Avian diversity in relation to logging in the coastal rainforests of British Columbia

Jean-Pierre L. Savard, Dale A. Seip
and Louise Waterhouse

Pacific and Yukon Region 2000
Canadian Wildlife Service
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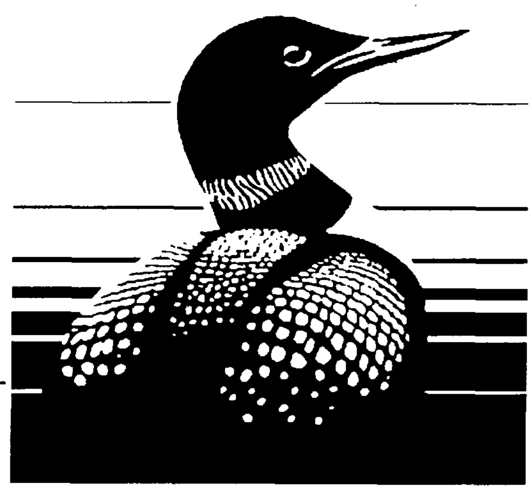

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1 Canadian Wildlife Service, 5421 Robertson Road, Delta, B.C. V4K 3N2
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2 Ministry of Forests, Prince George Forest Region, Forest Sciences Section, 1011 4th Avenue, Prince George, B.C. V2L 3H9

3 Ministry of Forests, Vancouver Forest Region, Forest Sciences Section, 2100 Labieux Road, Nanaimo, B.C. V9T 6E9

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Abstract

We characterized the abundance and diversity of bird communities in several seral stages of the coastal rainforests of British Columbia over the period 1989-1991 . First, we compared the avian communities of old growth (> 200 year old) and second growth (40-80 year old) forests to identify species associated with old growth forests. Second, we compared these avian communities with those found in deciduous forests and clearcuts, to evaluate and contrast how each forest type contributes to the avian diversity of the coastal rainforest.

We established study plots at three geographical locations along the coast: the Mainland South Coast near Vancouver, the Queen Charlotte Islands near Queen Charlotte City and Vancouver Island near Cowichan Lake. The diversity and abundance of birds was estimated with the point count method (396 points, 75 m radius, 12 min. duration) and the spot-mapping method (23 plots, 13-20 ha in size). Vegetation attributes were measured in a 30x30 m quadrate located at the center of each point count.

Species diversity, including richness and evenness of bird communities differed significantly between areas and between old growth and second growth forests. The breeding densities of 12 bird species varied between areas and those of 10 species varied with forest age. Results of point counts usually confirmed those obtained with spot-mapping. On the Queen Charlotte Islands, breeding bird densities were higher in old growth than in 40-80 year second growth forest (185 ± 27 pairs/40 ha *vs* 127 ± 2 pairs, $p = 0.05$). More species were detected (14.3 ± 1.7 *vs* 9.7 ± 0.3, $p = 0.05$), and diversity was higher (1.00 ± 0.02 *vs* 0.86 ± 0.01, $p = 0.05$) in the old growth, but evenness was similar (0.87 ± 0.02 *vs* 0.87 ± 0.01) between the two seral stages. On Vancouver Island, breeding bird densities (130.7 ± 2.0 *vs* 105.7 ± 4.6, $p = 0.05$), diversity

(1.06 ± 0.01 *vs* 0.94 ± 0.03, $p = 0.05$) and evenness (0.86 ± 0.00 *vs* 0.82 ± 0.01, $p = 0.05$) were higher in the old growth compared to the 40-80 year old forests. However, species richness did not differ between these seral stages (17.0 ± 0.6 *vs* 14.3 ± 1.7, $p = 0.11$). On the Mainland South Coast, breeding bird densities were quite variable within a given age class so that they did not differ significantly between age classes (OG = 175.1 ± 36.8 *vs* SG = 131.4 ± 12.0, $p = 0.56$). Evenness was significantly higher in old growth than in the 40-80 year old forest (0.87 ± 0.01 *vs* 0.82 ± 0.02, $p = 0.08$), but species diversity (1.01 ± 0.02 *vs* 0.93 ± 0.03, $p = 0.15$) and richness (14.5 ± 1.0 *vs* 13.8 ± 0.5, $p = 0.64$) did not differ.

Old growth bird communities of Vancouver Island were more similar to those of the Mainland South Coast than those of the Queen Charlotte Islands. Second growth (40 - 60 year old) bird communities were more similar to old growth communities on the Mainland South Coast than on either the Queen Charlotte Islands or Vancouver Island. Several species were consistently more abundant in old growth forest : Brown Creeper, Chestnut-backed Chickadee, Hairy Woodpecker, Marbled Murrelet, Pacific-slope Flycatcher, Red-breasted Nuthatch, Varied Thrush, Vaux's Swift and Winter Wren. Only two species, the Golden-crowned Kinglet and the Townsend's Warbler were more abundant in the second growth forest.

Avian communities of deciduous forest were more similar to those of old growth forest on the Queen Charlotte Islands (0.660) than on either Vancouver Island (0.391) or the Mainland South Coast (0.318-0.434). The young alder forest of the Queen Charlotte Islands supported fewer species than the older maple and alder forest of Vancouver Island and the Mainland South Coast. A few old growth species (Chestnut-backed chickadee, Pacific-slope Flycatcher, Winter Wren) were abundant in some deciduous stands, suggesting that these forests may help maintain populations of these species in intensively logged areas.

Old growth species were nearly absent from all clearcuts sampled. The low similarity between clearcuts and old growth avifauna indicates that at a regional scale, these seral stages support different avian communities.

We have identified several bird species that characterize the coastal old growth forests of British Columbia. The presence of some of these species in second growth and deciduous forests suggest, that with adequate management (i.e. changes in stand level management practices to enhance habitat structural diversity), younger forests could maintain larger populations of these species than they actually do. The second growth forest we studied had originated from old logging practices and it is likely that future second growth forests will be less suitable for old growth species as fewer residual trees are left by the modern logging techniques. Finally, we didn't investigate productivity and reproductive success of birds and these may differ between forest types for different species.

Résumé

Entre 1989 et 1991, nous avons caractérisé l'abondance et la diversité des communautés d'oiseaux de plusieurs stades de succession des forêts pluvieuses de la Colombie-Britannique. Dans un premier temps, nous comparons les communautés d'oiseaux des forêts anciennes (>200 ans) et des forêts de seconde venue (40-80 ans) afin d'identifier les espèces associées aux forêts anciennes. En second lieu, nous comparons ces communautés d'oiseaux avec celles que l'on retrouve dans les forêts décidues et dans les coupes à blanc (coupe totale) afin d'évaluer et de contraster comment chaque type de forêt contribue à la diversité aviaire de la forêt pluvieuse côtière.

Nous avons établi des places échantillons dans trois lieux géographiques le long de la côte : sur la terre ferme près de Vancouver, sur les îles de la Reine Charlotte près de la ville de Queen Charlotte et sur l'île de Vancouver près du lac de Cowichan. La diversité et l'abondance des oiseaux a été estimée avec la méthode des points d'écoute (396 points d'écoute, 75 m de rayon, 12 min. de durée) et avec la méthode des plans quadrillés (23 places échantillons, 13-20 ha en superficie). Les caractéristiques végétales ont été mesurées dans des places échantillons de 30 x 30 m localisées au centre de chacun des points d'écoute.

La diversité avienne, qui inclut à la fois la richesse en espèces et l'équitabilité des communautés d'oiseaux variait de façon significative entre les lieux d'études et entre les forêts anciennes et celles de succession. Les densités de couples nicheurs de 12 espèces d'oiseaux variaient entre les lieux géographiques et celles de 10 espèces selon l'âge des forêts. Les résultats des points d'écoute (densité relative) confirmaient habituellement les résultats obtenus

avec les plans quadrillés (densité absolue). Sur les îles des la Reine Charlotte, les densités d'oiseaux nicheurs étaient plus élevées dans les vieilles forêts que dans celles âgées seulement de 40-80 ans (185 ± 27 couples vs 127 ± 2 couples, p = 0.05), plus d'espèces ont été détectées dans les vieilles forêts (14.3 ± 1.7 vs 9.7± 0.3, p = 0.05), mais l'équitabilité des espèces était semblable dans les vieilles et jeunes forêts (0.87 ± 0.02 vs 0.87 ±0.01). Sur l'île de Vancouver, les densités d'oiseaux nicheurs (130.7 ± 2.0 vs 105.7 ± 4.6, p = 0.05), la diversité (1.06 ± 0.01 vs 0.94 ± 0.03, p = 0.05) et l'équitabilité (0.86 ± 0.0 vs 0.82 ± 0.01) étaient plus élevées dans les vieilles forêts que dans celles de 40-80 ans alors que la différence n'était pas significative pour la richesse en espèce (17.0 ± 0.06 vs 14.3 ± 1.7, p=0.11). Sur la terre ferme, les densités d'oiseaux nicheurs étaient très variables à l'intérieur d'un même âge de forêt de sorte qu'il n'y avait pas de différences entre les vieilles et jeunes forêts (175.1 ± 36.8 vs 131.4 ± 120, p = 0.56). L'équitabilité était plus élevée dans les vieilles forêts que dans les jeunes forêts (0.87 ± 0.01 vs 0.82 ± 0.02, p = 0.08) mais pas la diversité (1.01 ± 0.02 vs 0.93 ± 0.03, p = 0.15) ni la richesse en espèce (14.5 ± 1.0 vs 13.8 ± 0.05, p = 0.64).

Les communautés d'oiseaux des forêts anciennes ressemblaient plus à celles de la terre ferme qu'à celles des îles de la Reine Charlotte. Les communautés d'oiseaux des forêts de 40-60 ans ressemblaient plus à celles des vieilles forêts sur la terre ferme que sur les îles de la Reine Charlotte ou que sur l'île de Vancouver. Plusieurs espèces étaient de façon consistante plus abondantes dans les forêts anciennes : Grimpereau brun, Mésange à dos marron, Pic chevelu, Alque marbré, Moucherolle du Pacifique, Sitelle à poitrine rousse, Grive à collier, Martinet de Vaux et Troglodyte des forêts. Seulement deux espèces, le Roitelet à couronne dorée et la Paruline de Townsend étaient plus abondantes dans les jeunes forêts.

Les communautés d'oiseaux des forêts décidues ressemblaient plus à celles des forêts anciennes sur les îles de la Reine Charlotte (0.660) que sur l'île de Vancouver (0.391) ou sur la terre ferme (0.318 - 0.434). Les jeunes peuplements d'aulnes des îles de la Reine Charlotte supportaient moins d'espèces que les peuplements plus matures d'érables et d'aulnes de l'île de Vancouver et de la terre ferme. Quelques espèces associées aux forêts anciennes (Mésange à dos marron, Moucherolle du Pacifique, Troglodyte des forêts) étaient abondantes dans les peuplements décidus indiquant que ces peuplements peuvent aider à maintenir les populations de ces espèces dans les secteurs qui ont été coupés de façon intensive.

Les espèces associées aux forêts anciennes étaient absentes de toutes les coupes à blanc échantillonnées. La faible similitude entre les communautés aviennes des coupes à blanc et des forêts anciennes indique qu'à une échelle régionale, ces deux classes d'âge supportent des communautés d'oiseaux différentes.

Nous avons identifié plusieurs espèces d'oiseaux qui caractérisent les forêts anciennes de la côte de la Colombie-Britannique. La présence de certaines de ces espèces dans des forêts en régénération (40-80 ans) et dans les peuplements décidus suggère qu'avec un aménagement adéquat (i.e. modifications dans les aménagements au niveau du peuplement pour améliorer la diversité structurale du peuplement), les jeunes forêts pourraient supporter des nombres plus élevés de ces espèces qu'elles ne le font présentement. Les jeunes forêts (40-80 ans) que nous avons étudiées étaient le résultat de pratiques forestières moins mécanisées et il est probable que les jeunes forêts futures seront moins adéquates pour les espèces associées aux forêts anciennes puisque les pratiques forestières modernes laissent moins d'arbres résiduels sur le site. Finalement, nous n'avons pas étudié la productivité ni le succès de reproduction des oiseaux, qui peut différer entre les jeunes forêts et les forêts anciennes.

Contents

List of tables

List of figures

List of appendices

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Introduction

Interest in the preservation of biological diversity grew during the latter part of the 20th century (Soulé 1986, Wilson 1988, Hunter 1990, McNeely *et al.* 1990, Burton *et al.* 1992, Trauger and Hall 1992). However, as biological diversity cannot be maintained by the creation of reserves alone (Hunter 1990, Reid and Miller 1989, Salwasser 1990) we must adopt a strategy of sustainable development within semi-natural areas. This implies that the exploitation of a resource, in this case a forest, should not compromise the associated biological diversity. To adequately guide the exploitation of forests in a sustainable fashion we need to better understand the effect of forest exploitation on biological diversity.

The structure and composition of coastal old growth forests of the Pacific Northwest coast differ considerably from those of both natural and managed younger forests (Franklin *et al.* 1981, Franklin and Spies 1991, Spies and Franklin 1991, Spies 1991). Yet the following questions have not been addressed : (1) are the differences in the vegetation structure and composition of old growth, natural and regenerating forests reflected by their respective avifauna, and (2) are there old growth dependent bird species that will not be able to subsist in managed stands? The continued harvest of old growth forests and their conversion into 60-100 year sustained yield rotations stresses the urgent need to answer these questions. In British Columbia, the survival of two avian species, the Northern Spotted Owl (*Strix occidentalis caurina*) (Thomas *et al.* 1990) and the Marbled Murrelet (*Brachyramphus marmoratus*) (Rodway *et al.* 1993a, b, Carter and Morrison 1992) have been closely associated with old growth forests.

Recent studies in California, Oregon and Washington have revealed important differences in the bird communities of Douglas-fir old growth and younger forests (Carey *et al.* 1991, Gilbert and Allwine 1991, Manuwal 1991) confirming the results of earlier studies (Hagard 1960, Bowles

1963, Mannan and Meslow 1984, Manuwal *et al.* 1986). Similar studies are needed for the coastal forests of British Columbia.

Our main objective was to compare the avian communities of old growth (>200 year old) and second growth (40-80 year old) forests to identify species associated with old growth forests. In the coastal rainforests of British Columbia, a secondary objective was to compare these avian communities with those found in deciduous forests and clearcuts to evaluate and contrast how each forest type contributes to avian diversity.

Study area

We established study plots at three locations along the coast of BC : on the Mainland South Coast near the city of Vancouver, on the Queen Charlotte Islands near Queen Charlotte City and on Vancouver Island near Cowichan Lake (fig. 1). All three study sites are within the humid maritime and Highland Ecodivision of British Columbia (Demarchi *et al.* 1990). The climate is temperate and rainy with warm summers. The Queen Charlotte Islands sites are located in the Coast and Mountains Ecoprovince and in the Skidegate Plateau Ecosection characterized by forests of Western Hemlock, Sitka Spruce and Western Red Cedar. The Vancouver Island sites are located in the Georgia Depression Ecoprovince (Leeward Island Mountains Ecosection) and in the Coast and Mountains Ecoprovince (Windward Island Mountains Ecosection). The rainshadow of the Vancouver Island Range creates drier conditions than in the Queen Charlotte Islands or the Mainland South Coast sites. Forests of the Vancouver Island sites are dominated by Western Hemlock, Douglas-fir and Western Red Cedar. Riparian forests are dominated by Black Cottonwood, Red Alder and Bigleaf Maple.

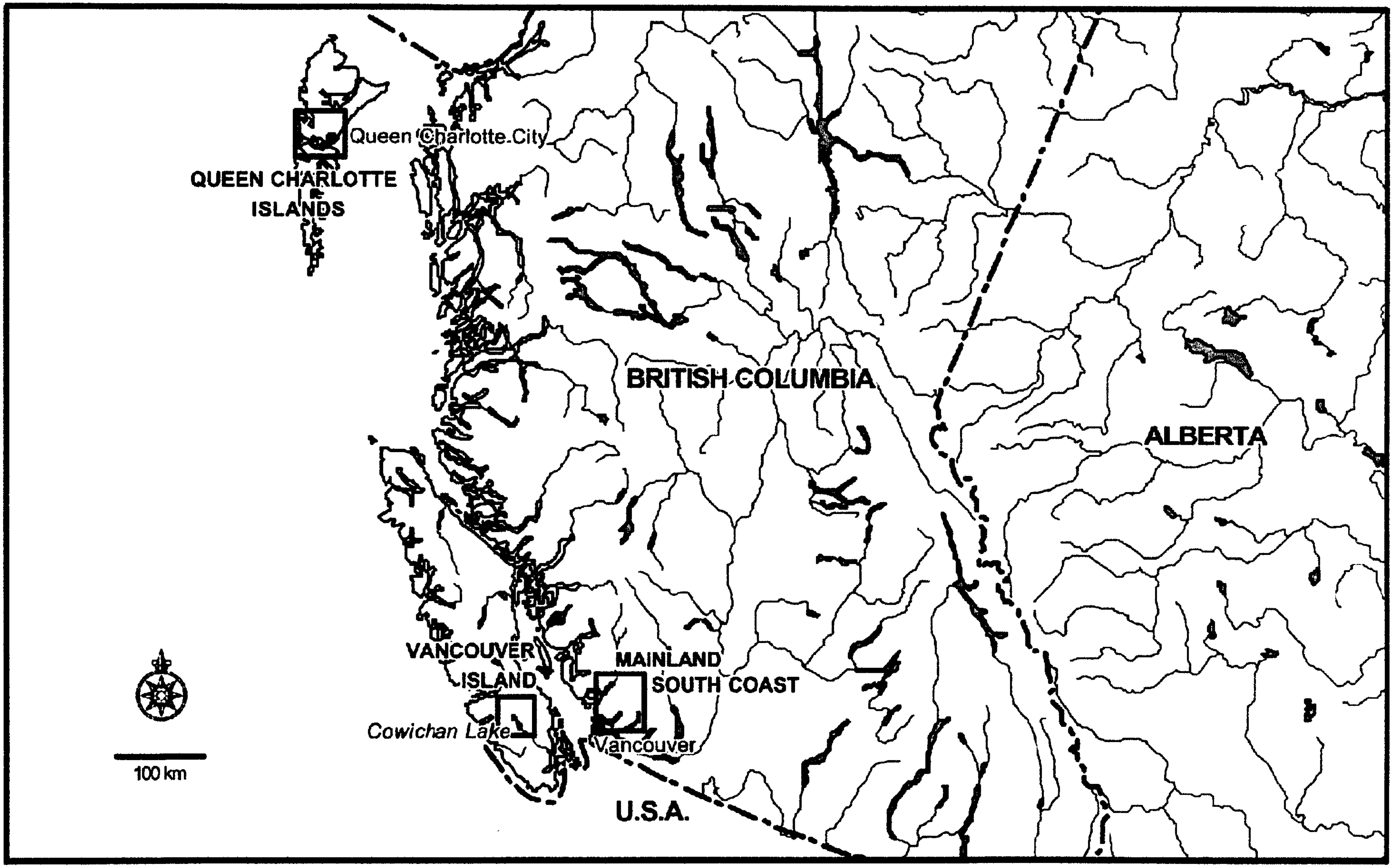

Figure 1. Location of study sites

The Mainland South Coast sites are located in two Ecoprovinces: the Georgia Depression (Georgia Lowland Ecosection) and the Coast and Mountains (Southern Pacific Ranges Ecosection). Fieldwork on the Queen Charlotte Islands and the Mainland South Coast was conducted in 1989 and 1990, and on Vancouver Island in 1991.

Methods

Bird survey techniques

Birds were sampled using two methods: point counts (Reynolds *et al.* 1980, Verner 1985), and spot-mapping (Williams 1936, Robins 1970). Point counts provide quick estimates of bird abundance and allow for a wider geographical coverage than spot-mapping. Spot-mapping is more labor-intensive but provides density estimates of territorial species. Point counts lasted 12 min. and all birds detected within a 75 m radius were recorded. Each point was surveyed 3-4 times between May 1st and July 1st. Points were at least 200 m apart to insure independence. Results are expressed as the number of detections per point with no correction factors for conspicuousness. We used, for each species, the average of the four counts at a given point as a measure of relative abundance at that point. However, for a few species in some locations the average was based on 3 counts only, because we excluded counts during which there was an obvious migration wave at the time of the count or when a species had not yet arrived at the time of the first count (e.g. Swainson's Thrush which is a late migrant). Counts were conducted between sunrise and 09:30h. Sampling effort varied between areas and forest stands (Table 1). Observer efforts were equally distributed between forest age classes.

Spot-mapping plots ranged between 10 and 20 ha in size. Each plot was gridded by markers located 50 m apart to facilitate mapping of the birds observed. A map plot survey usually lasted 3-4 hours. Surveys were usually completed by 09:00 h.. Each plot was surveyed 6-10 times between May 1st and July 1st. During each survey all birds detected were positioned on a gridded map. Composite maps of all surveys were generated for each species and territory boundaries were drawn. The total number of detections for a given species during a spot-mapping survey was tabulated to obtain an abundance index for non-territorial species. Each spot-mapping plot was also covered by four point counts. Results from spot-mapping produce density estimates of breeding birds. In spot mapping, all territorial birds are assumed to be breeding birds, a realistic assumption (Bibby *et al* 1992).

Vegetation sampling techniques

Individual plots of 900 m^2 (30 x 30 m) were used to measure vegetation characteristics. Plots were centered at each bird census point. For each plot, we estimated the percent coverage of all understory herbaceous and woody plant species as well as bryophytes. All living trees were counted, identified to species and the diameter at breast height (dbh) taken. Trees <10 cm dbh were recorded as saplings. Snags (dead standing trees >2 m height) were recorded by dbh and species and classified into one of four decay categories (fresh, slightly decayed, moderately decayed but hard, well decayed and soft). The first three categories were regrouped as hard snags and the fourth one as soft snags. Logs on the ground were sampled using the triangular transect method (Trowbridge *et al.* 1986). The species, diameter and decay category were recorded for all logs intercepted along the edges of a 90 m equilateral triangle located at the center of the study plot. In spot-mapping plots, the characteristics of the four point counts were averaged.

Statistical Analysis

The sampling design was constrained by forest patch size and accessibility factors. Points were distributed as groups of 3 to 6 per stand (cluster). The analyses were performed using stands as

Table 1 - Distribution of sampling effort among areas and forest types.

