

SCIENCE & RESEARCH SERIES NO.10

**A METHOD FOR ASSESSING
UPLAND GAME HABITAT
California quail in Central Otago**

by

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Published by
Head Office,
Department of Conservation,
P.O. Box 10-420,
Wellington,
New Zealand

ISSN 0113-3713
ISBN 0-478-01093-1

First published 1989

ACKNOWLEDGEMENTS

Many people contributed to the design and field testing of this upland gamebird habitat assessment method.

In particular, we wish to thank Murray Neilson (Wildlife Service) and Rob Soulsby (Otago Acclimatisation Society) for their assistance throughout. Ian Buchanan and Peter Taylor (Wellington Acclimatisation Society) and Steve McGill (Wildlife Service) also assisted with the design of the field sheet. Ross Pickard (Wildlife Service) was responsible for most of the computer analysis, and Drs. Murray Williams and Malcolm Crawley (Wildlife Service) and Richard Barker (Wellington Acclimatisation Society) provided useful criticisms of drafts of this report.

We also thank Stuart Sutherland and Mark Sutton (Southland Acclimatisation Society); Sue Maturin (Otago Acclimatisation Society); Sean Boswell and Simon Gooding (Alexandra Pest Board); John Cherry (Ministry of Agriculture and Fisheries, Alexandra); John Andrew, Graham Crump, Tom Kroos, Graeme Loh, and Hans Rook (Wildlife Service) for their assistance with the field survey at Alexandra.

We also acknowledge the help of Kevin Moynihan (Wildlife Service) and Jo Garrick (Rotorua) in preparing Figures 2 and 5, respectively.

Finally, we thank all landholders who allowed us to survey their lands for quail, and who often provided useful information on locations of coveys.

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**A METHOD FOR ASSESSING GAME HABITAT
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by

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1. INTRODUCTION

Priorities for research on gamebirds in New Zealand were identified for the Wildlife Research Liaison Group (WRLG)** by Williams, Westerskov and Johnson (1983). They noted that for California quail (*Lophortyx californica*), habitats had changed markedly since the work of G.R. Williams concluded more than 20 years ago (Williams 1952, 1955, 1957, 1959, 1960, 1963, 1965, 1966, 1967), and habitat utilisation and management were seen as needing new studies. "Habitats of the future", especially exotic forests and horticultural farmland, were specified for such studies.

Acting on these recommendations, in November 1984, a committee representing wildlife research, game management, and hunter interests, reviewed priorities for research on California quail in New Zealand. The managers indicated that because the habitat requirements of quail had never been quantified it was difficult to advise landholders wishing to encourage quail on their properties of appropriate management techniques. Therefore, priority needed to be given to identifying characteristics of the habitat of quail in non-forested land.

A subcommittee of the New Zealand Wildlife Service's research section decided that a survey method should be devised which would allow managers to determine quail habitat utilisation in farmland situations. The methodology was to be field tested in the Otago district, where quail are common, and would be undertaken by officers from the Wildlife Service, the Otago and Southland Acclimatisation Societies, and the Alexandra Pest Board.

* This report was presented at a California quail research and management seminar in Wellington, 17 October 1986 by the New Zealand Wildlife Service which is now part of the Department of Conservation.

** The Wildlife Research Liaison Group was formed in 1981, to promote the wildlife research in New Zealand by encouraging communication between all wildlife interest groups and to review recent and current research.

1.1 Objectives

The following objectives were set for this project:

- a) to identify the dominant features of the physical environment and vegetation in sites used by quail;
- b) to quantify these features;
- c) to describe quail habitat in sufficient detail for game managers to undertake appropriate habitat management to increase the numbers and extend the distribution of quail in New Zealand;
- d) to produce for wildlife managers a methodology which can be used or modified to assess habitat features of upland gamebirds, or other birds of pastoral country, anywhere in New Zealand.

This paper:

- a) provides details of a survey methodology for identifying quail habitat in non-forested land; and
- b) reports the findings from the field test of the methodology, which had itself resulted from field testing of earlier versions of the field card's format. The earlier fieldwork had been carried out in Central Otago, Manawatu, and Eastern Wairarapa by staff from the Wildlife Service, Wellington and Otago Acclimatisation Societies.

1.2 Quail habitat

California quail are active diurnally and roost in trees or tall scrub at night (Williams 1966). They are largely herbivorous, taking in soft green leaves and seeds from the ground and the occasional invertebrate (Williams 1952). Feeding is usually on rather open ground, but is close to scrub, hedges, or trees for escape cover. A source of drinking water is essential, especially for young birds (Williams 1955). Regular dusting in soft soil or sand is a characteristic activity. Quail pair up and breed in spring and remain in family groups until late summer, when these coalesce to form coveys of up to 50 or more birds. Coveys remain together until pair formation begins the following early spring (Williams 1966).

California quail are acclimatised in New Zealand to the extent that they are designated game in every hunting district of New Zealand except the Westland Acclimatisation district. Nevertheless, there are some large gaps within this wide distribution (Bull *et al.* 1985), and even in districts where quail are common, they often occur patchily.

Once their habitats are quantified, as the current research aims to do, wildlife managers should be able to increase the range and numbers of this popular upland translocation or habitat enhancement, without the expense and hazards of further introductions or captive-rearing programmes.

2. THE SURVEY FORM

The survey methodology was designed with several constraints:

- a) its field use should not require detailed botanical knowledge;
- b) it should be capable of being used wherever quail occur in a pastoral (i.e. non-forest) landscape in New Zealand;
- c) it should produce a local "blue-print" of quail habitat from a modest number of samples (we set an arbitrary lower limit of 50 records, with no more than two records from any single covey).

The work of Williams (*loc. cit.*), and the experience of field officers, quail hunters and naturalists were pooled to identify the likely environmental factors which determine whether or not quail are able to use an area as habitat. Those which could be recorded rapidly and simply in the field formed the basis of the form for the field trial. Figure 1 shows the two sides of the field sheet, and three pages of additional explanations (two pages being of amplified instructions and the third a labelled diagram of landform features which might be encountered).

Although the presence of preferred dietary items or roost trees, or the existence or abundance of predators, hunters or agricultural poisons, were suggested as possible important factors in determining whether quail use an area or not, the detection of such factors were beyond the scope of this survey.

Figure 1: Survey form & instructions (5 pages)

<u>Acclimatisation Society</u>		1-2	<input type="text"/>	<input type="text"/>
<u>Map reference</u>		4-12	<input type="text"/>	<input type="text"/>
<u>Date and time</u>		14-21	<input type="text"/>	<input type="text"/>
			Day	Month
			<input type="text"/>	<input type="text"/>
			Time	<input type="text"/>
		23-25	<input type="text"/>	<input type="text"/>
<u>Quail</u>	Lone	1	Number	00
	Pair	2		
	Brood	3		
	Covey	4	99	
	Sign	5		
<u>Terrain</u>				
<u>Major system</u>			<u>Minor system</u>	
Hill country	1	Ridge crest		1
Plain	2	Valley Side		2
Dune	3	Terrace Side		3
Riverbed	4	Gully head-dissected country		4
Rolling	5	Gully side " "		5
		Gully bottom " "		6
		Rolling		7
		Flat		8
<u>Aspect</u>			<u>Principal</u>	<u>Specific</u>
	North	1	North	1
	North-west	2	North-west	2
	West	3	West	3
	South-west	4	South-west	4
	South	5	South	5
	South-east	6	South-east	6
	East	7	East	7
	North-east	8	North-east	8
	Varied	9	Varied	9
	Zero	0	Zero	0
<u>Slope</u>	Steep	1		
	Moderate	2		
	Gentle	3		
	Flat	4		
<u>Exposed land surface</u>				
Rock	1	(List up to 3 in order of		
Scree	2	dominance of total area in		
Gravel	3	50 m radius)		
Sand-silt	4	% exposed	1	<10
Soil	5	% "	2	10<20
Road/Track-Sealed	6	% "	3	20<50
" " Metal	7	% "	4	>50
" " Pumice	8			
" " Sand-soil	9			
None	0			
<u>Vegetation type</u>				
<u>Principal</u>			<u>Specific in 50 m radius</u>	
Shrubland	1	Trees	1	(List up to 4 specific types in
Native woodlot	2	Hedge	2	order of dominance and as % cover
Exotic woodlot	3	Shrubs	3	of total area)
Pasture	4	Herbs	4	
Burnt-over	5	Grasses	5	% cover
Cut-over	6	Flat-weeds	6	1 <10
Swamp	7	Ferns	7	2 10<20
Rank Growth	8			3 20<50
Crop	9			4 >50

Plant type52-69

01 Barberry	30 Kahikatea	59 Rimu
02 Blackberry	31 Kanuka	60 Rootcrop
03 Boxthorn	32 Kowhai	61 Scabweed
04 Bracken	33 Lancewood	62 Scirpus/sedge
05 Briar	34 Lichen	63 Sorrel
06 Broadleaf	35 Lucerne	64 Spanish heath
07 Broom	36 Lupin	65 Spinifex
08 Cabbage tree	37 Macrocarpa	66 Tauhinu/Tauwhini
09 California poppy	38 Manuka	67 Thistle
10 Carex	39 Marram	68 Thyme
11 Clover	40 Matagouri	69 Totara
12 Coprosma	41 Mixed native trees	70 Tussock short
13 Dock	42 Mixed native shrubs	71 Tussock tall
14 Domestic garden	43 Mosses	72 Tutu
15 Elder	44 Nettle	73 Vipers bugloss
16 Eucalypt	45 Nightshade	74 Wattle
17 Fathen	46 Orchard citrus	75 Willow
18 Fivefinger	47 " grape	76 Purple fuzzweed
19 Flannel leaf	48 " hop	77 Storksbill (Cranesbill)
20 Flat-weeds	49 " kiwifruit	78 Hemlock
21 Flax	50 " pip	79 Bidibidi
22 Gorse	51 " stone	80 Stonecrop
23 Grain large (maize)	52 " tobacco	81 Bush lawyer
24 Grain small	53 Pampas/Toitoi	82 Small-leaved olearia
25 Grass (pasture)	54 Pinus	83 Hawthorn
26 Hakea	55 Polygonum	84 Watercross
27 Heather	56 Poplar	85 Asparagus
28 Hieracium	57 Poroporo	86 Horehound
29 Inkweed	58 Ragwort	99 Unidentified herb

List up to six in 50 m radius	1	<10
1st plant as % cover of total area	2	10<20
2nd " " " " " " " "	3	20<50
3rd " " " " " " " "	4	>50
etc.		

