

Vegetation associated with kakapo (*Strigops habroptilus* Gray) in Sinbad Gully, Fiordland, New Zealand

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(Received 21 October 1975)

ABSTRACT

The kakapo, a flightless, nocturnal, browsing parrot, is now known only from a few birds in the Milford Sound area where the forests are mostly unmodified by introduced browsing mammals. In February 1975 three male birds had courtship territories at 600-900 m altitude in the head of Sinbad Gully, where steep slopes, waterfalls, and avalanches largely determine the vegetation pattern. The three courtship territories comprised track and bowl systems in ridge-crest silver beech (*Nothofagus menziesii*) forest. A garden territory or "kakapo garden" is described; it is a scrub-covered debris fan, floristically very rich particularly with berry-bearing shrubs, where kakapo seem to feed. Nearby areas of forest and scrub, which show no signs of use by kakapo, may not be used by the birds because of lack of food or shelter.

INTRODUCTION

The kakapo (*Strigops habroptilus* Gray) is a large, flightless, nocturnal, browsing parrot, once widely distributed through New Zealand but now approaching extinction. In an attempt to save the kakapo from extinction, the Wildlife Service, Department of Internal Affairs, is transferring birds from near Milford Sound to Maud Island, a predator- and competitor-free island in the Marlborough Sounds. Intensive searches over two summers have revealed a total of nine birds in the Milford catchment and it is with these surviving birds that our hope of gaining further knowledge of kakapo behaviour and habitat rests. It appears from observation of these birds (D. V. Merton, pers. comm.) that male kakapo defend two distinct types of territory: booming or courtship territories and garden territories. Booming or courtship territories consist of several bowls or courts, scooped out on the downhill side of tree bases or rocks, on ridge crests or other vantage points. These bowls are linked by a network of well-cleared tracks. Courtship territories in Sinbad Gully were occupied from December 1974 to February 1975 inclusive, during which the birds made a booming noise which is thought to attract females. Both before and subsequently the birds inhabited neighbouring garden territories, or "kakapo gardens", a term used by Henry (1903) for "... areas at the bottoms of

valleys and around landslips where berries are produced in great quantity".

This paper describes the vegetation in and near the courtship territories of three male kakapo, and a kakapo garden in Sinbad Gully. It is intended to complement studies on the behaviour of these birds (Merton *et al.*, in preparation), and on the decline of kakapo, their food and their habitat in the Esperance Valley (Atkinson & Merton, in preparation). These observations were made from 24 to 27 February 1975.

THE STUDY AREA

Sinbad Gully (Fig. 1) is a steep-walled valley of glacial origin, running generally eastwards into the head of Milford Sound; it lies to the left of Mitre Peak when viewed from the Milford Hotel. The valley floor rises 300 m over a distance of 7 km and then rises very abruptly below the head cirque, where the main stream turns to drain the Llawrenny Peaks (1 900 m).

Silver beech forest (*Nothofagus menziesii*) covers the valley floor and the slopes up to c. 900 m near the valley mouth, though forest is absent from most of the steep north side of the valley. On the south

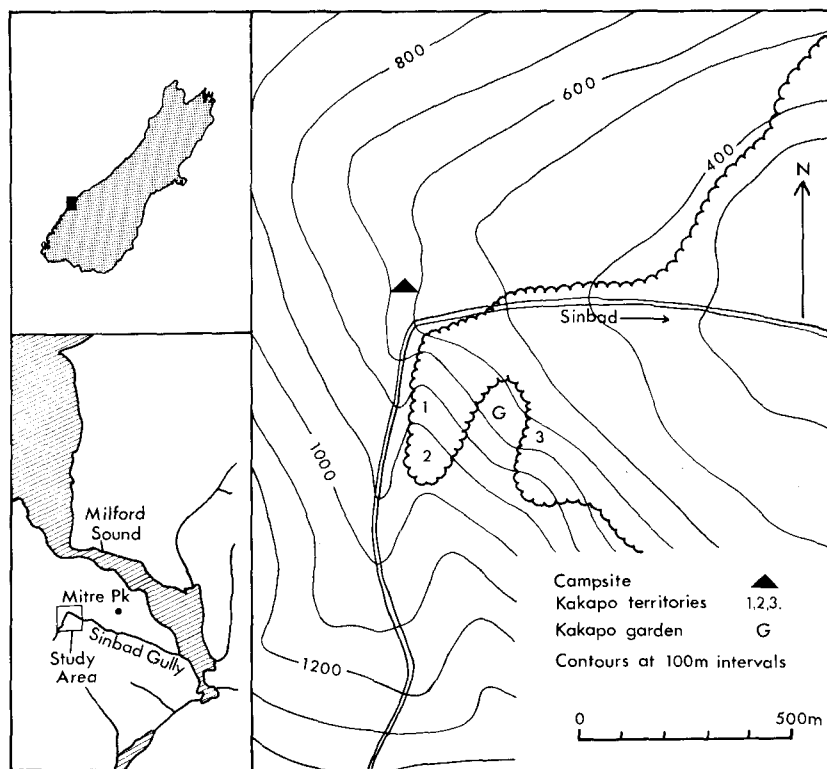


Fig. 1 Location and layout of the study area.