Forest types	Queen Charlotte Island			Vancouver Island			Mainland South Coast		
	Mapping plots	Points[1]	Clusters[2]	Mapping plots	Points	Clusters	Mapping plots	Points	Clusters
Old growth	3	29	7	3	31	7	4	48	13
40-60 year old	2	20	4	2	31	7	1	22	7
60-80 year old	1	4	1	1	21	7	3	26	5
Deciduous		18	4		21	5	3	61	14
Clearcuts	2	20	5		21	5	2	23	7

[1] Total number of point counts

[2] Number of clusters (stands) into which those points were grouped.

experimental units. For diversity and evenness, we used the Shannon-Weiner index (Magurran 1988). Coefficient of variation (cv) was used to portray variability. We used the Morisita Horn index as a measure of similarity between communities (Horn 1966, Krebs 1989). We used $P<0.1$ as the significance level.

Results

Spot-mapping results indicated that species richness (number of species), diversity and evenness differed significantly between areas and between old growth and second growth (40-80 years) forests (Table 2). Breeding bird densities (results of spot-mapping for all birds combined) differed between forest age but not between areas. This pattern was similar for all three areas, with higher breeding densities in old growth forest. The breeding densities of 12 species varied between areas and those of 10 species varied with forest age. However for five species, interactions between area and forest age were significant.

Point counts were located in the same three geographical areas but comparisons were limited to old growth and 40-60 year old forests (because of a lack of 60-80 year old forests in the Queen Charlotte Islands). Species evenness and diversity were expressed on a per point basis. Evenness did not differ between areas or between forest ages, but there were significant differences for both comparisons using diversity (Table 3). The relative abundance of four species varied significantly between areas and that of six species varied significantly with forest age.

However, for eight species, interactions between area and forest age were also significant indicating different patterns of abundance in different areas.

Table 2 - Two-way analysis of variance of spot-mapping results based on ranked values. Three areas (Queen Charlotte Islands, Vancouver Island and Mainland South Coast) and two forest ages (old growth and 40-80 year old forests) are compared. Probability values are presented.

Species	AREA (n = 3) P	AGE (n = 2) P	AREA*AGE P
American Robin	0.00**	0.36	0.30
Blue Grouse	0.01**	0.27	0.96
Brown Creeper	0.68	0.00**	0.97
Chestnut-backed Chickadee	0.06*	0.01**	0.40
Dark-eyed Junco	0.19	0.39	0.12
Golden-crowned Kinglet	0.01**	0.78	0.00**
Hairy Woodpecker	0.66	0.00**	0.53
Hermit Thrush	0.01**	0.16	0.98
Pacific-slope Flycatcher	0.06*	0.06*	0.08*
Red-breasted Nuthatch	0.32	0.00**	0.07*
Red-breasted Sapsucker	0.00**	0.00**	0.04**
Rufous Hummingbird	0.16	0.04**	0.34
Steller's Jay	0.00**	0.33	0.29
Swainson's Thrush	0.00**	0.11	0.63
Townsend's Warbler	0.06*	0.02**	0.06*
Varied Thrush	0.01**	0.00**	0.39
Winter Wren	0.00**	0.04**	0.39
Total density	0.14	0.01**	0.38
Number of species	0.02**	0.01**	0.22
Diversity	0.02**	0.00**	0.47
Evenness	0.09**	0.03**	0.13

* significant at 0.10
** significant at 0.05

Table 3 - Two-way analysis of variance of point count results based on ranked values. Three areas (Queen Charlotte Islands, Vancouver Island and Mainland South Coast) and two forest ages (old growth and 40-60 year old forests) are compared. Probability values are presented.

Species	AREA (n = 3) P	AGE (n = 2) P	AREA*AGE P
American Robin	*0.01	0.15	0.62
Blue Grouse	0.51	0.21	0.18
Brown Creeper	0.21	*0.05	0.51
Chestnut-backed Chickadee	0.22	0.16	0.69
Common Raven	0.15	0.22	0.12
Dark-eyed Junco	0.50	0.92	*0.02
Evening Grosbeak	*0.02	*0.03	0.87
Golden-crowned Kinglet	0.28	*0.07	0.52
Hairy Woodpecker	0.38	*0.02	0.74
Hermit Thrush	*0.04	0.25	0.11
Marbled Murrelet	0.43	0.30	*0.00
Northern Flicker	0.15	0.15	0.47
Pine Siskin	0.74	0.93	*0.00
Pacific Slope Flycatcher	0.88	0.12	*0.02
Red-breasted Nuthatch	0.51	0.13	0.11
Red-breasted Sapsucker	0.24	0.22	*0.00
Red Crossbill	0.54	0.59	*0.01
Steller's Jay	0.15	0.40	0.69
Swainson's Thrush	0.75	0.92	0.12
Townsend's Warbler	0.55	0.24	*0.00
Varied Thrush	*0.09	*0.07	*0.06
Wilson Warbler	0.46	0.31	0.52
Winter Wren	0.24	*0.02	0.67
Evenness	0.13	0.60	*0.10
Diversity	*0.00	*0.00	0.31

Anova clusters: means number of birds/station calculated for each cluster and then averaged.

* : $P < 0.1$

Bird communities of old growth and second growth (40-80 year old) forests

Bird communities of the Queen Charlotte Islands

Higher densities of breeding birds were found in old growth (185 ± 27 pairs/ 40 ha) than in 40-80 year old forests (127 ± 2 pairs/40 ha) (Table 4). More breeding species were found in old growth (14.3 ± 1.7 *vs* 9.7 ± 0.3) and diversity was also higher (1.00 ± 0.02 *vs* 0.86 ± 0.01). Evenness, which measures how similar (even) the abundance of species is in a given area (Magurran 1998), was similar in both forest types. Brown Creepers, Hairy Woodpeckers, Pacific-slope Flycatchers, Red-breasted Nuthatches, Red-breasted Sapsuckers and Varied Thrushes were more numerous in old growth stands whereas Golden-crowned Kinglets and Townsend's Warblers were most abundant in 40-80 year old stands. Chestnut-backed Chickadees and Hermit Thrushes were equally numerous in both forest types. Analyses based on the mean number of detections also indicated that species richness, diversity and evenness were higher in old growth stands (Table 5). Marbled Murrelets were observed more frequently in old growth forests. Breeding bird communities of old growth stands were slightly more similar (0.962, cv = 1%) than those of 40-60 year old stands (0.940, cv = 1%). Communities differed more between age classes (0.790, cv = 8%, Table 6) than within age classes (0.940, cv = 1%, Table 6).

Point count results revealed a greater abundance of Brown Creepers, Hairy Woodpeckers, Pacific-slope Flycatchers, Red-breasted Nuthatches and Red-breasted Sapsuckers in old growth forests and of Golden-crowned Kinglets and Townsend's Warblers in 40-80 year old forests (Table 7). Two results differed from the spot-mapping results. First, the Varied Thrush was not detected significantly more often in old growth. Point count results for this species were variable (cv of 69% and 79% in old growth and second growth).

Table 4 - Breeding bird densities (pairs/40 ha) in old growth and second growth forests of the Queen Charlotte Islands (spot-mapping 1990).

	OLD GROWTH			SECOND GROWTH			OLD GROWTH		40-80 YEARS		
Plot	QCHC	QCYA-1	QCYA-2	QCJC	QCSK-1	QCSK-2					
Area (Ha)	14.0	16.8	17.5	17.5	17.5	17.5	Mean	S.E.	Mean	S.E.	P
American Robin	1.4	0.0	0.0	0.0	0.0	0.0	0.5 ±	0.5	0.0 ±	0.0	0.31
Blue Grouse	0.0	2.4	0.0	0.0	0.0	0.0	0.8 ±	0.8	0.0 ±	0.0	0.32
Brown Creeper	8.6	11.9	8.0	6.9	5.7	0.0	9.5 ±	1.2	4.2 ±	2.1	0.05*
Chestnut-backed Chickadee	14.3	7.2	6.9	5.7	12.6	5.7	9.4 ±	2.4	8.0 ±	2.3	0.27
Common Raven	2.9	0.0	0.0	0.0	0.0	0.0	1.0 ±	1.0	0.0 ±	0.0	
Dark-eyed Junco	1.4	0.0	0.0	0.0	0.0	8.0	0.5 ±	0.5	2.7 ±	2.7	0.80
Fox Sparrow	0.0	2.4	0.0	0.0	0.0	0.0	0.8 ±	0.8	0.0 ±	0.0	
Golden-crowned Kinglet	12.9	11.9	12.6	17.1	17.1	14.9	12.5 ±	0.3	16.4 ±	0.8	0.05*
Hairy Woodpecker	2.9	3.6	2.3	1.1	0.0	0.0	2.9 ±	0.4	0.4 ±	0.4	0.05*
Hermit Thrush	17.1	9.6	6.9	0.0	10.3	11.4	11.2 ±	3.1	7.2 ±	3.6	0.83
Northern Flicker	0.0	1.2	0.0	0.0	2.3	0.0	0.4 ±	0.4	0.8 ±	0.8	
Pacific-slope Flycatcher	21.4	25.1	21.7	10.3	8.0	11.4	22.7 ±	1.2	9.9 ±	1.0	0.05*
Red-breasted Nuthatch	4.3	7.2	1.1	0.0	0.0	0.0	4.2 ±	1.7	0.0 ±	0.0	0.04*
Red-breasted Sapsucker	28.6	35.8	20.6	12.6	2.3	2.3	28.3 ±	4.4	5.7 ±	3.4	0.05*
Rufous Hummingbird	0.0	2.4	0.0	0.0	0.0	0.0	0.8 ±	0.8	0.0 ±	0.0	0.32
Steller's Jay	0.0	1.2	0.0	0.0	0.0	0.0	0.4 ±	0.4	0.0 ±	0.0	0.32
Swainson's Thrush	1.4	0.0	0.0	0.0	0.0	1.1	0.5 ±	0.5	0.4 ±	0.4	0.80
Townsend's Warbler	34.3	25.1	16.0	37.7	44.6	35.4	25.1 ±	5.3	39.2 ±	2.7	0.05*
Tree Swallow	2.9	0.0	0.0	0.0	0.0	0.0	1.0 ±	1.0	0.0 ±	0.0	
Varied Thrush	31.4	21.5	16.0	12.6	13.7	12.6	23.0 ±	4.5	13.0 ±	0.4	0.05*
Winter Wen	31.4	38.2	20.6	20.6	14.9	21.7	30.1 ±	5.1	19.0 ±	2.1	0.18
Total	217.1	206.6	132.6	124.6	131.4	124.6	185.4 ±	26.6	126.9 ±	2.3	0.05*
Number of Species	16	16	11	9	10	10	14.3 ±	1.7	9.7 ±	0.3	0.05*
Diversity	1.03	1.02	0.95	0.84	0.86	0.88	1.00 ±	0.02	0.86 ±	0.01	0.05*
Evenness	0.85	0.85	0.92	0.89	0.86	0.88	0.87 ±	0.02	0.87 ±	0.01	0.51

Table 5 - Mean number of detections (± SE) during the spot-mapping surveys (averaged across plots (n=3-4) from 6 to 10 surveys per plot).

	Queen Charlotte Island		Vancouver Island		Mainland South Coast	
	O.G.	**40-80y**	**O.G.**	**40-80y**	**O.G.**	**60-80y**
Number of plots	**3**	**3**	**3**	**3**	**4**	**4**
Marbled Murrelet	1.2 ± 0.6	*[1]	2.2 ± 0.7	0.4 ± 0.3	0.4 ± 0.3	
Vaux's Swift			1.0 ± 0.4	*	2.8 ± 1.2	0.2 ± 0.2*
Red Crossbill	0.3 ± 0.2	0.4 ± 0.2	4.5 ± 1.8	1.3 ± 0.8	0.5 ± 0.3	3.8 ± 1.5*
Pine Siskin	1.3 ± 1.0	1.2 ± 0.3	1.7 ± 0.5	0.6 ± 0.4	0.2 ± 0.1	0.6 ± 0.4
Total detections	85.3 ± 7.4	87.7 ± 4.4	69.1 ± 1.0	61.9 ± 6.5	64.6 ± 19.8	59.6 ± 14.8
Number of species	13.7 ± 0.7	10.9 ± 0.5*	16.2 ± 0.6	14.5 ± 1.2	13.2 ± 1.3	12.9 ± 0.7
Diversity	0.99 ± 0.02	0.84 ± 0.01*	1.06 ± 0.01	0.99 ± 0.03*	0.97 ± 0.02	0.93 ± 0.03
Evenness	0.87 ± 0.00	0.82 ± 0.02*	0.88 ± 0.01	0.86 ± 0.00*	0.88 ± 0.02	0.84 ± 0.03
Cumulative Number of species[2]	27	22	40	40	28	32
Total No. of Surveys[3]	21	18	28	27	36	36

[1] * Difference between age classes significant at $P < 0.10$
[2] Raptors excluded
[3] Given to help evaluate the cumulative number of species

Table 6 - Average similarity indices (Morisita-Horn) within and between old growth and second growth forest stands (based on spot-mapping plots).

Forest Type	Old growth			Second growth		
Area	Q.C.I.[1]	V.I.	M.S.C.	Q.C.I.	V.I.	M.S.C
Forest Age (Years)	> 200	> 200	> 200	40-80	40-80	60-80
Old growth						
Q.C.I.	0.962 (1)[2]	0.749(6)	0.835(3)	0.790 (8)	0.672 (9)	0.745(5)
V.I.		0.811(17)	0.854(4)	0.634(29)	0.630(31)	0.809(6)
M.S.C.			0.949(2)	0.783 (6)	0.754 (7)	0.914(4)
Second growth						
Q.C.I.				0.940 (1)	0.880 (2)	0.725(9)
V.I.					0.889 (5)	0.748(8)
M.S.C.						0.936(3)

[1] Q.C.I. = Queen Charlotte Islands, V.I. = Vancouver Island, M.S.C. = Mainland South Coast.

Table 7 - Mean number of birds detected per station[1] in the Queen Charlotte Islands in relation to forest age. (point counts 1990).

Forest type	Old growth			40-80 years			Anova(P)
	Mean	±	S.E.	Mean	±	S.E.	
No. of clusters[2]	7			5			
American Robin	0.03	±	0.02	0.07	±	0.07	0.92
Blue Grouse	0.14	±	0.06	0.01	±	0.01	0.13
Brown Creeper	0.25	±	0.05	0.06	±	0.04	0.02*
Chestnut-backed Chickadee	0.37	±	0.07	0.33	±	0.11	0.82
Common Raven	0.19	±	0.07	0.11	±	0.09	0.17
Dark-eyed Junco	0.04	±	0.03	0.03	±	0.03	0.77
Fox Sparrow	0.05	±	0.04	0.16	±	0.10	0.47
Golden-crowned Kinglet	0.82	±	0.04	0.98	±	0.10	0.09*
Hairy Woodpecker	0.11	±	0.04	0.02	±	0.02	0.06*
Hermit Thrush	0.46	±	0.13	0.66	±	0.15	0.35
Marbled Murrelet	0.05	±	0.03				
Northern Flicker	0.10	±	0.05	0.03	±	0.03	0.30
Pine Grosbeak	0.12	±	0.06	0.06	±	0.04	0.67
Pacific-slope Flycatcher	1.44	±	0.14	0.42	±	0.07	0.00*
Pine Siskin	0.08	±	0.04	0.14	±	0.06	0.37
Red-breasted Nuthatch	0.15	±	0.04				0.01*
Red Crossbill	0.15	±	0.08	0.02	±	0.02	0.19
Red-breasted Sapsucker	1.63	±	0.23	0.22	±	0.18	0.00*
Song Sparrow				0.02	±	0.02	0.19
Steller's Jay	0.01	±	0.01	0.01	±	0.01	0.91
Swainson's Thrush	0.08	±	0.05	0.35	±	0.23	0.47
Townsend's Warbler	0.93	±	0.29	3.56	±	0.36	0.00*
Varied Thrush	1.45	±	0.38	1.05	±	0.36	0.49
Wilson's Warbler	0.07	±	0.06				
Winter Wren	1.41	±	0.18	0.79	±	0.07	0.00*
Total	10.12			9.09			-
Number of species	24			22			-
Diversity	1.09			0.92			0.00
Evenness	0.790			0.685			0.05*

1 mean number of birds/station calculated for each cluster and then averaged.

2 clusters have 4-5 stations each.

* P <0.1

This greater variability may be due in part to the difficulty in estimating the distance of singing Varied Thrushes. Second, the Winter Wren was detected significantly more often in old growth than in the second growth (Table 7) but the difference in breeding densities was not significantly different (Table 4). However, the tendency was similar. Similarity between old growth and 40-80 year old forests in terms of bird community was greater with spot-mapping that point count results (0.79 *vs* 0.59, Morisita-Horn Index).

Bird communities of Vancouver Island

Higher densities of breeding birds were found in old growth (130.7 ± 2.0) than in 40-80 year old forests (105.7 ± 4.6). Species diversity and evenness were also higher in old growth forests but not species richness (P » 0.11) (Table 8). Chestnut-backed Chickadees, Brown Creepers and Red-breasted Nuthatches were more numerous in old growth stands whereas Townsend's Warblers and Dark-eyed Juncos were more abundant in 40-80 year old stands. For non-territorial species, analysis based on the mean number of detection during the spot-mapping censuses also indicated a greater diversity and evenness in old growth forest (Table 5). Vaux's Swifts were detected more frequently in old growth stands (Table 5). Breeding bird communities of 40-80 year old stands were more similar and less variable between stands (0.889, cv = 5%) than those of old growth stands (0.811, cv = 17%, Table 6).

Point count results for 60-80 year old growth stands showed a greater abundance of Red-breasted Nuthatches in old growth and of Townsend's Warblers in 60-80 year old forests (Table 9). Other trends which were significant in spot-mapping, although not significant in point count results, were all in the same direction.

An additional age class (40-60 year old forest) was also sampled with point counts. The relative abundance of 16 species differed significantly between the three age classes (Table 9). Seven species (Marbled Murrelet, Pacific-slope Flycatcher, Pine Siskin, Red-breasted Nuthatch, Red Crossbill, Varied Thrush, Vaux's Swift) were most numerous in old growth stands. Four species (Golden-crowned Kinglet, Hammond's Flycatcher, Townsend's Warbler, Hutton's Vireo) were least numerous or absent in old growth stands. Brown Creepers, Chestnut-backed Chickadees and Hairy Woodpeckers were more abundant in old growth than in 40-60 year old stands and one species, the Dark-eyed Junco was less abundant. The Hermit and Swainsons' Thrushes were more abundant in old growth than in 60-80 year old stands (Table 9). Only one species, the Hutton's Vireo, was most numerous in 40-60 year old stands.

Similarity indices within old growth and within second growth stands of Vancouver Island were lower and more variable than on the Queen Charlotte Islands (Tables 6-10) indicating a greater heterogeneity among plots on Vancouver Island. Bird communities of 40-80 year old stands were more similar (0.889) than those of old growth (0.811). Similarity indices between second growth and old growth plots averaged lower (0.630) on Vancouver Island than on the Queen Charlotte Islands (0.790) (Tables 6-10).

Bird communities of the Mainland South Coast

Comparisons of old growth and 60-80 year old stands indicated a great degree of variability in breeding bird densities within each forest ages. Evenness was significantly higher in old growth stands than in 60-80 year old ones but species richness and diversity were not (Table 11). Six species, the Red-breasted Sapsucker, Hairy Woodpecker, Chestnut-backed Chickadee, Brown Creeper, Varied Thrush and Golden-crowned Kinglet were more numerous in old growth stands. No species were more abundant in 60-80 year old stands than in old growth.

Table 8 - Breeding bird densities (pairs/40 ha) in old growth and second growth forests of Vancouver Island (spot-mapping 1991).

Plot	GAOL D1	MYOL D2	MEOL D3	CESE C1	RESE C2	SHSE C3	OLD GROWTH			40-80 YEARS			P
Plot size (ha)	17.5	16.1	17.5	17	17.5	17.5	Mean	±	S.E.	Mean	±	S.E.	
American Robin	9.14	7.45	6.86	5.88	9.14	10.29	7.8	±	0.7	8.4	±	1.3	0.66
Band-tailed Pigeon	2.29	0.00	0.00	2.35	1.14	0.00	0.8	±	0.8	1.2	±	0.7	
Blue Grouse	3.43	1.24	1.14	1.18	0.00	0.00	1.9	±	0.7	0.4	±	0.4	0.12
Brown Creeper	9.14	9.94	6.86	1.18	5.71	2.29	8.6	±	0.9	3.1	±	1.4	0.05*
Chestnut-backed Chickadee	10.29	7.45	11.43	2.35	0.00	4.57	9.7	±	1.2	2.3	±	1.3	0.05*
Dark-eyed Junco	1.14	3.73	0.00	8.24	4.57	4.57	1.6	±	1.1	5.8	±	1.2	0.05*
Golden-crowned Kinglet	9.14	8.70	10.29	8.24	10.29	13.71	9.4	±	0.5	10.7	±	1.6	0.66
Gray Jay	1.14	1.24	0.00	0.00	0.00	0.00	0.8	±	0.4	0.0	±	0.0	
Hairy Woodpecker	4.57	1.24	2.29	1.18	2.29	0.00	2.7	±	1.0	1.2	±	0.7	0.18
Hammond's Flycatcher	0.00	0.00	0.00	0.00	0.00	9.14	0.0	±	0.0	3.0	±	3.0	
Hermit Thrush	4.57	0.00	4.57	0.00	0.00	0.00	3.0	±	1.5	0.0	±	0.0	0.11
Hutton's Vireo	0.00	0.00	0.00	5.88	1.14	1.14	0.0	±	0.0	2.7	±	1.6	
MacGillivray's Warbler	0.00	0.00	0.00	0.00	0.00	2.29	0.0	±	0.0	0.8	±	0.8	
Olive-sided Flycatcher	0.00	0.00	2.29	0.00	0.00	0.00	0.8	±	0.8	0.0	±	0.0	
Pacific-slope Flycatcher	26.29	18.63	19.43	3.53	20.57	3.43	21.4	±	2.4	9.2	±	5.7	0.28
Pileated Woodpecker	0.00	2.48	1.14	0.00	0.00	0.00	1.2	±	0.7	0.0	±	0.0	
Red-breasted Nuthatch	12.57	4.97	13.71	0.00	0.00	0.00	10.4	±	2.7	0.0	±	0.0	0.04*
Red-breasted Sapsucker	0.00	0.00	0.00	0.00	0.00	0.00	0.0	±	0.0	0.0	±	0.0	
Ruffed Grouse	0.00	0.00	0.00	2.35	0.00	0.00	0.0	±	0.0	0.8	±	0.8	
Rufous Hummingbird	0.00	3.73	4.57	0.00	0.00	2.29	2.8	±	1.4	0.8	±	0.8	0.25
Song Sparrow	0.00	0.00	2.29	0.00	0.00	0.00	0.8	±	0.8	0.0	±	0.0	
Steller's Jay	1.14	1.24	0.00	2.35	0.00	1.14	0.8	±	0.4	1.2	±	0.7	0.82
Swainson's Thrush	2.29	2.48	2.29	2.35	0.00	1.14	2.4	±	0.1	1.2	±	0.7	0.27
Townsends Warbler	0.00	28.57	1.14	30.59	32.00	30.86	9.9	±	9.3	31.1	±	0.4	0.05*
Tree Swallow	0.00	0.00	1.14	0.00	0.00	0.00	0.4	±	0.4	0.0	±	0.0	
Varied Thrush	9.14	11.18	11.43	3.53	10.29	1.14	10.6	±	0.7	5.0	±	2.7	0.13
Western Tanager	0.00	0.00	0.00	0.00	0.00	1.14	0.0	±	0.0	0.4	±	0.4	
Winter Wren	27.43	17.39	24.00	15.29	13.71	20.57	22.9	±	2.9	16.5	±	2.1	0.13
Total Territories	133.71	131.68	126.86	96.47	110.86	109.71	130.7		2.0	105.7		4.6	0.05*
No. of Species	16	17	18	16	11	16	17.0		0.6	14.3		1.7	0.11
Diversity	1.04	1.06	1.08	0.99	0.88	0.96	1.06		0.01	0.94		0.03	0.05*
Evenness	0.86	0.86	0.86	0.82	0.85	0.80	0.86		0.00	0.82		0.01	0.05*

Table 9 - Mean (± S.E.) number of birds detected per station on Vancouver Island study area, in relation to forest age (point counts 1991).