<u>Water</u>		<u>Distance to water</u>
Soak	1	1 < 20 m
Swamp	2	2 21< 50 m
Pond	3	3 51<100 m
Lake	4	4 101<200 m
River	5	5 201<500 m
Stream	6	6 >500 m
Rivulet	7	
Ephemeral	8	
Unknown	9	
Other	0	

71-72 Notes

QUAIL HABITAT SURVEY DIRECTIONS

1. Acclimatisation Society

Space 1-2

01 Mangonui-Whangaroa
 02 Bay of Islands
 03 Whangerei
 04 Hobson
 05 Auckland
 06 Tauranga
 07 C.N.I.W.C.
 09 Taranaki
 10 Stratford
 11 Waimarino (Ward CNIWC)
 12 Wanganui
 13 Hawera
 14 Hawke's Bay
 15 Wellington

16 Nelson
 17 Marlborough
 18 West Coast
 19 North Canterbury
 20 Westland
 21 Ashburton
 22 South Canterbury
 23 Southern Lakes
 25 Waitaki Valley
 26 Otago
 27 Southland

2. Map reference

Space 4-12

NZMS1/NZMS269 Series to three places, i.e. Map 10, 351 east, 926 north,
 code = 010/351/926

3. Date and time (Note: year is not recorded) Space 14-21

Use 24 hour clock, 29 May at 1.20 p.m., code = 29/05/1320.

4. Quail

Space 23-25

The survey is positive, that is quail or positive sign must be seen. A covey of 25,
 code = 4/25.

A brood of 8 do not record adults, code = 3/08.

A lone bird, code = 1/01 etc.

5. Terrain

Space 27-28

The major system best describes the type of country. The minor system is site specific. On the attached diagram, the major system is hill country and the minor system is gully side, code = 1/5.

6. Aspect

Space 30-31

Refer to the diagram, the covey of quail are found in hill country with the principal aspect being north but the specific aspect is north-west. Code = ½.

7. SlopeSpace 33

This is largely subjective. Steep being difficult to move about on. Moderate is OK for man and dog to hunt on. Gentle OK for a golf course.

8. Exposed surfaceSpace 35-40

While up to three types of surface may be listed, in some instances only one may be present as in dune country with more than half of the 50m radius bare sand; here, code 44/00/00. In parts of Central Otago one third of the 50m radius may be exposed in equal proportions made of 10% rock, 10% scree and 10% soil, here, code 11/21/51. Rarely there may be no exposed surface, in that case code all zeros.

9. VegetationSpace 42-50

Principal, describes the substantial area. If the quail were found on a Taranaki or Waikato farm the principal vegetation is likely to be pasture. The specific within a 50m radius would be grasses dominant, have a boxthorn hedge with a few thistles and flatweeds. Code = 4/54/21/41/61.

A lupin-dominated dune near Pukepuke Lagoon with marram secondary, code = 1/34/53/00/00

10. Plant typeSpace 52-69

The plant list of 87 types to be coded in order of dominance similarly to the specific vegetation type, with up to six being nominated. If only two types are obvious as in the lupin/marram at Pukepuke Lagoon, the code = 364/393, the remaining 12 boxes will be zeros.

If the Taranaki, Waikato example given above were taken, the code = 254/031/671/201/000/000.

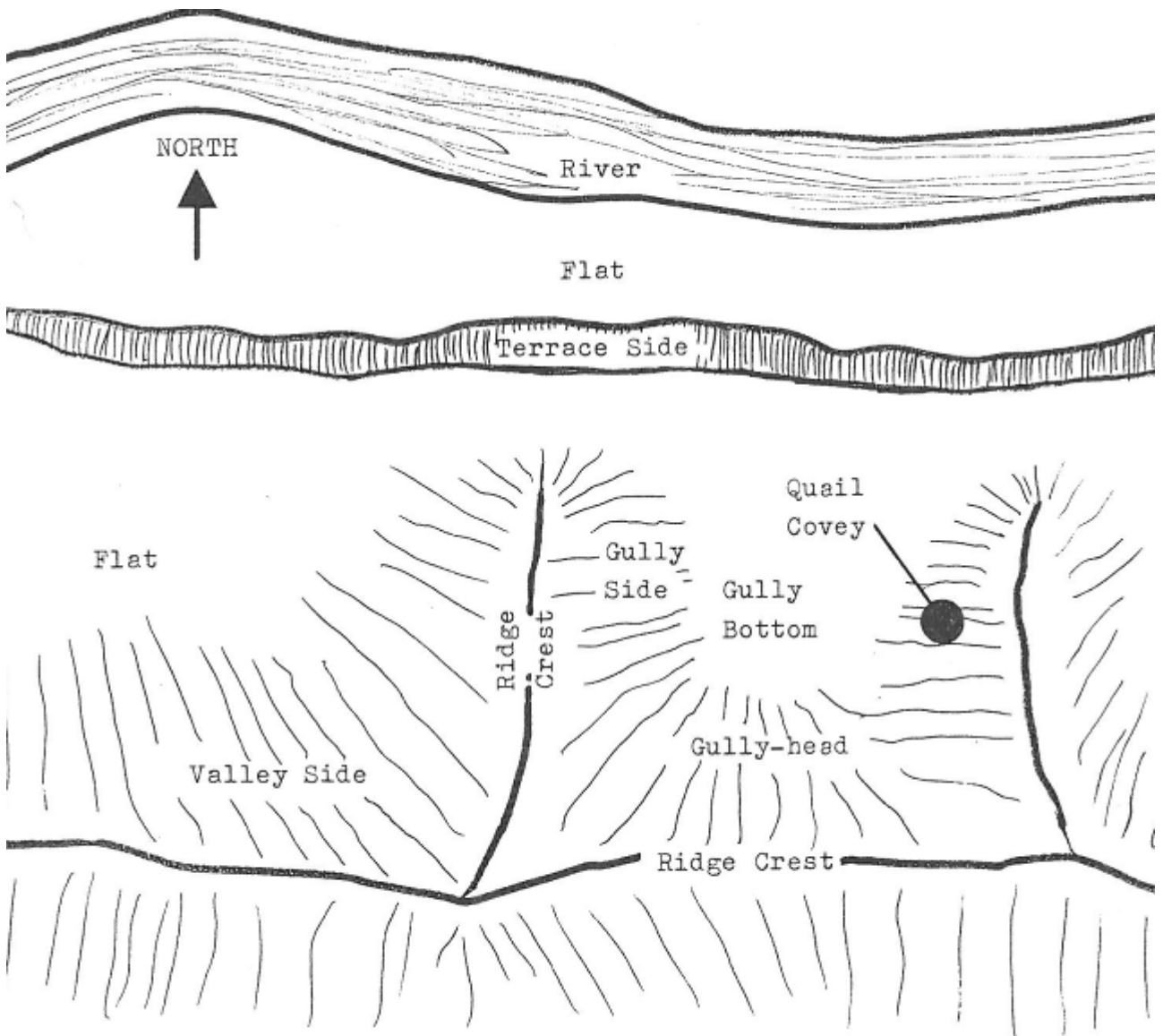
There no doubt plant types will be encountered which are not on this list. As they arise disregard the alphabetical order presented here and just follow the number sequence on, cannabis would be 87, sugarcane 88 etc. etc. Make sure though that you are consistent with your coding of additions and that they are carefully recorded under notes.

11. WaterSpace 71-72

A permanent soak 150m from birds, code = ¼ etc.

12. Notes

Record details not covered above. Nest found, describe the site, aspect etc. as above. If the roost is found, record the species, height, aspect, number of trees if applicable etc. Similarly for dust bowls.



Explanations of some landform & terrain terms

3. THE FIELD EVALUATION

A survey team comprising 14 persons with seven vehicles was assembled at Alexandra on 7 April 1986. A half-day was devoted to familiarisation with the field sheet, including a trial run on one quail covey.

The following three and a half days were devoted to the survey. Team members worked in pairs over designated areas of land and worked from NZMS1 (1:63,360) topographic map sheets. Areas likely to contain quail had been identified previously from information provided by land-holders, hunters, and the Alexandra Pest Board staff.

Quail were found by driving or walking; some teams used dogs to flush quail, and others used a caller to induce birds to reply. Most frequently, however, birds were sighted or heard calling spontaneously. The site where quail were first observed was used for the field record. If quail were not found, but unmistakable recent signs (e.g. dust-bowls) were present, a field record was taken. In a number of instances, the database was increased by visiting a covey in both the morning of one day and in the afternoon of a different day. Because quail range widely in the course of a day, records made at different times of the day sample different parts of their range. Two records from the same covey, made at different times on different days are, therefore, likely to be as different from each other as one record from each of two adjacent coveys.

