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HABITAT RELATIONSHIPS AND CONSERVATION OF THE YELLOWHEAD

Summary: The yellowhead, a forest-dwelling passerine endemic to the South Island of New Zealand, has declined in both abundance and range since the arrival of European settlers last century. In the last 30 years it has all but disappeared from the northern half of the South Island but remains widespread in the south. One possible explanation is that the yellowhead has declined in abundance throughout its range, disappearing from less suitable habitats in which it was never very abundant. To test this hypothesis a habitat suitability index was constructed and northern and southern forests compared. Yellowheads appear to be tall forest specialists and are most common in tall red beech dominated forests at low altitude on flat valley floors. No evidence was found that forests in the northern South Island are any less suitable for yellowheads than those in the south. Other explanations for the decline of yellowheads in the north of their range are discussed.

Keywords: Yellowhead; *Mohoua ochrocephala;* habitat suitability index; conservation; habitat relationships.

Introduction

The yellowhead *(Mohoua ochrocephala* (Gmelin)) is a forest dwelling passerine endemic to the South Island of New Zealand. It used to be found throughout the forests of the South and Stewart Islands, but since the arrival of European settlers yellowheads have declined in both range and abundance. Many New Zealand birds have declined in numbers and some have become extinct, but the pattern of decline of the yellow head is unusual. Last century it was found throughout the forests of the South and Stewart Islands, but by 1900 it had disappeared from all but beech *(Nothofagus* spp.) forests where it remained widespread. In the last 30 years it has contracted in range from the north southwards. There are now only a few small remnant populations in the northern South Island though it remains widespread in the south. It is considered "vulnerable" (Bell, 1986).

Several possible causes of yellowhead decline have been suggested including introduced predators (Gaze, 1985; Read, 1987; Elliott and O'Donnell, 1988), disease and forest clearance, and there are two ways in which they could have caused the north to south pattern of decline that has been observed. Firstly, some or all of the causes of decline may be absent or less severe in the south, e.g., stoats *(Mustela erminea* L.), an important predator of yellowheads, may be less common in the south. Secondly, the causes of decline may act equally in the north and south, but the structure and composition of northern forests may be such that they support only small vulnerable yellowhead populations, most of which have died out. In other words, southern forests are better for yellowheads. There is no evidence that predators, disease, or forest clearance have had any greater effect on yellowheads in the north of the South Island than in the south, and this study aims to test the second explanation which initially seems more likely.

I produced a model of the relationship between the distribution of yellow heads and landforms, forest structure and forest composition (a "habitat suitability index"; Berry, 1986). Using this scale, I compared habitats in the southern South Island which still have yellowheads, with habitats in the northern South Island from which yellowheads have disappeared or become rare. If the present pattern of yellowhead distribution results from differential habitat quality in the north and the south of the South Island, then:

1. habitat suitability values will be, on average, higher in the southern South Island than in the north, and
2. forests from which yellowheads have disappeared in the northern South Island should have lower habitat suitability values than those in which yellowheads survive.

If habitat quality is similar in the north and south of the South Island then some factors other than landform, forest structure and forest composition must account for the pattern of yellowhead distribution, and these factors must be more prevalent in the the north.

A by-product of the development of a habitat suitability index is the identification of factors likely to be important to the conservation of yellowheads. If, for example, forests are managed for timber production, it may be possible to identify forest components that need to be preserved if yellowheads are to survive. A habitat suitability index may also identify the most promising forests to search for remnant yellowhead populations.

Methods

Study areas

Habitat-suitability index

The habitat-suitability index was constructed from data collected in the Dart and Rees catchments in Mount Aspiring National Park (Fig. I). This area contained a variety of forest types some of which supported yellowheads and some of which did not. Because the forest within the study area is continuous, the areas without yellowheads probably lack them because of an unsuitable environment, rather than because they disappeared through some historical accident and have not recolonised.