Forest Age	Old growth(1)	60-80 years(2)	40-60 years(3)	Anova(P)[1]	Duncan Test	
Number of clusters (no. of points)	7(31)	7(21)	7(31)	Clusters		
American Robin	0.59 ± 0.11	1.16 ± 0.17	0.83 ± 0.13	0.09*	2,3=A	3,1=B[2]
Band-tailed Pigeon	0.01 ± 0.01		0.03 ± 0.02	0.35		
Black-headed Grosbeak	0.01 ± 0.01			-		
Blue Grouse	0.01 ± 0.01	0.03 ± 0.02		0.31		
Brown Creeper	0.50 ± 0.16	0.31 ± 0.09	0.19 ± 0.07	0.21	1,2=A	2,3=B
Chestnut-backed Chickadee	0.64 ± 0.11	0.51 ± 0.11	0.30 ± 0.05	0.06*	1,2=A	2,3=B
Common Raven	0.04 ± 0.02	0.01 ± 0.01		0.31		
Dark-eyed Junco	0.05 ± 0.03	0.20 ± 0.07	0.34 ± 0.09	0.09*	3,2=A	2,1=B
Evening Grosbeak		0.03 ± 0.02	0.03 ± 0.01	0.21		
Golden-crowned Kinglet	0.55 ± 0.07	0.92 ± 0.09	0.89 ± 0.09	0.01*	2,3=A	1=B
Gray Jay	0.02 ± 0.02	0.04 ± 0.04		-		
Hairy Woodpecker	0.11 ± 0.04	0.10 ± 0.04	0.02 ± 0.02	0.15	1,2=A	3,2=B
Hammond's Flycatcher	0.01 ± 0.01	0.39 ± 0.17	0.09 ± 0.03	0.01*	2,3=A	1=B
Hermit Thrush	0.08 ± 0.04		0.03 ± 0.02	0.06*	1,3=A	3,2=B
Hutton's Vireo		0.02 ± 0.02	0.08 ± 0.03	0.01*	3=A	1,2=B
MacGillivray's Warbler		0.04 ± 0.03		-		
Marbled Murrelet	0.29 ± 0.09	0.01 ± 0.01	0.01 ± 0.01	0.00*	1=A	2,3=B
Northern Flicker	0.03 ± 0.02		0.03 ± 0.02	0.33		
Olive-sided Flycatcher	0.01 ± 0.01		0.01 ± 0.01	0.61		
Orange-crowned Warbler	0.01 ± 0.01		0.01 ± 0.01	-		
Pacific-slope Flycatcher	1.35 ± 0.15	0.63 ± 0.20	0.61 ± 0.18	0.00*	1=A	2,3=B
Pileated Woodpecker	0.05 ± 0.02	0.09 ± 0.05	0.02 ± 0.02	0.36		
Pine Siskin	0.53 ± 0.16	0.07 ± 0.05	0.19 ± 0.09	0.01*	1=A	2,3=B
Purple Finch		0.01 ± 0.01		-		
Red-breasted Nuthatch	0.35 ± 0.09	0.16 ± 0.09	0.03 ± 0.02	0.02*	1=A	2,3=B
Red Crossbill	0.92 ± 0.53	0.15 ± 0.04	0.11 ± 0.04	0.00*	1=A	2,3=B
Red-breasted Sapsucker		0.01 ± 0.01		-		
Rufous Hummingbird	0.05 ± 0.04	0.10 ± 0.03	0.06 ± 0.03	-		
Rufous-sided Towhee			0.01 ± 0.01	-		
Song Sparrow	0.01 ± 0.01		0.01 ± 0.01	-		

Table 9 - Mean (± S.E.) number of birds detected per station on Vancouver Island study area, in relation to forest age (point counts 1991). (Continued)

Forest Age	Old growth(1)		60-80 years(2)		40-60 years(3)				
Number of clusters (no. of points)	7(31)		7(21)		7(31)		Anova(P)[1] Clusters	Duncan Test	
Steller's Jay	0.06 ±	0.03	0.08 ±	0.04	0.10 ±	0.06	1.00		
Swainson's Thrush	0.37 ±	0.12	0.09 ±	0.04	0.20 ±	0.11	0.17	1,3=A	3,2=B
Townsend's Warbler	0.21 ±	0.18	1.72 ±	0.18	1.85 ±	0.14	0.00*	1=B	2,3=A
Varied Thrush	0.63 ±	0.07	0.24 ±	0.07	0.35 ±	0.11	0.02*	1=A	2,3=B
Vaux's Swift	0.03 ±	0.02					0.03*	1=A	2,3=B
Warbling Vireo	0.02 ±	0.02	0.05 ±	0.04	0.24 ±	0.12	0.15		
Western Tanager	0.01 ±	0.01	0.01 ±	0.01	0.03 ±	0.02	0.70		
Western Wood Pewee	0.01 ±	0.01	0.01 ±	0.01			-		
Wilson's Warbler	0.01 ±	0.01	0.01 ±	0.01			0.61		
Winter Wren	1.32 ±	0.16	1.18 ±	0.17	0.55 ±	0.10	0.00*	3=B	1,2=A
Yellow-rumped Warbler			0.01 ±	0.01			-		
Total	8.87		8.39		7.27		-		
Number of species	34		32		30		-		
Diversity	1.17		1.12		1.12		0.04*	1=A	2,3=B
Evenness	0.77		0.74		0.76		0.24		

1 Anova clusters: mean number of birds/station calculated for each cluster and then averaged.

2 Age classes with different letters differ significantly between them.

* P <0.10

Analysis based on the mean number of detections during the spot-mapping surveys indicated a greater abundance of Vaux's Swifts in old growth stands than in younger stands, and of Red Crossbill in 60-80 year old stands than in old growth stands (Table 5). Species richness, diversity, evenness and total detection did not differ between old growth and 60-80 year old stands. Breeding bird communities were similar among old growth stands (0.949, cv = 2%) and among 60-80 year old stands (0.936, cv = 3%, Table 6). Also, communities of these two age classes were similar (0.914, cv = 4%).

Point counts and spot-mapping results contrasted more on the Mainland South Coast than they did in the other two areas. Varied Thrush and Vaux's Swift were the only species with a significant trend of greater abundance in old growth than 60-80 year old stands with both methods (Tables 5-11-12). Point counts indicated that Brown Creepers and Red-breasted Sapsuckers were significantly more abundant in old growth than in the younger stands (40-60 years). Although they tended to be more abundant in old growth than in 60-80 year old stands, the difference was not significant (Table 12). Chestnut-backed Chickadees were also less numerous in 40-60 year old stands but were similarly abundant in old growth and 60-80 year old stands (Table 12). Point count results for Golden-crowned Kinglets were quite variable and no significant difference in relative abundance was found between age classes. Winter Wrens were less numerous in 40-60 year old stands than in older ones and Western Tanagers were more numerous in 40-60 year old stands than in older stands (Table 12).

Comparison of the three areas

Similarity in breeding bird communities among sampled old growth forest stands was highest in the Queen Charlotte Islands (Morisita index, $\bar{x}$ = 0.962) and higher on the Mainland South Coast ($\bar{x}$ = 0.835) than on Vancouver Island ($\bar{x}$ = 0.749) (Table 6). Similar ranking of values occurred for second growth stands. Queen Charlotte Islands old growth bird communities were more similar to those of the Mainland South Coast than to those of Vancouver Island (Table 6). However, Queen Charlotte Islands second growth forest communities were more similar to those of Vancouver Island than those of the Mainland South Coast, possibly reflecting the similar age of the second growth stands of Vancouver Island and the Queen Charlotte Islands.

Similarities of bird communities based on point counts results were similar to the patterns obtained with spot-mapping results. Bird communities of the Queen Charlotte Islands were the most different of the three areas sampled (Table 10). Vancouver Island and Mainland South Coast stands of 60-80 years of age were less similar (0.667) than either 40-60 year old (0.853) or old growth stands (0.873). Old growth communities were more similar to 60-80 year old ones on the Mainland South Coast (0.861) than on Vancouver Island (0.676). Mainland South Coast old growth communities were more similar to 40-60 year old communities on the Mainland South Coast (0.878) than on either the Queen Charlotte Islands (0.586) or Vancouver Island (0.584). Finally, bird communities of 40-60 and 60-80 year old stands were more similar on Vancouver Island (0.945) than on the Mainland South Coast (0.771).

Several species were consistently more abundant in old growth forest stands in the three geographical areas. These species include the Brown Creeper, Chestnut-backed Chickadee, Hairy Woodpecker, Marbled Murrelet, Pacific-slope Flycatcher, Red-breasted Nuthatch, Varied Thrush, Vaux's Swift and Winter Wren (Table 13). Spot-mapping results indicate that a higher density of birds was detected per station in old growth than in 40-60 year old stands on the Queen Charlotte and Vancouver islands.

Table 10 - Similarity indices (Morisita-Horn) between old growth and second growth forest stands (based on point counts).

	Old growth		60-80 year old		40-60 year old		
	V.I.[1]	**M.S.C.**	**V.I.**	**M.S.C.**	**Q.C.I.**	**V.I.**	**M.S.C.**
Old growth							
Q.C.I.	0.709	0.812	0.627	0.607	0.586	0.602	0.700
V.I.		0.873	0.676	0.890	0.355	0.584	0.721
M.S.C.			0.794	0.861	0.573	0.703	0.878
60-80 years							
V.I.				0.667	0.774	0.945	0.851
M.S.C.					0.369	0.572	0.771
40-60 years							
Q.C.I.						0.851	0.737
V.I.							0.853

[1] V.I. = Vancouver Island, M.S.C. = Mainland South Coast, Q.C.I. = Queen Charlotte Islands

Table 11 - Breeding bird densities (pairs/40 ha) in old growth and second growth forests of the Mainland South Coast (spot-mapping 1990).

Plot	CQOLD1	CQOLD2	CAOLD3	CAOLD4	CASEC1	SYSEC2	SYSEC3	SYSEC4	Old Growth			40-80 years			P
Plot size (Ha)	15.3	13.3	13.3	13.8	14.1	18.8	17.5	19.0	Mean	±	S.E.	Mean	±	S.E.	
American Robin	0.0	0.0	6.0	1.5	5.7	3.2	2.3	10.5	1.9	±	1.4	5.4	±	1.8	0.15
Band-tailed Pigeon	0.0	0.0	0.0	0.0	0.0	0.0	1.1	2.1	0.0	±	0.0	0.8	±	0.5	
Blue Grouse	13.1	12.1	0.0	5.8	11.3	3.2	9.1	0.0	7.8	±	3.0	5.9	±	2.6	0.47
Brown Creeper	2.6	15.1	6.0	10.2	0.0	4.3	2.3	4.2	8.5	±	2.7	2.7	±	1.0	0.08*
Chestnut-backed Chickadee	10.5	15.1	12.1	14.5	8.5	8.5	4.6	11.6	13.1	±	1.1	8.3	±	1.4	0.04*
Dark-eyed Junco	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	2.3	±	2.3	0.0	±	0.0	0.32
Golden-crowned Kinglet	10.5	21.1	12.1	13.1	5.7	8.5	6.9	10.5	14.2	±	2.4	7.9	±	1.1	0.04*
Hairy Woodpecker	2.6	3.0	3.0	2.9	0.0	2.1	2.3	1.1	2.9	±	0.1	1.4	±	0.5	0.02*
Hermit Thrush	0.0	3.0	0.0	5.8	0.0	0.0	0.0	0.0	2.2	±	1.4	0.0	±	0.0	0.13
Pacific-slope Flycatcher	15.7	37.7	18.1	30.5	31.2	26.7	18.3	36.8	25.5	±	5.2	28.2	±	3.9	0.56
Pileated Woodpecker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	±	0.0	0.5	±	0.5	
Purple Finch	0.0	1.5	0.0	0.0	1.4	0.0	0.0	1.1	0.4	±	0.4	0.6	±	0.4	
Red-breasted Nuthatch	2.6	9.1	3.0	1.5	2.8	0.0	1.1	2.1	4.0	±	1.7	1.5	±	0.6	0.15
Red-breasted Sapsucker	2.6	9.1	1.5	2.9	0.0	2.1	0.0	0.0	4.0	±	1.7	0.5	±	0.5	0.04*
Rufous Hummingbird	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	±	0.8	0.0	±	0.0	0.32
Steller's Jay	1.3	3.0	3.0	2.9	2.8	3.2	3.4	4.2	2.6	±	0.4	3.4	±	0.3	0.15
Swainson's Thrush	7.9	15.1	6.0	2.9	5.7	4.3	2.3	7.4	8.0	±	2.6	4.9	±	1.1	0.25
Townsend's Warbler	14.4	36.2	15.1	29.1	29.7	18.1	14.9	17.9	23.7	±	5.4	20.2	±	3.3	1.00
Varied Thrush	14.4	24.2	6.0	10.2	5.7	1.1	4.6	0.0	13.7	±	3.9	2.8	±	1.4	0.02*
Western Tanager	0.0	0.0	0.0	0.0	5.7	0.0	2.3	0.0	0.0	±	0.0	2.0	±	1.3	
Winter Wren	28.9	61.9	27.2	40.7	28.3	44.8	22.9	41.1	39.7	±	8.0	34.3	±	5.2	0.77
Total	127.2	279.2	119.2	174.5	144.4	130.1	98.3	152.6	175.1		36.8	131.4		12.0	0.56
Number of species	13	17	13	15	13	13	15	14	14.5		1.0	13.8		0.5	0.64
Diversity	0.99	1.06	0.99	0.98	0.95	0.87	0.99	0.91	1.01		0.02	0.93		0.03	0.15
Evenness	0.89	0.86	0.89	0.83	0.85	0.78	0.84	0.80	0.87		0.01	0.82		0.02	0.08*

* $P < 0.10$

Table 12 - Mean (± S.E.) number of birds[1] detected per station on the Mainland South Coast in relation to forest age (point counts 1990).

Forest Age	Old growth (1)	60-80 years (2)	40-60 years (3)			
No. of clusters (No. of points)	13(48)	7(22)	5(26)	Anova(P)	Duncan Test	
American Goldfinch		0.06 ± 0.04		-		
American Robin	0.12 ± 0.04	0.32 ± 0.15	0.09 ± 0.06	0.39		
Band-tailed Pigeon		0.03 ± 0.01		0.01*	2=A	1,3=b
Barred Owl		0.02 ± 0.01	0.02 ± 0.02	-		
Brown-headed Cowbird		0.06 ± 0.05		-		
Blue Grouse	0.07 ± 0.03		0.03 ± 0.03	0.10	1,3=A	2,3=b
Brown Creeper	0.26 ± 0.05	0.19 ± 0.05	0.09 ± 0.04	0.14	1,2=A	2,3=b
Chestnut-backed Chickadee	0.64 ± 0.14	0.80 ± 0.24	0.27 ± 0.12	0.15	1,2=A	3=b
Common Raven	0.01 ± 0.01	0.01 ± 0.01		0.72		
Dark-eyed Junco	0.06 ± 0.02	0.01 ± 0.01		0.10	1,2=A	2,3=b
Evening Grosbeak	0.32 ± 0.15	0.73 ± 0.47	0.09 ± 0.04	0.65		
Golden-crowned Kinglet	0.69 ± 0.11	0.87 ± 0.26	0.96 ± 0.23	0.62		
Hairy Woodpecker	0.08 ± 0.02	0.07 ± 0.03		0.05*	1,2=A	3=b
Hammond's Flycatcher	0.03 ± 0.01			-		
Hermit Thrush	0.03 ± 0.01			0.06*	1=A	2,3=b
Hutton's Vireo	0.01 ± 0.01	0.02 ± 0.02		0.24		
MacGillivray's Warbler	0.02 ± 0.02			0.65		
Marbled Murrelet	0.01 ± 0.01		0.02 ± 0.02	0.52		
Northern Flicker	0.01 ± 0.01			0.65		
Olive-sided Flycatcher	0.01 ± 0.01			0.65		
Pacific-slope Flycatcher	1.18 ± 0.16	1.11 ± 0.27	0.93 ± 0.14	0.65		
Pileated Woodpecker		0.01 ± 0.01		0.29		
Pine Siskin	0.04 ± 0.04	0.90 ± 0.51	0.21 ± 0.13	0.14		
Purple Finch		0.06 ± 0.05		0.06*	2=A	1,3=b
Red-breasted Nuthatch	0.10 ± 0.03	0.17 ± 0.07		0.04*	1,2=A	3=b
Red Crossbill	0.30 ± 0.15	1.10 ± 0.31	0.16 ± 0.09	0.02*	2=A	1,3=b
Red-breasted Sapsucker	0.16 ± 0.05	0.06 ± 0.04	0.02 ± 0.02	0.06*	1,2=A	2,3=b
Rufous Hummingbird	0.02 ± 0.01			0.23		

Table 12 - Mean (± S.E.) number of birds[1] detected per station on the Mainland South Coast in relation to forest age (point counts 1990). (Continued)

Forest Age	Old growth (1)			60-80 years (2)			40-60 years (3)					
No. of clusters (No. of points)	13(48)			7(22)			5(26)			Anova(P)	Duncan Test	
Rufous-sided Towhee				0.02	±	0.02						
Steller's Jay	0.03	±	0.01	0.24	±	0.13	0.10	±	0.06	0.37		
Swainson's Thrush	0.20	±	0.06	0.16	±	0.08	0.30	±	0.06	0.46		
Townsend's Warbler	0.75	±	0.20	0.42	±	0.11	1.02	±	0.33	0.23	3,1=A	1,2=b
Varied Thrush	0.45	±	0.06	0.04	±	0.03	0.05	±	0.03	0.00*	1=A	3,2=b
Vaux's Swift	0.28	±	0.07	0.02	±	0.02	0.03	±	0.02	0.00*	1=A	3,2=b
Warbling Vireo							0.05	±	0.05	0.14		
Western Tanager	0.01	±	0.01	0.03	±	0.02	0.09	±	0.05	0.03	3=A	2,1=b
Western Wood-Pewee				0.01	±	0.01	0.02	±	0.02	-		
Wilson's Warbler	0.04	±	0.03	0.02	±	0.02	0.02	±	0.02	0.95		
Winter Wren	1.51	±	0.13	1.49	±	0.31	0.77	±	0.20	0.05*	3=B	1,2=a
Total	7.39			9.01			5.27					
Number of species	30			30			22					
Diversity	1.124			1.125			1.012					
Evenness	0.761			0.762			0.754					

1 mean number of birds/station calculated for each cluster and then averaged.

* P < 0.10

There were fewer breeding species associated with Queen Charlotte Islands old growth stands than with those of Vancouver Island or the Mainland South Coast (24 *vs* 34 and 30 species), respectively (Tables 7, 9, 12). There was a high abundance of Townsend's Warblers in the 40-60 year old stands of the Queen Charlotte Islands. In spite of the lower number of species, total bird abundance was higher or nearly as high in the Queen Charlotte Islands than in the other two areas.

Bird communities of deciduous forests

The age and structure of the deciduous stands surveyed varied between areas. Twenty three bird species were observed in the deciduous stands of the Queen Charlotte Islands compared to 41 and 44 for those of the Mainland South Coast, respectively (Table 14). Similarities in bird communities in deciduous stands were low, ranging between 0.302 and 0.874 (Table 15). The abundance of most species differed significantly between areas (Table 14). The similarity between avian communities of deciduous and old growth forest stands was higher on the Queen Charlotte Islands (0.660) than either on Vancouver Island (0.391) or the Mainland South Coast (0.318-0.434) (Table 15). On the Queen Charlotte Islands, five species (Fox Sparrow, Orange-crowned Warbler, Song Sparrow, Swainson's Thrush, Wilson's Warbler) were more numerous in deciduous stands than in either old growth or second growth stands and three species (Golden-crowned Kinglet, Hermit Thrush and Pacific-slope Flycatcher) were less numerous (Duncan $p < 0.05$). The relative abundance of Townsend's Warblers and Winter Wrens were similar in deciduous and old growth stands but respectively higher and lower in second growth stands (Tables 7-14).

Bird communities of Vancouver Island deciduous stands had higher species richness (32 species) than those of the Queen Charlotte Islands deciduous stands (23 species) and differed more from the old growth communities (Tables 14-15). On Vancouver Island, eight species (American Robin, Black-throated Gray Warbler, Hammond's Flycatcher, MacGillivray's Warbler, Orange-crowned

Warbler, Song Sparrow, Warbling Vireo, Yellow-rumped Warbler) were more numerous in deciduous forest stands than in either old growth or second growth stands (Duncan $p < 0.05$).