side it clothes the less steep lower slopes, but it is only on a few ridge crests and in gullies whose catchments do not ascend to the mountain tops—sites which get some respite from waterfalls and avalanches—that tongues of forest ascend to the potential tree line.

Rainfall at Milford averages 6 236 mm p.a., spread over 183 rain days (New Zealand Meteorological Service 1973). During rainfall the Sinbad slopes are covered with waterfalls; their vegetation is similar to that found near steep watercourses elsewhere in Fiordland.

A few lowland forest species maintain a hold on such sites (e.g., *Coprosma foetidissima*). There is a large element of species which descends from higher altitudes (e.g., *Coprosma serrulata* and *Anisotome haastii*), and several species are more common here than in adjacent habitats (e.g., *Celmisia holosericea* and *Chionochloa conspicua*). The altitudinal sequence of plant communities is thus much modified by waterfalls and avalanches, plant cover varying mainly with the nature of the substrate and the frequency of avalanches. At one extreme, coarse debris slopes tend to hold scrub dominated by *Fuchsia excorticata*, *Hoheria glabrata*, and *Coprosma rugosa*, and at the

other, *Blechnum capense* and *Phormium cookianum* dominate ledges and crevices on solid rock walls. Between these extremes is a mosaic of other communities, many covering very small areas (such as flushes dominated by *Schoenus pauciflorus* and *Celmisia glandulosa*).

Deer (*Cervus elaphus* Linn.) and opossums (*Trichosurus vulpecula* Kerr) are absent from the study area, though occasional chamois (*Rupicapra rupicapra* Linn.) have been reported from the head of Sinbad Gully since 1967 (K. G. Tustin, pers. comm.).

Two kakapo occupied courtship territories on a prominent forested ridge which runs from the bend in Sinbad Gully up on to the Llawrenny Peaks; the third bird was lower down, on a ridge 250 m to the east (Fig. 1). Between the two ridges is a steep face, with a scrub-covered debris slope below, which, because of its position relative to the male birds, the presence of feeding sign, availability of roosts, and abundance of food material, may contain female kakapo. This area is referred to as the "kakapo garden". Two areas without sign of kakapo habitation are also described here: an area of silver beech forest to the west of the kakapo garden, and scrub near the camp site (Fig. 1).