The forests and climate of Mount Aspiring National Park have been described in detail by Mark (1977). Rainfall within the study area ranges from about 3000 mm per annum on the main divide in the west, to about 1000 mm in the lower reaches of the Rees valley in the east. The forests are simple in both structure and diversity. They are dominated by three species of southern beech: silver beech *(Nothofagus menziesii**), red beech *(N. fusca),* and mountain beech *(N. solandri* var. *cliffortioides).* At low altitudes all three species occur but red beech dominates. With increasing altitude the red beech becomes less important, and above 700 m it is absent. In wetter western areas silver beech forms the dominant subcanopy species under red beech and replaces it at high altitude, whereas in the east this role is taken by mountain beech. The largest trees are red beech, which in the valley floors achieve diameters of 2 m and heights of 40 m. At the tree line between 1050 and 1200 m, trees are stunted, reaching only 8 m, with diameters of less than I m. The only other common trees are Hall's totara *(Podocarpus hallii),* which is sometimes a canopy tree but mostly occurs in the understorey, broadleaf *(Griselinia littoralis),* weeping mapou *(Myrsine divaricata)* and mountain toatoa *(Phyllocladus aspleniifolius* var. *alpinus* (Labill.) Hook. f.), which are understorey plants, and several small-leaved *Coprosma* species which arc rarely more than 2 m high.

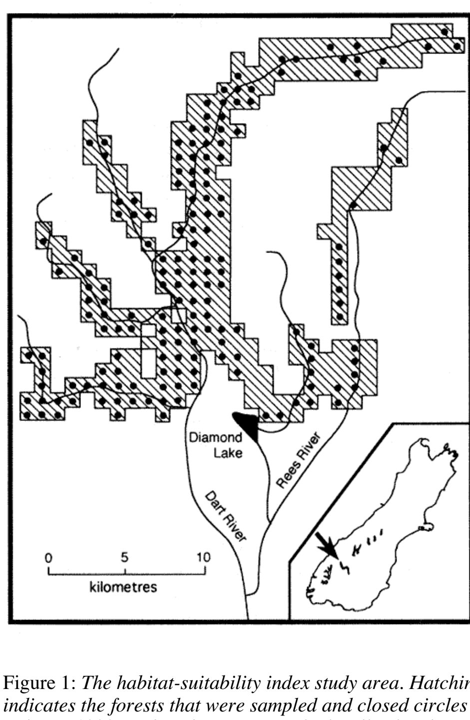

Figure 1: *The habitat-suitability index study area. Hatching indicates the forests that were sampled and closed circles indicate 1000 yard grid squares in which yellowheads were found.*

Sites for comparison

There are about 1.5 million hectares of forest in the northern half of the South Island in which yellowheads are extinct or nearly so. I sampled a selection of the best sites that were accessible by road on the assumption that if the best yellowhead habitats in the northern South Island were worse than the best southern sites, then overall habitat quality was probably lower in the north. The best sites were assumed to be those that still had yellowheads, those from which yellow heads had only recently disappeared, and those with landforms and forest types similar to southern sites in which the largest yellowhead populations were found. Figure 2 shows the location of 9 forest areas in the northern South Island that were sampled.

Sampling regime

In the Dart and Rees catchments field work was carried out by myself and 80 supervised Operation Raleigh venturers: young adults on a youth adventure course. The work was undertaken in four ten day periods, with 20 people involved in each. During each period, three days were spent training the field workers to identify forest birds and plants, and to carry out the vegetation measurement techniques. In the field the venturers operated in groups of three or four and where possible each group contained an experienced ornithologist. The field work was undertaken between 15 October and 30 November 1986. At this time of year yellow heads are territorial, vocal and resident in their nesting areas.

The Dart and Rees catchments were sampled

* Nomenclature of plants follows Allan (1961), except where noted.