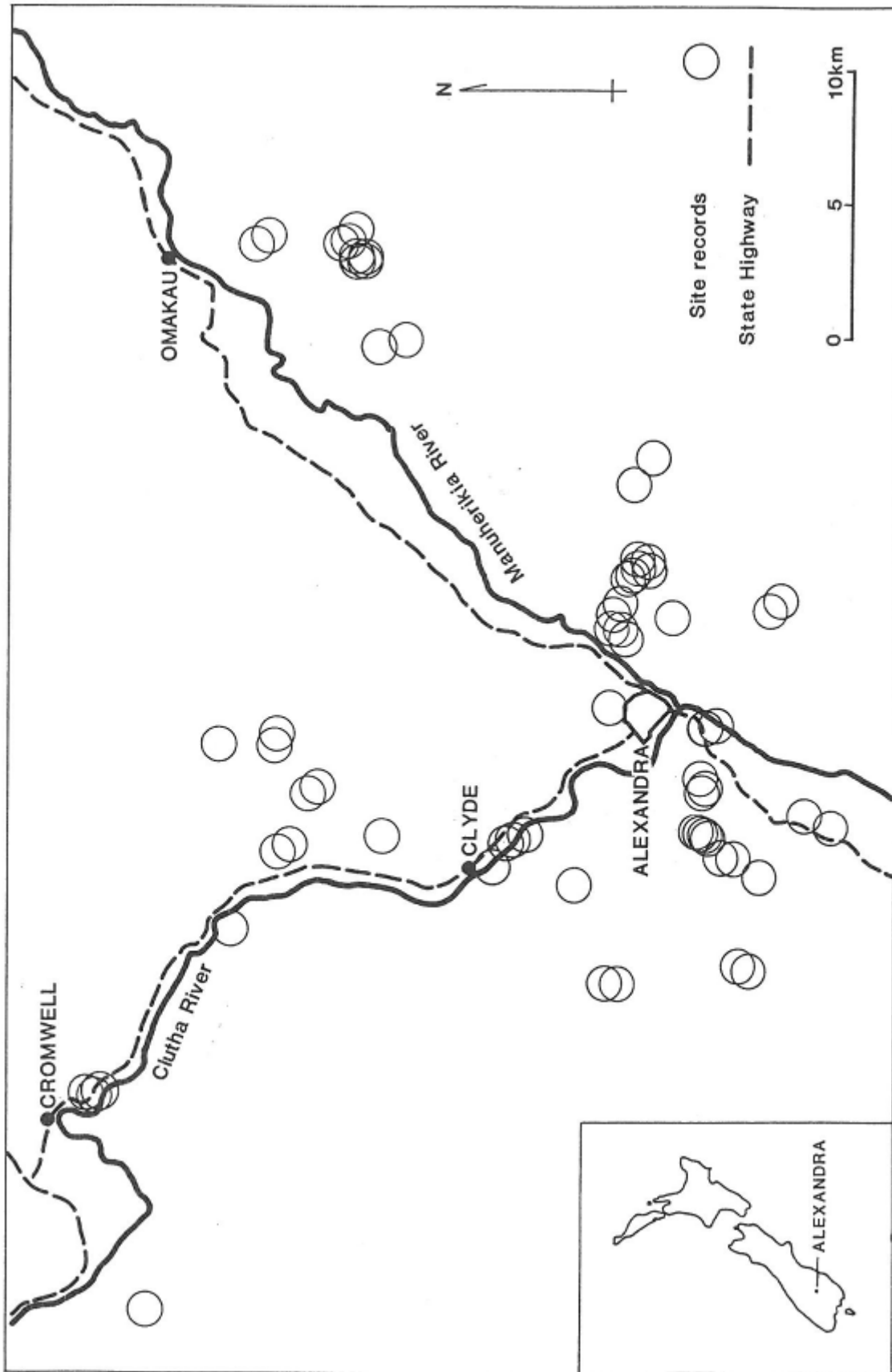
4. RESULTS

4.1 Number of records

Sixty-eight records were made of sites occupied by quail, of which three were based on sign only. Figure 2 shows the distribution of the 68 sites, representing between 45 and 50 different coveys.

Quail numbers per site varied between 1 and 60, with a median of 14. Some accurate counts were made but numbers were often estimated as birds were flushed over ridges or into dense cover. Because this report deals only with the presence of quail, differences in the accuracy of counts have no influence on the analysis.

Fig. 2. Distribution of study sites with California quail in the Alexandra district, 7-11 April 1986.



4.2 Landform

4.2.1 Terrain and Slope

On the broad scale, hill country accounted for 85% of the recorded sites with quail, flat land (plains and riverbeds) for 9%, and rolling country for 4%. Figure 3 shows the frequency of sites on different minor features of the terrain. Most sites were on slopes, 55% of which were classified as being of moderate slope, 29% as gentle slope, and 16% as steep slope.

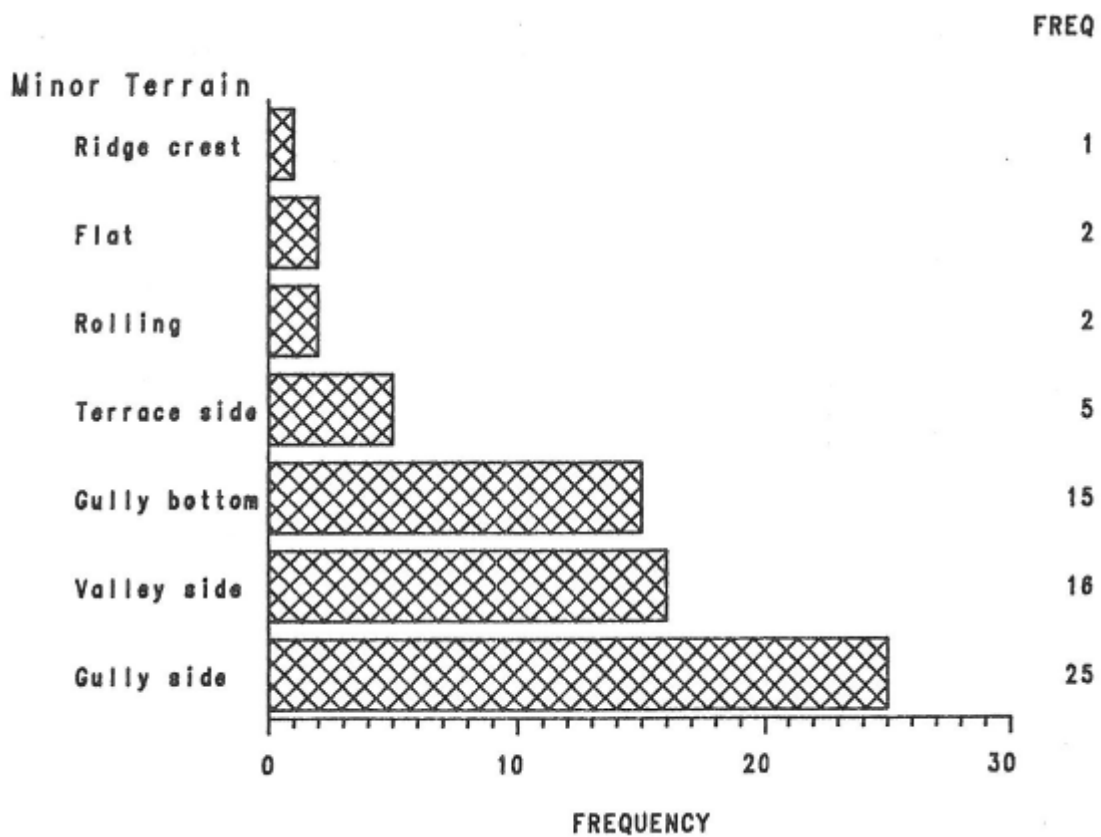


Fig. 3 The frequencies of different terrain features at 66 sites with California quail in Central Otago.

4.2.2 Aspect

The frequencies of the aspects of 63 quail sites on sloping ground are totalled in the right hand column of Figure 4. There was significantly greater use made of north-west, north, and north-east slopes than slopes of other aspects. However, if quail tend to move so as to be in the sun all day, as had been suggested prior to this survey (Caithness, pers. comm.), conclusions reached from the totals in Figure 4 could be misleading. For example, should quail occur on north-easterly slopes in the late afternoon, or on north-westerly slopes in the morning, they would clearly not be following the sun yet would have contributed to the totals.

Aspect of Sun

Aspect of slope	NORTH	NORTH-EAST	NORTH-WEST	WEST	TOTAL
NORTH	9	7	4	0	20
NORTH-WEST	3	0	5	0	8
WEST	1	1	0	2	4
SOUTH-WEST	2	1	2	0	5
SOUTH	1	0	0	0	1
SOUTH-EAST	3	1	3	0	7
EAST	1	1	3	0	5
NORTH-EAST	3	5	5	0	13
TOTAL	23	16	22	2	63

Fig. 4 Distribution of 63 sites with quail, according to the aspects of both the land and the sun; aspect data have been grouped in 45° intervals and expressed as compass bearings. Five flat sites with quail do not appear in this table.

Based on the time of day in which each record was made, each site was allocated a category which reflected both its geographical (compass) aspect and the direction of the sun at the time (the first four columns in Figure 4). The aspect of the largest numbers of sites generally matches that of the sun's direction at the time of making the observation (for example: north/north, 9 sites; north-west/north-west, 5 sites; north-east/north-east, 5 sites), or is in the next nearest 45 degree group (for example: north-east/north, 7 sites), but there are some deviations from this trend. There being too few sites in each category for statistical analysis, the data were re-grouped in five categories according to the amount of agreement between the aspects of slope and sun (Figure 5).

A chi-square test on the re-grouped data showed that there was a significant tendency for quail to occur on slopes facing the sun.