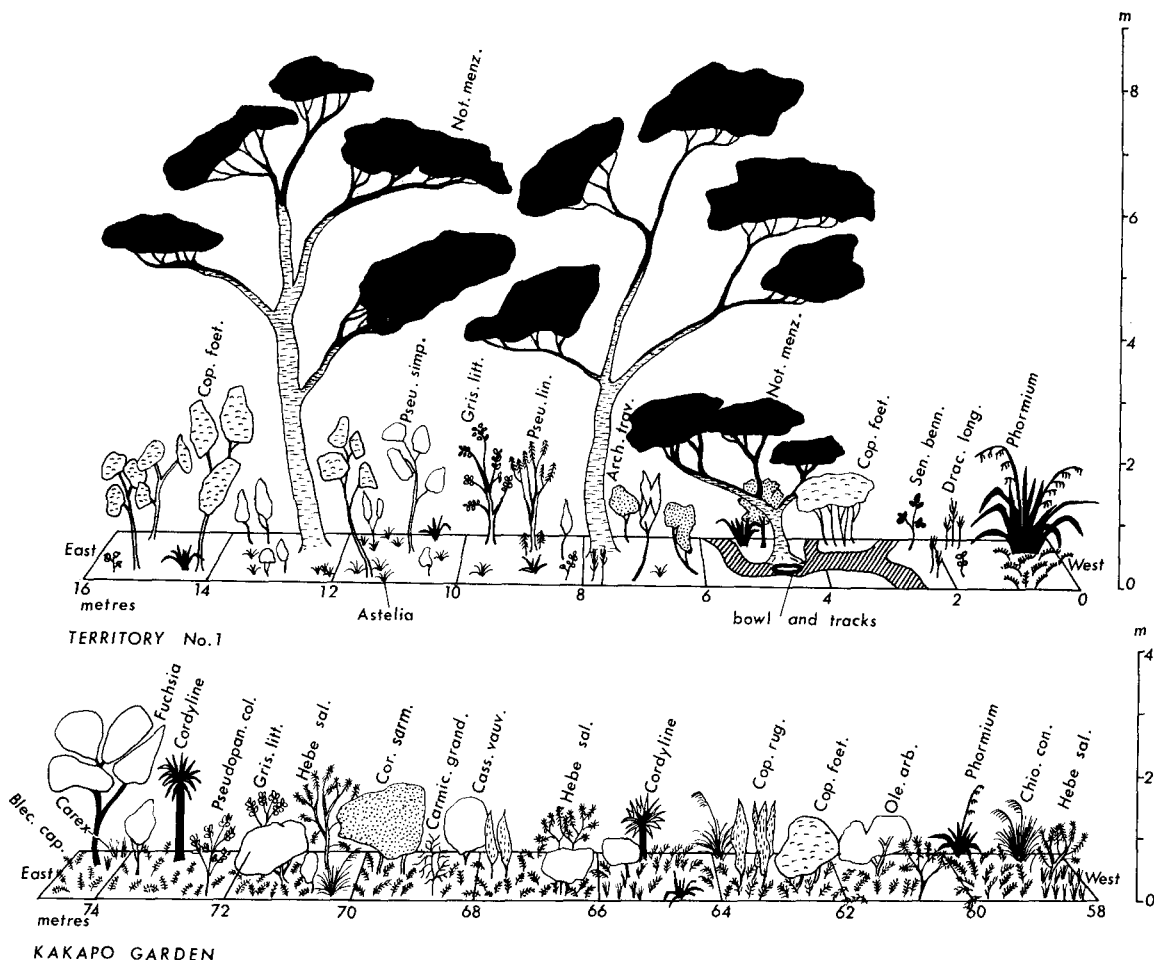


Fig. 2 Profile drawings representing a 1-m-wide transect across the contour in territory no. 1 (above) and part of a transect across the kakapo garden (below). Botanical names are given in full in the list of plants on p.156.

SITE DESCRIPTIONS

Kakapo territory no. 1

SITE TYPE: steep ridge crest, 30 m wide, with steeper faces on either side. **AGE OF SITE:** unknown, but probably climax forest as not within avalanche paths. **ALTITUDE:** 860 m. **SLOPE:** 50° but locally 30° and some rocky areas 90°. **ASPECT:** N–NNE. **SIZE OF TERRITORY:** track and bowl system restricted to 10-m-wide part of ridge crest. From the main booming bowl, territory seems to extend upwards to c. 900 m to meet territory no. 2. Less distinct tracks and bowls extend downslope to at least 650 m, though the bird here did not tend bowls or tracks below c. 840 m.

Vegetation structure is shown in a profile diagram (Fig. 2) which represents a 1-m-wide transect running along the contour, crossing the central part of the territory. Plant size, density, and canopy cover were recorded for each 1-m interval of the transect. Canopy height averages 4.5 m but varies from 0.6 m on the immediate ridge crest on the western boundary to 8 m on the eastern boundary. Here there is a slight gully with a small stream. Much-branched silver beech forms c. 50% of the canopy cover, *Archeria traversii* 10%, *Pseudopanax simplex* 8%, *P. linearis* 6%, and *Coprosma* species 13% (see list of plants on p.156 for details of minor species and their abundance). Over c. 10% of the area there is no canopy of woody plants.

Young shrubs predominate in the 30–60 cm tier, though small plants of *Astelia nervosa* and *Phormium cookianum* are common. Ground cover (< 30 cm high) was measured in 0.5 × 0.5-m quadrats at 1-m intervals along the transect. Mean cover values are: litter 46%, cryptogams 30%, *Hymenophyllum multifidum* + *H. sanguinolentum* 15%, woody seedlings 3.7%, and herbs 5.3% (mainly *Astelia nervosa*, *Uncinia filiformis*, and occasional *Schoenus pauciflorus*). Seedlings and saplings of silver beech are completely absent.

A network of tracks covers a 10-m width of the ridge crest, and at any one level there are usually three parallel tracks running uphill. The tracks are kept bare of vegetation and of any large leaves or twigs over a width of c. 50 cm. Leaves of young *Astelia* plants have been nipped off at about their midpoint, though this possibly represents more of a track-clearing activity than a feeding one, because no fibrous chews remained attached to most plants. The only feeding signs noted near this territory were on *Phormium*, where shredded pith was left at the base of flower stalks, on *Chionochoa flavescens* and *C. conspicua* leaves, and *Coprosma colensoi* twigs. Berried shrubs, mainly *Coprosma* and *Pseudopanax* species, are common in this territory, though not in the same abundance as in more scrubby areas which lack a beech canopy.