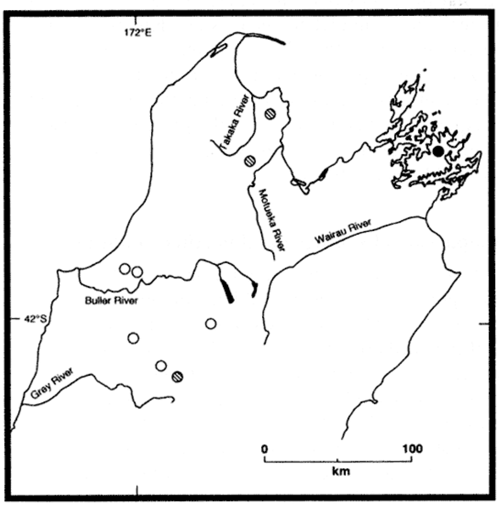

Figure 2: *The location of sample sites in the northern South Island. Closed circles are sites where yellowheads are present. Hatched circles are sites at which yellowheads are no longer present but have been recorded in the last 10 years. Open circles are sites from which yellowheads have not recently been recorded, but which appear to be good yellowhead habitat.*

according to the 1000 yard (914 m) grid on 1:63360 scale topographical maps. Data were collected from the centres of 73% of the 354 forested grid squares within the study area which were visited either once or twice. Unvisited squares were either too steep for safe foot access, or contained only a small area of forest. The centres of gird squares were located using compass and map. Even though some squares were surveyed twice, the imprecision in locating the centre of squares was so great that it is unlikely that two samples were ever taken from exactly the same place. Furthermore these grid squares were scattered throughout the study area and are unlikely to introduce any bias. Therefore, all observations are treated as independent random samples and included in the analysis.

Field work in the northern South Island was undertaken by myself at all but one locality, where it was undertaken by Greg Sherley of the Department of Conservation. At each locality a sample site was chosen that was representative of the surrounding forest. Yellow heads were still present at one locality, had been reported from three other localities since 1980, and the remaining five localities had landforms and forest types similar to southern forests in which the largest yellowhead populations were found.

The following data were recorded at all sites in the Dart and Rees catchments and in the northern South Island:

1. Yellow heads: The presence or absence of yellowheads within 200m of the sample site was recorded. Yellowheads were detected by their calls or by sight. Forty-five minutes were spent at each sample site.
2. Aspect: North, south, east or west; determined by taking a bearing with the compass facing away from the slope of the hill.
3. Slope: <5∞, 5-14∞,15-25∞, >25∞; measured using a protractor and plumb-bob.
4. Landform: valley floor (terraces and fans), hill slopes.
5. Altitude: Measured in metres below the tree line in order to eliminate the confounding effect of latitude.
6. Grid reference.
7. Vegetation: The vegetation at each site was quantified using the variable area plot method (Batcheler and Craib, 1985). Each plant measured was classified by species and whether it was greater or less than 2 m high. Stem densities and basal areas were calculated for each species in each height class in every plot.
8. Nutrient levels: From the silver beech tree nearest to the centre of the vegetation plot, a cupful of live leaves was collected from about head height, placed in a plastic bag and frozen as soon as possible. The leaves were later dried at 40∞C for 24 hours, ground to a fine powder and the levels of ammonium-nitrogen, potassium, phosphorous, calcium, sodium, chlorine, sulphur, magnesium, manganese, iron, aluminium, copper and zinc measured. Ammonium nitrogen was measured by digesting a sample of dried, ground leaf in sulphuric acid in the presence of a catalyst ("Kjeldahl digestion") and measuring the ammonia concentration in the solution with a microanalyser. All the remaining nutrients were measured by x-ray fluorescence.

Habitat suitability index

Two statistical methods can be used to construct habitat suitability indices from presence/absence data: logistic regression and discriminant function analysis (D.F.A.). Logistic regression was used because it is more robust with respect to departures from normality (Press and Wilson, 1978), and it constructs non-linear functions rather than the unrealistic linear functions of D.F.A. (Goldstein, 1977).

