

## Habitat selection by South Island saddlebacks and Stewart Island robins reintroduced to Ulva Island

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**Abstract:** Determining whether animals select some habitats over others provides basic information about how animals meet their requirements for survival and reproduction. Habitat selection is therefore an important component of conservation research. Studies involving the release and establishment of threatened species on island refuges can be particularly insightful because breeding pairs should be able to select habitat of the highest quality within the range available. This study uses GIS technology to investigate the spatial distribution of breeding territories in relation to overall habitat availability of two threatened passerines, South Island saddlebacks (*Philesturnus carunculatus carunculatus*) and Stewart Island robins (*Petroica australis rakiura*) two years after their release onto predator-free Ulva Island. Both species established breeding territories around the periphery of the island in coastal forest fringe habitat and away from mature forest in the interior of the island. Compositional analysis suggested that both species prefer dense, fringe-type habitat with open ground cover and deep litter layers and avoid more mature forests, especially with moss cover. Thus habitat structure is likely to be more important for both species than plant-species composition. However, the possibility exists that the preference of coastal fringe habitat could represent an 'ecological trap', where habitat preference does not correspond to better quality habitat in terms of reproductive fitness. It will be useful to continue monitoring saddlebacks and robins to obtain data on survival and fecundity as the density of birds increases, and breeding pairs are forced to establish territories in what is presently perceived to be less preferred habitat in the interior part of the island.

**Keywords:** habitat preference; habitat requirements; source-sink; ecological traps; reintroduction.

## Introduction

Determining which habitat types are selected by animals more often than others can provide basic information about how animals meet their requirements for survival and reproduction. A number of factors can contribute to habitat selection, including availability of food and adequate breeding sites, intra- and interspecific competition, and the presence of predators (Hilden, 1965; Cody, 1985; Manly *et al.*, 1993). Habitat selection can also be hierarchical (Johnson, 1980): first-order selection includes the geographical range of a species; second-order selection includes home range of an individual or group; third-order selection involves the use of various habitat components within the home range.

Second-order habitat selection has a long history of study, particularly in birds (Hilden, 1965; Cody, 1985), but has recently received renewed interest in ecology and conservation biology in terms of source-

sink systems and ecological traps (Schaeffer *et al.*, 2002; Kristan, 2003; Battin, 2004). In source-sink systems, which are based on classic optimal habitat choice models (Fretwell and Lucas, 1970), animals settle into superior habitat (source) until it is full and then the remaining individuals are forced to settle in an inferior habitat (sink) (Pulliam, 1988; Pulliam and Danielson, 1991). Source-sink systems are likely to apply to the establishment stage of island reintroductions in New Zealand because individuals are released on islands with few or no competitors, and hence have the opportunity to exploit preferred habitats within the range available (Armstrong and McLean, 1995). In contrast to source-sink systems, ecological traps are low quality habitats that are preferred over other available higher quality habitat (Schaeffer *et al.*, 2002). Ecological traps are thought to be uncommon and generally associated with human modified habitats although there are examples in pristine habitat (Battin, 2004). In the case of island reintroductions, the released

individuals might settle in habitat that is most familiar or similar to that found in the source population (Armstrong and McLean, 1995), or closest to the release site, even though other habitat of better quality is available.

Both concepts, source-sink and ecological traps, presume that individuals are attracted to a certain type of habitat over another and therefore are likely to be responding to cues in the environment. Furthermore, identifying those cues that determine habitat selection in threatened species can lead to insights into habitat requirements, which can help managers to determine the most important habitats to conserve and the most appropriate release sites for species destined for reintroductions. In most cases, however, the data available on habitat selection of particular species are subjective and lack quantitative analyses. This study uses GIS technology and compositional analysis to investigate habitat selection (in terms of vegetative composition and structure) of two threatened passerines South Island saddlebacks (*Philesturnus carunculatus carunculatus*) and Stewart Island robins (*Petroica australis rakiura*) two years after their release on a predator-free Ulva Island in Paterson Inlet, Stewart Island. The spatial distribution of breeding territories is investigated in relation to overall habitat availability. The pattern of colonisation of the island's habitat can be seen as a natural experiment and this is compared with cited habitat preferences of these species derived from the literature (see below).