Kakapo territory no. 2

SITE TYPE: steep ridge crest with steeper faces on either side. AGE OF SITE: unknown as for territory no. 1. ALTITUDE: 910 m. SLOPE: 50–55°. ASPECT: N–NNE. SIZE OF TERRITORY: from central bowl, tracks extend only c. 5 m on either side, upslope c. 20 m and downslope c. 30 m to abut on territory no. 1.

This is very similar to territory no. 1. Silver beech canopy is fairly continuous, varying from 3 to 8 m and averaging 6.6 m in height. Plant composition is similar, though with more *Olearia lacunosa* and *Coprosma pseudocuneata*. A transect 15 m long and 1 m wide along the contour showed *Coprosma pseudocuneata*, *Pseudopanax linearis*, *Archeria traversii*, and *Senecio bennettii* to be the commonest shrubs over 2 m high. Small plants of *Phormium cookianum* share the 30–60 cm tier with small *Astelia nervosa* plants and an abundance of young shrubs, principally *Coprosma* spp. Ground cover consists of litter (71%), cryptogams (12%), *Uncinia filiformis* (7%), *Hymenophyllum sanguinolentum* (5%), other ferns and herbs (1.8%), and woody seedlings (2.4%).

Young *Astelia* plants were nipped, as in territory no. 1 and there were similar but less distinct signs on

Uncinia filiformis. The bird in this territory was quite tame and could be readily observed at night, but I did not see it feeding other than on an apple provided.

Kakapo territory no. 3

SITE TYPE: broad ridge crest near scrubby kakapo garden. AGE OF SITE: unknown, probably climax forest. ALTITUDE: 600 m. SLOPE: 40–45°. ASPECT: N–NNE. SIZE OF TERRITORY: From the scrub of the kakapo garden at the western boundary tracking extends 35 m across the forested ridge and a total of 80 m upslope and downslope.

Silver beech forms a closed canopy up to 22 m high, slightly lower in places. Kamahi (*Weinmannia racemosa*) and rata (*Metrosideros umbellata*) are common as small trees. Shrubs are not dense, being mainly *Coprosma foetidissima* and *Pseudopanax simplex*, with less *Senecio bennettii*, *Olearia arborescens*, and *Griselinia littoralis*. Large herbs are also rather sparse on the ridge, though on the face to the east *Blechnum capense* forms a dense undergrowth. The ridge holds rather scattered *B. capense* and a few *B. fluviatile*. Woody seedlings are abundant, except for beech which occurs only as mature trees. Small herbs are common, especially *Viola filicaulis*, *Uncinia rupestris*, young *Astelia nervosa*, and *Ourisia crosbyi*. Cryptogams cover 80% of the ground surface, though most kakapo tracks are bare. Leaves had been nipped off some *Astelia* plants.

This territory holds fewer berried shrubs than the other territories, though they are abundant in the adjacent kakapo garden. Several tracks lead from the track and bowl system in the forest, towards the kakapo garden.

Kakapo garden

SITE TYPE: debris from slips, rockfalls, and avalanches in a shallow basin below rock face. AGE OF SITE: possibly 20–40 years; wineberry (*Aristotelia serrata*) and *Fuchsia excorticata*, both pioneers on slip debris, are of this order of age. ALTITUDE: 600 m. ASPECT: N–NNE. SLOPE: c. 40°. SIZE OF GARDEN: c. 1.5 ha. See Fig. 3.

The garden lies below a 60–70° rock face which holds ledges of fern and scrub. Water draining the face forms two small streams through the garden area. On its western margin scrub grows directly on bedrock but elsewhere the scrub grows on loose rocks. In the lower part of the garden the latter are sufficiently large (1–2 m) and loosely packed to offer holes big enough for kakapo roosts.



Fig. 3 View east across the kakapo garden. *Cordyline indivisa* is conspicuous among dense scrub on a debris fan which lies below a rock face (top right). Territory no. 3 is in the silver beech forest beyond the scrub.

A point intercept transect, 104 m long, across the contour is partly shown in Fig. 2. Canopy height varies regularly, extremes being 0.4 and 8.0 m, with a mean height of 2.5 m. Canopy composition (measured by frequency of occurrence at the 104 points) was: *Griselinia littoralis* (15), *Olearia arborescens* (12), *Coprosma rugosa* (10), *Olearia ilicifolia* (8), *Coriaria sarmentosa* (6), *Pseudopanax colensoi* (6), *Hebe salicifolia* (6), and *Blechnum capense* (5). The other 36 points were shared by a further 12 shrub and 4 herb species.