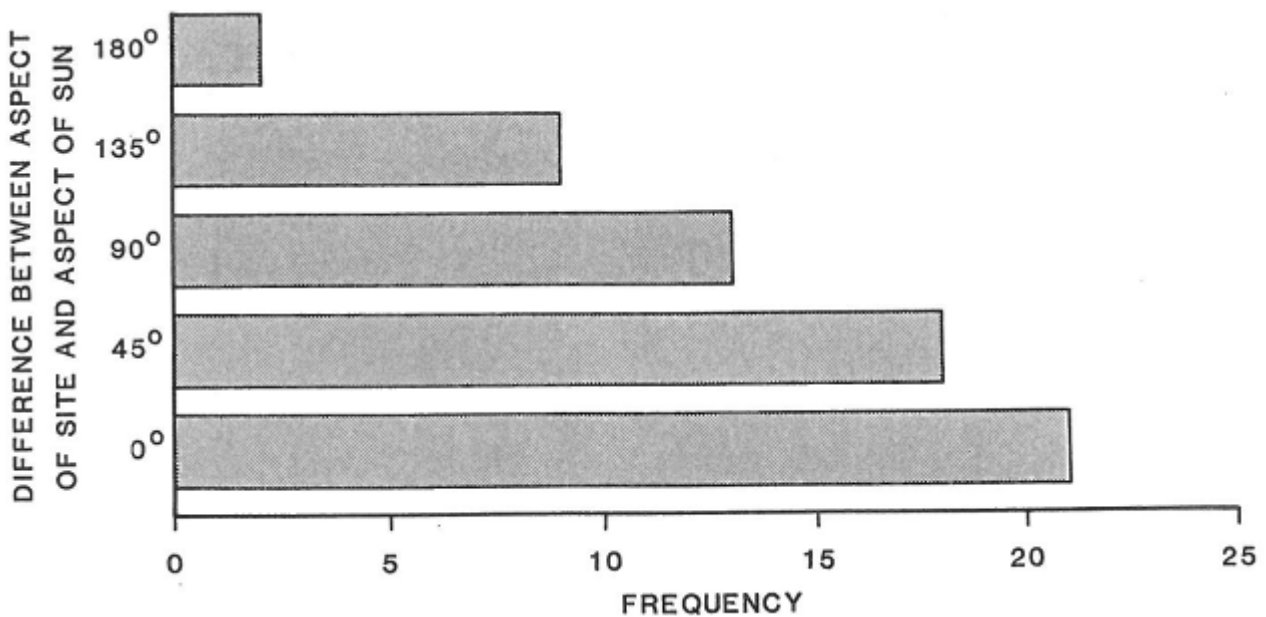


Fig. 5 Distribution of 63 sites with quail, according to the amount of agreement between the aspect of the site and the sun's aspect at the time of making the record (see Fig.4). Chi-square = 17.87, degrees of freedom = 4, probability < 0.06.

4.2.3 Nature of Surface

Within a 50m radius of where quail were recorded, there was always some bare surface, ranging from less than 10% to almost totally bare ground. Figure 6 summarises the frequencies of various surface materials, and shows that rock, soil, gravel, and sand-silt, in descending order of their contribution to bare ground, together comprised over 94% of the records of bare ground.

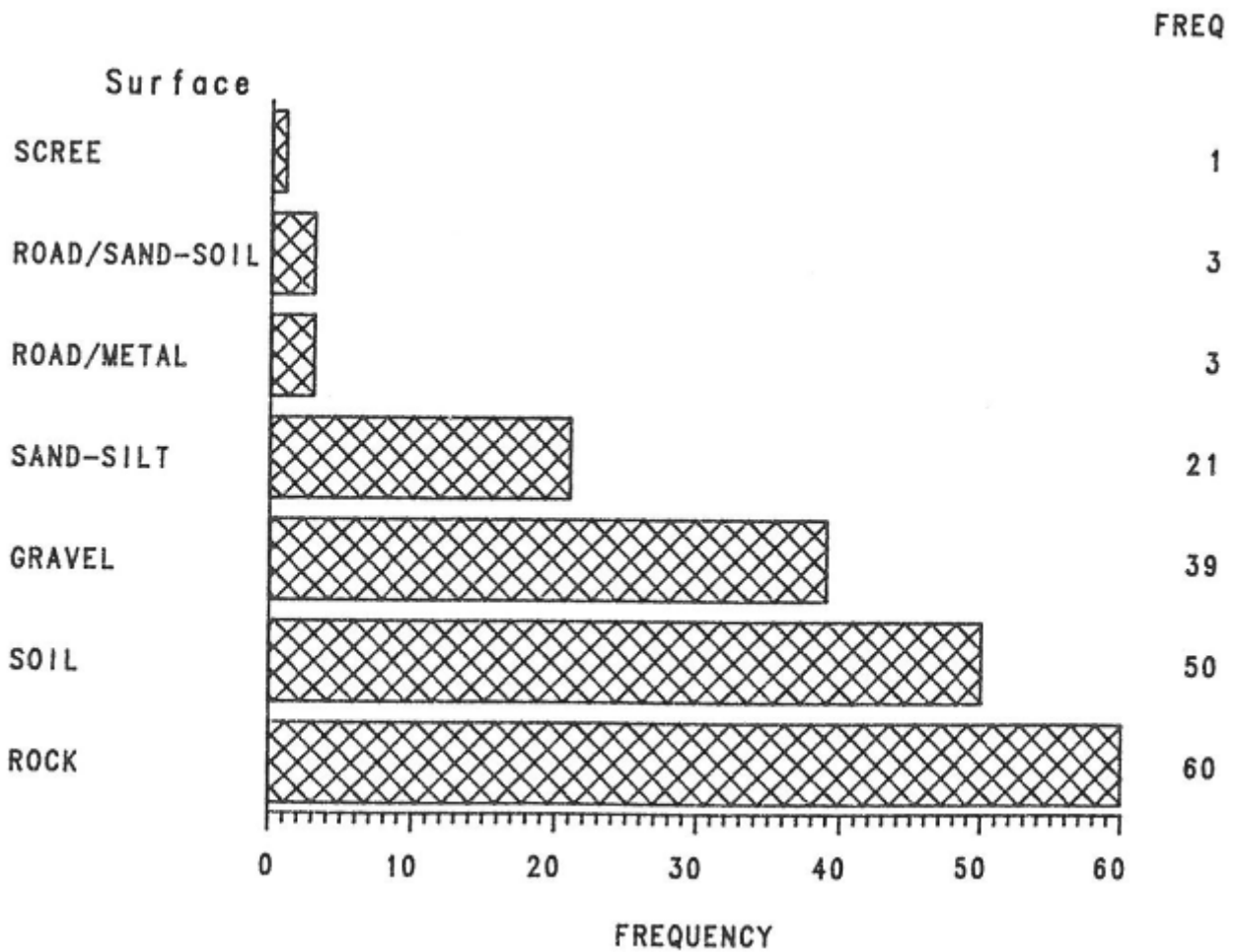


Fig. 6 The frequencies of different types of exposed surface materials on sites with California quail in Central Otago. Up to three types were listed at each of 68 sites which quail were found.

The amount of bare ground occupied by each of the types of surface materials is shown in Figure 7. Although rock was the most frequently (60%) encountered substrate (Figure 6), it was less frequent in the lowest cover category (< 10%) than soil or gravel (Figure 7). When individual site data were examined, soil or gravel was the most common substrate in sites with the most plant cover. The eight sites which lacked rock had areas of exposed soil and/or sand-silt and, in some cases, gravel. In one site rock was the only type of exposed surface present.