A habitat suitability index was contructed using the data collected in the Rees and Dart catchments and using only those variables that showed significant differences between sites with and without yellowheads (Brennan, Block and Gutierrez, 1986). To further select variables to be added to the model, I used the stepwise option of SAS's logistic regression procedure (Harrell, 1986). This option successively selects variables that contribute the greatest increase in the explanatory power of the model. Variable selection ceases when there are no more variables that significantly increase explanatory power.

To compare habitats in the southern and northern South Island, habitat suitabilities were calculated for all sample sites by inserting values of altitude, stem density and red beech stem density into the logistic equation produced using the Dart/Rees data.

Results

Patterns of yellowhead distribution

Yellowheads were widely distributed in the study area (Fig. 1). They were found at most sample sites in the lower reaches of the Dart catchment, but in less than half of the sites in the Rees Valley and in the head-waters of the Dart.

To characterise yellowhead habitat, all of the vegetation and topographic parameters were tested for differences between those sites that had yellowheads and those that did not. The Kruskal-Wallis test was used for continuous variables and contingency table analysis for categorical variables.

Sites at which yellowheads were recorded had high levels of phosphorous, aluminium, iron, and magnesium; they were at low altitude, had a low total stem density of trees greater than 2m high, had a high stem density and basal area of red beech, and had low stem densities and basal areas of mountain and silver beech (Table 1). Yellowheads were more frequently found on valley floors than on hill slopes, and they were more frequently found on gentle slopes than steep ones (Table 2).

Habitat suitability index

Though many of the environmental parameters that I measured were associated with the distribution of yellowheads (Table 1), there were many intercorrelations between them and only three, altitude, total stem density (>2m) and red beech stem density (>2m), significantly contributed to the explanatory power of the logistic regression (Table 3). The logistic equation relating the likelihood of finding a yellowhead to these environmental parameters is given by:

$$\frac{e^{(-0.782 + 0.00021 \times \text{alt.} - 2.736 \times \text{TSD} + 7.590 \times \text{RBSD})}}{1+e^{(-0.782+ 0.00021 \times \text{alt.} - 2.736 \times \text{TSD} + 7.590 \times \text{RBSD})}}$$

($X^2 = 61.07$, d.f. = 3, $P < 0.001$) where altitude (alt.) is the vertical distance below the tree line (in m), TSD is the total stem density of trees greater than 2 metres high (in stems ha^{-1}) and RBSD is the stem density of red beech trees greater than 2 metres high (in stems ha^{-1}). Values of this equation above 0.5 predict the presence of yellowheads, values below predict the absence, and the equation correctly predicted the presence or absence of yellowheads in 66% of the samples collected in the Dart and Rees catchments.

Comparison of southern and northern habitats

Table 4 shows the habitat suitabilities of northern sites, and Figure 3 compares the habitat suitabilities of southern sites where yellowheads were detected, with all of the northern sites. Though I did not randomly sample habitat suitabilities in both the north and south of the South Island, it is clear that the best sites in the northern South Island are as good as the best sites in the south (see Fig. 3), suggesting that habitat quality was no worse in the north. Furthermore, yellowheads in the northern South Island seem to have disappeared from some of the best habitat but remained in some of the worst. The one site that still had yellow heads, had the lowest habitat suitability; those sites which had recent reports of yellowheads had the next highest habitat suitabilities; the sites from which yellowheads had not been reported for a long time had the highest habitat suitabilities (Table 4).

