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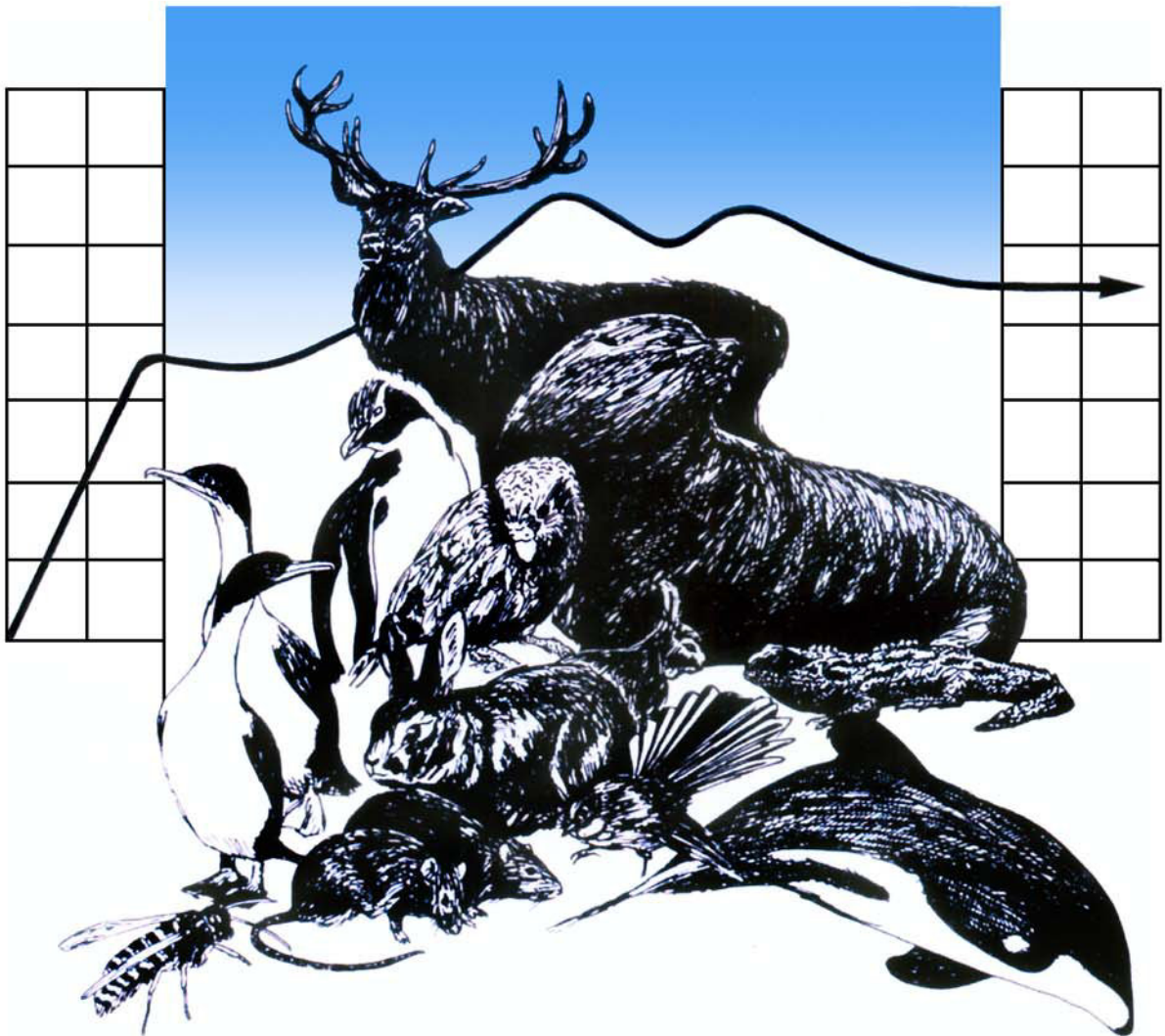
*Te Whare Wānanga o Otāgo*

NEW ZEALAND

# DEPARTMENT OF ZOOLOGY



# WILDLIFE MANAGEMENT

# Is the bush better than the tree?
# Does habitat type play a
# significant role in nesting success
# of the Stewart Island robin
# (Petroica australis rakiura)

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# Is the bush better than the tree? Does habitat type play a significant role in nesting success of the Stewart Island robin (Petroica australis rakiura)

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**Abstract**

Determining whether an animal prefers one habitat over another provides important information on an animal's requirements within the environment. The habitat chosen by the individual or species may further influence reproductive success or survival and therefore has to be carefully considered for species that have small population sizes. Habitat selection can be specifically analysed when a group of individuals are translocated to an unoccupied island. This allows the species to choose habitat of the highest quality within the range available. There have been few studies that have looked at the affects of habitat preference on reproductive success, and this current investigation examines a past reintroduction of a species to a protected island. This study uses ArcGIS technology to investigate the distribution of Stewart Island robins (Petroica australis rakiura) after their translocation to Ulva Island, New Zealand, and whether their preference to a particular habitat influences the nesting success of the breeding pair. The distribution of all nests showed a random pattern throughout all habitat types. With observable nests, reproductive success was not shown to be significantly affected by habitat selection. A number of biological factors are discussed as possibly masking the interaction between habitat types and nesting success. However, the prospect exists that robins are flexible breeders and require no specific habitat for successful nesting.