Only one species, the Golden-crowned Kinglet was less numerous in deciduous stands. Swainson's Thrush and Red Crossbill abundance did not differ significantly between old growth and deciduous stands. The Chestnut-backed Chickadee and Winter Wren were the only old growth species well represented in these stands.

Two distinct deciduous forests were sampled on the Mainland South Coast, both had high numbers of species (Table 14) and both had communities distinct from that of old growth stands (Table 15). Ten species were more abundant in deciduous stands than in either old growth or second growth stands (American Robin, Black-throated Gray Warbler, Brown-headed Cowbird, Hammond's Flycatcher, MacGillivray's Warbler, Purple Finch, Red-eyed Vireo, Swainson's Thrush, Warbling Vireo, Wilson Warbler) and three species (Golden-crowned Kinglet, Townsend's Warbler, Varied Thrush) were less numerous (Duncan $p < 0.05$).

Spot-mapping surveys were conducted only on the Mainland South Coast. Breeding bird densities and species richness were higher in the Squamish area than in the Vancouver area (Table 16). Dominant species included the Winter Wren, Pacific-slope Flycatcher, American Robin, Black-throated Gray Warbler, Warbling Vireo, Swainson's Thrush and Hammond's Flycatcher.

Table 13 - Comparison of bird abundance in old growth and second growth forests.

Area	Queen Charlotte Island		Vancouver Island			Mainland South Coast		
Census technique	Mapping	Point	Mapping	Point	Point	Mapping	Point	Point
Age of second growth	40-60	40-60	40-80	60-80	40-60	60-80	60-80	40-60
American Robin				Y*				
Blue Grouse							0*	
Brown Creeper	0**	0**	0**		0*	0**		0*
Chestnut-backed Chickadee			0**		0*	0**		0*
Dark-eyed Junco			Y**		Y*			0*
Golden-crowned Kinglet	Y**	Y*		Y**	Y**	0**		
Hairy Woodpecker	0**	0*			0**	0**		0**
Hammond's Flycatcher				Y**	Y**			
Hermit Thrush				0*			0*	0*
Hutton's Vireo					Y**			
Marbled Murrelet	0**			0**	0**			
Pacific-slope Flycatcher	0**	0**		0**	0**			
Pine Siskin				0**	0**			
Red Crossbill				0**	0**	Y*	Y**	
Red-breasted Nuthatch	0**	0**	0**	0**	0**			0**
Red-breasted Sapsucker	0**	0**				0**		0*
Swainson's Thrush				0*				
Townsend's Warbler	Y**	Y**	Y**	Y**	Y**		0*	
Varied Thrush	0**			0**	0**	0**	0**	0**
Vaux's Swift			0**	0**	0**	0**	0**	0**
Western Tanager								Y**
Winter Wren		0**			0**			0**
Number of species	O*	-		-	-		-	-
Diversity	O*	-	O*	-	-		-	-
Total abundance	O*	-	O*	-	-		-	-
Evenness			O*	-	-		-	-

0** more abundant in old growth P < 0.05
0* more abundant in old growth P < 0.10
Y** more abundant in second growth P < 0.05
Y* more abundant in second growth P < 0.10
\- Not tested

Table 14 - Mean number of birds (mean ± S.E.) detected per station in deciduous forest stands (point counts, 1991).

	Queen Charlotte Islands(1)	Mainland South Coast Squamish(2)	Mainland South Coast Vancouver(3)	Vancouver Island(4)	Anova(P) Clusters	Duncan Test		
Number of clusters[2]	4	8	6	5				
Tree height (m)	13	26	15	26				
American Goldfinch			0.31 ± 0.19	0.03 ± 0.02	0.01*	1,2=A	3,4=b	
American Robin	0.05 ± 0.03	1.89 ± 0.09	1.42 ± 1.42	1.94 ± 0.25	0.00*	1=A	2,4=b	3=c
Band-tailed Pigeon		0.03 ± 0.03			0.63			
Barn Swallow			0.07 ± 0.06		-			
Black-capped Chickadee		0.14 ± 0.05	0.38 ± 0.16		0.00*	1,4=A	2,3=b	
Black Swift			0.04 ± 0.02		-			
Black-throated Gray Warbler		0.99 ± 0.04	0.57 ± 0.11	0.17 ± 0.09	0.00*	All diff		
Brown-headed Cowbird		0.18 ± 0.07	0.28 ± 0.12		0.06*	1,4=A	2,3=b	
Blue Grouse			0.02 ± 0.01		-			
Brown Creeper		0.13 ± 0.06	0.17 ± 0.08	0.09 ± 0.03	0.23			
Cedar Waxwing		0.18 ± 0.08			-			
Chestnut-backed Chickadee	0.17 ± 0.09	0.77 ± 0.08	0.14 ± 0.07	0.60 ± 0.10	0.00*	1,3=A	2,4=b	
Common Raven	0.02 ± 0.02	0.06 ± 0.02	0.02 ± 0.01	0.05 ± 0.03	-			
Dark-eyed Junco	0.02 ± 0.02	0.07 ± 0.04	0.10 ± 0.05	0.41 ± 0.18	0.03*	1,2,3=A	4=b	
Downy Woodpecker		0.06 ± 0.03	0.02 ± 0.01		0.05*	2,3=A	1,3,4=b	
European Starling				0.06 ± 0.03	-			
Evening Grosbeak		0.64 ± 0.30	0.23 ± 0.10	0.04 ± 0.02	0.00*	1,4=A	2,3=b	
Fox Sparrow	0.89 ± 0.20				0.00*	1=A	2,3,4=b	
Golden-crowned Kinglet	0.55 ± 0.14	0.36 ± 0.09	0.17 ± 0.08	0.40 ± 0.05	0.09*	1,4=A	1,2=b	3=c
Golden-crowned Sparrow								
Gray Jay								
Hairy Woodpecker	0.04 ± 0.04	0.14 ± 0.05	0.04 ± 0.02	0.13 ± 0.07	0.22	1,3=A	2,4=b	
Hammond's Flycatcher		0.45 ± 0.10	0.27 ± 0.18	1.38 ± 0.16	0.00*	1,3=A	2=b	4=c
Hermit Thrush	0.18 ± 0.04		0.01 ± 0.01	0.02 ± 0.02	0.00*	2,3,4=A	1=b	
Hutton's Vireo								
MacGillivray's Warbler		0.26 ± 0.10	0.02 ± 0.02	0.10 ± 0.02	0.02*	2,4=A	1,3=b	
Marbled Murrelet								
Northern Flicker	0.02 ± 0.02	0.03 ± 0.02	0.01 ± 0.01		0.67			
Northern Pigmy Owl			0.02 ± 0.02		-			
Olive-sided Flycatcher			0.01 ± 0.01		-			
Orange-crowned Warbler	0.80 ± 0.18		0.04 ± 0.03	0.10 ± 0.06	0.00*	3,4=A	2,3=b	1=c
Pacific-slope Flycatcher	1.13 ± 0.07	1.18 ± 0.14	1.03 ± 0.36	0.39 ± 0.10	0.09*	4=A	1,2,3=b	
Pileated Woodpecker		0.06 ± 0.03	0.01 ± 0.01		0.24	3,4=A	1,3=b	2=c
Pine Grosbeak	0.08 ± 0.05				0.01*	1=A	2,3,4=b	
Purple Finch		0.19 ± 0.03	0.02 ± 0.01		0.00*	2=A	1,3,4=b	

Table 14 - Mean number of birds (mean ± S.E.) detected per station in deciduous forest stands (point counts, 1991). (Continued)

	Queen Charlotte Islands(1)	Mainland South Coast Squamish(2)	Mainland South Coast Vancouver(3)	Vancouver Island(4)	Anova(P) Clusters	Duncan Test		
Number of clusters[2]	4	8	6	5				
Tree height (m)	13	26	15	26				
Red-breasted Nuthatch		0.15 ± 0.06	0.26 ± 0.13		0.02*	2,3=A	1,4=b	
Red Crossbill	0.06 ± 0.02	0.28 ± 0.09		0.39 ± 0.22	0.00*			
Red-breasted Sapsucker	0.26 ± 0.12	0.04 ± 0.03	0.01 ± 0.01		0.00*	2,3=A	1=b	4=c
Red-eyed Vireo		0.46 ± 0.14	0.09 ± 0.06		0.00*	1,4=A	2=b	3=c
Ruffed Grouse		0.02 ± 0.01	0.06 ± 0.04	0.06 ± 0.04	-			
Rufous Hummingbird		0.06 ± 0.03	0.05 ± 0.03	0.15 ± 0.05	0.12			
Rufous-sided Towhee		0.03 ± 0.03	0.70 ± 0.23	0.02 ± 0.02	0.02*	3=A	1,2,4=b	
Song Sparrow	0.15 ± 0.06	0.47 ± 0.17	0.24 ± 0.18	0.44 ± 0.14	0.24	2,3,4=A	1,3,4=b	
Solitary Vireo		0.03 ± 0.02	0.02 ± 0.01		-			
Steller's Jay	0.02 ± 0.02	0.05 ± 0.02		0.08 ± 0.04	0.12			
Swainson's Thrush	1.07 ± 0.07	1.43 ± 0.22	1.94 ± 0.53	0.48 ± 0.10	0.01*	1,2=A	3=b	4=c
Townsend's Warbler	0.96 ± 0.12	0.03 ± 0.02	0.07 ± 0.07	0.80 ± 0.11	0.00*	1,4=A	2,3=b	
Tree Swallow	0.06 ± 0.02				-			
Varied Thrush	1.71 ± 0.13	0.28 ± 0.11	0.08 ± 0.03	0.20 ± 0.09	0.01*	1=A	2,3,4=b	
Vaux's Swift								
Violet-green Swallow								
Warbling Vireo		0.42 ± 0.10	0.64 ± 0.14	1.54 ± 0.24	0.00*	All diff		
Western Tanager		0.07 ± 0.02	0.33 ± 0.14	0.08 ± 0.06	0.03*	3=A	2,4=b	
Western Wood-Pewee		0.01 ± 0.01	0.06 ± 0.02		-			
Wilson Warbler	0.42 ± 0.21	0.16 ± 0.04	0.82 ± 0.29	0.03 ± 0.02	0.03*	4=A	1,2,3=b	
Winter Wren	1.56 ± 0.09	0.84 ± 0.19	0.90 ± 0.27	0.91 ± 0.18	0.16			
Yellow Warbler		0.33 ± 0.15	0.03 ± 0.03	0.01 ± 0.01	0.00*	2=A	1,3,4=b	
Yellow-rumped Warbler		0.07 ± 0.02	0.05 ± 0.05	0.20 ± 0.07	0.02*	2,4=A	1,3=b	
Total	10.26	13.12	11.85	11.47				
Number of species	23	41	44	32				
Diversity	1.08	1.29	1.24	1.18				
Evenness	0.80	0.80	0.75	0.78				

[1] Mean number of birds/station calculated for each cluster and then averaged.
[2] Between 3-5 stations per cluster.
* P < 0.10

Table 15 - Similarity indices between deciduous, old growth and second growth forest bird communities (based on point count results).

	Deciduous Q.C.I.	Deciduous V.I.	Deciduous M.S.Q.[1]	Deciduous M.S.E[2].
Deciduous V.I.	0.302			
Deciduous M.S.Q.	0.451	0.726		
Deciduous M.S.E.	0.438	0.622	0.874	
Old growth Q.C.I.	0.660	0.228	0.310	0.224
40-60 years Q.C.I.	0.583	0.312	0.160	0.138
Old growth V.I.	0.497	0.391	0.572	0.442
60-80 years V.I.	0.448	0.583	0.467	0.352
40-60 years V.I.	0.560	0.600	0.466	0.386
Old growth M.S.C.	0.526	0.309	0.434	0.318
60-80 years M.S.C.	0.337	0.324	0.474	0.321
40-60 years M.S.C.	0.553	0.367	0.415	0.362

[1] M.S.Q. = Mainland South Coast Squamish
[2] M.S.E. = Mainland South Coast Vancouver

Bird communities of clearcuts

Bird communities in clearcuts were highly variable. The relative abundance of birds was twice as high in the Vancouver Island clearcuts as in the Mainland South Coast and Queen Charlotte Islands clearcuts. The relative abundance of 14 species varied significantly between clearcuts of different areas (Table 17).

Similarity between bird communities of clearcuts and old growth was low everywhere, but higher on the Queen Charlotte Islands (0.419) than on either Vancouver Island (0.285) or the Mainland South Coast (0.116). In general, clearcut bird communities were the most distinct of all communities sampled in terms of species composition and structure (evenness) (Table 18).

The Dark-eyed Junco was abundant in all clearcuts sampled. The MacGillivray's Warbler, a dominant species of both Vancouver Island and the Mainland South Coast clearcuts does not breed on the Queen Charlotte Islands. Two species seem to fill the void created : Winter Wren and Fox Sparrow. Fox Sparrows, Orange-crowned Warblers and Song Sparrows were more numerous and Hermit Thrushes were less numerous in clearcuts and deciduous stands than in old growth and second growth stands of the Queen Charlotte Islands. On Vancouver Island, Song Sparrows and MacGillivray's Warblers were most numerous in clearcuts and Orange-crowned Warblers were most abundant in clearcuts and deciduous stands (Duncan, $p < 0.05$). On the Mainland South Coast, Rufous Hummingbird were most numerous in clearcuts and Cedar Waxwings most abundant in clearcuts and deciduous stands (Duncan, $p < 0.05$). Vancouver Island clearcuts had the most species (26) and Queen Charlotte Islands clearcuts had the least (18). Total relative abundance (point counts) of birds was similar in the Queen Charlotte Islands and on the Mainland South Coast but twice as great on Vancouver Island. However, spot-mapping surveys suggested a greater abundance of breeding birds on the Mainland South Coast than on the Queen Charlotte Islands (Table 19).

Clearcuts supported no old growth species, except on the Queen Charlotte Islands where Winter Wrens were numerous in clearcuts.

Variability between years

Over the four years of the study, some stations were surveyed over two or three years providing data on year-to-year variability in bird numbers. As expected, there were significant differences in the relative abundance of several species between the years (Table 20). Relative densities of Brown Creepers and Pacific-slope Flycatchers differed significantly between all three years compared. Differences were especially noticeable between 1990 and 1992 where 11 of 18 species differed significantly in abundance.

Habitat-species relationships

Vegetation

Old growth and second growth stands

The structure of the forest differed greatly between old growth and second growth age classes (Fig. 2,3,4). Trees with a diameter at breast height (dbh) < 60 cm were more numerous in young forests whereas those with dbh >60 cm were more abundant in old growth forests. However, most second growth stands had some residual large trees. Small snags (< 30 cm dbh) were most numerous in 40-80 year old forests, presumably a result of the higher tree density in those stands resulting in heavy competition among trees. Large snags (>30 cm dbh) were most numerous in old growth forests and more abundant in 60-80 year old stands than in 40-60 year old ones. All young stands had a few residual large snags, heritage of old logging. Large snags and large woody debris (pieces of downed wood) >60 cm dbh were most abundant in the Queen Charlotte Islands forests and least abundant in the Mainland South Coast forests. Old growth stands of the Queen Charlotte Islands and the Mainland South Coast had more shrubs and herbs than younger stands but this wasn't the case on Vancouver Island. Vegetation attributes of spot mapping plots evidence these differences but also portray the variability that can be found within a given forest type (Fig. 5, 6, 7).

Tree species composition varied greatly between areas (Tables 21-22). Sitka Spruce dominated the Queen Charlotte Islands stands but was not present on Vancouver Island or the Mainland South Coast, being replaced by Douglas-fir and Amabilis Fir. Western Red Cedar was most numerous on the Mainland South Coast. Old growth and second growth stands differed in species composition. On the Queen Charlotte Islands, Sitka Spruce was most numerous in second growth stands but relatively rare in old growth stands. On the Mainland South Coast 60-80 year old stands had a greater component of Douglas-firs than either 40-60 year old or old growth stands (Table 21).

Differences in vegetation likely influenced the avifauna but our sample size and study design are not adequate to address this issue. Snags were more abundant in terms of both number and basal area per ha in old growth stands of the Queen Charlotte Islands than in the other two areas (Table 22). This may account in part for the greater abundance of cavity nesters in the Queen Charlotte Islands. The 60-80 year old stands of the Mainland South Coast were more similar to old growth stands in terms of snag size and abundance than the 60-80 year old stands of Vancouver Island.

Table 16 - Breeding bird densities (pairs/40 ha) in deciduous stands of the Mainland South Coast (spot-mapping).

	Vancouver		Squamish			
WATERSHED 1989	ALDER 1	ALDER 2				
Plot size (ha)	17.50	8.00	17.50			
Year	1991	1991	1992	Mean	±	S.E.
American Robin	11.4	17.5	20.6	16.5	±	2.7
Bewick's Wren	0.0	0.0	1.1	0.4	±	0.4
Black-capped Chickadee	4.6	5.0	0.0	3.2	±	1.6
Black-headed Grosbeak	0.0	0.0	5.7	1.9	±	1.9
Black-throated Gray Warbler	6.9	20.0	19.4	15.4	±	4.3
Brown Creeper	0.0	0.0	4.6	1.5	±	1.5
Brown-headed Cowbird	3.4	10.0	0.0	4.5	±	2.9
Chesnut-backed Chickadee	0.0	0.0	12.6	4.2	±	4.2
Downy Woodpecker	0.0	0.0	1.1	0.4	±	0.4
Golden-crowned Kinglet	0.0	0.0	11.4	3.8	±	3.8
Hairy Woodpecker	2.3	0.0	3.4	1.9	±	1.0
Hammond's Flycatcher	13.7	17.5	3.4	11.5	±	4.2
MacGillivray's Warbler	2.3	0.0	0.0	0.8	±	0.8
Orange-crowned Warbler	2.3	0.0	0.0	0.8	±	0.8
Pacific-slope Flycatcher	2.3	22.5	25.1	16.6	±	7.2
Pileated Woodpecker	0.0	0.0	1.1	0.4	±	0.4
Purple Finch	0.0	0.0	2.3	0.8	±	0.8
Red-breasted Nuthatch	0.0	0.0	4.6	1.5	±	1.5
Ruffed Grouse	3.4	7.5	0.0	3.6	±	2.2
Rufous Hummingbird	3.4	2.5	2.3	2.7	±	0.4
Swainson's Thrush	9.1	10.0	14.9	11.3	±	1.8
Song Sparrow	16.0	5.0	2.3	7.8	±	4.2
Varied Thrush	2.3	2.5	12.6	5.8	±	3.4
Warbling Vireo	9.1	20.0	14.9	14.7	±	3.1
Western Tanager	2.3	0.0	2.3	1.5	±	0.8
Wilson's Warbler	0.0	0.0	2.3	0.8	±	0.8
Winter Wren	2.3	15.0	33.1	16.8	±	9.0
Yellow-rumped Warbler	4.6	0.0	0.0	1.5	±	1.5
Total	108.6	155.0	205.7	156.4		28.1
Number of species	18	13	22	28		

Table 17 - Mean number of birds (mean ± S.E.) detected per station in clearcuts (point counts).

	Queen Charlotte Islands(2)	Vancouver Island(1)	Mainland South Coast(3)		
Number of clusters (no. of points)	5(20)	5 (21)	7 (23)	Anova(P)	Duncan Test
Year	1990	1991	1990	Clusters	
American Robin	0.03 ± 0.02	1.26 ± 0.25	0.24 ± 0.08	0.00*	all diff.
Brown-headed Cowbird		0.09 ± 0.08		0.07*	2,3=A 1=B
Blue Grouse	0.24 ± 0.09	0.12 ± 0.07		0.01*	1,3=A 2=B
Cedar Waxwing		0.08 ± 0.08	0.19 ± 0.10	0.28	
Dark-eyed Junco	0.44 ± 0.12	1.29 ± 0.31	1.03 ± 0.17	0.02*	1,3=A 2=B
Fox Sparrow	0.67 ± 0.26			0.00*	
Hermit Thrush	0.13 ± 0.06	0.01 ± 0.01	0.01 ± 0.01	0.12	
MacGillivray's Warbler		1.09 ± 0.26	0.88 ± 0.11	0.01*	1,3=A 2=B
Northern Flicker	0.07 ± 0.03	0.04 ± 0.02	0.02 ± 0.02	0.40	
Olive-sided Flycatcher		0.05 ± 0.05	0.03 ± 0.02	0.51	
Orange-crowned Warbler	0.51 ± 0.19	0.09 ± 0.03	0.10 ± 0.05	0.03*	1,3=A 2=B
Pacific-slope Flycatcher	0.13 ± 0.08		0.06 ± 0.05	0.11	
Pine Siskin	0.03 ± 0.02	0.05 ± 0.02	0.05 ± 0.03	0.86	
Red Crossbill		0.63 ± 0.63	0.02 ± 0.02	0.62	
Red-breasted Sapsucker	0.04 ± 0.03		0.03 ± 0.03	0.34	
Rufous Hummingbird	0.03 ± 0.03	0.16 ± 0.09	0.77 ± 0.20	0.00*	1,3=A 2=B
Rufous-sided Towhee		0.13 ± 0.11	0.02 ± 0.02	0.33	
Song Sparrow	0.39 ± 0.20	0.99 ± 0.17	0.05 ± 0.05	0.00*	all diff.
Steller's Jay	0.02 ± 0.02	0.13 ± 0.07	0.07 ± 0.03	0.17	
Swainson's Thrush	0.02 ± 0.02	0.17 ± 0.07	0.20 ± 0.08	0.14	
Tree Swallow	0.06 ± 0.04	0.03 ± 0.03		0.23	
Varied Thrush	0.05 ± 0.03	0.01 ± 0.01		0.19	
Vaux's Swift			0.31 ± 0.09	0.00*	
Violet-green Swallow		0.13 ± 0.11		-	
Warbling Vireo		0.07 ± 0.04		0.07*	
White-crowned Sparrow		0.94 ± 0.15	0.20 ± 0.08	0.00*	all diff.
Wilson's Warbler	0.12 ± 0.10	0.04 ± 0.03	0.05 ± 0.02	0.98	
Winter Wren	1.66 ± 0.27	0.51 ± 0.19	0.08 ± 0.05	0.00*	all diff.
Yellow Warbler		0.07 ± 0.06		0.07*	
Total	4.60	8.54	4.41		
Number of species	18	26	22		
Diversity					
Evenness					

* $P < 0.10$

Table 18 - Similarity indices between clearcuts, old growth and second growth bird communities (based on point count results).

