.125	Yarrs Flat	
T16	S43 42.860 E172 27.131	Yarrs Flat	
T17	S43 42.887 E172 27.136	Yarrs Flat	
T18	S43 42.916 E172 27.143	Yarrs Flat	

T19	S43 42.940 E172 27.157	Yarrs Flat	
T20	S43 42.968 E172 27.166	Yarrs Flat	
T21	S43 42.935 E172 27.701	Yarrs Flat	
T22	S43 42.953 E172 27.736	Yarrs Flat	
T23	S43 42.956 E172 27.776	Yarrs Flat	
T24	S43 42.970 E172 27.809	Yarrs Flat	
T25	S43 42.982 E172 27.843	Yarrs Flat	
T26	S43 42.970 E172 27.881	Yarrs Flat	
T27	S43 42.973 E172 27.918	Yarrs Flat	
T28	S43 42.977 E172 27.955	Yarrs Flat	
T29	S43 42.980 E172 27.996	Yarrs Flat	
T30	S43 42.988 E172 28.021	Yarrs Flat	

Wooden discs

WDR1	S43 43.085 E172 27.724	Yarrs Flat	Saltmarsh ribbonwood
WDR2	S43 43.117 E172 27.670	Yarrs Flat	Saltmarsh ribbonwood
WD3	S43 42.983 E172 27.685	Yarrs Flat	Areas planted 2015
WD4	S43 42.979 E172 27.725	Yarrs Flat	Areas planted 2015
WD 5	S43 42.936 E172 27.661	Yarrs Flat	Herbicided grass
WD6	S43 42.727 E172 27.093	Yarrs Flat	Willow trees
WD7	S43 42.716 E172 27.102	Yarrs Flat	
WD11	S43 41.016 E172 26.987	Yarrs Lagoon	Native rushland
WD12	S43 41.018 E172 26.985	Yarrs Lagoon	Native rushland
WD13	S43 41.026 E172 26.996	Yarrs Lagoon	Native rushland
WD14	S43 41.025 E172 26.997	Yarrs Lagoon	Native rushland
WD15	S43 41.017 E172 26.991	Yarrs Lagoon	Native rushland
WD16	S43 40.957 E172 27.389	Yarrs Lagoon	Willow/native understory
WD17	S43 40.953 E172 27.394	Yarrs Lagoon	Willow/native understory
WD18	S43 40.956 E172 27.394	Yarrs Lagoon	Willow/native understory
WD19	S43 40.959 E172 27.388	Yarrs Lagoon	Willow/native understory
WD20	S43 40.962 E172 27.383	Yarrs Lagoon	Willow/native understory

Weta Motels

WM1	S43 43.098 E172 27.720	Yarrs Flat
WM2	S43 43.098 E172 27.721	Yarrs Flat
WM3	S43 43.095 E172 27.725	Yarrs Flat
WM4	S43 43.086 E172 27.728	Yarrs Flat
WM5	S43 43.106 E172 27.722	Yarrs Flat
WM6	S43 43.109 E172 27.721	Yarrs Flat
WM7	S43 43.113 E172 27.719	Yarrs Flat
WM8	S43 43.119 E172 27.729	Yarrs Flat
WM9	S43 43.120 E172 27.721	Yarrs Flat
WM10	S43 43.128 E172 27.725	Yarrs Flat
WM11	S43 41.018 E172 27.008	Yarrs Lagoon
WM12	S43 41.014 E172 27.004	Yarrs Lagoon
WM13	S43 41.016 E172 26.986	Yarrs Lagoon
WM16	S43 41.040 E172 26.977	Yarrs Lagoon
WM17	S43 41.038 E172 26.975	Yarrs Lagoon
WM18	S43 41.040 E172 26.972	Yarrs Lagoon
WM19	S43 41.040 E172 26.968	Yarrs Lagoon

WM20	S43 41.040 E172 26.970	Yarrs Lagoon	
Bird Monitoring			
PLOT 1	S43 43.109 E172 27.746	Yarrs Flat BIRD COUNT PLOT 1	
PLOT 2	S43 43.182 E172 27.674	Yarrs Flat BIRD COUNT PLOT 2	
PLOT 3	S43 42.988 E172 27.742	Yarrs Flat BIRD COUNT PLOT 3	
PLOT 4	S43 42.951 E172 27.579	Yarrs Flat	
Onduline Lizard refuge			
LIZLOD1	S43 42.966 E172 27.741	Yarrs Flat	
LIZLOD2	S43 43.273 E172 27.691	Yarrs Flat	
YL LIZ LOD 1	S43 41.024 E172 27.102	Yarrs Lagoon	Lizard Refuge1
YL LIZ LOD 2	S43 41.011 E172 27.158	Yarrs Lagoon	Lizard Refuge2
Miscellaneous			
MANUKA 1	S43 41.034 E172 26.971	Yarrs Lagoon	
MANUKA PRESENT	S43 40.804 E172 27.795	Yarrs Lagoon	
MANUKA PRESENT2	S43 40.811 E172 27.690	Yarrs Lagoon	
BRIDGE 1	S43 42.968 E172 27.888	Yarrs Flat	Yarrs Flat BRIDGE 1
AQUATIC-yl	S43 40.788 E172 26.979	Yarrs Lagoon	Aquatic stream sampling
CAR PARK	S43 41.004 E172 27.109	Yarrs Lagoon	
CAR PARK 2	S43 42.907 E172 27.607	Yarrs Lagoon	
ENTER SCRUB	S43 41.030 E172 26.999	Yarrs Lagoon	Track into manuka