### Habitat selection in saddlebacks and robins

Saddlebacks are mainly insectivorous, foraging on tree trunks, in foliage and in the leaf litter on the ground, but they will consume berries and nectar when available (Atkinson and Campbell, 1966, Merton, 1975; Roberts, 1994; Pierre, 2000). Saddlebacks are generally tree-cavity nesters, but they also nest under embankments, in flax bushes and in tree ferns (Hooson and Jamieson, 2003a). A number of studies have noted the preference of North Island saddlebacks (*P. c. rufusater*) for establishing territories in regenerating or secondary habitat (Atkinson and Campbell, 1966, Lovegrove, 1980; Lovegrove and O'Callaghan, 1982). Armstrong *et al.* (2005) reported that pairs of North Island saddlebacks released on Mokoia Island that settled on primary territories (i.e. those occupied in the first year) had higher reproductive success than other pairs. It was noted that primary territories were in flat areas of the island near the shoreline and had greater habitat diversity, but specific habitat types were not quantified. Only Pierre's (2001) study specifically examined habitat use by South Island saddleback, although this translocated population on Motuara Island in the Marlborough Sounds (on the north coast of the South Island) was located 800 km north of its source

population and in forest habitat atypical of most other current South Island saddleback populations (Hooson and Jamieson, 2004).

Robins are ground-feeding insectivores but will feed on berries when invertebrates are scarce. They forage mainly in the litter layer on the forest floor but occasionally capture prey in the bark of trees (Powlesland, 1981; Armstrong *et al.*, 2000). In terms of habitat preference, robins are believed to avoid establishing territories in areas where trees are widely scattered and favour forest habitats without extensive coarse ground cover (Flack, 1979). Studies of North Island robins found that they breed only in forest patches with a canopy of at least 6 m and prefer flat areas with open forest floor, damp gullies and tree ferns (Armstrong *et al.*, 2000; Clubb, 2003).

## Methods

### Study site

Ulva Island (46° 56' S, 168° 08' E) is located in Paterson Inlet and 800 m from the nearest shoreline of Stewart Island, New Zealand. Ulva Island is 259 ha and 74 m a.s.l. at its highest point; apart from a few steep cliffs edges, the terrain is gentle throughout. The vegetation is in a near-pristine state with only a small area cleared and planted with *Pinus radiata* and *Cupressus macrocarpa* around Post Office Bay on the north shore of the central part of the island. Vegetation consists mainly of mature podocarp forest in the interior of the island. On the periphery is a narrow strip of coastal scrub and further from the shore, the coastal scrub species intermix with kamahi (*Weinmannia racemosa*) and rata (*Metrosideros umbellata*) (i.e. 'coastal forest fringe') before merging with the mature podocarp forest (Hooson and Jamieson, 2004).

Ulva Island is an 'open sanctuary' managed by the Department of Conservation. After an eradication programme, Ulva Island was free of introduced Norway rats (*Rattus norvegicus*) by 1996. In April 2000, 30 South Island saddlebacks were translocated to Ulva Island from Big Island south west of Stewart Island (Hooson and Jamieson, 2003b). 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). Saddlebacks on Big Island are found predominantly in large areas of low coastal scrub as well as in smaller patches of taller rata, kamahi and rimu (*Dacrydium cupressinum*) forest that are restricted to a few sheltered parts of the island (Hooson and Jamieson, 2004). Robins are thought to have persisted in stunted manuka forest (*Leptospermum scoparium*) in Freshwater Flats because it holds low densities of rats and feral cats relative to other areas of Stewart Island (Greer, 2000). Manuka forest is not found on Ulva Island.