**Keywords:** Habitat selection; Stewart Island robin (Petroica australis rakiura); nesting success

## Introduction

Habitat selection is the process, or the behaviour, a species can use to choose the habitat it resides in (Rosenzweig, 1981). A number of factors can influence habitat selection including food

availability, adequate breeding sites, intra- and inter-specific competition and the presence of predators (Rosenzweig, 1981; Cody, 1985; Manly et al., 1993; Lovegrove, 1996). Establishing which habitats are selected for by animals can provide detailed information on the species' requirements within the area (Steffens et al., 2005). Understanding habitat selection in various animals is particularly important for successful recovery of threatened species, prior to translocation to proposed release sites (Wolf et al., 1998). Without high quality habitats, translocation programmes and newly translocated species have a low chance of survival (Lovegrove, 1996). Translocating species to unoccupied islands can also provide a framework to analyse and investigate habitat preference in a number of species without requiring experimental manipulations (Manly et al., 2002; Michel et al., 2010). In most cases, unoccupied islands can additionally provide insight to investigations into habitat selection with no resident population or predator interactions, particularly the islands that are predator free (Manly et al., 2002; Michel et al., 2010).

There is a possibility that source-sink habitat selection occurs when translocating species. This is where animals settle first into the superior habitat (source) and then the remaining individuals will fill the inferior habitat (Pulliam, 1988; Pulliam and Danielson, 1991). Other types of habitat selection such as 'ecological traps' can occur when low quality habitat is preferred over the higher quality habitat, which is readily available (Schaepfer et al., 2002). These forms of habitat selection models are important to understand to observe how the species responds to the environment or habitat, and whether the habitat is suitable for the species (Schaepfer et al., 2002). Source-sink systems are thought to apply to island reintroductions in areas such as New Zealand, as individuals are typically released on islands with few competitors, thus can exploit all habitat types (Armstrong and McLean, 1995). Choices of habitat selection can ultimately influence and effect reproduction and survival (Steffens et al., 2005). Habitat selection and resource availability are usually studied to determine how reproduction is affected by habitat (Manly et al., 2002). Low quality habitats could also potentially affect reproduction in terms of hatching or fledgling success (Hanski et al., 1996). Ultimately, regardless of successful species translocation, populations may fail to establish (Lovegrove, 1996).

The New Zealand robin (Petroica australis) is a small, forest dwelling passerine endemic to New Zealand (Powlesland, 1981; Armstrong et al., 2000). Robins are ground-feeding insectivores and will feed on berries when invertebrates are scarce (Powlesland, 1981). They forage mainly in the litter layer on the forest floor but will occasionally find prey within the bark of trees (Powlesland, 1981; Armstrong et al., 2000). There are three different subspecies, the North Island robin (Petroica australis longipes), the South Island robin (Petroica australis

australis) and the rarest of the three, the Stewart Island robin (Petroica australis rakiura). Stewart Island robins were originally widespread throughout Stewart Island but have been isolated to areas of stunted mānuka forest within the Freshwater Flats area (Greer, 2000). They have been thought to be confined to stunted mānuka forest as densities of rats and feral cats are considerably lower in these forests than in other parts of Stewart Island (Greer, 2000; Harper et al., 2005). In September 2000 and January 2001, 18 Stewart Island robins were translocated from Freshwater Flats on Stewart Island to Ulva Island (Alexander and Beaven, 2002). After this translocation, the individuals settled into areas on the periphery of Ulva Island, in the coastal habitat (Steffens et al., 2005). Since this translocation to Ulva Island, the population of robins have been monitored by researchers and other individuals from the Department of Conservation and the University of Otago Zoology Department. The data has been complied into a long term study of survival and reproductive success. Banding of the robins occurred throughout this time, and from 2008 onwards the nestlings were banded instead of the individual adults. On Ulva Island, the robins are very curious and will approach tourists frequently. This occurs as the robins are trained to approach humans at the sound of tapping or clapping and are rewarded with mealworms (Steffens et al., 2005). In December of 2010, rats had reinvaded Ulva Island (Masuda and Jamieson, 2013). Brodifacoum poison was aerially dropped onto the island in 2011 to treat the reinvasion, which was successful, yet a considerable number of non target species deaths occurred, including some within the reintroduced robin population (Masuda and Jamieson, 2013). A number of breeding seasons after the brodifacoum baiting, the population of robins was seen to increase to original numbers (Masuda and Jamieson, 2013). The breeding season of the summer of 2012-2013 was the last year of monitoring the breeding and nesting of the Stewart Island robin.