Discussion

A weakness of studies such as this one is that they do not model relationships between yellowheads and the environmental features to which they are likely to be directly responsive. For example, my model does not relate yellowhead distribution to the availability of food,

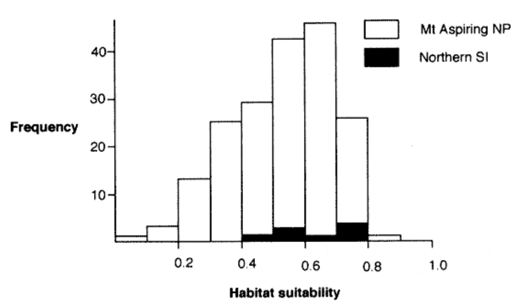

Figure 3: *Habitat suitability of sites with yellowheads in the Dart and Rees catchments, and all sites in the northern South Island.*

Table 1: *Means and Kruskal-Wallis tests for differences in nutrient levels and forest structure between samples with and without yellowheads. Nutrient levels are measured in % or ppm of dry weight, basal areas in* $m^2\ ha^{-1}$, *and stem densities in stems* ha^{-1}.
* = *significant at the 5% level,* ** = *at the* 1% *level*.

	Mean				
	Yellowheads	Yellowheads			
Variable	Present	Absent	X^2	d.f.	*P*
Nitrogen (%)	1.15	1.15	0.20	1	0.65
Phosphorous (%)	0.176	0.162	6.83	1	<0.01 **
Sulphur (%)	0.081	0.080	1.64	1	0.20
Potassium (%)	0.581	0.565	1.12	1	0.29
Aluminium (%)	0.017	0.010	15.15	1	<0.01 **
Iron (ppm)	121	88	15.91	1	<0.01**
Manganese (ppm)	976	943	0.60	1	0.44
Magnesium (%)	0.100	0.095	4.55	1	0.03 *
Copper (ppm)	4.04	3.87	2.34	1	0.13
Zinc (ppm)	29.1	27.6	1.19	1	0.28
Calcium (%)	0.798	0.798	0.00	1	0.94
Altitude (metres below tree line)	479	359	36.85	1	<0.01 **
Total basal area (>2m)	96	106	0.06	1	0.81
Total stem density (>2m)	1759	2908	26.61	1	<0.01 **
Red beech basal area (>2m)	40	19	34.57	1	<0.01 **
Red beech stem density (>2m)	285	164	26.56	1	<0.01 **
Mountain beech basal area (>2m)	25	42	15.25	1	<0.01 **
Mountain beech stem density (>2m)	634	1521	21.90	1	<0.01 **
Silver beech basal area (>2m)	18	25	4.36	1	0.04 *
Silver beech stem density (>2m)	425	555	2.04	1	0.15
Hall's totara basal area (>2m)	0.2	0.7	0.14	1	0.71
Hall's totara stem density (>2m)	33	44	0.05	1	0.82
Mountain toatoa basal area (>2m)	0.05	0.11	1.06	1	0.30
Mountain toatoa stem density (>2m)	25	50	1.03	1	0.31
Dead tree basal area (>2m)	12	17	1.49	1	0.22
Dead tree stem density (>2m)	247	385	6.71	1	<0.01**
Other trees basal area (>2m)	0.3	1.2	0.13	1	0.72
Other trees stem density (2m)	109	188	0.27	1	0.60
Total basal area (<2m)	42	2	0.40	1	0.53
Total stem density (<2m)	2075	1771	0.57	1	0.45
Red beech basal area (<2m)	0.015	0.003	7.95	1	<0.01 **
Red beech stem density (<2m)	801	43	7.33	1	<0.01 **
Mountain beech basal area (<2m)	39	0	0.21	1	0.64
Mountain beech stem density (<2m)	328	681	0.16	1	0.68
Silver beech basal area (<2m)	0.037	0.040	5.59	1	0.02 *
Silver beech stem density (<2m)	106	75	4.51	1	0.03 *
Hall's totara basal area (<2m)	0.010	0.006	0.12	1	0.73
Hall's totara stem density (<2m)	39	37	0.01	1	0.91
Mountain toatoa basal area (<2m)	0.048	0.006	0.39	1	0.53
Mountain toatoa stem density (<2m)	148	69	0.38	1	0.54
Dead tree basal area (<2m)	2.6	1.7	1.14	1	0.29
Dead tree stem density (<2m)	151	153	0.09	1	0.76
Other trees basal area (<2m)	0.23	0.10	0.05	1	0.82
Other trees stem density (<2m)	502	712	0.11	I	0.74