	Clearcuts Q.C.I.[1]	Clearcuts V.I.	Clearcuts M.S.C.
Clearcuts V.I.	0.377		
Clearcuts M.S.C.	0.222	0.684	
Deciduous Q.C.I.	0.233	0.067	0.083
Deciduous V.I.	0.084	0.444	0.214
Deciduous M.S.Q.	0.073	0.429	0.208
Deciduous M.S.E.	0.064	0.342	0.184
Old growth Q.C.I.	**0.419**	0.515	0.064
40-60 years Q.C.I.	0.212	0.067	0.041
Old growth V.I.	0.465	**0.285**	0.122
60-80 years V.I.	0.395	0.324	0.150
40-60 years V.I.	0.238	0.293	0.166
Old growth M.S.C.	0.542	0.193	**0.116**
60-80 years M.S.C.	0.461	0.231	0.088
40-60 years M.S.C.	0.369	0.130	0.071

[1] Q.C.I. = Queen Charlotte Islands, V.I. = Vancouver Island, M.S.C. = Mainland South Coast

(Comparison of old growth - clearcuts in bold)

Table 19 - Breeding bird densities (pairs/40 ha) in clearcuts of the Queen Charlotte Islands and the Mainland South Coast in 1989 (spot-mapping).

	Queen Charlotte Islands		Mainland South Coast	
Area (ha)	**QCCL1 27.5**	**QCCL2 30.0**	**SCCL1 9.0**	**SCCL2 12.0**
American Robin	2.2	0.7	11.1	1.7
Blue Grouse			2.2	
Cedar Waxwing			8.9	8.3
Dark-eyed Junco	6.6	5.3	37.8	16.7
Fox Sparrow	10.2	6.7		
Hermit Thrush	4.4	1.3		
Lincoln's Sparrow	2.9			
MacGillivray's Warbler			44.4	60.0
Olive-sided Flycatcher			2.2	
Orange-crowned Warbler	2.9	2.7	6.7	6.7
Rufous Hummingbird			4.4	10.0
Song Sparrow	8.0	8.0	8.9	1.7
Swainson's Thrush			15.6	11.7
White-crowned Sparrow				20.0
Willow Flycatcher			2.2	26.7
Winter Wren	19.6	18.7		
Total	56.8	43.4	144.5	163.4
Number of species	8	7	11	10

Table 20 - Comparison of the relative abundance of birds (point counts) between years in old growth stands (Wilcox, Z values)

Years compared	1990-1992		1990-1993		1992-1993	
number of stations	26		19		20	
American Robin	0.01		-0.75		0.31	
Blue Grouse	1.79	*	0.33		-1.72	
Brown Creeper	-1.79	•	-3.95	***	-1.76	•
Chestnut-backed Chickadee	-1.54		-2.46	**	-0.56	
Golden-crowned Kinglet	1.54		-0.60		-1.45	
Hairy Woodpecker	-0.85		-0.45		0.33	
Hermit Thrush	-1.99	**	-0.76		1.61	
Pine Siskin	-2.23	**	0.85		2.12	**
Pacific-slope Flycatcher	-2.29	**	-1.75	•	-1.75	*
Red-breasted Nuthatch	-0.85		0.02		0.33	
Red-breasted Sapsucker	1.92	*	-0.31		1.26	
Red Crossbill	-4.27	***	1.40		3.99	***
Steller's Jay	-3.22	**	-2.34	**	1.01	
Swainson's Thrush	-3.34	***	1.63		1.17	
Townsend's Warbler	3.33	***	-0.90		-1.72	•
Vaux's Swift	0.93		-1.02		-1.02	
Varied Thrush	-3.84	***	0.29		1.14	
Winter Wren	0.01		0.28		1.14	

* $P < 0.10$
** $P < 0.05$
*** $P < 0.01$

Table 21 - Tree species composition in relation to location and age (mean number of trees/ha).

	Queen Charlotte Islands		Vancouver Island			Mainland South Coast		
	Old Growth mean ± S.E.	40-60 years mean ± S.E.	Old Growth mean ± S.E.	60-80 years mean ± S.E.	40-60 years mean ± S.E.	Old Growth mean ± S.E.	60-80 years mean ± S.E.	40-60 years mean ± S.E.
Sitka spruce	29.9 ± 6.9	565.6 ± 75.1						
Western hemlock	218.0 ± 22.3	243.3 ± 40.5	248.2 ± 23.7	285.2 ± 44.1	321.8 ± 60.9	206.2 ± 14.0	216.6 ± 28.7	445.0 ± 41.1
Mountain hemlock	41.0 ± 17.2							
Douglas fir			20.1 ± 8.6	191.5 ± 25.7	424.7 ± 38.0	2.5 ± 1.6	180.5 ± 24.0	6.1 ± 3.6
Amabilis fir			87.8 ± 21.1	0.5 ± 0.5		98.6 ± 18.6	0.4 ± 0.4	149.4 ± 35.7
Western red cedar	39.8 ± 7.5	25.7 ± 15.9	44.4 ± 7.9	20.1 ± 7.5	14.6 ± 6.5	63.0 ± 8.4	66.7 ± 14.2	115.0 ± 30.2
Yellow cedar	28.7 ± 9.5							
Western yew			5.2 ± 2.5			7.2 ± 2.2		1.7 ± 1.7
Red alder		21.1 ± 12.9	1.4 ± 1.1	3.7 ± 1.8	22.6 ± 9.1		7.1 ± 3.5	11.7 ± 5.8
Big leaf maple				3.2 ± 1.7			2.0 ± 1.6	2.2 ± 1.7

Table 22 - Structural characteristics of sampled forest stands.

Structural Variables	Queen Charlotte Islands n = 48		Vancouver Island n = 83			Mainland South Coast n = 96		
	Old Growth mean ± S.E.	40-60 years mean ± S.E.	Old Growth mean ± S.E.	60-80 years mean ± S.E.	40-60 years mean ± S.E.	Old Growth mean ± S.E.	60-80 years mean ± S.E.	40-60 years mean ± S.E.
Tree no./ha.	361 ± 21	844 ± 57	422 ± 15	511 ± 15	794 ± 30	383 ± 15	477 ± 20	733 ± 32
Tree mean size m^2	0.20 ± 0.02	0.08 ± 0.01	0.24 ± 0.01	0.11 ± 0.01	0.07 ± 0.00	0.33 ± 0.02	0.14 ± 0.06	0.10 ± 0.01
Tree max. size m^2	1.29 ± 0.20	0.78 ± 0.27	2.10 ± 0.18	0.45 ± 0.04	0.62 ± 0.14	2 81 ± 0.21	0.58 ± 0.04	0.70 ± 0.12
Tree tot. basal area/ha	60 ± 5	63 ± 6	91 ± 2	53 ± 2	51 ± 2	107 ± 6	60 ± 1	63 ± 2
Snag no./ha.	173 ± 16	194 ± 19	102 ± 5	112 ± 9	83 ± 11	62 ± 4	174 ± 1	207 ± 16
Snag mean size m^2	0.37 ± 0.04	0.18 ± 0.03	0.31 ± 0.02	0.09 ± 0.01	0.05 ± 0,01	0.42 ± 0.07	0.22 ± 0.05	0.05 ± 0.00
Snag max. size m^2	1.6 ± 0.2	0.7 ± 0.1	1.0 ± 0.08	0.50 ± 0.07	0.17 ± 0.03	1 ± 0.02	1.2 ± 0.02	0.48 ± 0.08
Snag tot. basal area/ha.	56 ± 7	21 ± 3	29 ± 2	11 ± 1	5 ± 1	23 ± 3	27 ± 4	10 ± 1
No. of logs/90m trans.	28 ± 1	26 ± 2	26 ± 1	32 ± 2	18 ± 1	15 ± 1	21 ± 1	18 ± 1
Log mean diameter (cm)	34 ± 1	26 ± 2	31 ± 1	25 ± 1	29 ± 1	36 ± 9	28 ± 7	29 ± 1
Log max. diameter (cm)	86 ± 4	89 ± 7	86 ± 6	25 ± 1	57 ± 2	83 ± 4	71 ± 3	82 ± 4
Log tot. bas. area m^2/trans.	2.3 ± 0.3	3.8 ± 0.4	2.9 ± 0.2	2.1 ± 0.1	1.7 ± 0.2	2.3 ± 0.2	1.7 ± 0.1	1.8 ± 0.2
Herb total cover %	47 ± 5	16 ± 3	14 ± 2	36 ± 3	20 ± 2	156 ± 6[1]	112 ± 5[1]	60 ± 4[1]
Shrub total cover %	60 ± 4	18 ± 3	31 ± 3	20 ± 2	26 ± 3	52 ± 3	27 ± 2	20 ± 2
Sapling no./ha.	1820 ± 274	444 ± 91	1078 ± 73	243 ± 15	563 ± 52	890 ± 57	236 ± 26	103 ± 13

[1] % herb cover calculated with overlap and thus not directly comparable to the other areas.

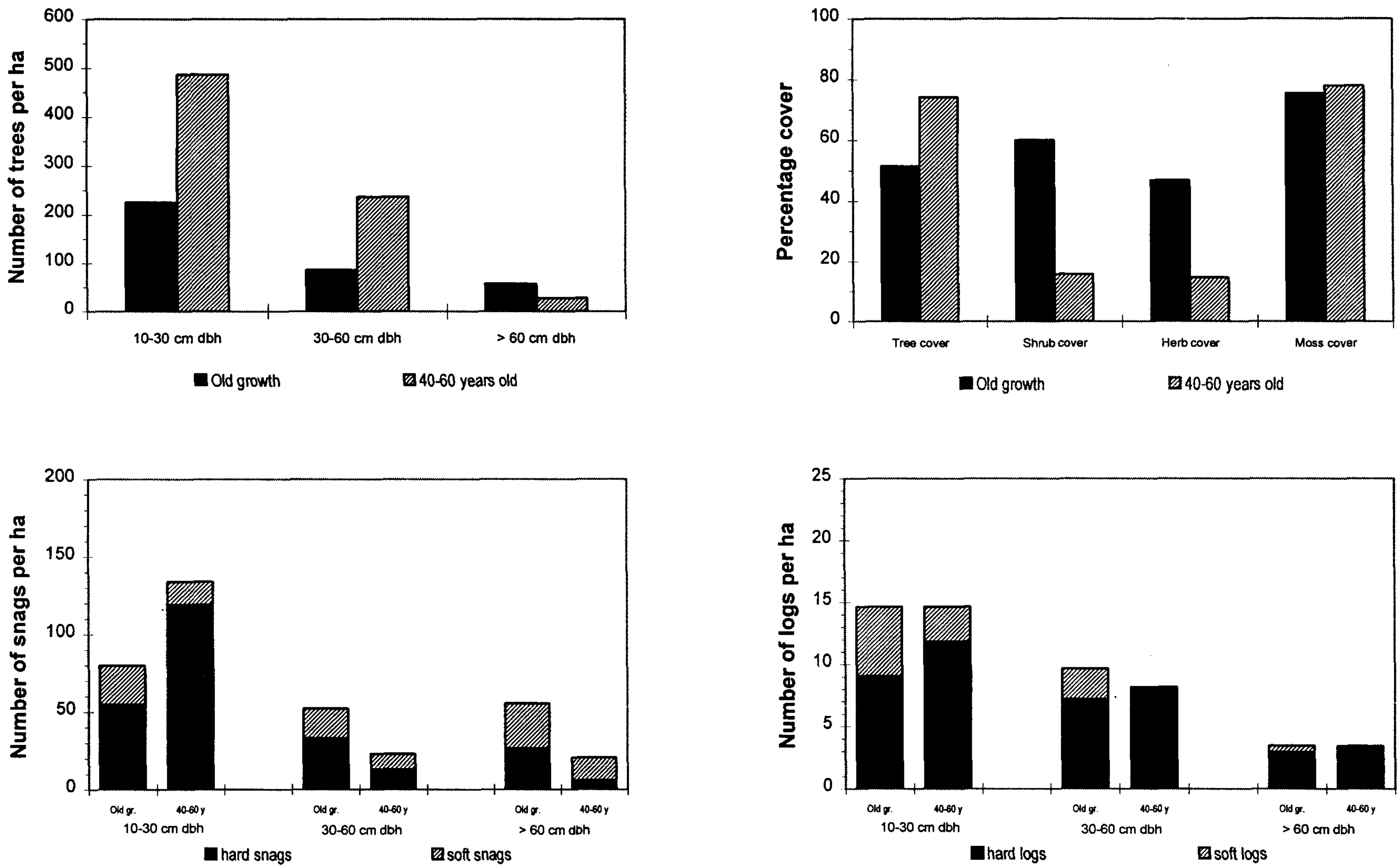

Figure 2. Density of trees, snags and logs in old growth and 40-60 year old forest stands of the Queen Charlotte Islands.

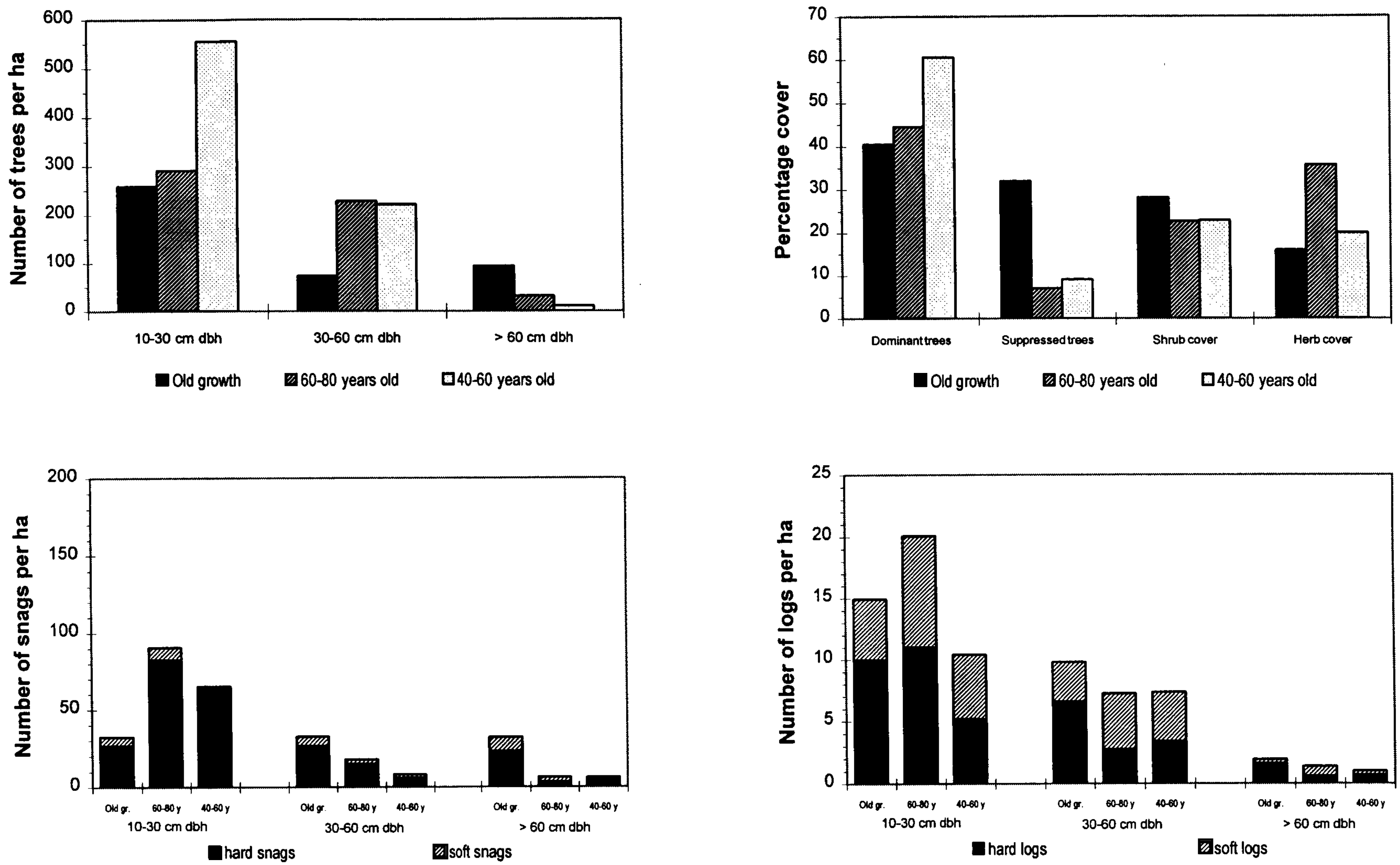

Figure 3. Density of trees, snags and logs in old growth, 60-80 year and 40-60 year old forest stands of Vancouver Island.

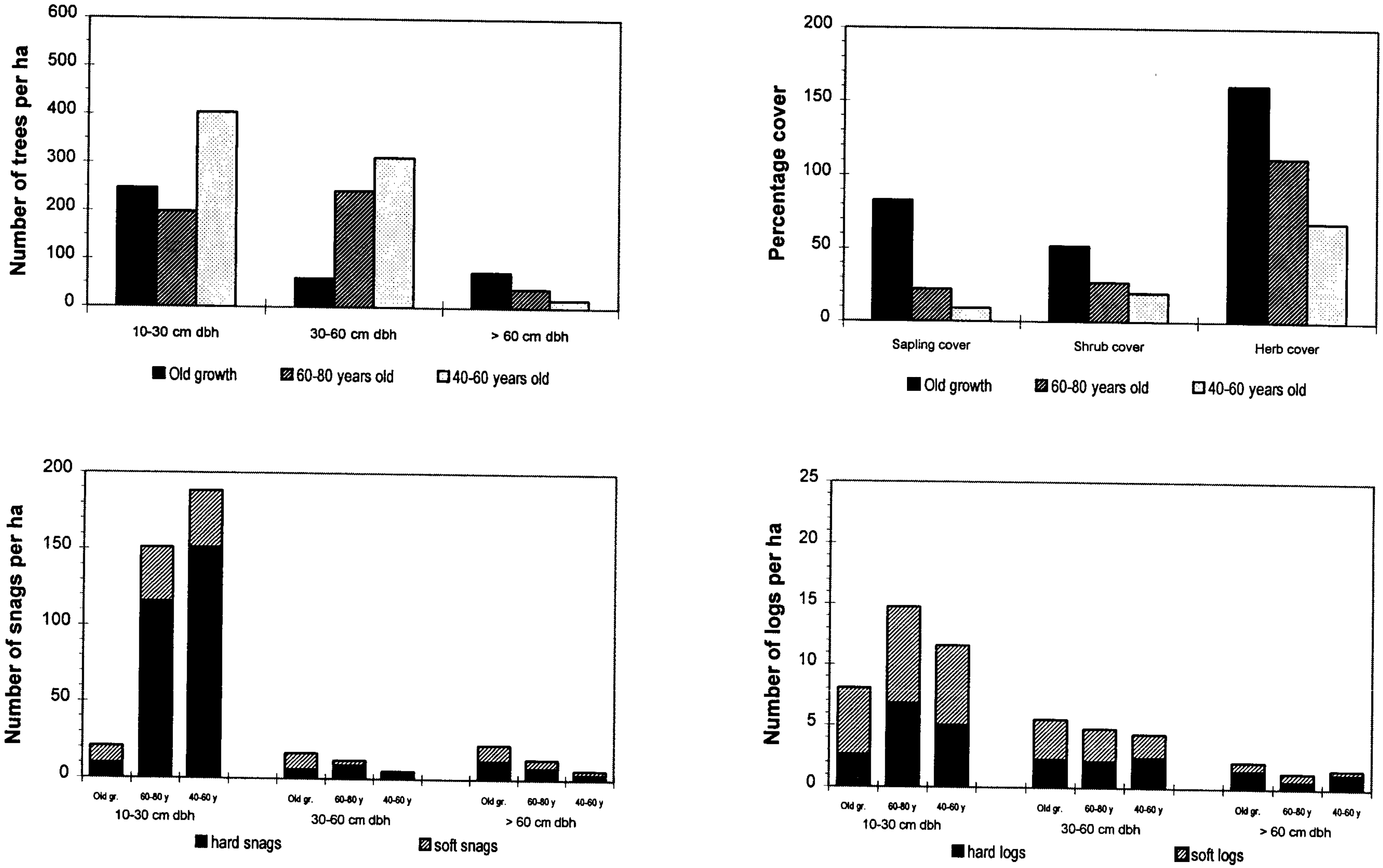

Figure 4. Density of trees, snags and logs in old growth, 60-80 year and 40-60 year old forest stands of the Mainland South Coast

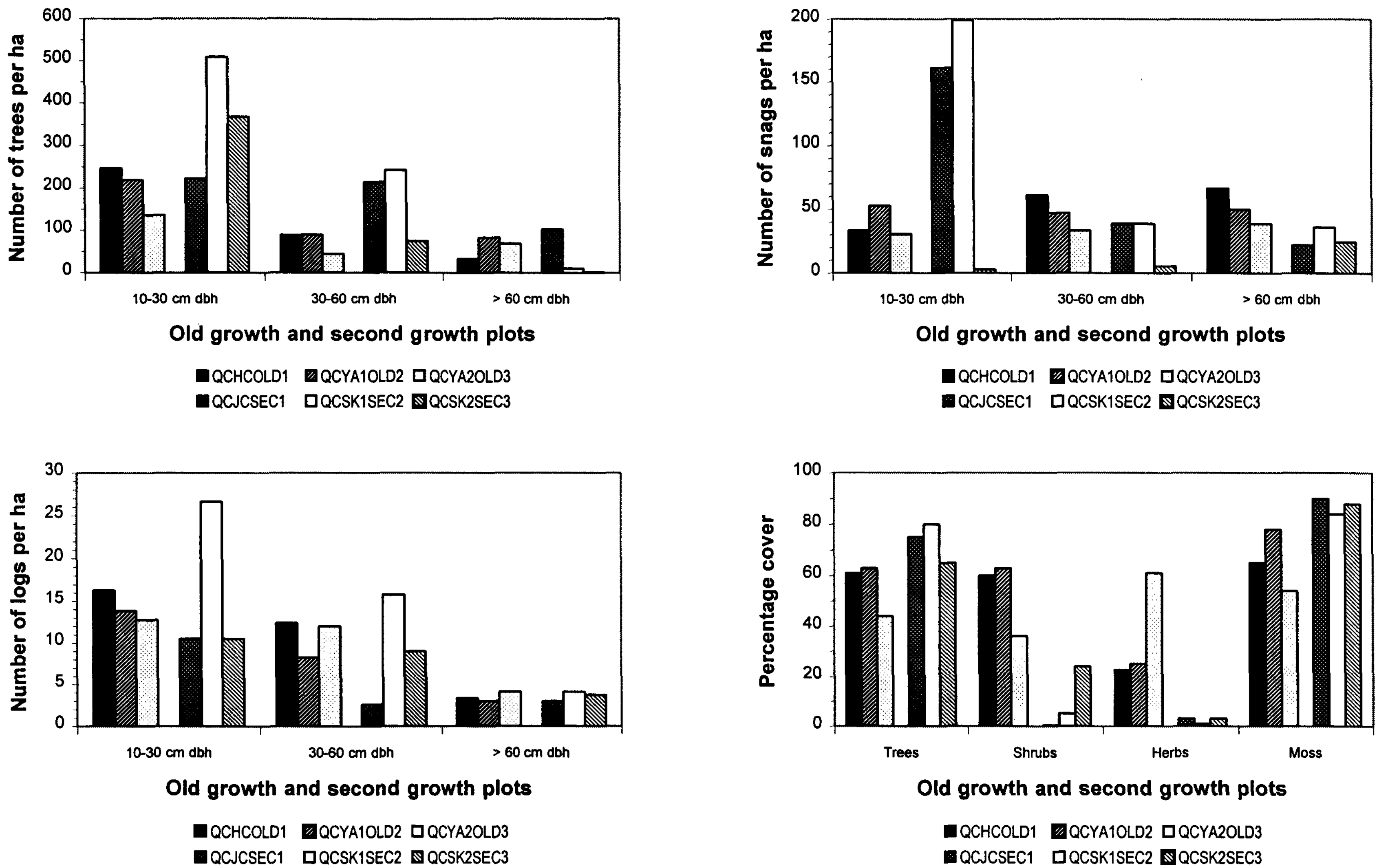

Figure 5. Density of trees, snags and logs in the spot-mapping plots of the Queen Charlotte Islands.