The robin breeding season is typically between September and March (Powlesland et al., 2000). Robins are sedentary and live as pairs or as solo males in territories and, because they are non-migratory, remain in their territories all year round (Steffens, 2003). They usually build their open-cup nests within tree forks or inside tree cavities (Higgins and Peter, 2002). A large number of robin nests are reachable or observable which allows for accurate calculations of hatching and overall nesting success. The primary objective for this investigation was to determine if habitat type placed a key role in the survival and reproduction of the reintroduced population of South Island robins. Specifically this aimed to determine whether (1) habitat type affects laying date, hatching success and nest success, and (2) if habitat type and age (or cohort) of the robin pair further influenced the nesting success (or number of eggs hatched). This study also addressed whether there was an observed preference of habitat type for nesting Stewart Island robins in the breeding season of 2012/2013.

**Methods**

**Study Site**

Ulva Island (46° 56' S, 168° 08' E) is a predator-free 'open sanctuary' island situated in Paterson Inlet, Stewart Island, New Zealand. Ulva Island is a 259 hectare island managed by the Department of Conservation. An eradication programme eradicated introduced Norway rats (Rattus norvegicus) by 1996. The terrain is gentle throughout the island apart from a small number of cliff edges, with its highest point at 74 metres. There is a small area (around Post Office Bay) where the near-pristine forest was cleared and planted with exotics including pine trees and macrocarpa. The vegetation on the island consists of mature podocarp forest, coastal scrub and 'coastal forest fringe'. Mature podocarp dominates the interior of the island, while the coastal scrub surrounds the exterior of the island. This coastal scrub meets and intermixes with mature podocarp forest species such as kamahi, Weinmannia racemosa and rata, Metrosideros umbellata creating the coastal forest fringe (Hooson and Jamieson, 2004).

**Habitat mapping**

The habitat map for Ulva Island used for this report was replicated from Steffens et al. (2005). Steffens et al. (2005) completed vegetation surveys of the island using the RECCE method – each bait station line was walked down and the vegetation was recorded (along with GPS co-ordinates also taken) each time it changed. Characteristics of vegetation that were recorded included canopy height, ground cover, dominant species and density. Twenty metre circular plots were also surveyed within twenty metres of each of the vegetation types. Dominant plant species, average tree height, average tree trunk diameter at breast height, ground cover and canopy cover were in addition recorded in the plots (Table 1). Aerial photographs of Ulva Island were also taken and used with the vegetation survey to produce a habitat map. The vegetation survey was overlaid on the geo-referenced image from the aerial photography. Boundaries between each of the habitat types were delineated by interpreting both the vegetation patterns from the air and the vegetation survey. The 75 reachable nesting sites collected from this year's study were plotted onto the habitat map using ArcGIS (by Esri). Two nesting sites were removed as GPS co-ordinates were incorrectly recorded. All nesting sites (both reachable and not reachable) were also plotted onto the habitat map to determine possible preference of habitat type (n=165), two nests were removed due to error. Only the first clutch of every robin pair was used for this study. One blank habitat map is included in supplementary material as total (reachable and non-reachable) nest sites on the habitat map is faded due to copying.

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**Table 1:** Summary of main habitat types found on Ulva Island, New Zealand. From Steffens et al. (2005).

| Habitat type (ha) | General description | Characteristic plants[1] | Average height (m) | Average DBH (cm) |
|---|---|---|---|---|
| Mature-open forest (88.4) | large mature trees; open undergrowth | rimu, miro, rata, totara, kamahi, lancewood, tree fern | 25 | 70 |
| Mature-moss forest (62.0) | large mature trees; moss ground cover | rimu, miro, totara, kamahi, haumakoroa | 21 | 50 |
| Coastal forest fringe (55.1) | mixture of coastal and forest species; moderate undergrowth | rata, kamahi, muttonbird scrub, inaka, totara, supplejack, tree fern, ferns, broadleaf | 13 | 35 |
| Stunted forest (33.0) | trees much smaller than mature forest; open undergrowth | totara, rata, kamahi, rimu, miro, gahnia, ferns | 13 | 35 |
| Kamahi-rata forest (19.8) | moderately dense and dominated by kamahi and rata; moderate undergrowth | kamahi, rata, tree fern, supplejack, totara | 21 | 44 |
| Coastal scrub (10.8) | dense scrub of mostly dracophyllum and muttonbird scrub; moderate undergrowth | inaka, muttonbird scrub, leatherwood, rata, ferns | 5 | 16 |
| Exotic forest (2.5) | mixture of exotic canopy trees and native shrubs; moderate undergrowth | pine, macrocarpa, muttonbird scrub, tree fern, ferns | 30 | 80 |