Table 2: *Association between landform, aspect, slope and the presence or absence of yellow heads.*
** = significant at the 5% level, ** = at the 1% level.*

Classification	Categories	% of samples with yellowheads	Contingency table analysis
Landform	Valley floor	58	$X^2 = 7.62$
	Hill slopes	42	D.F. = 1
			P = 0.006**
Aspect	North	38	$X^2 = 7.04$
	South	55	D.F. = 3
	East	45	P = 0.07
	West	38	
Slope	<5°	66	$X^2 = 18.5$
	5-14°	47	D.F = 3
	15-25°	37	P < 0.001**
	>25°	40	

Table 3: *Results of stepwise logistic regression. Variables are listed in the order in which they were added to the model.*
** = significant at the 5% level,** = at the 1% level.*

Variable	Regression coefficient	X^2	Probability
Intercept	-0.7821	19.24	<0.01 **
Altitude	0.00021	16.58	<0.01 **
Total stem density (>2m)	-2.7362	12.39	<0.01 **
Red beech stem density (>2m)	7.5898	5.65	0.02 *

Table 4: *Habitat suitability values of northern sites.*

Place	Latitude	Longitude	Yellowheads present	Habitat suitability
Mt Stokes	41°5"16'	174°6"37'	yes	0.46
Matakitaki Valley	42°31"0'	172°31"23'	no	0.79
Canaan	40°56"52'	172°52"36'	recent report	0.57
Flora Stream	41°10"7'	172°41"38'	recent report	0.50
Orikaka	41°46"36'	171°54"49'	no	0.53
Blue Duck Creek	41°47"31'	171°55"49'	no	0.76
West Bank Maruia	42°17"36'	172°10"50'	no	0.78
Alfred River	42°19"57'	172°14"19'	recent report	0.66
Waitahu Valley	42°8"50'	171 °59"9'	no	0.75

nesting, roosting, and foraging sites, but rather to some measures of topography, forest structure and composition to which the former may be correlated. However, the approach I have taken enables one to produce useful models using existing forest mensuration techniques and to produce models that are readily interpreted by conservation managers. For example, a model that predicted that yellowheads were most likely to be found in forests with a certain range of invertebrate, nest, roosting and foraging site densities is much less usable than one which defines suitable habitat in terms of stem density, and forest composition-features which are easily measured though less reliable.

Yellowheads were most often found in tall, low density, red beech dominated forests growing at low altitude on valley floors. They were least often found in short, dense, silver and mountain beech forests growing on steep slopes at high altitudes. Why should yellowheads prefer these low altitude, tall forests? Evidence from yellowhead foraging and nesting behaviour as well as their morphology suggests that they are tall forest and/or large tree specialists. Both Read (1988a) and Elliott (1990) found that yellowheads selectively foraged in large trees. Olson (1990a,b) noted that the pelvis and hindlimbs in all three species of *Mohoua* have become specialised for use of the feet in moving vegetation and litter while foraging, and that the yellowhead is most specialised in this respect. While yellowheads occasionally scratch amongst litter on the ground, they more frequently scratch amongst the accumulations of litter in the crooks of large branches and the epiphytes growing on the trunks or the bark of large trees (about 7-9% of their total activity budget; Read, 1988b; Elliott, 1990) - it is an important activity. Such a feeding method can only be employed in large trees, since only large trees have such sites.

Elliott (1990) concluded that hole nesting was possible for yellowheads because they lived in tall forests with large trees. The cavities yellowheads built their nests in were never less than 10 cm in cross section and such cavities never occurred in trees less than 30 cm diameter at breast height and most occurred in much larger trees. Forests comprising only small diameter trees would have few, if any, cavities suitable for yellowhead nests.