### **Territory size estimate and mapping**

All saddlebacks and robins on Ulva Island were colour banded to allow individual birds to be identified. The two species were studied over one breeding season, from early October 2002 until mid February 2003. Home ranges of paired birds within their breeding territories were calculated, mapped and imported into a GIS database (Arc Map 8.2) as polygon features. Home ranges of pairs were determined by gathering about 30 GPS locations (estimated positional error of < 12 m) of the male, female or both, for eight nesting pairs of saddlebacks and eight nesting pairs of robins. No more than three sightings > 15 min apart were collected on any one day for a given individual. Each pair was located at various times of the day, every three to four days. We used 95% Minimum Convex Polygon (MCP) to estimate territory size using RangesV computer programme (Kenward and Hodder, 1996). For two and five additional pairs of robins and saddlebacks respectively, we did not obtain enough sightings to accurately estimate home range location. In these cases, we created rectangular territories, based on the average size, width and length of the calculated home ranges of each species. A rectangle was the most logical geometrical shape to describe the shape of the home range of each species. The rectangular territories were centred around the GPS location of the nest sites and oriented parallel to the coastline. Due to the proximity of nests to the shoreline, the territory shapes usually encroached onto the sea. Coastal territory boundaries were then cropped to fit along Ulva Island's coastline.

On Ulva Island, the robins are trained to approach humans at the sound of tapping and are rewarded with mealworms. This food reward could influence where robin pairs are setting up their territories. The gravel walking tracks on Ulva Island were mapped to investigate any potential relationship between the distribution of robin territories and human presence. GPS locations were taken every 10 to 20 steps along the gravel tracks and were imported into a GIS database as line features.

### **Vegetation survey and mapping**

The vegetation survey used the RECCE method (Allen, 1992). Running north to south across Ulva Island are 38 parallel bait station lines spaced approximately 100 m apart which were used in the rat eradication programme in the late 1990s. Each line was walked starting at either the north or south coast where the first GPS reading was taken. At each point where the vegetation visibly changed in terms of canopy height, ground cover, dominant species or density, a GPS reading was taken. Twenty meters further into the new vegetation type (to avoid sampling within the transition

zone), a 20 m diameter circular plot was surveyed. In this plot we recorded dominant plant species, average tree height (estimated using a clinometer), average diameter at breast height (DBH) of tree trunks, ground cover and canopy cover. A ground cover of less than 40% of vascular vegetation was considered to be relatively open and a ground cover of greater than 60% of vascular vegetation was considered to be relatively dense.

Three natural-colour 1:12 000 aerial photographs of Ulva Island were used in conjunction with the vegetation ground survey data to produce a habitat map. The photographs were taken in October 2000 with a hand held camera. Paper prints were obtained from Environment Southland and were scanned at 2000 dpi. Six ground control points (GCPs) were surveyed using a GPS to provide reference points for the photographs. All GCPs were located along the coastline since no easily identifiable features were found in the interior of the island due to a thick forest cover. No information was available about the camera calibration, image format or the printing of the hard copies. Two software programmes, Digital Video Plotter (DVP, 2004) and Australis (Fraser 2000), were used for correcting orientation of the photographs and for computing error triangulation, respectively. The final locational error was about 6 m and consistent for all three images (excluding the GPS error). It is expected that the maximum locational error was less than 10 m.

The three photographs were merged and imported in the GIS database. The GPS points depicting different habitat types recorded in the vegetation survey, were reclassified according to seven key habitat classes (Table 1) and overlaid on the geo-referenced image of Ulva Island. The points corresponding to different habitats were displayed using different colour-pattern codes. The boundaries between habitat units were finally delineated by interpreting both the vegetation patterns visible on the aerial photographs and the vegetation transects surveyed on the ground.

### **Habitat availability and habitat use**

To determine the habitat preferences of an animal, the frequency of use of a resource component has to be related to the frequency at which that component is available in the area. The final habitat map of Ulva Island was used to estimate the overall area of each habitat available to saddlebacks and robins. The saddleback and robin territories were then overlaid as polygon shape-files onto the habitat map. The nests of each breeding pair were also added to the habitat map as point shape-files. The proportion of each habitat type within each territory was estimated to the nearest hectare.