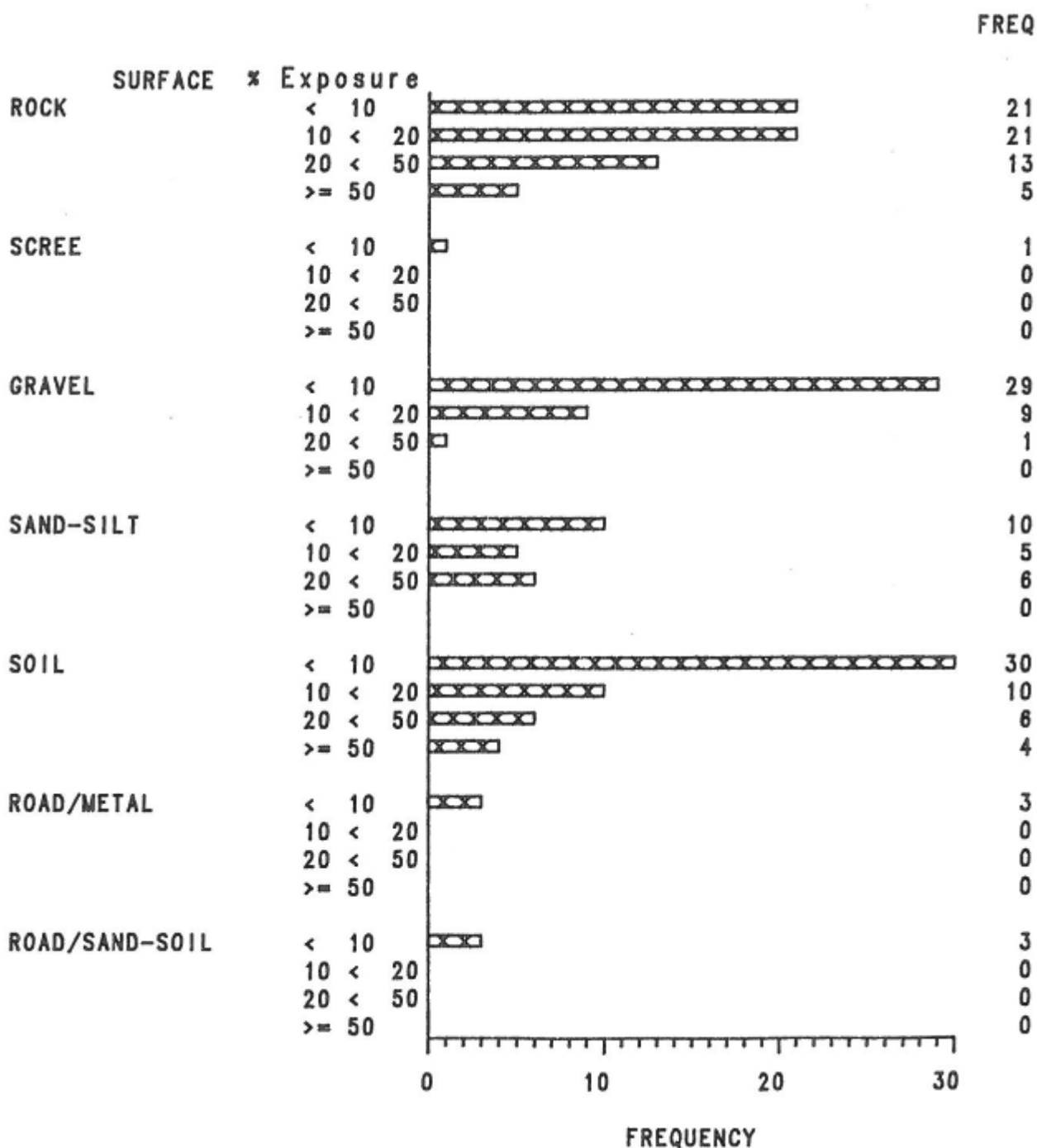


Fig. 7 The amount of exposed surface by the various types of surface materials on sites with California quail in Otago (see Fig. 6).

4.3 Water

At over one third of the sites quail were recorded within 20m of water, more than half were within 50m of water, and 92% were within 200m of water (Figure 8). At the remaining five sites water was more than 200m away.

However, the fact that water was not located nearer than 200m does not mean that it was not present. One covey was seen in an apparently arid area but a leaking water-pipe provided a small permanent puddle a mere 16m from where the quail were first seen.

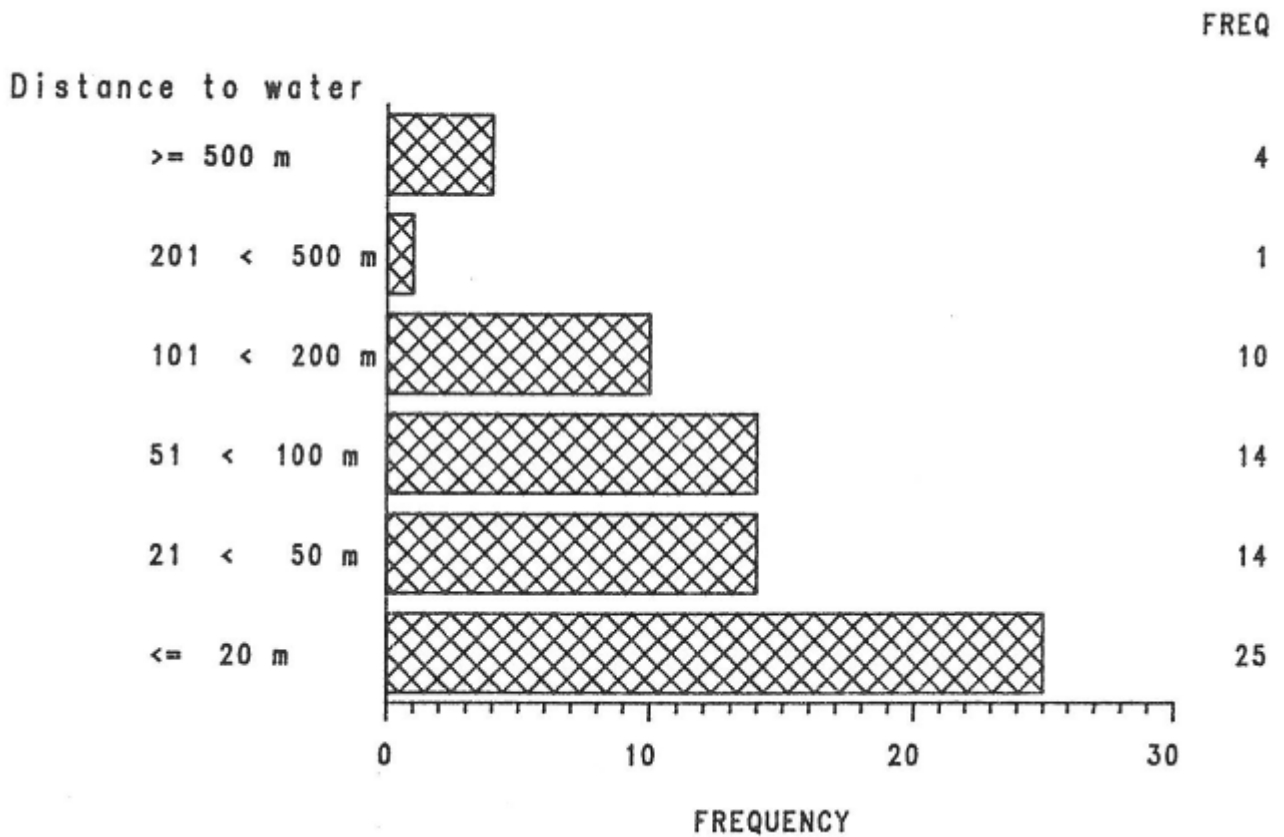


Fig. 8 The frequencies of the distances from water of 68 sites with quail in Central Otago.

Figure 9 shows that there was considerable variation in the nature of the water available, with roughly equal numbers of sites having either flowing or stationary water as the nearest source.

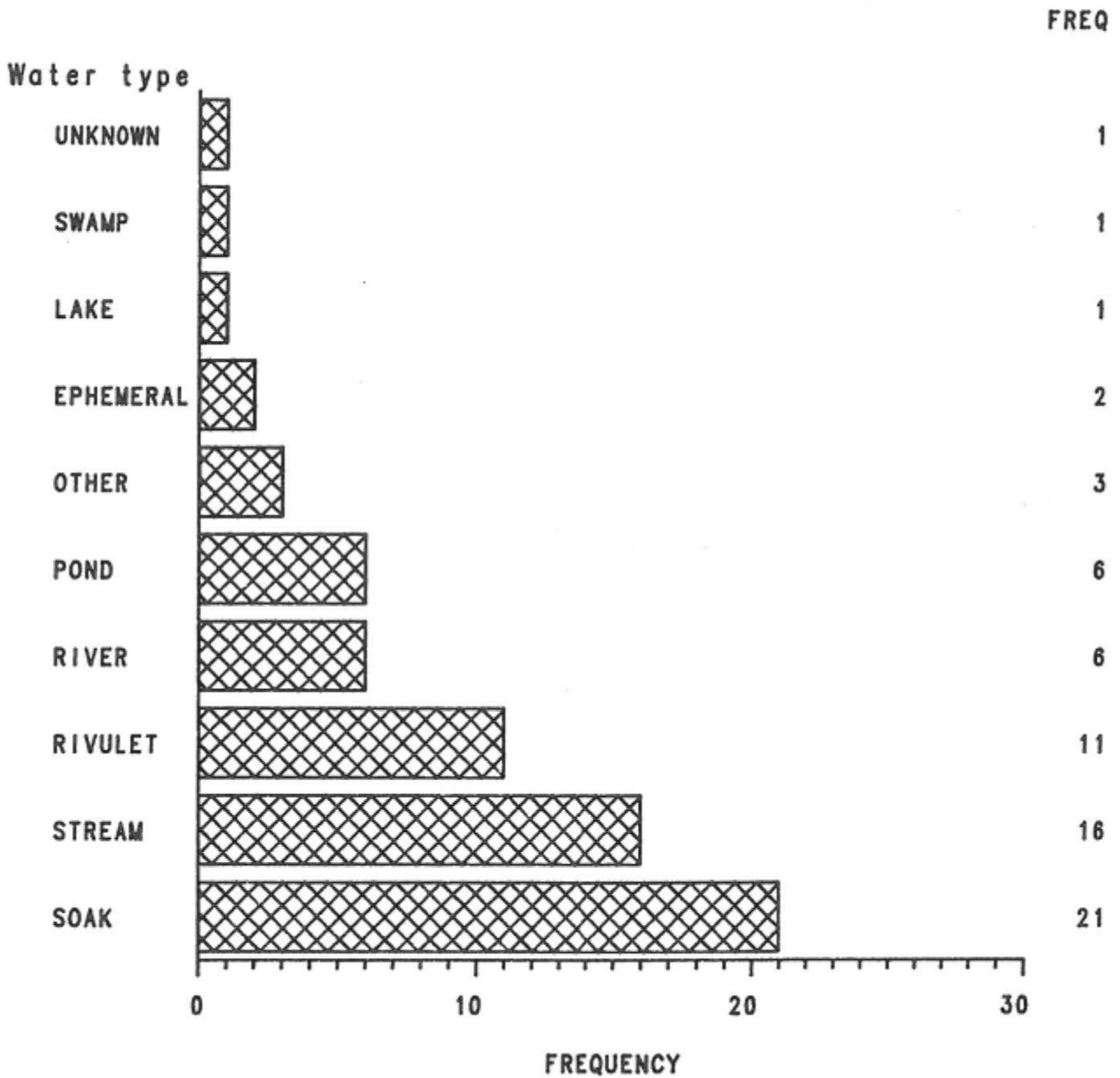


Fig. 9 The frequencies of the nearest sources of surface water to 68 sites with quail in Central Otago.