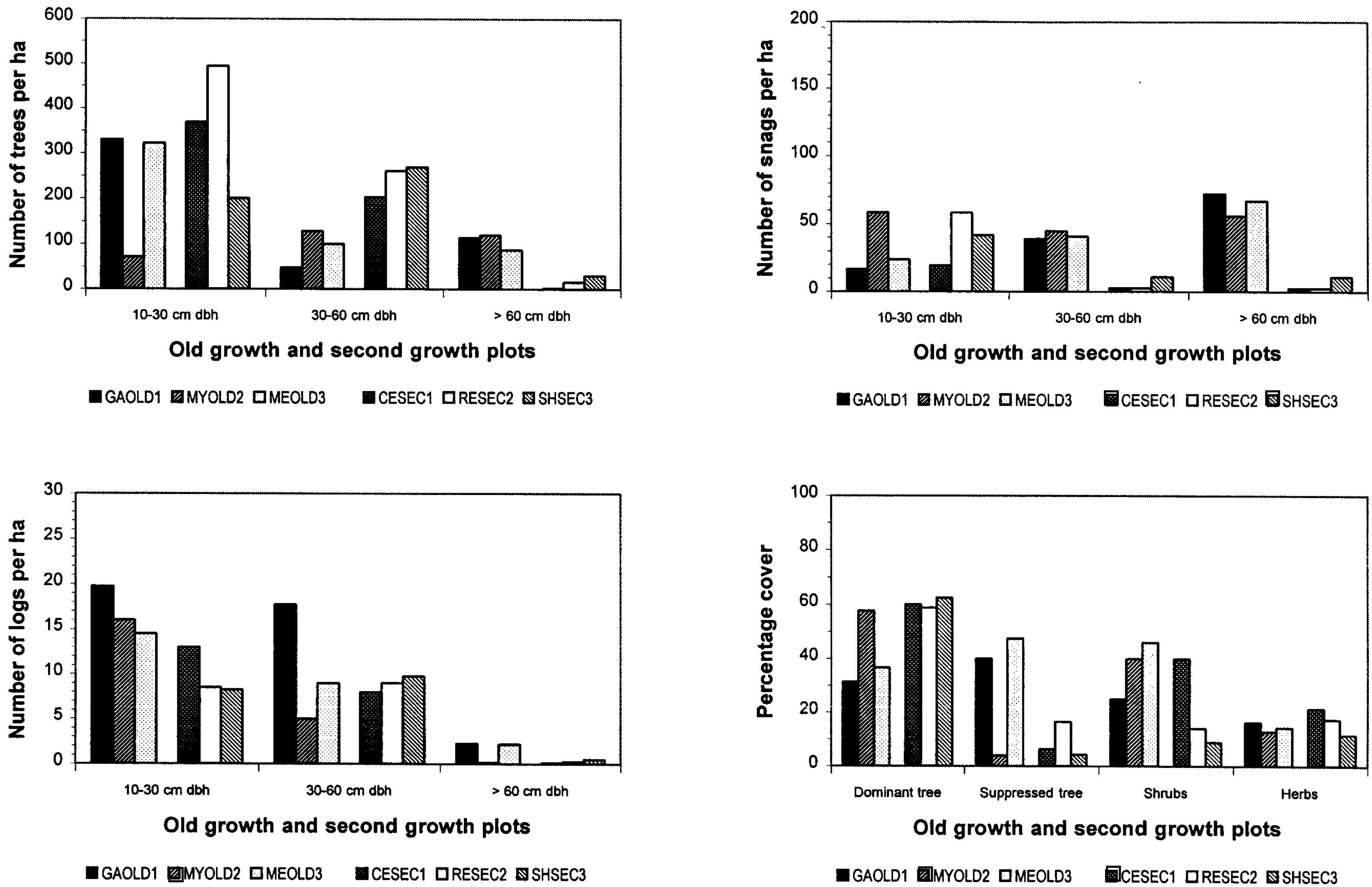

Figure 6. Density of trees, snags and logs in the spot-mapping plots of Vancouver Island.

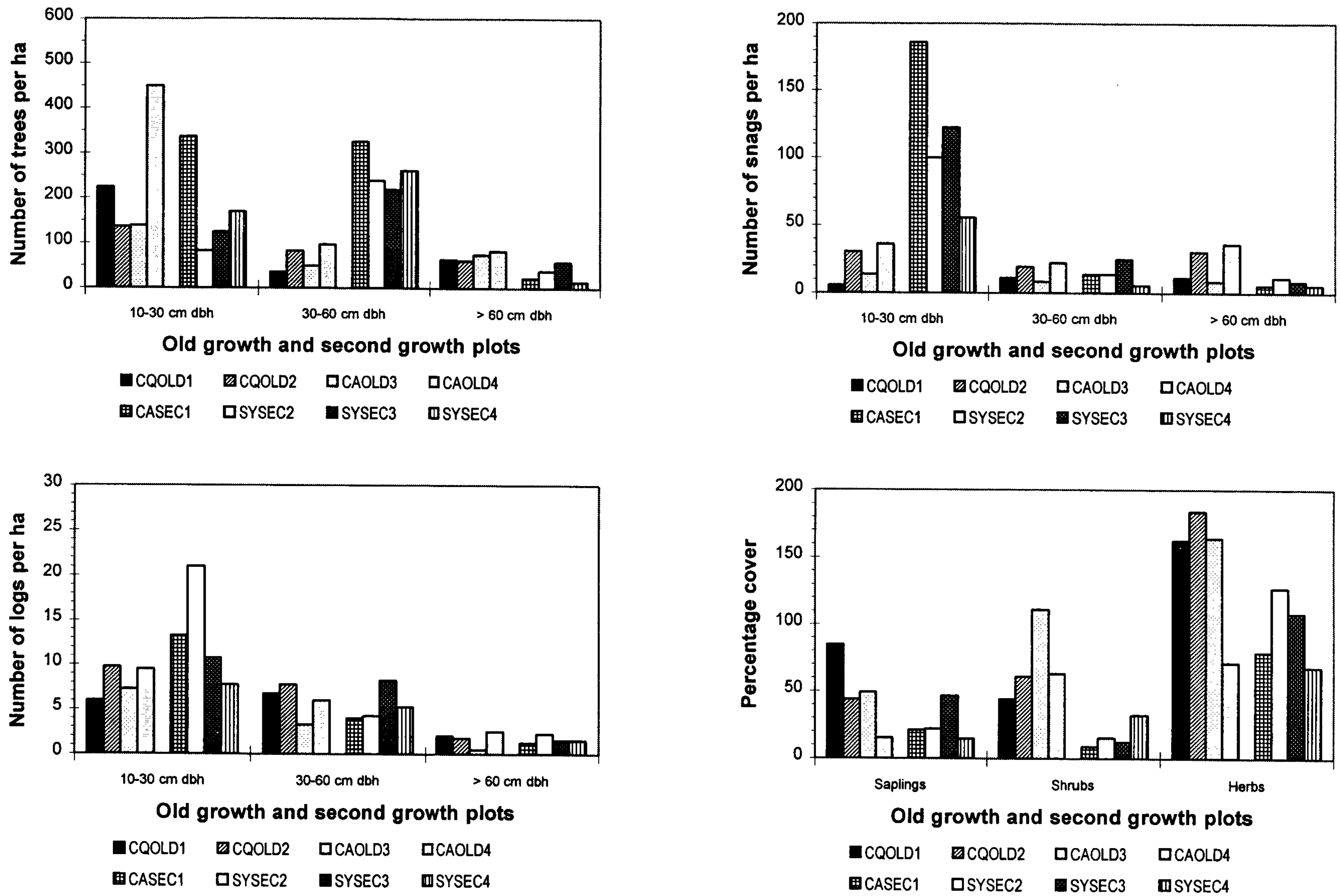

Figure 7. Density of trees, snags and logs in the spot-mapping plots of the Mainland South Coast.

Deciduous forest stands

Deciduous stands were highly variable in tree composition and structure (Table 23). Deciduous stands sampled in the Queen Charlotte Islands were comprised mostly of young Red Alder growing on harvested slopes. The shrub layer was sparse in these stands, allowing for an important herb and moss layer. Vancouver Island deciduous stands were located on small floodplains and composed mostly of Black Cottonwoods and Red Alders with a few Big Leaf Maples. Trees in these stands averaged 26 m in height and there was an abundant shrub layer. The two sites on the Mainland South Coast differed greatly: the Squamish site resembled the Vancouver Island sites with trees averaging 26 m in height and dominated by Black Cottonwoods but with fewer Red Alders and more Big Leaf Maples and the Vancouver site had much younger trees and few Big Leaf Maples (Table 23).

The two spot-mapping plots near Vancouver were similar, both being located in Red Alder stands. Tree height was about 15 m and there was a well developed shrub component. The Squamish plot had higher trees (30 m) consisting mostly of Black Cottonwoods and Big Leaf Maples. The shrub layer covered 60 % of the plot (Table 24).

Clearcuts

Clearcuts surveyed differed in species composition, structure and age (Table 25). Queen Charlotte Islands clearcuts were approximately 5 years old and composed mostly of young Western Hemlocks and Sitka Spruces. They had nearly twice as much woody debris on the ground as clearcuts of Vancouver Island or the Mainland South Coast. Vancouver Island clearcuts ranged between 3 and 7 years of age and were dominated either by Douglas-firs or Western Hemlocks with a few Red Alders. Vegetation height averaged about 1.6 m. The Mainland South Coast clearcuts were among the oldest sampled ranging between 5 and 12 year old and were all dominated by small Douglas-firs with a small number of Western Hemlocks and Western Red-Cedars (Table 25).

The two Queen Charlotte Islands spot-mapping plots were virtually identical, being dominated by small Western Hemlocks and Sitka Spruces. Coarse woody debris were abundant (Table 26). The Mainland South Coast stands were also similar but differed considerably from the Queen Charlotte Islands stands in vegetation height and composition. Small trees were taller on the Mainland South Coast and composed mostly of Douglas-firs with a few Western Hemlocks and Western Red-Cedars. Coarse woody debris abundance was half that of the Queen Charlotte Islands clearcuts.

Bird species

Comparisons between bird abundance and vegetation characteristics suggest possible explanations of the differences observed between areas. However, with only three areas compared we can only speculate on the biological relevance of these relationships. The importance of some vegetative attributes to particular bird species is summarized in Tables 27-28. Correlations differed between areas, possibly a consequence of low sample size, different requirements within the range of attributes present or different population densities. These correlations suggest biological relationships which can only be confirmed through experimental manipulation and/or control of alternate variables within a much larger sample size.

Table 23 - Vegetation characteristics of deciduous stands.

	Queen Charlotte Islands	Vancouver Island	Mainland South Coast	
			Squamish	Vancouver
Trees height (m)	13	26	26	15
Dominant (%)	15	12	18	9
Co-Dominant (%)	60	55	15	51
Suppressed (%)	30	13	45	17
Small trees >2 m (%)	4	8	31	9
Shrubs <2 m (%)	13	62	58	45
Herbs (%)	41	25	8	5
Mosses (%)	40	8	4	4
Coarse woody debris (%)	15	7	23	8
Douglas-fir (%)		3		
Western Hemlock (%)	3	2	0	1
Western Red Cedar (%)	0	3	6	5
Sitka Spruce (%)	3	0	5	2
Red Alder (%)	95	35	11	46
Black Cottonwood (%)	0	55	53	43
Maple (%)	0	2	86	2

Table 24 - Vegetation characteristics of deciduous spot-mapping plots.

	Vancouver Island		Squamish
	Alder 1	Alder 2	
Trees height (m)	15	15	30
Dominant (%)	5	10	20
Co-Dominant (%)	65	60	10
Suppressed (%)	10	10	50
Small trees >2 m (%)	5	7	30
Shrubs <2 m (%)	30	40	60
Herbs (%)	5	7	7
Mosses (%)	3	3	3
Western Red Cedar (%)	10	5	5
Sitka Spruce (%)			10
Red Alder (%)	90	85	5
Black Cottonwood (%)	0	0	50
Big Leaf Maple (%)	0	10	30

Table 25 - Vegetation characteristics of clearcuts.

	Queen Charlotte Islands	Vancouver Island	Mainland South Coast
Age	5	3-7	5-10
$\bar{x}$ Vegetation height (m)	2.2	1.6	2.9
Small trees >2 m (%)	28	15	37
Shrubs <2 m (%)	44	73	33
Herbs (%)	19	16	8
Mosses (%)	11	5	7
Coarse woody debris (%)	35	19	14
Douglas-fir (%)	0	48	79
Western Hemlock (%)	1	45	10
Western Red Cedar (%)	1	0	9
Sitka Spruce (%)	17	0	0
Red Alder (%)	1	7	0

Table 26 - Vegetation characteristics of clearcut spot-mapping plots.

	Queen Charlotte Islands		Mainland South Coast	
	QCCL 1	QCCL 2	SCCL 1	SCCL 2
Age	5	5	12	
$\bar{x}$ Vegetation height (m)	2.5	2.5	4	
Small trees >2 m (%)	20	20	60	
Shrubs <2 m (%)	60	60	30	
Herbs (%)	20	20	7	
Mosses (%)	10	10	5	
Coarse woody debris (%)	30	30	15	
Douglas-fir (%)			70	80
Western Hemlock (%)	80	80	15	10
Western Red Cedar (%)			15	10
Sitka Spruce (%)	20	20		

Table 27 - Associations between vegetation attributes and species.

	Mainland South Coast	Vancouver Island	Queen Charlotte Islands
LIVE TREES			
10-30 cm dbh	+ WETA* - RECR - VATH - WIWR	+ GCKI + HUVI + TOWA - BLGR - BRCR - CBCH - HAWO - MAMU - PIWO - WIWR	+ HETH + OCWA + SWTH - BRCR - PSFL - RBSA - WIWR
30-60 cm dbh	+ PISI + RBSA + WETA - BLGR - VASW - VATH - WIWR	+ GCKI + HAFL+ RUHU + TOWA - MAMU - NOFL - PISI - PSFL - HETH - RBNU - VATH - RECR - WIWR	+ GCKI + RBSA + TOWA - PSFL - WIWR
> 60 cm dbh	+ BRCR + RBSA + VASW + VATH - PISI - STJA - WETA	+ CBCH + MAMU + PSFL + PISI + WIWR + RECR - DEJU - HUVI - TOWA - RBNU	+ BRCR + RBSA - HETH - OCWA - TOWA
% Shrub	+ PISI + VATH	- RBNU	+ BLGR + BRCR + PSFL + RBNU + RBSA + RECR + WIWA + WIWR - GCKI - TOWA
% Herb	+ RBSA + VATH + WIWR - PISI - STJA	- MAMU	+ BLGR + BRCR + PSFL + RBSA + RECR + WIWR - GCKI - PISI

* Species underlined were correlated with basal area but not Number of trees.

Table 28 - Associations between snag type and size (dbh) and species using snags (only species using snags listed here)

	Mainland South Coast	Vancouver Island	Queen Charlotte Islands
HARD SNAGS			
10-30 cm	- VASW	+ PIWO	
30-60 cm		+ BRCR + CBCH + HAWO + PIWO + CBCH* + HAWO + RBNU	+ BRCR + HAWO + RBSA + NOFL + RBNU
> 60 cm	+ CBCH + HAWO + RBNU + RBSA		+ BRCR + RBNU + RBSA
SOFT SNAGS			
10-30 cm	- VASW	+ HAWO + PIWO + RBNU	+ BRCR + CBCH
30-60 cm	+ VASW	+ RBNU	+ HAWO + NOFL + RBNU + RBSA
> 60 cm	+ RBSA + VASW	+ CBCH + PIWO + RBNU	+ HAWO + CBCH + RBNU + RBSA

* Species underlined were correlated with basal area but not Number of snags.

The abundance of large trees was positively associated with bird species typical of old growth. Species breeding or feeding on snags were all positively associated with the abundance of large snags (Table 28). The only negative correlation found was between Vaux's Swift and the abundance of small diameter snags. The abundance of a few species were not correlated with small size hard snags but were correlated with small size soft snags (*i.e.* Brown Creeper, Chestnut-backed Chickadee and Red-breasted Nuthatch).

Brown Creeper (*Certhia americana*)

Spot-mapping results indicated that Brown Creeper occurred in higher densities in old growth stands than in either 40-60 or 60-80 year old stands. Point counts results, although not all statistically significant, supported these results with the lowest Brown Creeper abundance occurring in the youngest stands.

Stand attributes significantly correlated ($p < 0.1$) with Brown Creeper relative abundance included:

A) Queen Charlotte Islands (QCI): hard snags 30-60 cm dbh ($r = 0.60$), >60 cm dbh (0.51), soft snags 10-30 cm dbh (0.59); trees >0.60 cm dbh (0.68), 10-30 cm (-0.58); % tree cover (-0.70), shrub cover (0.68) and herb cover (0.59).

B) Vancouver Island (VI): hard snags 30-60 cm dbh (0.44), trees 10-30 cm dbh (-0.58), >60 cm dbh (0.40).

C) Mainland South Coast (MSC): trees >60 cm dbh (0.52).

Spot-mapping results support the above relationships. In the Queen Charlotte Islands, the second growth stand with no Brown Creepers had also the lowest number of large trees and snags (fig. 5). On the Mainland South Coast, two old growth plots had Brown Creeper densities twice as high as the two other old growth plots. Densities of large snags were greater in these plots as were densities of trees 30-60 cm dbh (fig. 7). Characteristics of the second growth plot with no Brown Creepers (plot CASEC1 Table 11, Fig. 7) included a higher density of trees 10-30 cm dbh and a relatively small density of large trees and snags. This second growth plot was 40-60 years old compared to the others that were 60-80 years old.

Brown Creepers were present in 3 of 4 deciduous stands sampled, reaching abundance levels similar to those of second growth stands. They were absent from the young alder stands of the Queen Charlotte Islands. In Washington and Oregon, Brown Creepers reached densities similar to old growth forests in 95-190 year old stands (Manuwal 1991, Carey *et al.* 1991, Gilbert and Allwine 1991). Carey *et al.* (1991) found that in Oregon, Brown Creepers preferred to forage on the largest trees available and their abundance increased with the abundance of large trees. These results strongly suggest that Brown Creepers are associated with specific attributes of older forests and will require special management to be maintained in areas with intensive forest exploitation.

Chestnut-backed Chickadee (*Parus rufescens*)

Breeding densities of Chestnut-backed Chickadees were higher in the old growth stands of Vancouver Island and the Mainland South Coast but not on the Queen Charlotte Islands (Table 13). Point count results yielded a significant difference in relative abundance only between old growth and 40-60 year old stands of Vancouver Island.

Stands attributes correlated with Chestnut-backed Chickadee relative abundance included:

A) QCI: soft snags 10-30 cm dbh (0.65), >60 cm dbh (0.63);

B) VI: hard snags 30-60 cm dbh (0.44); soft snags 10-30 cm dbh (0.41), >60 cm dbh (0.60), trees 10-30 cm dbh (-0.40), >60 cm dbh (0.51);

C) MSC: hard snags >60 cm dbh (0.37).

Relationships varied with areas but reflected in general a preference for large trees and snags. Spot-mapping results confirm this pattern. On the Queen Charlotte Islands, breeding densities of Chestnut-backed Chickadees were high in one of the old growth and one of the second growth plots. This old growth plot (QCHC) had a high density of large snags (30-60 and >60 cm dbh, fig. 5), and the second growth plot (QCSK1) had a high density of large trees and snags (>60 cm dbh). On Vancouver Island, the plot with the lowest density of Chestnut-backed Chickadees had a lower density of large snags (>60 cm dbh) and of trees 10-30 cm dbh than the other two old growth plots (fig. 6). The second growth plot with the highest density of chickadees also had the highest density of snags >60 cm dbh. On the Mainland South Coast, the two old growth plots with the highest densities of snags >60 cm dbh and trees 30-60 cm dbh had also the highest densities of chickadees (fig. 7). The only habitat variable associated with low density of Chestnut-backed Chickadees observed in one of the second growth plot was the density of saplings.