**Table 1.** Summary of main habitat types found on Ulva Island listed in order of largest to smallest (in ha).

| Habitat type (ha)            | General description   | Characteristic plants <sup>1</sup>   | 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               |

<sup>1</sup> 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 analyses

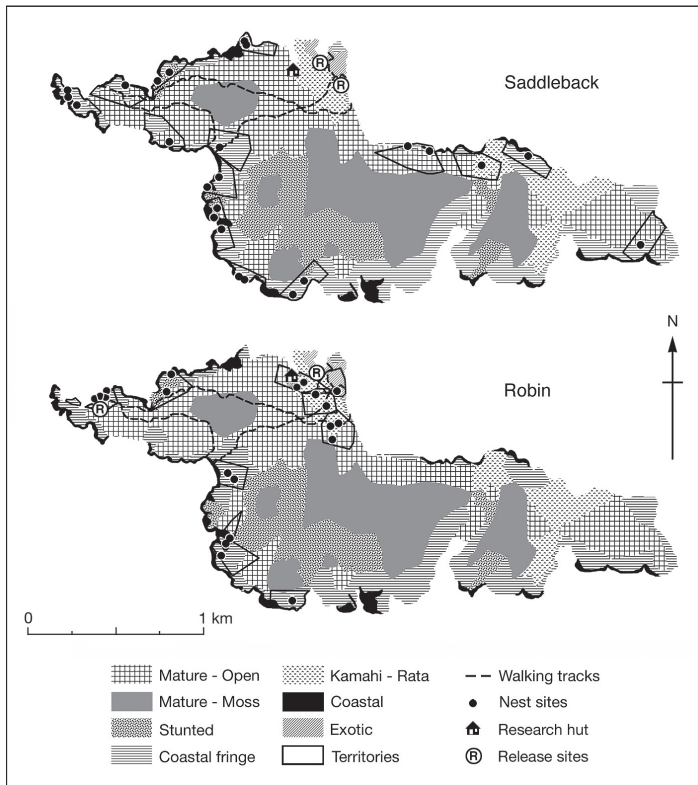
Habitat selection was quantified using compositional analysis (Smith 2003), a general multivariate methodology that reduces dimensionality by dealing with the unit sum constraint through a log ratio (Allredge *et al.*, 1998). In a compositional analysis, use of each habitat  $U_i$  is expressed relative to each of the other habitats  $U_j$ , as a log ratio  $\ln(U_i/U_j)$ , with availability the equivalent  $\ln(V_i/V_j)$ . No difference between  $\ln(U_i/U_j) - \ln(V_i/V_j)$  indicates animals have a similar association for each habitat pair  $i$  and  $j$ , whereas a difference  $\neq 0$  indicates a preference of one habitat over another. Using an assumption of normality, Wilk's  $\Lambda$  can be calculated for the resulting matrix of pair-by-pair values for an overall test of non-random use (Kenward, 2001).

Compositional analysis is a good method for analysing resource selection due to its modest requirements for sample sizes, capability to evaluate resource selection among identifiable animal groups and usefulness in conducting multiple comparisons among animal groups (Leban *et al.*, 2001). Compositional analysis comes closest to testing selection according to the definition given by Johnson

(1980) (see Introduction), in that habitat units are used disproportionately to their availability. One downfall of using compositional analysis is its requirement that each individual uses all the available habitat types (Allredge *et al.*, 1998). Territorial birds such as saddlebacks and robins are unlikely to use all available habitat types because they are restricted by the boundaries of their territories. However, Aebischer *et al.* (1993) suggested that when a particular habitat type is available but not utilised by an animal, the zero denominator of an unused habitat can be replaced by a small positive value, less than the smallest recorded non-zero proportion of utilised habitat type. The default value 0.01 was used in place of zero for habitats that were available but unused by particular pairs of birds.

## Results

The seven major habitat types on Ulva Island ranked from largest to smallest were mature-open forest (33% of total land area), mature-moss forest (23%), coastal forest fringe (20%), stunted forest (12%), kamahi-rata



**Figure 1.** Nest sites and estimated territories of South Island saddlebacks and Stewart Island robins (from the 2002/2003 breeding season) overlaid on a habitat map of Ulva Island. The release sites for the two species are also shown.

forest (7%), coastal scrub (4%) and exotic forest (0.9%) (Table 1). Saddleback breeding territories were located around the periphery of the island primarily in coastal scrub and fringe vegetation and bordering on mature-open forest (Fig. 1). Twenty-two nests belonging to 13 pairs were found. The majority of nests were located in coastal fringe (68%) with the remaining in coastal scrub (14%), stunted (14%), and kamahi-rata (4%) forests. No nests were found in mature forest (Fig. 1).