[1] Scientific names of plants listed: rimu *Dacrydium cupressinum*; miro *Prumnopitys ferrugineus*; rata *Metrosideros umbellata*; totara *Podocarpus hallii*; kamahi *Weinmannia racemosa*; lancewood *Pseudopanax crassifolius*; tree fern *Dicksonia squarrosa*; haumakoroa *Pseudopanax simplex*; muttonbird scrub *Senecio reinoldii*; inaka *Dracophyllum longifolium*; supplejack *Ripogonum scandens*; ferns *Blechnum sp.*; broadleaf *Griselinia littoralis*; gahnia *Gahnia procera*; leatherwood *Olearia colensoi*; pine *Pinus radiata*; macrocarpa *Cupressus macrocarpa*.

**Statistical Analysis**

To determine if habitat type significantly affected nest success, hatching success and laying date were investigated by taking into account the number of hatched and un-hatched eggs for each reachable first-clutch nest (n=73). Nest survival and experience (age) of each of the nests analysed was also taken into account. It was hypothesised that a specific habitat type would be more advantageous to nest in and would result in earlier lay dates, greater hatching success and nesting survival. To test this hypothesis, nest site locations were collected for nests that could be reached and observed on Ulva Island to ensure that hatching and nest survival was accurately calculated. All variables (hatching success, lay date, nest survival, age) were modelled using generalised linear models (GLMs) in the computer software package R 2.8.1 for Windows (Auckland, New Zealand). Four GLM models were analysed with response variables taken into account – (1) the number of eggs hatched and not hatched in relation to the habitat type, (2) the number of eggs hatched and not hatched in each habitat type and lay date, (3) the number of eggs hatched and not hatched in each habitat and age (or experience) of each female, (4) the number of eggs hatched and not hatched in each habitat and the overall chick survival of each nest. The two incorrectly recorded nest sites were also removed from the statistical analysis. A chi-square test for goodness-of-fit was completed for the total number of nest sites, with two removed due to error (first clutch).

## Results

Reachable robin nesting sites (first clutch) show a random distribution throughout the habitat types of Ulva Island (Figure 1). There was also no significant different of hatching success, laying date, age of female robins and chick survival between habitat types (Table 2). One model was close to being statistically significant (Test 1) which only took the number of hatched and un-hatched eggs into account (Table 2). This may indicate that with a larger sample size, habitat type could play a possible role in the number of hatched and un-hatched eggs within a nest (regardless of other biological factors).

**Table 2**: Results of the four generalised linear models (GLMs) for (1) habitat type, (2) habitat type and lay date, (3) habitat type and age (experience) of the female and (4) habitat type and overall chick survival of each nest. P values indicate no statistical significance for any of the tests completed. Table includes estimate, standard error and t values for each statistical test. (n = 73).

|        | Est     | Std. Error | t value | p value |
|--------|---------|------------|---------|---------|
| Test 1 | 0.8095  | 0.4262     | 1.8990  | 0.0623  |
| Test 2 | 1.4932  | 1.3335     | 1.1201  | 0.2670  |
| Test 3 | 0.6502  | 0.7851     | 0.8280  | 0.4110  |
| Test 4 | -0.0953 | 0.5118     | -0.1860 | 0.8530  |

For the total number of both reachable and non-reachable nests (Figure 2), there was no significant difference between the observed and expected values for nesting in the different habitat types (Table 3).

**Table 3**: Results from chi square goodness-of-fit test for total number of nesting sites (reachable and un-reachable) in the breeding season of 2012/2013 on Ulva Island, New Zealand. First clutch calculations only of observed and expected numbers for nesting sites. Habitat types are listed in order from largest to smallest (in hectares). Degrees of freedom (df) is also included. (n=165).