4.4 Vegetation

The principal types of vegetation surrounding the sites with quail were recorded as 68% pasture, 29% shrubland, and 3% (2 sites) in exotic woodlots. The frequencies of the main plant growth-forms within a 50m radius of where quail were recorded are summarised in Figure 10.

Of particular note is the presence of shrubs on 67 of the 68 sites (98%), and grasses on 62 (91%) sites (Figure 10). The single site without shrubs as one of the four dominant vegetation cover types nevertheless did have matagouri* and briar listed as two of the six species in that section of the data sheet (Figure 1).

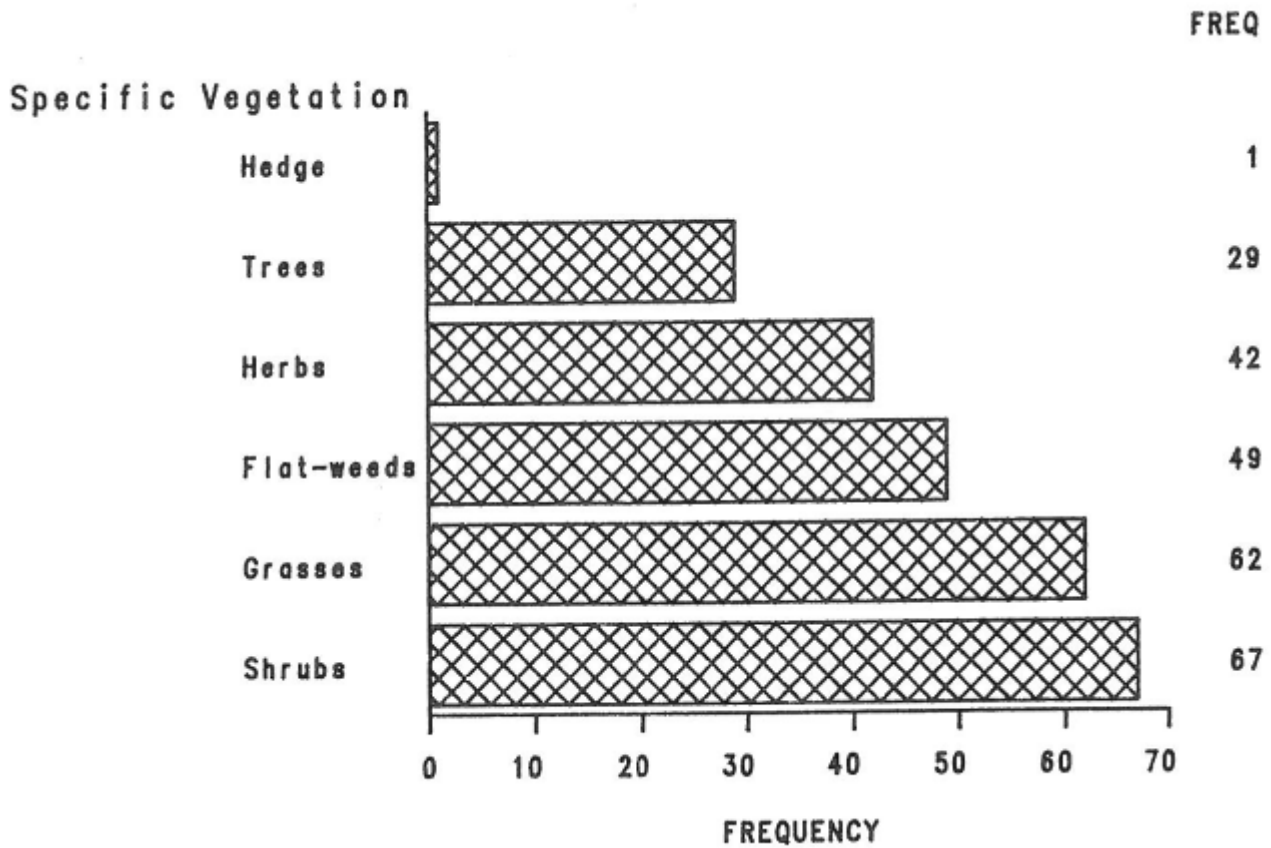


Fig. 10 The frequencies of the main plant growth-forms on sites with California quail in Central Otago. Up to four types were recorded at each of 68 sites in which quail were found.

* Formal names of plants named in this report-are given in Appendix 1.

The percentage cover contributed by each growth-form is depicted in Figure 11. This, too, shows that shrubs and grasses occurred most frequently, but especially in the higher values (20 < 50% and \geq 50%). In this respect, shrubs and grasses contrast with flat-weeds and herbs which were more common in the lowest cover class (< 10%). Flat-weeds and/or herbs occurred on all but seven sites, usually as minor components; grasses occurred on a similar number of sites, but were more often a major component of the vegetation.

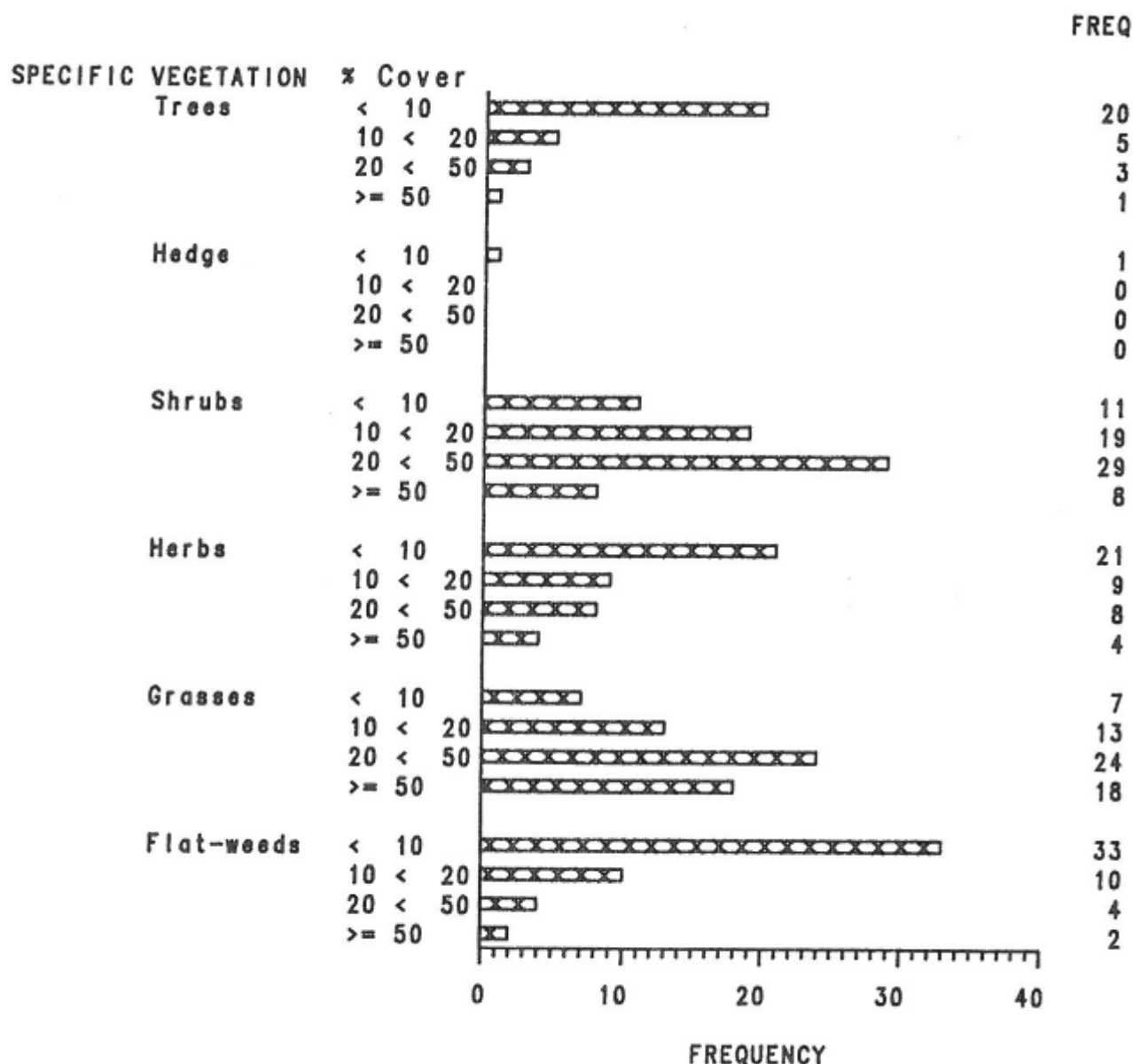


Fig. 11 The frequencies of the main plant growth-forms in various cover classes on sites with California quail (see Fig. 10). Flat-weeds included the rosette stages of thistles, docks, vipers bugloss, flannel leaf (mullein); herbs were the upright (flowering and/or fruiting) stages of those same plants, and also non-rosette species such as hemlock, stonecrop, clovers and thyme.

The summed frequencies of the plant species which contributed most cover in each site (up to six species per site) are shown in Figure 12. Forty species were recorded. Here we have omitted those which were recorded only once, namely boxthorn, dock, orchard stonefruit tree, hawthorn, ragwort, tall tussock, bidibidi, watercress, asparagus, horehound, *Olearia odorata*, and an "unidentified herb".