How can a habitat suitability index help conservation managers? Spurr (1987) has already shown that yellowheads do not survive in forests that are extensively cut-over for timber production and this study supports the notion that yellowheads are tall forest specialists. It also predicts that the best yellowhead populations are likely to occur in tall valley floor forests. Such areas may be the best focuses for future conservation of yellowheads.

The habitat suitability index I created is best used only on the forests within my habitat suitability study area, though it can reasonably be extended to forests outside this area if they are of types that occur within it. The habitat suitability index study area was chosen because it included most recognisable types of beech forest, and all of the forest types in northern samples were also found in the habitat suitability study area. The forests of northern and southern samples differed only in the presence and absence of some locally endemic understorey plants; structurally they were very similar.

The explanation of yellow head decline that this study was designed to test made two predictions:

1. that forests from which yellow heads have disappeared in the northern South Island will be less suitable yellowhead habitat than those in which yellowheads survive, and
2. habitat quality will be, on average, higher in the southern South Island than in the north.

The first prediction is unsubstantiated. The one site in the northern South Island with yellowheads had the lowest habitat suitability of all the sites, and yellow heads seem to have disappeared from sites with the highest habitat suitabilities first. The second prediction is more difficult to test using my data because I did not randomly sample habitat suitabilities in both the north and south of the South Island. However, the best sites in the northern South Island appeared to be as good as the best sites in the south (see Fig. 3), suggesting that habitat quality was no worse in the north.

Since habitat quality (as I measured it) is similar in the north and south of the South Island then some factors other than landform, forest structure and forest composition must account for the pattern of yellowhead distribution, and these factors must be more prevalent in the north.

The spread of Vespulid wasps in the South Island is roughly coincident with the disappearance of yellowheads from most of the northern South Island. Furthermore, wasp densities are much higher in beech forests in the northern South Island than they are further south because of the presence of the beech honeydew scale insect *(Ultracoelostoma assimile* (Maskell)) which produces a secretion (honeydew) on which wasps feed (Sandlant and Moller, 1989). It is perhaps significant that the only known yellowhead population in the northern South Island is in high altitude forest that does not support the beech honeydew scale insect and has very few wasps *(pers. obs.)*.

Recent work on yellow head breeding biology (Elliott, 1990; Elliott and O'Donnell, 1988) has identified two types of yellowhead population. Some populations produce only one brood each year and their productivity is insufficient to survive the periodic stoat plagues that occur in beech forests: they are slowly declining. In contrast some other populations produce two broods per year and their productivity is high enough to survive repeated stoat plagues. If most yellowhead populations in the northern South Island had been of the one-brood type, then repeated stoat plagues that have been occurring in beech forests since stoats were introduced to New Zealand in the 1880s may have accounted for the yellow heads' disappearance from the northern South Island. Of course there is no way of knowing whether all northern populations were of the one-brood type since most are extinct. However, if we make the reasonable assumption that most one-brood populations were in worse habitats than most two-brood ones, we can investigate this possible explanation indirectly. This study provides no support for this explanation since some of the forests I measured in the northern South Island appeared to be very high quality yellow head habitat in which yellow heads probably raised two broods per year. Furthermore even if all the northern yellowhead populations had been of the one brood type we would not expect all but one of them to be extinct. In the southern South Island there are many small isolated yellow head populations living in poor habitats that probably only raise one brood per year. Though these populations are small and probably heading toward extinction, they are still extant.

Other possible explanations are that predators or competitors other than wasps are more numerous in the north than the south. These possibilities require further investigation.

This study suggests that there are some unknown factors, unrelated to landform, forest structure and forest composition, that have caused yellowheads to decline in the north of their range that do not apply in the south. In the short-term, conservation management of yellowheads should concentrate on protecting the remaining yellowheads, most of which occur in the south. For this reason finding an explanation of the disappearance of yellowheads in the north need not be a top priority. In the long-term however, the maintenance or re-introduction of yellowheads throughout their range will require that these factors be further investigated.

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References

Allan, H.H. 1961. *Flora of New Zealand, Volume* 1. Government Printer, Wellington, New Zealand. 1085 pp.