In the 30–60 cm tier, frequency values were: *Blechnum capense* (48), *Polystichum vestitum* (9), *Coriaria sarmentosa* (6), *Carex coriacea* (5), *Olearia arborescens* (4), *Chionochloa conspicua* (4), other species 28 (contributed by 13 shrub and 6 herb species). In the 0–30 cm tier, *Blechnum capense* was dominant again (42 points) with *Uncinia clavata* (8), *Viola filicaulis* (7), *Astelia nervosa* (7), *Polystichum vestitum* (5), *Carex coriacea* (5), and other species 30 (contributed by 6 shrub and 12 herb species).

Vascular plant species total 98 in the kakapo garden; compared with the three forested kakapo territories which, combined, give a total of 56. The garden area holds 37 tree and shrub species, 22 of which bear fleshy fruits. Herbs and ferns are varied and abundant (60 species, compared with 27 in the forested territories). Chews were seen on a few leaves of *Chionochloa conspicua* and *Carex coriacea*, mostly growing along the upper edge of the garden where it abuts steeper rock. No definite track systems were seen in the garden area.

Silver beech forest

VEGETATION TYPE: tall silver beech forest. SITE TYPE: moist face. AGE OF SITE: unknown, probably climax forest. ALTITUDE: 600 m. SLOPE: 40–45°. ASPECT: N–NNE. SIZE OF STAND: c. 3 ha.

This forest occupies the slope between the kakapo garden and the base of the tracked ridge below territories no. 1 and 2. No kakapo sign was seen

here, other than an old bowl, c. 10 m inside the forest near the west edge of the kakapo garden.

Silver beech forms an even canopy at 20 m. A few canopy gaps are filled by *Metrosideros umbellata* and *Griselinia littoralis*. Large shrubs are predominantly *Pseudowintera colorata*, *Pseudopanax simplex*, and *Coprosma foetidissima*. Smaller shrubs of *C. colensoi* are common, in a tier up to 1 m high which is dominated by *Blechnum capense*, *Polystichum vestitum*, *Astelia nervosa*, and *Cyathea colensoi*. These cover c. 80% of this tier, yet herbs are abundant beneath: *Uncinia clavata*, *U. filiformis*, *U. rupestris*, *Nertera dichondraefolia*, *Ourisia crosbyi*, *Blechnum fluviatile*, and *Viola flicaulis*.

This stand of forest has a more low-altitude appearance than the forest stands in the kakapo territories. Thus there is a lesser component of subalpine scrub species and a greater abundance of lowland plants like *Pseudowintera* and *Weinmannia*. It is moister underfoot than the ridge crest kakapo territories and contains less food material than the kakapo garden scrub, so for these reasons it may not be much used by the birds.

Scrub near camp site

SITE TYPE: rock slabs, ledges, debris fans, and watercourses below cirque wall. AGE OF SITE: various, but perpetually young after repeated disturbance by avalanche, rockfall, and flooding streams. ALTITUDE: 600 m. SLOPE: 40–60°. ASPECT: E–ENE. SIZE OF SITE: c. 5 ha.

The scrub of the slabs and ledges near the camp site contains no sign of kakapo living there. This may simply reflect the present rarity of the birds, or alternatively the site may be less suitable for them, for example, it does not have adjacent beech forest which might offer shelter, protection from avalanches, or places for track and bowl systems. Otherwise the scrub here would appear to be comparable to that in the kakapo garden, but by encompassing a wider range of vegetation types, may offer better food sources. Scrub of similar structure and composition to that on the kakapo garden grows on ledges and in wider crevices between bare rock slabs. At the scrub edges, in smaller crevices and in flushes in slight depressions, herbaceous vegetation is more varied than in the kakapo garden (84 herb species here compared with 60 in the garden).

VASCULAR FLORA

Authorities for names are based on Allan (1961) and Moore & Edgar (1970) except where noted otherwise. Abundance of each species is recorded for

three kakapo territories (1, 2, 3), kakapo garden (G), silver beech forest (F), and scrub near the camp site (C). Specimens of most species are deposited in the Botany Division, DSIR, herbarium.