Robin territories were also situated around the periphery of the island, meaning that coastal scrub and fringe vegetation types were common in robin territories along with mature-open and kamahi-rata habitat (Fig. 1). Only one territory was located primarily in stunted forest vegetation, and overall, robins did not appear to use mature-moss forest habitat (Fig. 1). Twenty nests belonging to 10 robin pairs were found. Most were in fringe habitat (45%), followed by kamahi-rata forest (30%), stunted forest (10%), and mature-open forest (10%). The high density of territories in the kamahi-rata forest in the north-central part of the island also coincides with the area where the robins were first released and where the greatest concentration of visitors and walking tracks is found. One of these territories is

also located next to the research hut.

The overall comparison of habitat use by saddlebacks, derived from 95% MCP home ranges and habitat availability on Ulva Island, gave Wilk's  $\Lambda = 0.0139$  ( $\chi^2 = 59.85$ ,  $df = 6$ ,  $P < 0.0001$ ) indicating significant non-random placement of breeding territories by saddlebacks. A ranking matrix ordered the habitat types in the sequence fringe>coastal scrub>mature-open>>>exotic>stunted>kamahi-rata>mature-moss (where >>> denotes a significant difference between two consecutively ranked variables) (Table 2A). Mature-moss forest was used significantly less than all other habitats except kamahi-rata and stunted habitat. Coastal forest fringe was used significantly more than all but coastal scrub habitat, while coastal scrub was used significantly more than all remaining habitats but mature-open forest (Table 2A).

The overall comparison of habitat use by robins and habitat availability gave Wilk's  $\Lambda = 0.0528$  ( $\chi^2 = 29.42$ ,  $df = 6$ ,  $P < 0.0001$ ) indicating significant non-random placement of territories as well. A ranking matrix ordered the habitat types in the sequence coastal scrub>fringe>mature-open>exotic>kamahi-

**Table 2.** Simplified habitat preference ranking matrix for (A) South Island saddlebacks ( $n = 13$ ) and (B) Stewart Island robins ( $n = 10$ ) based on expressing the use of one habitat  $U_i$  relative to each of the other habitats  $U_j$ , as a log ratio  $\ln(U_i/U_j)$ ; availability is expressed similarly as  $\ln(V_i/V_j)$ . A difference in  $\ln(U_i/U_j) - \ln(V_i/V_j)$  indicates a preference of one habitat over another. The calculated pair-by-pair values for the resulting matrix were replaced by their sign (+/-): an asterisk represents a significant deviation from random at  $P < 0.05$  (see Methods). Habitat types are listed in order of largest to smallest (see Table 1).

| <b>A. Saddleback</b> | Mature-open | Mature-moss | Coastal fringe | Stunted | Kamahi-rata | Coastal scrub | Exotic | Rank (by preference) |
|----------------------|-------------|-------------|----------------|---------|-------------|---------------|--------|----------------------|
| Mature-open          |             | +           | -              | +       | +           | -             | +      | 3                    |
| Mature-moss          | -           |             | -              | -       | -           | -             | -      | 7                    |
| Coastal fringe       | +           | +           |                | +       | +           | +             | +      | 1                    |
| Stunted              | -           | +           | -              |         | +           | -             | -      | 5                    |
| Kamahi-rata          | -           | +           | -              | -       |             | -             | -      | 6                    |
| Coastal scrub        | +           | +           | -              | +       | +           |               | +      | 2                    |
| Exotic               | -           | +           | -              | +       | +           | -             |        | 4                    |