|               | Observed | Expected | df | Chi-square | p value (two-tailed) |
|---------------|----------|----------|----|------------|----------------------|
| Mature - Open | 48       | 53.71    | 6  | 11.62      | 0.071                |
| Mature - Moss | 28       | 37.67    |    |            |                      |
| Coastal fringe| 39       | 33.48    |    |            |                      |
| Stunted       | 19       | 20.05    |    |            |                      |
| Kamahi – rata | 19       | 12.03    |    |            |                      |
| Coastal scrub | 11       | 6.42     |    |            |                      |
| Exotic        | 1        | 1.65     |    |            |                      |
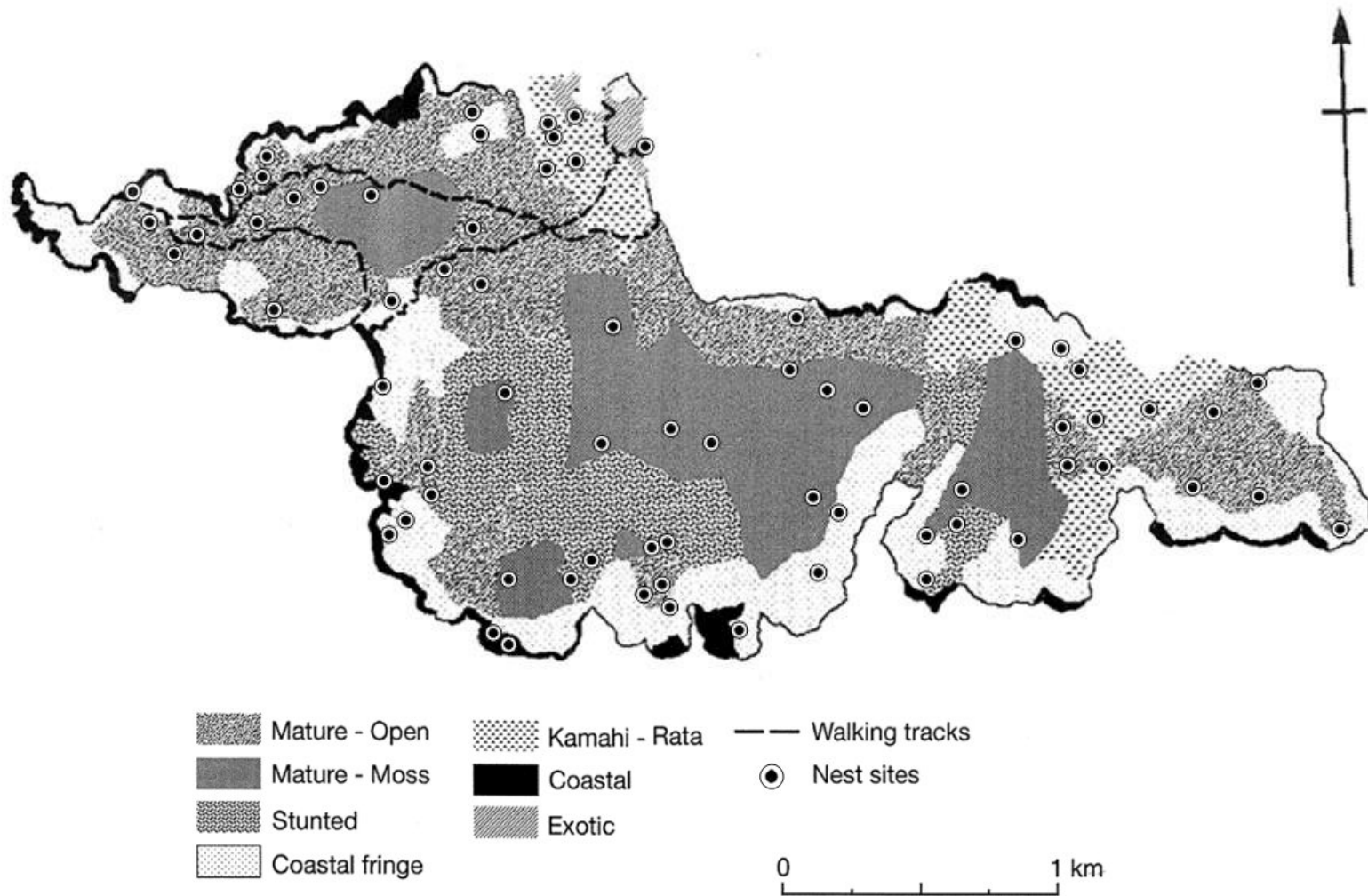
**Figure 1:** The nesting sites for the 73 Stewart Island robin pairs (for the 2012/2013 breeding season) overlaid on the habitat map of Ulva Island near Stewart Island, New Zealand. Two outliers (or incorrectly recorded nest sites) were removed.
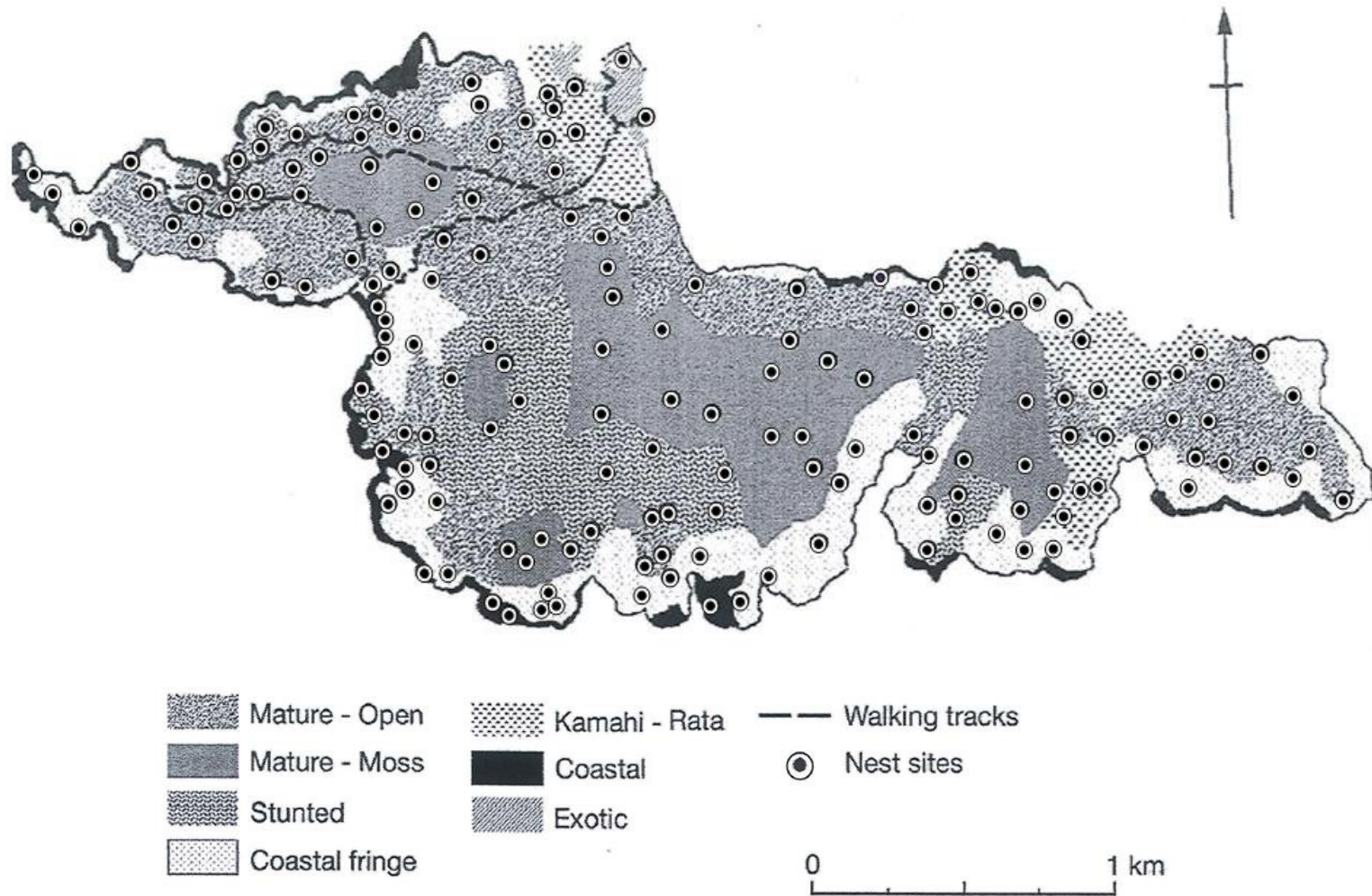
**Figure 2:** The total number of first clutch nesting sites for the 165 Stewart Island robin pairs (for the 2012/2013 breeding season) overlaid on the habitat map of Ulva Island near Stewart Island, New Zealand. Includes both reachable and non-reachable nests. Two outliers (or incorrectly recorded nest sites) were removed.