These results indicate the importance of large snags for Chestnut-backed Chickadees, especially in second growth forest. Chestnut-backed Chickadees are foliage gleaners which should be able to use the large volume of foliage present in second growth forests (Sturman 1968). However, they require tree cavities for nesting and roosting and this may limit their numbers in young forests. The lower breeding densities in the 40-60 year old stands of Vancouver Island are likely due to the low abundance of snags in these stands (Table 22). If nest sites are available in second growth stands, these stands may support high breeding densities of Chestnut-backed Chickadees. Although they prefer coniferous forest they may breed in deciduous forest (Sturman 1968). They were present in some of the deciduous stands sampled (Table 14). In Douglas-fir forests of southern Washington, Chestnut-backed Chickadees were more numerous in wet old growth forests than in mesic and dry stands and less numerous in young (55-80 year old) and mature stands (95-190 year old) than in old growth ones (Manuwal 1991). Carey *et al.* (1991) obtained results similar to Manuwal (1991) in Oregon and found that in young forests, the species was positively associated with the density of large snags. Patterns of Chestnut-backed Chickadee abundance seem to vary geographically, likely in response to nest site availability and conifer foliage volume. Provision of adequate numbers of snags in young forest may be required to support high breeding densities of Chestnut-backed Chickadees in these stands.

Hairy Woodpecker (*Picoides villosus*)

Breeding densities of Hairy Woodpeckers were highest in old growth stands of the Queen Charlotte Islands and the Mainland South Coast (Table 13). The tendency was similar for Vancouver Island although results did not differ significantly. Point counts confirmed the higher abundance of Hairy Woodpecker in old growth than in 40-60 year old stands in all three areas. They also indicated similar abundance of Hairy Woodpecker in old growth and 60-80 year old forests of both Vancouver Island and Mainland South Coast.

Stand attributes correlated with Hairy Woodpecker relative abundance included:

A) QCI: soft snags 30-60 cm dbh (0.70), >60 cm dbh (0.70);

B) VI : hard snags 30-60 cm dbh (0.60), >60 cm dbh (0.41); soft snags 10-30 cm dbh (0.39), live trees 10-30 cm dbh (-0.42); % dominant tree cover (-0.65);

C) MSC: hard snags >60 cm dbh (0.38); trees 30-60 cm dbh (-0.38); % saplings cover (0.40).

On the Queen Charlotte Islands, the only second growth stand with breeding Hairy Woodpeckers was the stand with the highest density of large trees (>60 cm dbh) (fig. 5). On Vancouver Island, the old growth stand with the highest density of Hairy Woodpeckers also had a greater density of snags

>60 cm dbh and of downed woody debris 30-60 cm dbh (fig. 6). The second growth plot with the greatest percentage of suppressed trees also had high densities of Hairy Woodpeckers. On the Mainland South Coast, the two second growth plots with the lowest breeding densities of Hairy Woodpeckers also had the lowest densities of large trees and snags (fig. 7). Hairy Woodpeckers occurred in the two oldest deciduous stands but were rare in the younger one (Table 14). This species, as for the Brown Creeper, requires large trees and should be of special concern in the exploited forest.

Pacific-slope Flycatcher (*Empidonax difficilis*)

Breeding densities of Pacific-slope Flycatchers were highest in old growth stands of the Queen Charlotte Islands but not in those of the Mainland South Coast or Vancouver Island. However, on Vancouver Island densities of flycatchers were quite variable in the three second growth stands sampled (3.5, 20.6 and 3.4 pairs). Point counts indicated a higher abundance of Pacific-slope Flycatchers in old growth than in second growth on both the Queen Charlotte Islands and Vancouver Island (Table 15). Relative abundance of Pacific-slope Flycatchers did not differ among the forest stands of the Mainland South Coast.

Stands attributes correlated with the relative abundance of Pacific-slope Flycatcher included:

A) QCI: hard snags 30-60 cm dbh (0.69), >60 cm dbh (0.66), woody debris 30-60 cm dbh (0.64), trees 10-30 cm dbh (-0.54), 30-60 cm dbh (-0.69); % tree cover (-0.81), shrub cover (0.86) and herb cover (0.70);

B) VI : soft snags >60 cm dbh (0.37), hard woody debris >60 cm dbh (0.37); soft woody debris 10-30 cm dbh (-0.56), >60 cm dbh (-0.46); live trees 30-60 cm dbh (-0.62), >60 cm dbh (0.57); % suppressed tree cover (0.61);

C) MSC: hard snags 10-30 cm dbh (-0,36), soft snags >60 cm dbh (0.50).

The second growth stand with the highest density differed from the other two by having a greater density of trees 10-30 cm dbh and a greater % of suppressed trees. On Vancouver Island the old growth plot supporting the highest densities of Pacific-slope Flycatchers also had the highest density of large snags (>60 cm dbh) and down woody debris 10-30 cm dbh and 30-60 cm dbh (fig. 6). It had also the lowest density of trees 30-60 cm dbh. On the Mainland South Coast breeding densities of Pacific-slope Flycatchers were twice as high in two of the four old growth plots (Table 11). These two plots had higher densities of snags of all sizes, of trees 30-60 cm dbh and greater densities of woody debris than the two old growth plots with lower breeding densities (fig. 7).

Pacific-slope Flycatchers were abundant in the deciduous stands of the Queen Charlotte Islands and the Mainland South Coast which supported numbers similar to those in old growth stands. However, their abundance was much lower in the Vancouver Island deciduous stands (Table 14). Pacific-slope Flycatchers seem to prefer old growth stands but also frequent younger stands, sometimes in high numbers (Manuwal 1991, Carey *et al.* 1991). Their maintenance in the context of intensive forestry may not prove to be too difficult, especially as they are migrants and do not winter in the coastal forests of British Columbia.

Varied Thrush (*Ixoreus naevius*)

Breeding densities of Varied Thrush were highest in old growth stands of the Queen Charlotte Islands and the Mainland South Coast (Table 13) with a similar but non significant tendency on Vancouver Island (Table 8). Point counts supported the above relationship for old growth stands of Vancouver Island and the Mainland South Coast and indicated a similar trend for the Queen Charlotte Islands. Varied Thrush breeding densities were twice as high on the Queen Charlotte Islands (Table 4) than on either Vancouver Island (Table 8) or the Mainland South Coast (Table

11). In fact, densities of Varied Thrushes in the Queen Charlotte Islands second growth stands were as high as in the old growth stands of the other two areas.

Stands attributes correlated with relative abundance of Varied Thrushes included:

A) QCI: % moss cover (-0.53);

B) VI : soft snags >60 cm dbh (0.76), hard snags >60 cm dbh (0.39); trees 30-60 cm dbh (-0.67), % suppressed tree cover (0.45);

C) MSC: hard snags 10-30 cm dbh (-0.66), >60 cm dbh (0.40), soft snags 10-30 cm dbh (-0.66), 30-60 cm dbh (0.44), >60 cm dbh (0.44), hard woody debris 10-30 cm dbh (-0.48), soft woody debris 10-30 cm dbh (-0.35), trees 30-60 cm dbh (-0.72), >60 cm dbh (0.69); % shrub cover (0.54), saplings cover (0.72), herb cover (0.63).

In the Queen Charlotte Islands, breeding densities of Varied Thrush in old growth stands were positively associated with the density of trees 10-30 cm dbh, density of snags 30-60 cm dbh and >60 cm dbh (fig. 5). Breeding densities were similar in all three second growth stands (Table 4). On Vancouver Island, densities were similar in old growth stands but varied greatly among second growth stands. The stand with the highest density of Varied Thrush differed from the two others in the following characteristics : a greater density of trees 10-30 cm dbh, snags 10-30 cm dbh and greater percentage of suppressed trees (fig. 6). On the Mainland South Coast, the old growth stand with the highest breeding density had a greater percentage of herb cover and a greater quantity of downed woody debris 30-60 cm dbh. The stand with the lowest breeding density had the lowest density of snags of any size. In second growth stands, the only characteristic correlated with Varied Thrush density was the number of snags 10-30 cm dbh. Manuwal (1991) recorded twice as many Varied Thrushes in Washington old growth Douglas-fir forests than in 55-80 year old and 95-190 year old stands. However, Carey *et al.*, (1991) found similar abundance of Varied Thrush in Oregon's old growth and 80-120 year old Douglas-fir stand but nearly 4 times fewer birds in 40-72 year old ones. However, both studies noted a significant association of Varied Thrush with wet old growth stands which may explain in part, the greater abundance of Varied Thrush in the wetter stands of the Queen Charlotte Islands. Carey *et al.* (1991) in Douglas-fir forests of Oregon found a positive correlation between Varied Thrush abundance and the proportion of herbs, ferns and berry-producing shrubs and a negative one with evergreen shrubs.

Varied Thrushes were abundant (1.71 detections/point) in the young alder stands of the Queen Charlotte Islands but not those of the Mainland South Coast (0.08 detection/point, Table 14). Their abundance in the older deciduous stands of the Mainland South Coast and Vancouver Island was much lower than in old growth stands. There was considerable variation in the breeding density of Varied Thrushes between plots, especially in younger forests. The results suggest that some younger stands if properly managed could sustain a small population of Varied Thrush. More detailed studies are needed to identify the required habitat attributes in younger stands.

Townsend's Warbler (*Dendroica townsendi*)

Breeding densities of Townsend's Warblers were highest in second growth forests on the Queen Charlotte Islands and Vancouver Island (Table 13). On the Mainland South Coast, old growth stands supported higher densities of Townsend's Warblers than 60-80 year old ones (Table 12). Breeding density varied greatly between areas with the greatest (39.2 pairs/40 ha) occurring in the 40-60 year old stands of the Queen Charlotte Islands and the lowest (9.9 pairs/40 ha) in Vancouver Island old growth stands. Point count results confirmed these patterns (Tables 6-8-12). Stand attributes correlated with Townsend's Warbler relative abundance included:

A) QCI: hard and soft snags 30-60 cm dbh, >60 cm dbh (>-0.55); trees 10-30 cm dbh (0.60), 30-50 cm dbh (0.60), >60 cm dbh (-0.681); % tree cover (-0.74), shrub cover (-0.75), moss cover (-0.52);

B) VI : hard snags 10-30 cm dbh (0.65), 30-60 cm dbh (-0.54), >60 cm dbh (-0.64); trees 10-30 cm dbh (0.70), >60 cm dbh (-0.56); % dominant tree ones (0.53), suppressed tree cover (-0.68);

C) MSC: no significant correlations when old growth and second growth stands are combined but their abundance was negatively correlated with trees >30 cm dbh (-0.70) in 40-60 year old stands and negatively correlated with hard and soft snags >30 cm dbh (-0.89) and % shrub cover (-0.90) in 40-60 year old stands.

In the Queen Charlotte Islands, breeding densities of Townsend's Warbler in old growth stands were positively associated with the density of trees 10-30 cm dbh, snags 30-60 cm dbh and >60 cm dbh and with density of woody debris 10-30 cm dbh (Table 4, fig. 5). The second growth stand with the highest breeding density (QCSK1) was characterized by a greater density of trees 10-30 cm dbh, snags 10- 30 cm dbh and woody debris 10-30 cm dbh. On Vancouver Island, Townsend's Warblers were numerous in only one of the three old growth stands (Table 8). Among the habitat attributes measured, this stand differed from the two others by having a lower density of trees 10-30 cm dbh, of woody debris 30-60 cm dbh and a lower percentage of suppressed trees (fig. 6). It had also a greater density of snags 10-30 cm dbh and dominant trees. This plot was also the driest one of the three plots, which supports the preference of this species for dry old growth plots (Manuwal 1991). On the Mainland South Coast, breeding densities in old growth stands were positively associated with abundance of snags of all sizes and the density of woody debris 10-30 cm dbh (fig. 7). The second growth stand with the highest breeding density of Townsend's Warblers also had the highest density of trees 10-30 cm dbh and 30-60 cm dbh, and of snags 10-

30 cm dbh. Our data suggest a greater abundance of Townsend's Warblers in 40-60 year old stands with a decrease in 60-80 years stands, followed possibly by a slight increase in older stands. Although present in old growth stands, the Townsend's Warbler seems to prefer younger stands. Townsend's Warbler, a migratory species, should do well in intensively managed forests.

Winter Wren (*Troglodytes troglodytes*)

Breeding densities of Winter Wrens were significantly higher on average in old growth stands (Table 2). Their relative abundance was similar in old growth and 60-80 year old stands of Vancouver Island and the Mainland South Coast but was significantly lower in 40-60 year old stands (Tables 8-12). Stand characteristics associated with Winter Wren abundance included:

A) QCI: hard snags 10-30 cm dbh (-0.71), >60 cm dbh (0.57); woody debris 30-60 cm dbh (0.72), >60 cm dbh (-0.74); % trees cover (-0.70), shrub cover (0.55), herb cover (0.68);

B) VI : hard snags 30-60 cm dbh (0.50), >60 cm dbh (0.39); soft snags 10-30 cm dbh (0.52), 30-60 cm dbh (0.49), >60 cm dbh (0.56); woody debris 10-30 cm dbh (0.54), >60 cm dbh (0.53); trees 10-30 cm dbh (-0.50), 30-60 cm dbh (-0.55), >60 cm dbh (0.59); % dominant tree cover (-0.71);

C) MSC: Hard snags 30-60 cm dbh (0.40), >60 cm dbh (0.37); woody debris 10-30 cm dbh (0.50), trees 10-30 cm dbh (-0.27), 30-60 cm dbh (-0.38); % shrub cover (0.39), herb cover (0.34).

In the Queen Charlotte Islands, the old growth plot with the lowest breeding density of Winter Wrens (20.6 pairs/40 ha) (Table 4) had the lowest percentage of tree and shrub cover and a relatively high % of herb cover (fig. 5). Also this plot had the lowest number of snags 30-60 and >60 cm dbh. No particular attributes were apparent in explaining the low variation in breeding densities of Winter Wren on Vancouver Island (Table 8, fig. 6). Breeding densities were more variable on the Mainland South Coast. Two old growth plots had higher breeding densities of Winter Wren. These plots differed from the other two old growth plots by a high density of woody debris 10-30 cm dbh, and of snags of all sizes (fig. 7).

Manuwal (1991) found significantly higher numbers of Winter Wrens in wet old growth stands than in either mesic or dry ones. Abundance of Winter Wrens in young (55-80 years) and mature (95-190 years) Douglas-fir stands was similar to that found in mesic and dry old growth stands (Manuwal 1991).

Winter Wrens were as numerous in the young alder stands of the Queen Charlotte Islands as in old growth stands (Tables 6-14). On Vancouver Island and the Mainland South Coast, they were more numerous in deciduous stands than in 40-60 year old stands, but were most numerous in older stands (Tables 8-12-14). Their abundance in clearcuts varied greatly between areas from nearly absent in the Mainland South Coast clearcuts to very abundant in the Queen Charlotte Islands ones (Table 17). These differences are quite striking and deserve future studies. The optimal habitat of Winter Wren is found in old growth forests but their use of younger stands, deciduous stands and clearcuts in some areas should facilitate their maintenance in managed forests.

Red-breasted Nuthatch (*Sitta canadensis*)

Breeding densities and relative abundance of Red-breasted Nuthatches were greater in old growth stands of Vancouver Island and the Queen Charlotte Islands. On the Mainland South Coast, their relative abundance was similar in old growth and 60-80 year old stands but lower in 40-60 year old stands. Stand attributes correlated with the relative abundance of Red-breasted Nuthatch included:

A) QCI: Hard snags >60cm dbh (0.53), 30-60 cm dbh (0.65); soft snags 30-60 cm dbh (0.66), >60 cm dbh (0.50); hard woody debris 10-30 cm dbh (0.78), 30-60 cm dbh (0.87); % shrub cover (0.54), moss cover (-0.57).

B) VI : Hard snags 30-60 cm dbh (0.76), >60 cm dbh (0.76); soft snags 10-30 cm dbh (0.49), 30-60 cm dbh (0.59), >60 cm dbh (0.60); hard woody debris 10-30 cm dbh (0.55), 30-60 cm dbh (0.60), >60 cm dbh (0.44), trees 30-60 cm dbh (-0.50), >60 cm dbh (-0.63), % dominant tree cover (-0.63), suppressed tree cover (0.53), shrub cover (-0.40).

C) MSC: Hard snags >60 cm dbh (0.35); soft coarse woody debris 30-60 cm dbh (0.41).

In the Queen Charlotte Islands old growth stands, the lowest density of Red-breasted Nuthatches was found in the plot with the lowest density of snags >30 cm dbh, % tree cover, % shrub cover and % moss cover and with the highest % herb cover (Table 4, fig. 5). On Vancouver Island, the lowest breeding densities were found in the driest old growth plot (MYOLD2, Table 8) which had a lower density of trees 10-30 cm dbh, of woody debris 30-60 cm dbh, of % tree cover, and a greater % of dominant tree cover than the other two old growth plots (Fig. 6). On the Mainland South Coast, Red-breasted Nuthatch density was three times higher in one of the four old growth plots (CQOLD2) which contrasted with the others by a greater % of herb ground cover and a greater density of large snags than two of three other old growth plots. In the Douglas-fir forests of southern Washington Cascades, Red-breasted Nuthatches were more numerous in dry and mesic old growth stands than in either wet old growth stands or younger stands (Manuwal 1991). They were also more abundant in 95-190 year old stands than in 55-80 year old ones. Carey *et al.* (1991) found similar higher abundances in older stands in Oregon.

Red-breasted Nuthatches were absent from the deciduous stands of the Queen Charlotte Islands and Vancouver Island but occurred in small numbers in those of the Mainland South Coast. It is thus unlikely that deciduous stands will provide adequate refuges for that species in the exploited forest.

Red-breasted Sapsucker (*Sphyrapicus ruber*)

Both spot-mapping and point count results indicated a greater abundance of Red-breasted Sapsuckers in old growth stands of Queen Charlotte Islands and Mainland South Coast (Table 13). Stand attributes correlated with the relative abundance of Red-breasted Sapsuckers included:

A) QCI: Hard snags 30-60 cm dbh (0.53); >60 cm dbh (0.51), soft snags 30-60 cm dbh (0.64); >60 cm dbh (0.69), hard coarse woody debris 30-60 cm dbh (0.84); trees 10-30 cm dbh (-0.64), 30-50 cm dbh (0.54), >60 cm dbh (0.54); % tree cover (-0.77), shrub cover (0.59), herb cover (0.58).

B) VI : too few birds detected there (Tables 8-9).

C) MSC: hard snags >60 cm dbh (0.48); soft snags >60 cm dbh (0.50), soft woody debris >60 cm dbh (0.40); trees 30-60 cm dbh (-0.38), >60 cm dbh (0.35); % sapling cover (0.49), herb cover (0.40).

In the Queen Charlotte Islands, the old growth plot with the lowest (but still high) breeding density of sapsuckers was also the plot with the lowest density of large snags, % tree cover, % shrub cover and with the highest % of herb cover. The second growth plot with the highest density of sapsuckers was older than the two other second growth plots and had a greater density of large trees (Fig. 5). On the Mainland South Coast, the breeding density of Red-breasted Sapsuckers was highest in plot CQOL2 a pattern similar to that of Red-breasted Nuthatches. That plot had a greater % of shrub cover and a greater density of large snags than two of the three other old growth plots

(Fig. 7). Red-breasted Sapsuckers were rare in the deciduous stands of Vancouver Island and the Mainland South Coast but did occur in small numbers in those of the Queen Charlotte Islands (Table 14), thus deciduous stands may not provide adequate habitat for Red-breasted Sapsuckers in Coastal British Columbia. In young coniferous stands, large trees and snags appear to be a requirement for Red-breasted Sapsuckers.

Golden-crowned Kinglet (*Regulus satrapa*)

Golden-crowned Kinglets were more numerous in second growth stands than in old growth stands on the Queen Charlotte Islands, but not on the Mainland South Coast where breeding densities were twice as high in old growth stands. However, point count results suggest a trend similar to other areas with a possible lower abundance in old growth stands. These results contrast with those obtained in Douglas-fir forests of Washington and Oregon where young stands tended to support fewer or similar number of kinglets than old growth stands (Manuwal 1991, Carey *et al.* 1991). Stand attributes correlated with Golden-crowned Kinglets relative abundance included:

A) QCI: Hard snags 10-30 cm dbh (0.65); trees 30-50 cm dbh (0.63); % tree cover (0.54), shrub cover (-0.65).

B) VI : Hard snags >60 cm dbh (-0.55), 30-60 cm dbh (-0.51); hard woody debris 30-60 cm dbh (-0.43); trees 30-60 cm dbh (0.55), 10-30 cm dbh (0.44).

C) MSC: No significant correlations.

Breeding densities were similar in all three old growth plots and all three second growth plots of the Queen Charlotte Islands (Table 4, fig. 5). On Vancouver Island, the pattern of abundance in second growth plots was positively associated with an increase in trees 30-60 cm dbh, woody debris 30-60 cm dbh and negatively associated with % of shrub cover and % of herb cover (Table 8, fig.

6). There were no obvious associations between Golden-crowned Kinglet density and plot vegetation features on the Mainland South Coast (Table 11, fig. 7).

Golden-crowned Kinglets were detected in all deciduous stands sampled but their relative abundance was lower than in other stands. Their presence in these deciduous stands is intriguing as the species is usually associated with conifers. However, their presence in deciduous stands may reflect the presence of conifers in these stands or the proximity of conifer stands nearby. Further studies are needed to determine if these deciduous stands support viable breeding population of Golden-crowned Kinglets. Their greater abundance in younger stands indicates that at least during the breeding season, Golden-crowned Kinglets could be easily accommodated in the managed forest.

Red Crossbill (*Loxia curvirostra*)

Red Crossbills were not detected in high numbers on the Queen Charlotte Islands. However, point counts suggest a possible greater abundance in old growth forests (Table 7). On Vancouver Island, the relative abundance of Crossbills was significantly higher in old growth stands (Table 9) and a similar trend was apparent in spot-mapping plots (Table 5). On the Mainland South Coast, they were detected more often in 60-80 year old stands than in old growth ones. Manuwal (1991) found the species most numerous in mesic old growth stands whereas Carey *et al.* (1991) found it most numerous in young and mature stands. Holimon *et al.* (1998) found that mature forests are critical for maintaining Red Crossbills in years of poor cone production.

Red Crossbills were detected in the two older deciduous stands but the significance of that observation in unknown. Our sample methods were not adequate for sampling this species which often travels in flocks. Further sampling will be necessary to properly identify the habitat requirements of Red Crossbills.