| <b>B. Robin</b> | Mature-open | Mature-moss | Coastal fringe | Stunted | Kamahi-rata | Coastal scrub | Exotic | Rank (by preference) |
|-----------------|-------------|-------------|----------------|---------|-------------|---------------|--------|----------------------|
| Mature-open     |             | +           | -              | +       | +           | -             | +      | 3                    |
| Mature-moss     | -           |             | -              | -       | -           | -             | -      | 7                    |
| Coastal fringe  | +           | +           |                | +       | +           | -             | +      | 2                    |
| Stunted         | -           | +           | -              |         | -           | -             | -      | 6                    |
| Kamahi-rata     | -           | +           | -              | +       |             | -             | -      | 5                    |
| Coastal scrub   | +           | +           | +              | +       | +           |               | +      | 1                    |
| Exotic          | -           | +           | -              | +       | +           | -             |        | 4                    |

habitat>stunted>mature-moss (Table 2B). Mature-moss forest was used significantly less than all other habitats, except stunted forest. The top three habitats were used significantly more than the last two, but there was no detectable difference in use between coastal scrub habitat, coastal forest fringe, mature-open, exotic and kamahi-rata forest, implying that the true order of the top five habitats can not be assigned (Table 2B).

## Discussion

Although both saddlebacks and robins were likely to have been on Ulva Island at some time in the past, neither species occurred there at the time of their release in 2000 (Roberts, 1994; Greer, 2000). Two years after their release, both species had settled and established breeding territories almost exclusively around the periphery of Ulva Island in or near coastal habitat. Here the range of habitat types was greater and size of habitat patches smaller than that of the interior of the island where mature forest dominates. Thus breeding territories tended to contain a mosaic of habitat types.

Although choice experiments are deemed necessary to determine an animal's preference for certain food items or resources, the term 'habitat preference' is often used when an animal occurs in a

habitat more than expected by chance (Kenward, 2001). If we apply this to saddlebacks on Ulva Island, then coastal forest fringe (vegetation between coastal scrub and mature forest) is a preferred habitat. Although some breeding territories also encompassed coastal scrub and mature forest, this was likely due to their close proximity to coastal fringe habitat. Indeed, the vast majority of mature forest area (55% of available habitat), particularly areas with a moss understorey (41% of mature forest), was the least used habitat even though it was the largest habitat type available.

Tree cavities are also relatively more abundant in coastal fringe than in mature forests further from the coast (Steffens, 2003). The most common foraging locations of saddlebacks on Ulva Island during the breeding season were southern rata, tree ferns, kamahi and on the ground, and they rarely foraged above 7 m off the ground (Steffens, 2003). Coastal fringe habitat had a high coverage of litter as well as containing dense stands of southern rata, kamahi and tree ferns. Differences in nest site quality and food availability between habitats are currently being examined in more detail as part of a more general model on habitat selection in saddlebacks (P. Michel, University of Otago, Dunedin, unpubl. data).

Previous studies have noted that North Island saddlebacks have a preference for regenerating or dense secondary habitat. Lovegrove (1980) reported

that regenerating forest with its rich source of berry producing plants and deep litter layer was ideal habitat for North Island saddlebacks on Cuvier Island. Furthermore, old pohutukawa (*Metrosideros excelsa*) within this regenerating habitat also provided an adequate supply of cavities for saddleback nesting sites (Lovegrove, 1980). On Hen Island, North Island saddlebacks forage in the secondary and coastal forests where the understorey is dense and plant turnover is rapid (Atkinson and Campbell, 1966).