**Discussion**

  Habitat quality can strongly affect fitness through various environmental cues and therefore strong selective pressures for optimal breeding habitat are likely to occur (Martin, 1993; Doligez et al., 1999). There is evidence in a number of studies that individuals are able to determine high quality habitat sites (Newton & Marquiss 1982; Stacey & Ligon 1987; Petit & Petit 1996). This indicates that individuals are able to identify high quality sites. Individuals may do this by using various environment cues, which could be either direct or more integrative such as the effect of quality on fitness (Doligez et al., 1999). The South Island subspecies of New Zealand robin were found to be extremely flexible with regards to their nesting requirements (Duncan et al., 1999). The robins would nest in tree cavities, on branches and in tree forks (Duncan et al., 1999). Duncan et al. (1999) therefore found it unlikely that the availability of nesting sites would cause a variation of density in different habitat types. Michel et al. (2010) found with the habitat on Ulva Island, the upper-canopy cover and numbers of cavities did not differ significantly between Stewart Island robin nesting sites. This would result in a random distribution in robin nesting areas and would explain the results collected within the 2012/2013 breeding season. In 2010, the most common tree species within the robin's territories were tree ferns, Dickonia squarrosa, and other broadleaf species and less podocarp species (Michel et al., 2010). This may indicate that instead of robins nesting in particular habitat, they prefer specific trees or vegetation. However, densities of favoured nesting trees could be situated in particular habitat types. This would explain why in Steffens et al. (2005) the majority of robins nested within the coastal fringe forest as it contained a high density of southern rata, kamahi and tree ferns (Steffens et al., 2005). Steffens et al. (2003) also found that tree cavities were more abundant in coastal fringe than in other habitat. This again could possibly influence robin distribution within habitats especially if several habitat types are not as advantageous to live in. Flack (1979) found that robins are believed to avoid establishing in areas where trees are widely scattered. A possibility of competition and increasing population size could have meant the Stewart Island robins dispersed away from the coastal fringe and moved into the interior of the island keeping to particular tree species. Conversely, habitat structure was assumed to be more important than species composition which is slightly at odds with the current findings (Steffens et al., 2005). For both the random distribution of nesting sites both in the total number of nests for first clutch (reachable and non-reachable) and the reachable nests sites, other factors such as ground cover or leaf litter could explain this distribution and underlying influences causing differences in nesting success.