Batcheler, C.L; Craib, D.G. 1985. A variable area plot method of assessment of forest condition and trend. *New Zealand Journal of Ecology 8*: 83-95.

Bell, B.D. 1986. *The conservation status of New Zealand wildlife*. Occasional Publication No. 12, New Zealand Wildlife Service, Department of Internal Affairs, Wellington, New Zealand. 103 pp.

Berry, K. 1986. Introduction: Development, testing and application of wildlife-habitat models. *In* : Verner, J.L; Morrison, M.L; Ralph, C.J. (Editors), *Wildlife 2000,* pp. 3-4. University of Wisconsin Press, Wisconsin, United States of America. 470 pp.

Brennan, LA.; Block, W.M.; Gutiérrez, R.J. 1986. The use of multivariate statistics for developing habitat suitability index models. *In* : Verner, J.L; Morrison, M.L; Ralph, C.J. (Editors), *Wildlife 2000,* pp. 177-182. University of Wisconsin Press, Wisconsin, United States of America. 470 pp.

Elliott, G.P. 1990 (unpublished). *The breeding biology and habitat relationships of the yellowhead*. Ph.D. thesis, Victoria University of Wellington, Wellington, New Zealand. 183 pp.

Elliott, G.P.; O'Donnell, C.F.J. 1988. *Recent declines in yellowhead populations*. Science and Research Internal Report No. 29. Department of Conservation, Wellington, New Zealand. 11 pp.

Gaze, P.D. 1985. Distribution of yellow heads *(Mohoua ochrocephala)* in New Zealand. *Notornis 32*: 261-269.

Goldstein, R.A. 1977. Reality and models: Difficulties associated with applying general ecological models to specific situations. *In:* Solomon, D.L; Walters, C.F. (Editors), *Mathematical models* in *biological discovery,* pp. 207-215. Springer-Verlag, New York, United States of America. 240 pp.

Harrell, F.E. Jr. 1986. The logistic procedure. *In:* Joyner, S.P. (editor), *SUGI supplementary library user's guide, version five edition,* pp. 269-293. SAS Institute Inc., Cary, North Carolina, United States of America. 662 pp.

Mark, A.F. 1977. *Vegetation of Mt Aspiring National Park New Zealand*. National Parks Scientific Series Number 2, National Parks Authority, Wellington, New Zealand. 79 pp.

Olson, S.L 1990a. Comments on the osteology and systematics of the New Zealand passerines of the genus *Mohoua*. *Notornis 37*: 157-160.

Olson, S.L 1990b. Osteology and systematics of the fernbirds (Bowdleria: Sylviidae). *Notornis 37*: 161-171.

Press, S.J.; Wilson, S. 1978. Choosing between logistic regression and discriminant analysis. *Journal of the American Statistical Association 73*: 699-705.

Read, A.F. 1987. The breeding and flocking behaviour of yellowheads at Arthur's Pass National Park. *Notornis 34*: 11-18.

Read, A.F. 1988a. Habitat use by yellowheads, *Mohoua ochrocephala* (Aves: Muscicapidae), in the Hawdon River Valley, Arthur's Pass National Park. 1. Habitat preferences. *New Zealand Journal of Zoology 15*: 461-470.

Read, A.F. 1988b. Habitat use by yellowheads, *Mohoua ochrocephala* (Aves: Muscicapidae), in the Hawdon River Valley, Arthur's Pass National Park. 2. Time budgets and foraging behaviour. *New Zealand Journal of Zoology 15*: 471-480.

Sandlant, G.R.; Moller, H. 1989. Abundance of common wasps (Hymenoptera: Vespidae) in the honeydew beech forests of New Zealand in 1987. *New Zealand Journal of Zoology 16*: 333-343.

Spurr, E.B. 1987. *Beech management - its effects on bird populations*. What's New in Forest Research No. 146. Forest Research Institute, Rotorua, New Zealand. 4 pp.