+ = present; plant seen in fewer than five areas
m = many
a = abundant
l = locally abundant

	1	2	3	G	F	C
Trees and shrubs						
<i>Archeria traversii</i>	a	a	m	+		+
<i>Aristolelia fruticosa</i>				a		a
<i>A. serrata</i>				+		
<i>A. hybrids</i>				+		
<i>Carmichaelia grandiflora</i>	m	+	m	a	+	a
<i>Cassinia vauvilliersii</i>				m		m
<i>Coprosma astonii</i>	m	m		a	m	a
<i>C. ciliata</i>	+			+		+
<i>C. colensoi</i>	a	a	m	m	a	
<i>C. foetidissima</i>	m	m	a	a	a	a
<i>C. parviflora</i>	+	+		+	+	a
<i>C. pseudocuneata</i>	m	a	m			m
<i>C. pumila</i>						+
<i>C. rugosa</i>				a		a
<i>C. serrulata</i>						a
<i>Cordyline indivisia</i>			+	a	m	
<i>Coriaria plumosa</i>				+		a
<i>C. sarmentosa</i>				a		m
<i>Dracophyllum fiordense</i>			+			+
<i>D. longifolium</i>	a	m	m	a		a
<i>D. oliveri</i>						+
<i>Fuchsia excorticata</i>				a		a
<i>Gaultheria depressa</i>	a					m
<i>G. rupestris</i>	m		+	a		a
<i>Griselinia littoralis</i>	+	m	a	a	a	a
<i>Hebe cockayneana</i>						+
<i>H. salicifolia</i>				a		a
<i>H. subalpina</i>		+		m		a
<i>Hoheria glabrata</i>				a	+	a
<i>Metrosideros umbellata</i>	m		a		a	m
<i>Muehlenbeckia axillaris</i>						l
<i>M. complexa</i>				+		
<i>Myrsine divaricata</i>	m	+	m	a	a	a
<i>M. nummularia</i>		+				
<i>Nothofagus menziesii</i>	a	a	a	+	a	+
<i>Olearia arborescens</i>			m	a		a
<i>O. colensoi</i>	m	a	m	m	+	m
<i>O. ilicifolia</i>				+		a
<i>O. lacunosa</i>		a				
<i>O. macrodonta</i>		+				m
<i>Parahebe catarractae</i>				m	+	a
<i>P. lyallii</i>						+
<i>Pernettya macrostigma</i>				+		m
<i>P. macrostigma</i> x <i>Gaultheria rupestris</i>						+
<i>Pittosporum colensoi</i>			+	+	+	
<i>P. crassicaule</i>						+
<i>Pseudopanax colensoi</i> (Hook. f.)						
Philipson var. <i>fiordense</i>						
<i>P. Wardle</i>	+	m	m	a	m	a
<i>P. linearis</i>	a	a	m	+	m	
<i>P. simplex</i> (Forst. f.)						
Philipson	a	m	a	m	a	a
<i>Pseudowintera colorata</i>				+	a	
<i>Rubus cissoides</i>				m		m
<i>Schefflera digitata</i>					+	
<i>Senecio bennettii</i>	m	m	m	m	m	a
<i>Weinmannia racemosa</i>			a	+	m	

	1	2	3	G	F	C
Ferns and lycopods						
<i>Asplenium bulbiferum</i>				+		+
<i>A. flaccidum</i>	+	m	+	+	m	+
<i>Blechnum capense</i>	a	a	a	a	a	a
<i>B. colensoi</i> (Hook. f.)						
Wakefield			+	+	+	
<i>B. discolor</i>			+		m	
<i>B. fluviatile</i>		+	m	m	m	+
<i>B. penna-marina</i>				m		m
<i>B. vulcanicum</i>				+	+	l
<i>Cyathea colensoi</i>				+	a	+
<i>Grammitis billardieri</i>	a	a	a	m	m	+
<i>G. heterophylla</i>				+		
<i>Hymenophyllum demissum</i>					m	
<i>H. flabellatum</i>				+	+	
<i>H. multifidum</i>	a	a		+	a	a
<i>H. rarum</i>	+			+	+	
<i>H. sanguinolentum</i>	a	a		+	a	a
<i>Hypolepis millefolium</i>				+		m
<i>Lycopodium fastigiatum</i>						+
<i>L. scariosum</i>				+	+	+
<i>L. varium</i>	+	+	+	+	+	m
<i>Phymatodes diversifolium</i>				+		m
<i>Polystichum vestitum</i>			+	a	a	m
<i>Pyrrosia serpens</i>			+			
<i>Todea superba</i>					+	
Grasses						
<i>Chionochloa conspicua</i>						
(Forst.f.) Zotov		+		a		a
<i>C. flavescens</i> (Hook.f.)						
Zotov	+	m		+		a
<i>Hierochloa recurvata</i> Zotov				+		m
<i>Lachnagrostis</i> spp. (<i>L. richardii</i>)						
Zotov, <i>L. filiformis</i> (Forst.f.)						
Trin. var. <i>semiglabra</i>						
(Hack. in Cheesem.) Zotov						
and <i>L. "humillior"</i>				+		m
<i>Notodanthonia gracilis</i> (Hook.f.)						
Zotov				+		m
<i>N. setifolia</i> (Hook.f.) Zotov				m		a
<i>Poa colensoi</i> Hook.f.				m		a
Sedges and rushes						
<i>Carex coriacea</i>				l		l
<i>Eleocharis pusilla</i>						l
<i>Gahnia procera</i>		+				
<i>Juncus novae-zelandiae</i>					+	
<i>Luzula picta</i> var. <i>limosa</i>					+	
<i>L. picta</i> var. <i>picta</i>				+		m
<i>Schoenus pauciflorus</i>	+	a	m	a		a
<i>Ucinia clavata</i>			m	a	a	+
<i>U. divaricata</i>				+		+
<i>U. filiformis</i>	a	a	+	+	a	
<i>U. rupestris</i>			a	m	a	m