  Duncan et al. (1999) found that under each of the forest types analysed, there was a noticeable difference of ground cover which could have affected the distributions of robins within

each of the four forest type's analysed (Duncan et al., 1999). The study by Duncan et al. (1999) was completed with a South Island robin population in a predominantly non-native forest; nevertheless the findings can still be partially applied to the current study. Each of the habitat types found on Ulva Island may have a significant number of nesting and perching areas and therefore no individual robins would favour a particular forest type. However, when ground cover is taken into account, significant differences can be found within each habitat type (Duncan et al., 1999; Steffens et al., 2005) and as a result this would influence nesting sites. Flack (1979) found that robins typically favour forest habitat that has little extensive coarse ground cover. In this case, densities of robins could be assumed to be distributed in areas with more preferable ground cover. In Michel et al. (2010), in the majority of observations, robins foraged on ground with less than 50% vegetation cover and these sightings were typically in the coastal habitat type. In Steffens et al. (2005) robins on Ulva Island were found to establish territories near the coast and on the whole avoid mature forest with a moss understory. A mossy forest floor is presumably avoided as it has a lack of suitable foraging substrate (Steffens et al., 2005). The other forest habitat types found on the island (coastal scrub, coastal fringe, mature-open, exotic and kamahi-rata forests) all have patches of open ground cover and thick litter layers. However, out of these five different habitat types, Steffens et al. (2005) was unable to determine a preferred habitat. Coastal fringe forest was found to have a high coverage of leaf litter (Steffens et al., 2005) which could explain why a considerable number of nesting sites were situated within the coastal fringe forest for this study. The litter samples were also found to have a greater number of Amphipoda, Coleoptera and Diplopoda in areas of bird foraging compared to un-used areas (Michel et al., 2010).

There are only a few studies that investigate the effect of habitat selection or habitat type correlating to nesting success and fitness. In these studies, a wide range of other variables are also analysed including group or population density, predation, competition, parasitism (from bird species including cowbirds), habitat fragmentation and edge effects (Gates and Gysel, 1978; Hanski et al., 1996; Burke and Nol, 1998). When looking at the effects that habitat has upon reproductive success in general, studies such as Hanski et al. (1996) found that canopy cover was found to have a significant effect on nesting success in a wide range of avian species. Nesting success was higher in more open canopies (Hanski et al., 1996). Distance to the edge of the forest ("Edge effects") and forest fragmentation can also have an effect on reproductive success (Hanski et al., 1996; Burke and Nol, 1998), but as the habitat on Ulva Island is near pristine, these factors are not applicable. The number of insects available in any habitat types can cause preferences in habitats for a number of species (Southwood and Cross, 1969). Differences in the biomass of insects and other arthropods in various areas were found to influence the breeding success of the

partridge (Southwood and Cross, 1969). This was also assumed in the study by Michel et al. (2010), as the abundance of different insects within each of the habitat types (and the foraging strategy) would affect the amount of food each chick would consume and thus nesting success. In this case, an important factor to include in any habitat selection study would be detailed information on the micro-fauna within the habitat (Southwood and Cross, 1969).

Other biological factors may also explain differences in nesting success between robin pairs and could possibly mask interactions between different habitats. Inbreeding depression, defined as the decline in the value of a trait due to inbreeding, has been found to often take the form of an increase in hatching failure in birds (Wright, 1977; Briskie and Mackintosh, 2004; Mackintosh and Briskie, 2005). Inbreeding depression can also lead to increases in nestling mortality, poor recruitment and reduced adult survival (Bulmer, 1973; Greenwood et al., 1978; Keller, 1998; Jamieson, 2010). Food limitation due to high population density was originally assumed to limit reproductive success in bird species such as New Zealand robins (Mackintosh and Briskie, 2005). A study on the South Island robin subspecies investigated whether supplementary feeding could reduce hatching failure and increase clutch size (Mackintosh and Briskie, 2005). Mackintosh and Briskie (2005) found that regardless of supplementary feeding, there was no significant change in hatching failure. The study by Mackintosh and Briskie (2005), and a number of other studies have found that instead of food limitation, inbreeding reduces fecundity of a population (Byrne, 1999; Jamieson, 2010). Inbreeding depression due to a small founder population is therefore more likely to explain hatching failure within the Stewart Island robin subspecies. Inbreeding may mask the effect that habitat types and habitat selection plays upon the species and environment. Studies such as Steffens et al. (2005) and Michel et al. (2010) determined that the preference of habitat was evident within the Stewart Island robin species, and this may, in combination with inbreeding depression, could affect the robin population rather than being the main cause of reduced fecundity.