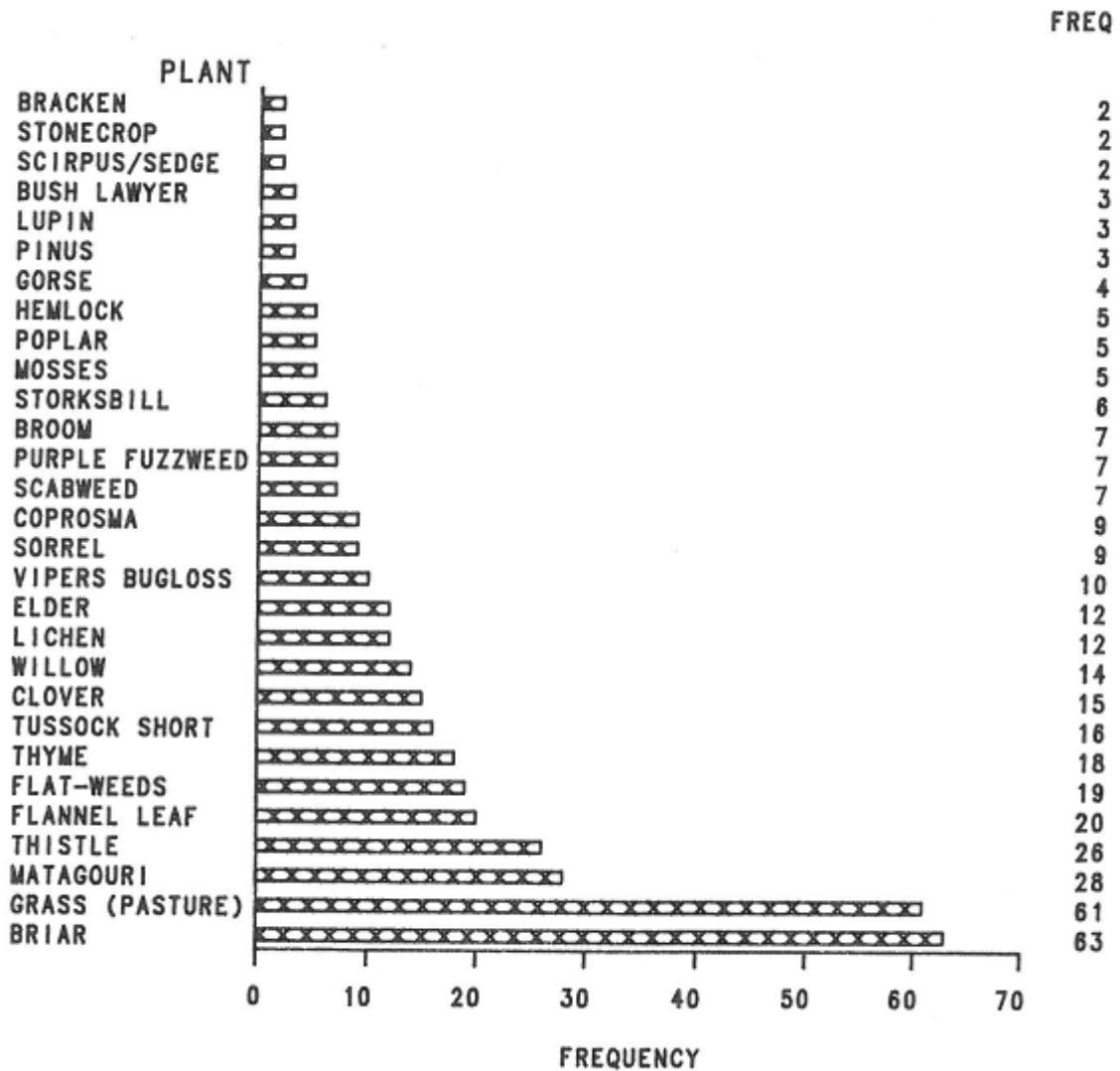


Fig 12. The frequencies of plant species on 68 sites with California quail in Central Otago. Up to 6 species were recorded per site; plants recorded on only one site do not appear in this figure.

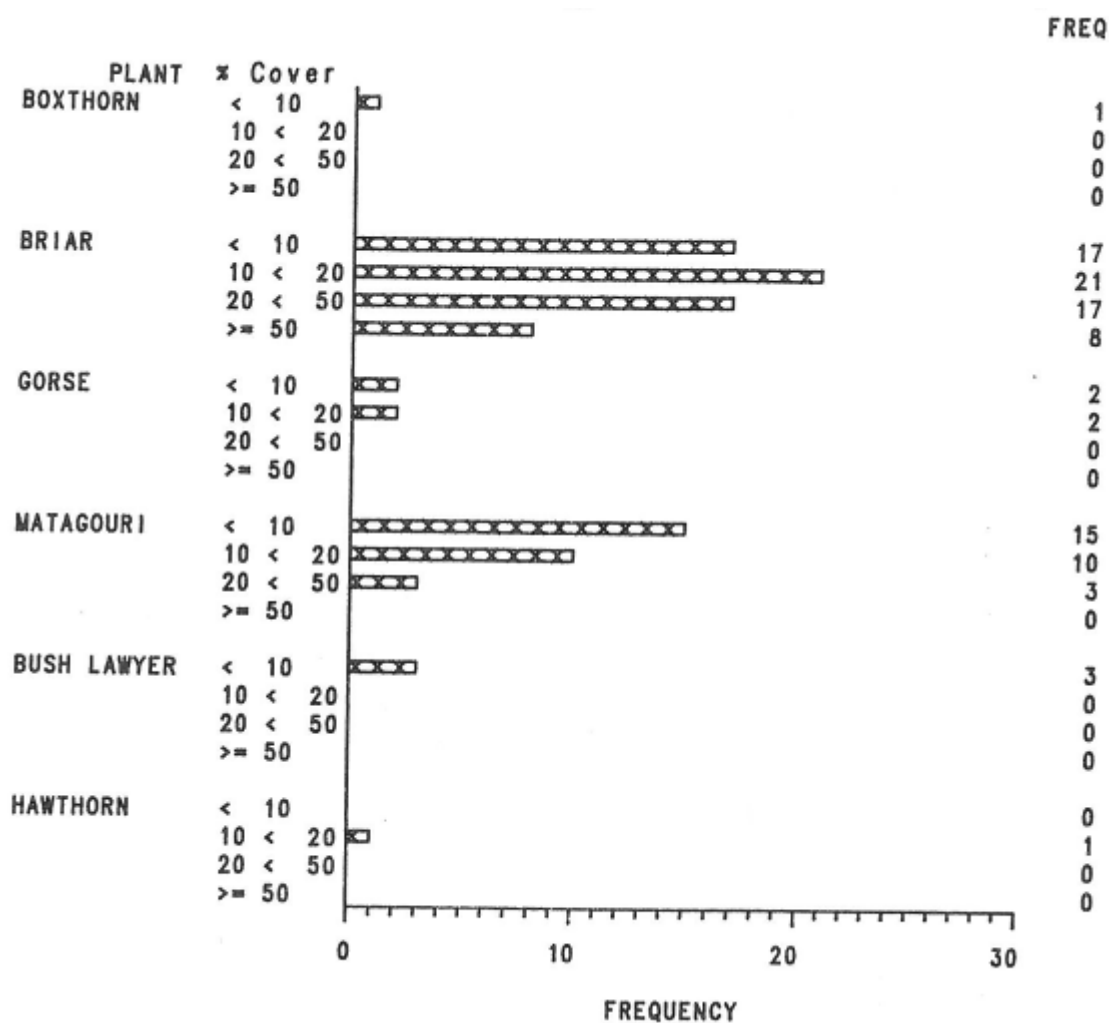


Fig. 13 The frequencies of thorny shrubs in various cover classes on sites with California quail, Central Otago.

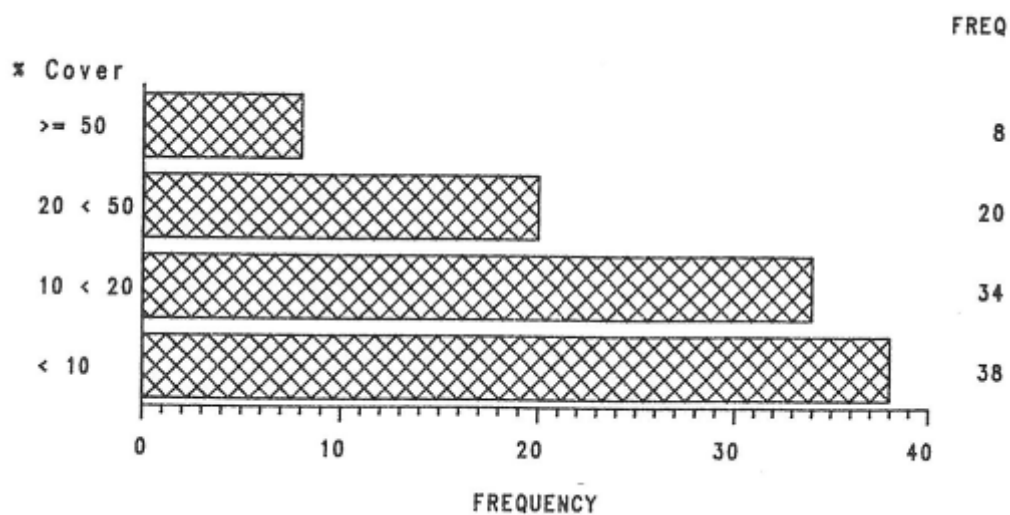


Fig. 14 The summed frequencies of thorny shrub species shown in Fig. 13.

5. DISCUSSION

5.1 Landform

5.1.1 Terrain and Slope

Quail were found on such a wide range of slopes, from flat to steep country, and variety of terrains, that no preferences can be detected for these habitat features. It is likely that if other requirements are met by a site, then the type of landform has little or no influence on whether quail will use a site. In the study area around Alexandra, most quail records came from sloping ground, perhaps because scrub was more common in that district on hill country than on flat land. The few records from flat sites were from river beds, gold-mining tailings, and ridge crests.