Monocotyledonous herbs

<i>Aporostylis bifolia</i>						+
<i>Astelia nervosa</i>	a	a	a	a	a	a
<i>Bulbinella gibbsii</i>						
var. <i>balanifera</i>						l
<i>Corybas triloba</i>				m	m	
<i>Earina autumnalis</i>			+			
<i>Luzuliaga parviflora</i>			+			
<i>Phormium cookianum</i>	m	m		m	+	a
<i>Prasophyllum colensoi</i>						+
<i>Pterostylis australis</i>				m	+	m

Dicotyledonous herbs

	1	2	3	G	F	C
<i>Acaena anserinifolia</i>					+	
var. <i>sericeinifens</i>						l
<i>Angelica montana</i>					+	m
<i>Anisotome haastii</i>					+	m
<i>Caltha novae-zelandiae</i>						+
<i>Cardamine debilis</i>					+	+
<i>Celmisia coriacea</i>						a
<i>C. du-rietzii</i>						+
<i>C. glandulosa</i>						l
<i>C. holosericea</i>					+	a
<i>C. verbascifolia</i>						m
<i>Colobanthus affinis</i>						+
<i>Cotula squalida</i> Hook.f.						
var. <i>mediana</i> Lloyd						l
<i>Craspedia robusta</i>					+	a
<i>Epilobium alsinoides</i> A. Cunn.						
subsp. <i>atriplicifolium</i> (A. Cunn.)					+	m
Raven et Engelhorn						
<i>E. brunnescens</i> (Ckn.)					m	
Raven et Engelhorn						
<i>E. glabellum</i>						+
<i>E. matthewsii</i>						l
<i>Euphrasia petriei</i>						a
<i>Forstera tenella</i>						m
<i>Gentiana montana</i>	+					m
<i>Geum parviflorum</i>					+	m
<i>Gnaphalium hookeri</i>					+	
<i>G. trinerve</i>					+	+
<i>Gunnera monoica</i>					+	m
<i>Helichrysum bellidioides</i>					+	a
<i>Hydrocotyle microphylla</i>						+
<i>H. novae-zelandiae</i>					+	a
<i>Lagenifera petiolata</i> Hook.f.						m
<i>Montia fontana</i>					+	+
<i>Nertera ciliata</i>						m
<i>N. depressa</i>					+	a
<i>N. dichondraefolia</i>					+	m
<i>Ourisia caespitosa</i>						+
<i>O. crosbyi</i>	+	a	m	m	a	+
<i>O. macrocarpa</i> var. <i>macrocarpa</i>					+	a
<i>Oxalis lactea</i>					+	m
<i>Plantago novae-zelandiae</i>						m
<i>Pratia angulata</i>			+	m		a
<i>Ranunculus hirtus</i>						m
<i>R. lyallii</i>						m
<i>Raoulia glabra</i>						+
<i>R. tenuicaulis</i>						+
<i>Schizaelema nitens</i>						m
<i>Senecio glomeratus</i>					+	+
<i>S. lyallii</i>					+	a
<i>S. scorzoneroideus</i>						m
<i>Viola cunninghamii</i>					m	m
<i>V. filicaulis</i>			a	a	a	+
<i>Wahlenbergia albomarginata</i>						m
Total	34	35	40	98	49	125

DISCUSSION

The forest communities of the upper Sinbad correspond to those described from elsewhere in Fiordland. Territories no. 1 and 2 are in silver beech forest floristically and structurally similar to that described by Wardle *et al.* (1971) from Northern Fiordland as silver beech - *Archeria* - *Senecio* forest (association

C1). Comparable forest has been described from Secretary Island (Class IVC of Wardle 1963, Wardle *et al.* 1970) and from Lake Shirley (community B3 of Given 1971). It seems to be a widespread forest type particularly of steep spurs near tree line. The taller silver beech forest at a lower altitude in territory no. 3 and west of the kakapo garden resembles that described by Wardle *et al.* (1971) as silver beech - *Coprosma* forest (association C2), by Wardle (1963) from Secretary Island (class IVB), and as community B₂ by Given (1971). Given (1972) notes that silver beech in this community at Lake Shirley is present virtually only as mature trees, a phenomenon that occurs also throughout the Sinbad study area.