Possible preferences for habitat selection may occur for Stewart Island robins on Ulva Island; however the significance could be masked by factors such as a small population size. Other factors that may influence the findings of this report could include a small sample size from the limited first clutch data. In future investigations, including second and third clutches could result in observable habitat preferences. As the New Zealand robin species have been found to have flexible nesting requirements, Stewart Island robins may have no particular preference for a specific habitat which allows them to inhabit all forest types.

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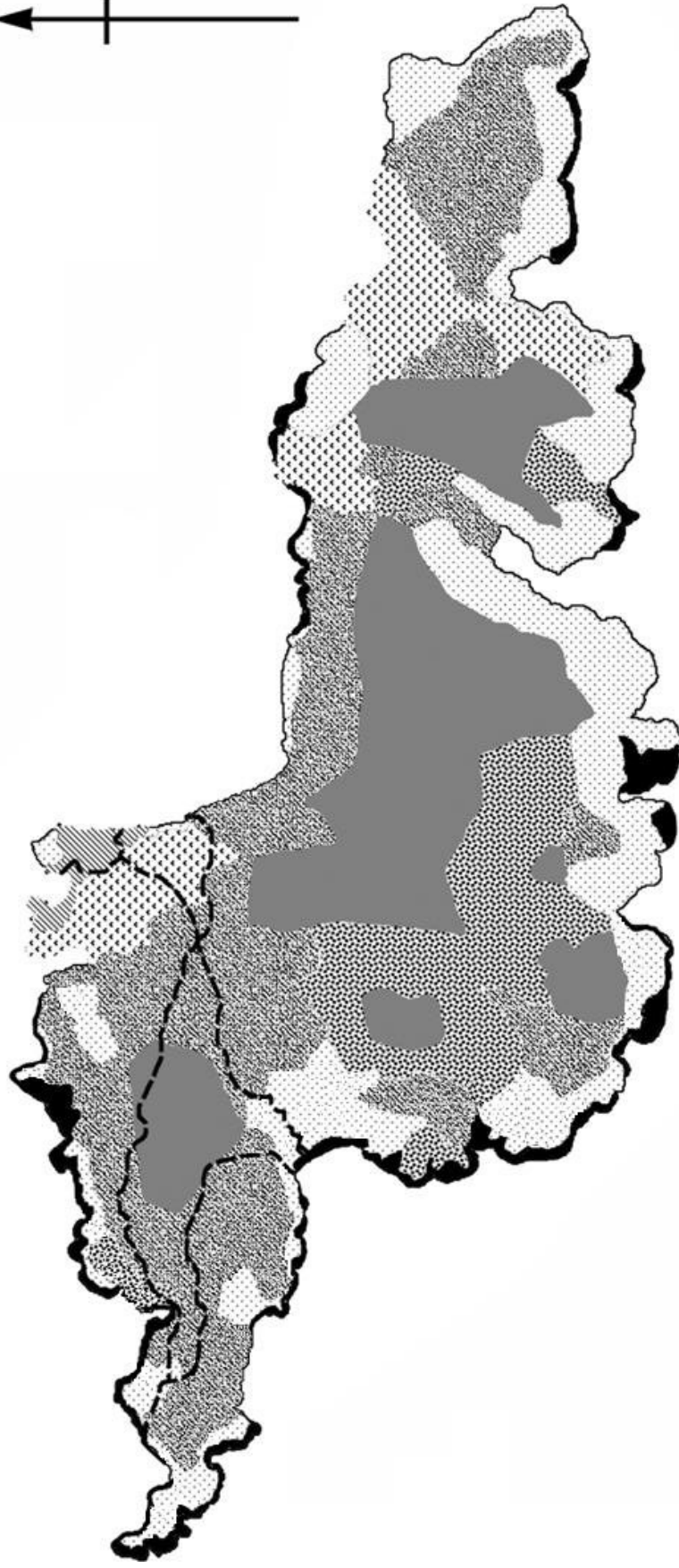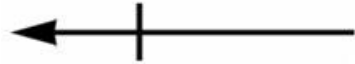
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**Supplementary Material**

Blank habitat map used for the mapping process of the study

Mature - Open      Kamahi - Rata      ──── Walking tracks

Mature - Moss      Coastal      • Nest sites

Stunted      Exotic      ☐ Territories

Coastal fringe

0      1 km