Elsewhere in New Zealand California quail occur on a wide range of landforms, both coastally and inland, including dunes, riverbeds, plains, and both gentle and steep hill country.

5.1.2 Aspect

The survey has supported the earlier view of one of us (Caithness, pers. comm.) that quail prefer sunny aspects and move diurnally to follow the changing direction of incident sunlight. Such behaviour is probably related to the quails' need for a dry, loose substrate for dusting. At least some sites where quail were found on an apparently shady aspect were on relatively gentle slopes. Such sites still received direct sunlight unless the sun's angle was very low, and it may be that other features of such sites out-weighed any disadvantages of a slightly less sunny situation.

5.1.3 Nature of Surface

Bare surfaces occurred on all sites and, with the exception of one site in which rock was the only bare surface recorded, there was always some finer textured material for quail to use for dusting. Dust-bowls were seen in some sites, always on sunny aspects and mostly under the edge of over-hanging bushes. On almost all sites, even where the total area of bare surface was not great, the vegetation was sparse. Here the quail, essentially walking birds, could move without difficulty throughout their home range.

General observations of quail habitat elsewhere in New Zealand support this correlation between patches of bare ground and the presence of quail. Even in land dominated by dense, lush pasture, such as dairy farms of South Taranaki, quail use bare ground in gate-ways, and dust beneath and navigate their home range along the bare surface commonly associated with the bases of hedges.

There is no doubt that open and lightly vegetated habitats are those most commonly sought by quail.

5.2 Water

Williams (1955) stressed the need for an "unfailing supply" of water for California quail, especially during the hatching period when very young birds are about. He cited the work of Emlen and Glading (1945) in California, where special watering devices termed "gallinaceous guzzlers" were constructed for quail, with "highly satisfactory results".

In our survey, the close proximity of water to all but a very few sites with quail (and it should be recalled that water may have been present but not found near some or all of the sites where water was not recorded nearby) supports this view that the availability of water is an important factor in determining an area's suitability as quail habitat. Quite extensive parts of the Alexandra district lack quail, but appear to be suitable quail habitat apart from the absence of nearby surface water.

Because quail usually walk from one part of their home range to another during the course of each day's activities, water needs to be within walking range. The source of such water is unlikely to be important, and a considerable range of water sources was found on this survey (Figure 9). Elsewhere, quail are known to use water from sources such as water troughs for livestock and hence would be amenable to using artificial water supplies if these were provided for quail specifically.

5.3 Vegetation

Because the survey did not require a detailed botanical knowledge, plants were placed in broad categories such as flat-weeds, thistles, and pasture grasses. Quail are opportunistic feeders on seeds, flowers, buds, and foliage (Caithness *et al.* 1987), so that the absence of a complete species list of plants at each site is not a serious omission from this methodology. As it was, many of the same or closely-related plant species to those found to be eaten by quail in Kaingaroa (*ibid*) featured in the top six species on sites in our Otago survey. Food is unlikely to be a limiting factor to the local abundance or distribution of quail.

The most obvious common feature of sites with quail was the presence of scrub. Furthermore, in almost all cases this scrub comprised or contained species which were thorny or spiny. Briar was by far the most common of these, followed by matagouri, gorse, bush lawyer, and boxthorn and hawthorn in descending order of occurrence on sites. Non-thorny shrubs and trees such as pines, elderberry, willows, broom, and species of *Coprosma* and were on some sites, but there are no clear trends in the data on these.

Our survey could not determine the specific uses of thorny shrubs to quail, but it is likely that quail either roost in them at night or use them as escape cover if disturbed during the day, or both. Dense scrub or trees also provide shelter, particularly for roosting birds, and thorny bushes would fill this role in winter better than deciduous trees or even open-form, mature pines.

Although little is known of preferred roost sites of quail in New Zealand, thorny shrubs would offer more protection to roosting birds from climbing mammalian predators such as mustelids, cats, and ship rats, than would thornless shrubs or trees. Because quail are alert during the day, there seem to be few advantages of thorny shrubs over thornless ones for escape cover alone.

We considered quail habitats in some other parts of New Zealand subjectively and found support for our hypothesis regarding thorny vegetation as quail roosting habitat. In the sand dunes of Manawatu and Hawkes Bay quail occur where there are scattered clumps of boxthorn, and sometimes blackberry, and boxthorn hedges are used by quail in dairy farms of South Taranaki. Around Wellington, quail are uncommon and local, but occur in some areas with tall gorse. Spiny *Hakea* scrub is a frequent component of quail habitat in the far north of Northland, and in the Queenstown and districts quail occur among the common thorny shrub, hawthorn.

6. MANAGEMENT IMPLICATIONS

This survey of some aspects of quail habitat has identified the following characteristics of sites used by quail:

- a) almost any type of terrain can be used;
- b) if the land is of rolling to steep topography then areas with a sunny aspect (between north-east and north-west) should be present, and preferably such that quail can move to obtain direct sun for a major portion of the day;
- c) bare surfaces are required, with materials sufficiently soft and fine to make dust-bowls;
- d) fresh water must be available in some form within walking distance of quail;
- e) dense, woody vegetation, preferably containing thorny or spiny species, must be present for roosting and/or escape cover.
- f) the surface vegetation should have an open habit to permit quail easy access throughout their home range.

Game managers and land holders wishing to preserve, improve, or even create habitat for California quail in specific places will easily recognise some habitat management techniques which can be derived from these findings. The retention or planting of patches of thorny, woody vegetation on sunny sites with some open ground, and the provision of a year-round water supply are obvious devices.

7. FUTURE SURVEYS OF UPLAND GAME HABITAT: A RE-DESIGNED SURVEY FORM

The survey techniques described in this report have allowed us to identify and quantify some important characteristics of California quail habitat in Central Otago. We believe that these findings can be applied to California quail elsewhere in New Zealand. In addition, the survey techniques should be useful in determining features of the habitat of other birds of open country, with possible minor changes to suit individual species.

At a debriefing meeting before the survey participants left Alexandra, there were suggested a number of improvements to the survey form for its future use in quail habitats. Our analysis of the data from the survey has also indicated some needs for a re-designed form. Figure 1 incorporates those which were purely concerned with form lay-out. Because there were some problems during the analysis of data with the interpretation of individual hand-writing on the field forms, and the presence of gaps or possible errors in the raw data, future users of the form should record the following additional information on it. Apart from the year of making the record, such details need not be coded for entry into a computer.

- 1) The name of the observer.
- 2) The name of the nearest major geographical feature (river, hill, town, etc.), to check against possible errors in the recorded grid reference.
- 3) The year in which the record was made, for archival purposes and to allow analysis of differences in the habitat or quail use of it from year to year.

It is reiterated that this survey methodology does not assess some other elements of quail habitat which may influence their success or distribution. These include the identification of preferred dietary items or roost trees, the presence or abundance of predators, levels of hunting, and effects of agricultural chemicals. By surveying at dusk or dawn, roosts could be identified. An investigation of other factors would require different kinds of survey, or extended research and monitoring of populations.

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APPENDIX ONE

FORMAL NAMES OF PLANTS NAMED IN THE TEXT

asparagus	<i>Asparagus officinalis</i>
bidibidi	<i>Acaena</i> spp.
blackberry	<i>Rubus fruticosus</i> agg. <i>Lyceum ferocissimum</i>
bracken	<i>Pteridium esculentum</i>
briar (sweet briar)	<i>Rosa rubiginosa</i>
broom	<i>Cytisus scoparius</i>
bush lawyer	<i>Rubus schmidelioides</i> var.
clovers	Species of <i>Trifolium</i> and similar legumes (e.g. <i>Medicago</i> spp.)
<i>Coprosma</i>	Small leaved <i>Coprosma</i> spp. especially <i>C. propinqua</i>
dock	Large leaved <i>Rumex</i> spp. especially <i>R. crispus</i> , <i>R. obtusifolius</i>
elder (elderberry)	<i>Sambucus nigra</i>
flannel leaf (mullein)	<i>Verbascum Thapsus</i> , <i>V. virgatum</i>
gorse	<i>Ulex europaeus</i>
<i>Hakea</i>	Thorny <i>Hakea</i> spp. e.g. <i>H. sericea</i> , <i>H. gibbosa</i>
hard tussock	<i>Festuca novae-zelandiae</i>
hawthorn	<i>Crataegus monogyna</i>
hemlock	<i>Conium maculatum</i>
horehound	<i>Marrubium vulgare</i>
lupin	<i>Lupinus arboreus</i>
matagouri	<i>Discaria toumatou</i>
pinus	<i>Pinus</i> spp.
Poplar (Lombardy poplar)	<i>Populus nigra</i> 'Italica'
purple fuzzweed	<i>Vittadinia</i> spp.
ragwort	<i>Senecio jacobaea</i>
scabweed	<i>Raoulia</i> spp.
short tussock	hard tussock and/or silver tussock (q.v.)
silver tussock	<i>Poa cita</i>
sorrel	<i>Rumex acetosella</i>
stonecrop	<i>Sedum acre</i>
storksbill	<i>Erodium</i> spp.
tall tussock	<i>Chionochloa</i> spp.
thistle	Species of <i>Cirsium</i> , <i>Carduus</i> , <i>Silybum</i>
thyme (wild thyme)	<i>Thymus vulgaris</i>
vipers bugloss	<i>Echium vulgare</i>
watercress	<i>Nasturtium microphyllum</i> , <i>N. officinale</i>
willow	<i>Salix</i> spp.