The historical distribution of a bird species normally suggests that the range of suitable habitats is wider than those currently utilised (Gray and Craig, 1990). The fact that saddlebacks on Ulva Island avoided nesting in mature podocarp forest and were rarely observed foraging in trees such as rimu, miro and totara is interesting given that South Island saddleback were thought to inhabit podocarp forests historically (Oliver, 1955; Merton, 1975). The apparent preference for coastal fringe could represent an ecological trap, perhaps because the dense scrub-like habitat near the coast is more familiar – a legacy that has persisted from the source population on Big Island or even the original remnant population from Big South Cape Island (Hooson and Jamieson, 2004). In the case of an ecological trap, habitat preference does not correspond with better quality habitat and thus saddlebacks would be better off, in terms of reproductive fitness, settling in mature forest. Indeed, the effects of habitat imprinting and early exposure to a limited diet can result in a species apparently selecting or preferring suboptimal habitat (Gray and Craig, 1990). We believe, however, that the preference of coastal fringe and avoidance of mature podocarp forest is more likely to represent a source-sink system. Given that North Island saddlebacks seem to prefer dense secondary growth, dense coastal fringe habitat could be favoured by South Island saddlebacks as well. Mature forest, whether it is podocarp, beech or some other type, is perhaps less preferred by saddlebacks because its structure is not as suitable for foraging and breeding compared with fringe or secondary habitat. Source-sink systems and ecological traps are both characterised by organisms preferring certain habitats over others but habitat selection leads to increased fitness in source populations whereas the opposite is true of ecological traps. We will continue monitoring saddlebacks to obtain data on annual reproductive success and recruitment rates as the population expands into the mature forest.

Like saddlebacks, robins on Ulva Island tended to establish their breeding territories near the coast and avoided mature forest with moss understorey in the interior of the island. Avoidance of the latter habitat was not surprising considering that robins in many areas spend about 90% of their foraging time on the

ground, in relatively open understorey with a thick litter layer, feeding mainly on earthworms and other soil invertebrates (Flack, 1979; Powlesland, 1981; Duncan *et al.*, 1999; Armstrong *et al.*, 2000; Steffens, 2003). A mossy forest floor is presumably avoided by robins because of its lack of suitable foraging substrate.

Coastal scrub, fringe, mature-open, exotic and kamahi-rata forests all have patches of open ground cover and thick litter layers, but we were unable to discern which of these specific habitats, if any, was most preferred. In one study, South Island robins were found in greatest abundance in Douglas fir (*Pseudotsuga menziesii*) plantations, which had very open forest floor and were thought to represent the best foraging habitat in the area (Duncan *et al.*, 1999). Although abiotic features may also affect habitat selection (e.g. Clubb, 2003), the structure of the vegetation rather than the composition of plant species may be the most important component of habitat selection for robins, as it is for many insectivorous birds (Cody, 1985).

It is also possible that the robins on Ulva Island established their territories in areas near the release site, as six of the ten territorial pairs we studied were located near the two release sites at Post Office Bay and West End Beach (Fig. 1). Aggregating around the original release sites might result from conspecific attraction, although robins released onto similar-sized Tiritiri Matangi Island dispersed widely across the available habitat (Armstrong, 1995). Indeed five of the 16 robins initially released on Ulva Island flew back to their original territories in Freshwater Inlet on Stewart Island, a distance of over 20 km (Oppel and Beaven, 2002).

Six out of ten robin territories encompassed tracks where people often walk and a seventh territory contained our research hut (see Fig. 1). Robins are well known to be tame around humans and will take advantage of any invertebrates that are stirred up by human activity (Robertson, 1985). Therefore, the location of robin territories in human-frequented areas may not be coincidental. However, given that the greatest extent of walking tracks went through the interior part of the island where there were no robin territories, we suggest that habitat type and not human activity is the overriding factor driving territory establishment.

In conclusion, saddlebacks and robins released on Ulva Island in 2000 tended to settle and establish breeding territories near the periphery of the island in coastal fringe or secondary growth and away from mature (particularly moss-covered) forest habitat in the interior of the island. Although both species may have been responding to different habitat features, habitat structure is likely to be more important than species composition *per se*. Until now, the distance from the mainland (to limit the chances of mammalian

predator re-invasion) and the size of the island have been the main determining factors for choosing release sites for threatened New Zealand endemics such as saddlebacks and robins. The results of this habitat selection study should be taken into account in planning future reintroductions of these two species. For example, it might be prudent to choose release sites with dense, secondary forests (saddlebacks) with open under-storey and thick litter layers (robins) over sites of exclusively tall, mature forest. Many islands may have a mixture of these two extremes but mainland reserves may tend toward one or the other. That is why it will be especially interesting to continue monitoring the saddlebacks and robins on Ulva Island as their densities increase and breeding pairs are forced to set-up territories in what is presently perceived to be less preferred, mature forest habitat.

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