There are no published descriptions of vegetation quite like that of the kakapo garden. Similar debris-fan sites have been described in detail from Lake Thomson (Mark *et al.* 1964), and these sites share several of the major woody species. But the kakapo garden is floristically much more complex (98 species compared with 47 in the two youngest debris fans at Lake Thomson). Among the herbs and ferns the difference is more striking (60 cf. 18 spp.). Its floristic complexity is much greater also than any of the communities described by Wardle *et al.* (1971), and it may owe this feature to the absence of browsing mammals.

Although many authors comment on the precipitous nature of Fiordland valley sides and heads, and on depressed tree lines at valley heads, where avalanche tracks abound, there are few accounts of the vegetation on such sites. Steep rocky sites tend to be vegetated with a mixture of plants from all the surrounding communities. Both Cockayne (1925) and Poole (1951) note how subalpine plants descend to low altitudes via waterfalls. Given's (1972) descriptions of three cliff sites near Lake Shirley show how variable their vegetation may be.

The subalpine scrub of rock ledges, faces, and water courses in the Sinbad contains a similar assemblage of plants to that listed from the head of the Harrison Valley by Wells *et al.* (1967), though a few species were absent from the Sinbad study area, e.g., *Phyllocladus alpinus* and *Podocarpus nivalis*.

This vegetation pattern would seem to offer kakapo a diversity of plant communities which contain a large assemblage of alpine, subalpine, and lowland species, all within a limited area. Occasional spurs covered in beech forest offer sites safe from avalanches, and ground which does not become waterlogged during heavy rain. Rockfalls offer places to roost, plus seral vegetation of different ages. Perhaps the plants growing on fertile rejuvenated soils of slip debris are able to provide more nutritive foods than

those comprising climax vegetation. Secondly, fast-growing seral species like *Fuchsia* and *Aristotelia* may produce greater quantities of edible fruit than slow-growing and long-lived species of climax vegetation.

Deer and opossums will greatly alter the vegetation of the Upper Sinbad if and when they spread to it. In the kakapo garden, for example, most of the dominant plants are palatable to deer (Wardle *et al.* 1971). These same palatable plants - especially species of *Pseudopanax*, *Coprosma*, and *Griselinia* - are major producers of fleshy fruits. In February, fleshy fruits were abundant in the kakapo garden and several species, particularly *Pseudopanax simplex*, *P. colensoi*, *Pseudowintera*, *Nertera*, and *Pratia* still held fruits in July 1975 (R. J. Nilsson, pers. comm.).

The three courtship territories do not seem to contain sufficient food, and all booming males observed (D. V. Merton, pers. comm.) fed very little during occupation of courtship territories. Even in the kakapo garden feeding sign was scarce, suggesting that the birds feed over a wide area, or that plants on which chewed fibres are left hanging, form a minor part of the diet, compared with fleshy fruits, grass seed, or herbaceous foliage on which feeding sign is less easy to detect.

It is probable that kakapo use several different plant communities, because their needs for food, overhead and underground shelter, and their social behaviour vary with the seasons and from one year to the next (kakapo are said to breed at from 1- to 3-year intervals (Henry 1903)). Thus the habitats described here cannot be assumed to furnish all the requirements of the birds. It must be stressed that the three territories belong to male birds: the habitat requirements of female kakapo are unknown. Furthermore, the Sinbad may not be typical kakapo habitat, but simply a fortuitous refuge. Nevertheless, it does share many features with kakapo-containing sites described by earlier workers, e.g., Williams (1956, 1960), Hall-Jones (1960a, b), Reischek (1885), and Henry (1903).

Considering the degree to which New Zealand vegetation has been modified by introduced browsing animals, it would be interesting to know how it developed in the presence of herbivorous birds, which are now mostly extinct. But these Sinbad Gully kakapo leave surprisingly little sign on the plants they use and seem to cause little modification of their habitat.

ACKNOWLEDGMENTS

I am grateful to Mr D. V. Merton and the Wildlife Service, Department of Internal Affairs, for the opportunity to visit Sinbad Gully and to the Fiordland National Park Board for permission to collect

plant specimens. For plant identifications I thank Miss B. H. Macmillan, Mr K. R. West, Dr E. Edgar, and Dr D. R. Given, and for comments and discussion, Dr I. A. E. Atkinson, Dr P. Wardle, Mr R. J. Nilsson, Mr D. V. Merton, and Mr K. G. Tustin.

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