Swainson's Thrush (*Catharus ustubatus*)

Breeding densities of Swainson's Thrushes were higher in the old growth stands of Vancouver Island than in 60-80 year old stands but no differences were found in the other areas (Table 4-8-11). Stand attributes correlated with the relative abundance of Swainson's Thrushes included:

A) QCI: Trees 10-20 cm dbh (0.51); % moss cover (-0.53);

B) VI : hard snags 30-60 cm dbh (0.31);

C) MSC: soft snags 10-30 cm dbh (0.36); soft woody debris 10-30 cm dbh (0.48), 30-60 cm dbh (0.36), >60 cm dbh (0.37).

On Vancouver Island, the only second growth plot with a breeding density similar to old growth stands had also the highest density of woody debris 10-30 cm dbh, % of shrubs and % herb cover among the second growth stands (Table 8, fig. 6). On the Mainland South Coast, % herb cover was associated with breeding densities in old growth stands (Table 11, fig. 7). In Oregon, Carey *et al.* (1991) found the species equally abundant in old growth, 40-72 year old and 80-120 year old stands. In Washington, Manuwal (1991) found higher densities in mesic and dry old growth stands than in either wet old growth or young stands.

Swainson's Thrushes were most abundant in the deciduous stands in all three areas although the difference between coniferous and deciduous stands was much lower on Vancouver Island (Table 14-16). Swainson's Thrushes were present in some clearcuts (Table 17, 19). Maintenance of this species in the context of managed forest will likely not present a major problem due to its utilization of a variety of seral stages.

Hermit Thrush (*Catharus guttatus*)

Breeding densities of Hermit Thrushes did not differ significantly with age classes in any of the three areas (Table 4-8-11). However, their relative abundance was greater in old growth stands than in the 60-80 year old stands on Vancouver Island and on the Mainland South Coast (Table 13). Stands attributes correlated with the relative abundance of Hermit Thrush included:

A) QCI: soft coarse woody debris 10-30 cm dbh (0.71), 30-60 cm dbh (0.52); trees 10-30 cm dbh (0.72), >60 cm dbh (-0.84);

B) VI : hard snags 10-30 cm dbh (-0.46), >60 cm dbh (0.41); hard woody debris 30-60 cm dbh (0.48), >60 cm dbh (0.43), soft woody debris 30-60 cm dbh (0.43); trees 30-60 cm dbh (-0.39); % suppressed tree cover (0.42)

C) MSC: soft snags 10-30 cm dbh (-0.52), 30-60 cm dbh (0.36); hard snags 10-30 cm dbh (-0.40); trees 30-60 cm dbh (-0.44), >60 cm dbh (0.37); % sapling cover (0.39).

On Queen Charlotte Islands old growth plots, breeding densities of Hermit Thrush were positively associated with density of trees 10-30 cm dbh, density of snags 30-60 cm dbh and >60 cm dbh, and woody debris 10-30 cm dbh. The second growth plot with no breeding Hermit Thrush differed from the other two plots by having a lower density of trees 10-30 cm dbh, woody debris 30-60 cm dbh, % shrub cover and a greater density of trees >60 cm dbh. Breeding densities of Hermit Thrush were low on Vancouver Island. The old growth plot with no Hermit Thrush differed from the other two by having a lower density of trees 10-30 cm dbh, snags >60 cm dbh, woody debris 30-60 cm dbh, % suppressed tree cover and a greater density of trees 30-60 cm dbh, snags 10-30 cm dbh, % dominant tree cover. On the Mainland South Coast, old growth plots with breeding Hermit Thrushes had a higher density of trees 30-60 cm dbh, snags of all sizes and woody debris 10-30 cm dbh.

Hermit Thrushes were not abundant in the deciduous stands sampled (Table 14). In the Douglas-fir forests of Washington, Hermit Thrushes were more abundant in 55-80 year old stands than in either 95-190 year old or old growth stands (Manuwal 1991). They were also more numerous in dry old growth stands than wet ones (Manuwal 1991). Similar preferences for younger stands were found in Oregon (Carey *et al.* 1991). Our results and those of others suggest that the Hermit Thrush could be easily accommodated in the managed forest. The regional differences in some of the relationships could be due in part to the preference of the species for high elevation forests and its interaction with Swainson's Thrush at lower elevation.

Discussion

Methodological problems

We used three different methods to estimate the relative abundance of birds in forested stands. Spot-mapping, the most labour intensive technique (Williams 1936, Robins 1970), provided localized estimates of breeding densities for territorial species whereas the number of detections in spot-mapping plots provided indices of relative abundance for non-territorial species. We used point counts (Reynolds *et al.* 1980, Verner 1985) to obtain a more extensive estimate of bird relative abundance. These points allowed for a greater geographical coverage than spot-mapping.

Yearly variability in the results from point counts represents a combination of real change and observer effect. A study spanning three years necessitated different observers each year which contributed to a source of bias in the results. This mainly affects comparisons between areas as in each area observer efforts were equally distributed among forest types and age within a year and area. Spot-mapping was based on a minimal number of surveys which has undoubtedly lowered the precision of the estimates. The number of spot-mapping plots was relatively low for a given forest age class (3-4) as was the number of stands sampled by point counts (4-17). Larger numbers of samples would have been necessary to fully capture the landscape heterogeneity of a given age class. However, high numbers of significant relationships emerged from these low sample sizes. The results show significant differences between areas, age classes and forest types. The extent of the study and its geographical coverage increased the variability of the results but also strengthened their significance and interpretation.

Bird communities of old growth and second growth forest stands

Comparisons between our study and those done in Washington and Oregon forests must be carefully interpreted because of different methodology, different age classes sampled, and different forest types sampled. The American studies (Carey *et al.* 1991, Gilbert and Allwine 1991, Manuwal 1991) compared 30-80 year old stands (young) with 95-190 year old stands (mature) and old growth stands (>200 year old). We did not sample stands 95 to 190 year old in British Columbia because there are no such stands due to logging. However, we did divide young stands in two age classes (40-60 and 60-80 years). Also, our forests were much more diverse in terms of dominant tree species (Sitka Spruce or Western Hemlock or Western Red Cedar) than those in Washington and Oregon . In contrast to the forest studied in the United States, few of our stands were dominated by Douglas-fir. The combined results of our study with those from the United States permit a broad characterization of the avifauna associated with different successional stages of coastal forests.

Bird communities of old growth and second growth forests differed in several aspects. More species reached their highest abundance in old growth stands than vice versa (15 *vs* 2) suggesting that old growth provides a better habitat for those species. As expected, differences were greater between old growth and 40-60 year old stands than between old growth and 60-80 year old stands. These results confirmed in part the patterns observed in Washington State, Oregon and California (Carey *et al.* 1991, Gilbert and Allwine 1991, Manuwal 1991).

Our comparison of 60-80 year old stands to old growth may not be representative of future conditions because most of the 60-80 year old stands and some of 40-60 year old ones have retained some features of old growth (snags, woody debris, etc.) due to the less industrial logging techniques of the past. Most of the forest stands logged in the last 2-3 decades do not have that old growth legacy (due to more complete harvesting of the forest) and thus are less suitable for species associated with tree trunks and tree cavities.

Breeding bird densities (as determined by spot-mapping) were higher in old growth forests than in either 40-60 and 60-80 year old stands in all three areas. Point counts indicated that relative bird abundance was higher in old growth than in 40-60 year old stands but that 60-80 year old stands sometimes had similar or higher bird relative abundances. Similarly, Manuwal (1991) obtained higher relative abundance of birds in old growth stands in Washington State whereas Cary *et al.* (1991) did so in one year of a two year study in Oregon.

Bird communities of deciduous forest stands

The deciduous stands surveyed in this study were quite variable in terms of age, structure and species composition. The young alder stands of the Queen Charlotte Islands supported fewer species than the Maple and older Alder stands of Vancouver Island and the Mainland South Coast. A few "old growth" species were abundant in some deciduous stands, indicating that some stands may help maintain populations of these species in intensively logged areas.

Older deciduous stands were used by two cavity nesters, Hairy Woodpeckers and Chestnut-backed Chickadees. Pacific-slope Flycatchers were abundant in the Queen Charlotte Islands and Mainland deciduous stands but were replaced by Hammond's Flycatcher on Vancouver Island. These two species are reported to avoid each other (Beaver and Baldwin 1975), although coexistence of both flycatchers has been observed on Vancouver Island (Bryant *et al.* 1993).

Bird communities of clearcuts

Old growth species were nearly absent from all clearcuts sampled. One exception, the Winter Wren on the Queen Charlotte Islands was quite abundant in clearcuts. Reasons for this are speculative but may be due in part to the absence of MacGillivray's Warblers on the Queen Charlotte Islands. MacGillivray's Warbler is a dominant species of the Vancouver Island and Mainland South Coast clearcuts. Dense natural regrowth and abundant logging debris in the Queen Charlotte Islands clearcuts may also contribute to this difference.

Several species present in low numbers in old growth and second growth forests reached high densities in clearcuts, underlining the degree of low similarity between clearcuts and old growth avifauna.

Relationships between birds and habitat attributes

We have presented ranked correlations obtained between point counts results and the habitat attributes measured. For breeding densities, we only highlighted major habitat attributes associated with either high or low breeding densities. While point counts present relationships at a very local scale (i.e. 2 ha), spot-mapping examines relationships at the scale of the plot (i.e. 10 ha). Most of the associations found confirm the results of previous studies from west coast old growth forests (Manuwal 1991, Carey *et al.* 1991). As expected, associations varied between study sites as the three areas differed in the range of the variables measured. Contrasts in terms of structure and age between old growth and second growth stands were greater in some areas. Also tree species composition differed greatly between areas.

The use of rank correlations of many variables coupled with low sample sizes demands much caution in the interpretation of these correlations. We have also highlighted the habitat attributes associated with contrasting breeding densities in spot-mapping plots. Our purpose was only to highlight possible bird habitat relationships that may help formulate more rigorous hypothesis for future testing.

Caution should also be applied when comparing breeding densities of some species between stands of a given age class. Although there were several obvious similarities, there were also many differences within a given age class of forest. Although the majority of species reached their highest abundance in old growth stands, only a few of those were absent from second growth stands 60-80 years old. However, the abundance of those species in second growth stands was quite variable indicating a great variability in the suitability of these stands for "old growth" species. What made some second growth stands more suitable than others to some species needs to be better quantified.

We should reiterate that we only measured bird abundance during the breeding season. Several of the species associated with British Columbia old growth forests are non migratory and thus depend on the forest as winter habitat. The value of old growth and second growth stands for the winter survival of resident birds is unknown and caution is warranted before generalizing across seasons. Finally, relationships between breeding densities, relative abundance and productivity have not been established in these forests. It is not shown whether old growth species breeding in second growth stands have similar reproductive success as in old growth.

We have identified several bird species that characterize coastal old growth forests of British Columbia. The presence of some of these species in second growth and deciduous forests suggests that with adequate management, these forests may support some of these species during the breeding season. However, the reproductive success of old growth species in second growth stands remains to be determined. It is clear however that even if second growth stands could support old growth species, much larger areas would likely be required to sustain similar bird abundance.

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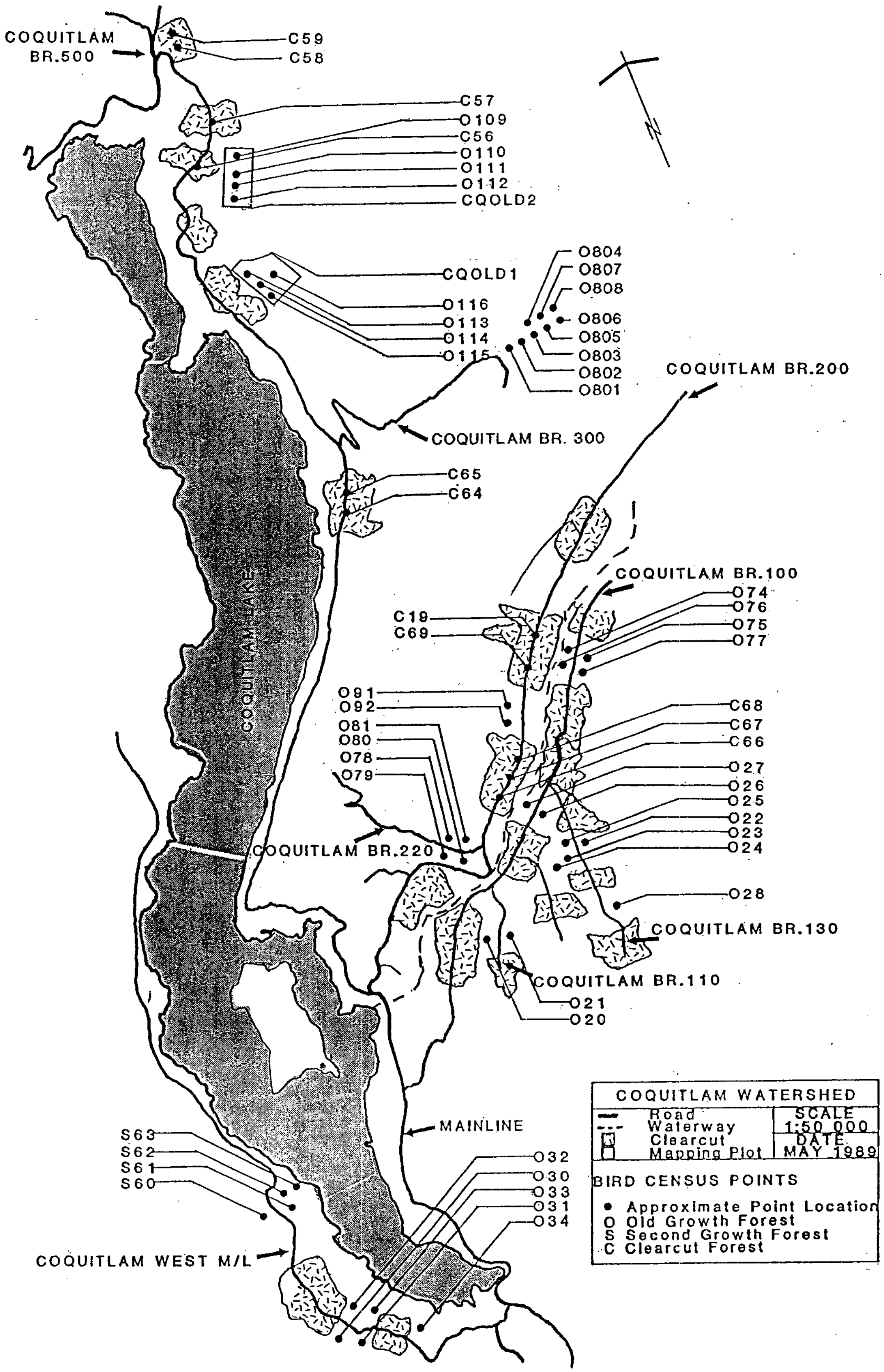
APPENDIX I. Location of spot-mapping plots and point counts

1.1 Mainland South Coast

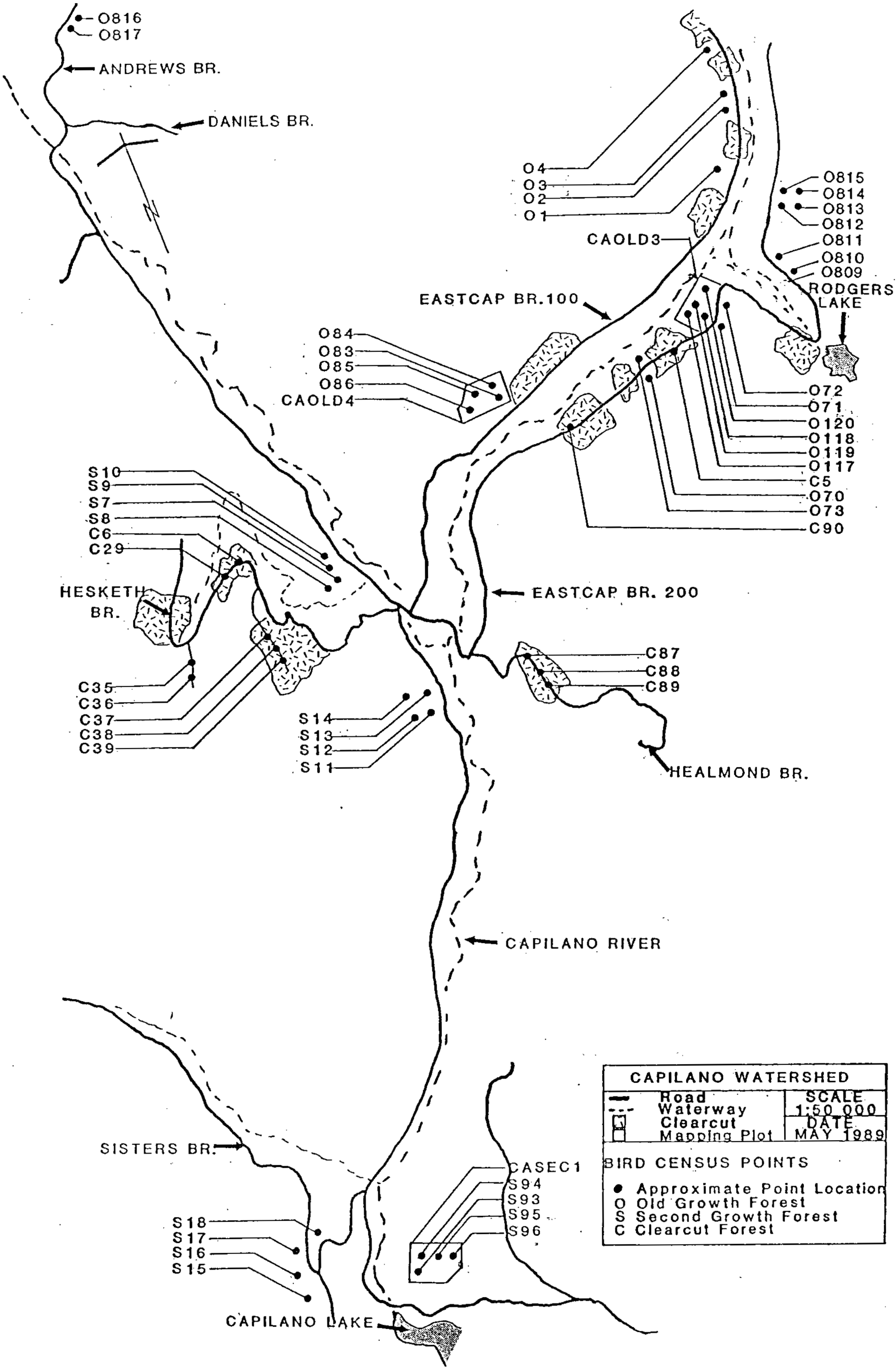
1.2 Vancouver Island

1.3 Queen Charlotte Islands

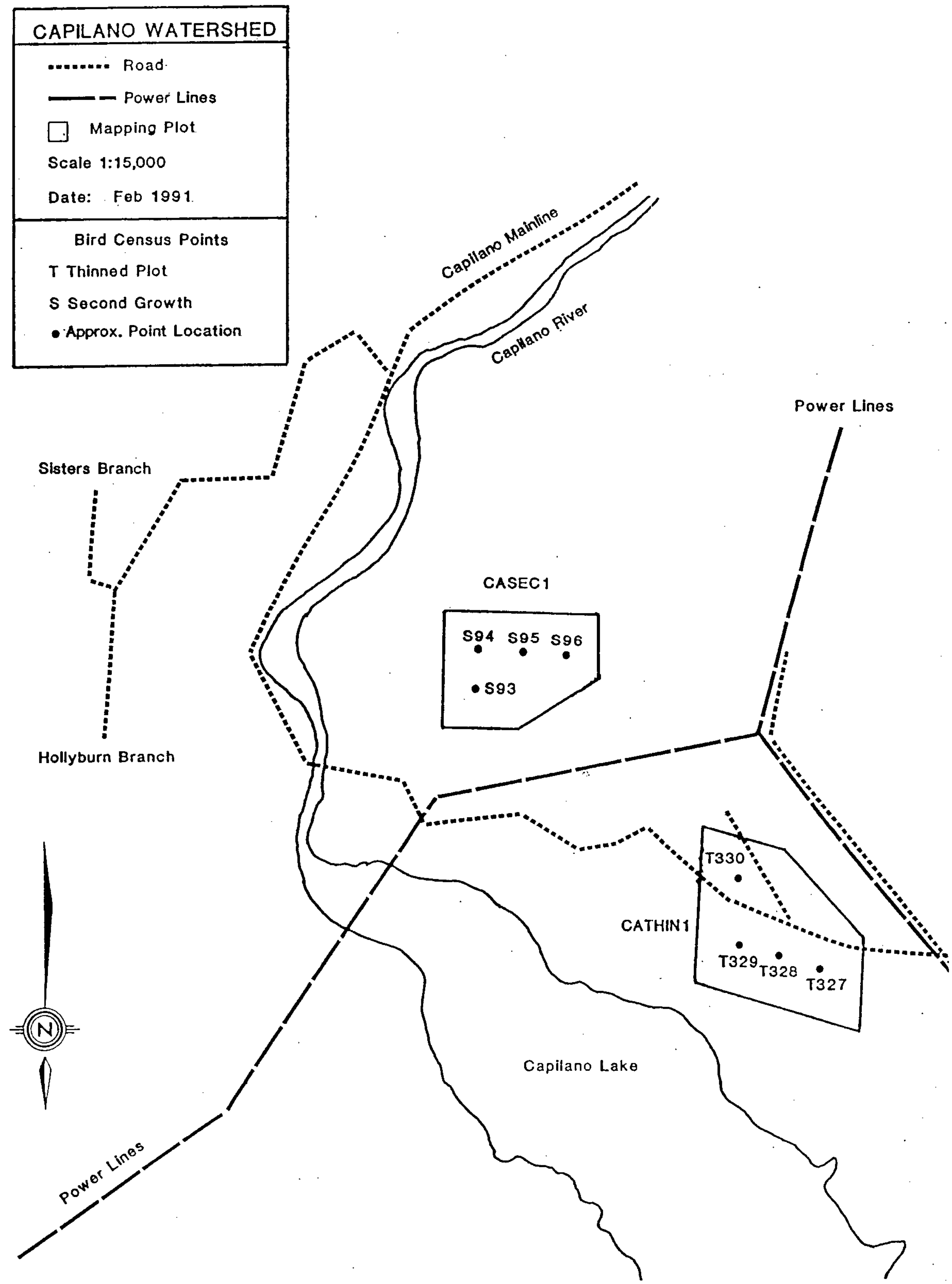
1.1 MAINLAND SOUTH COAST



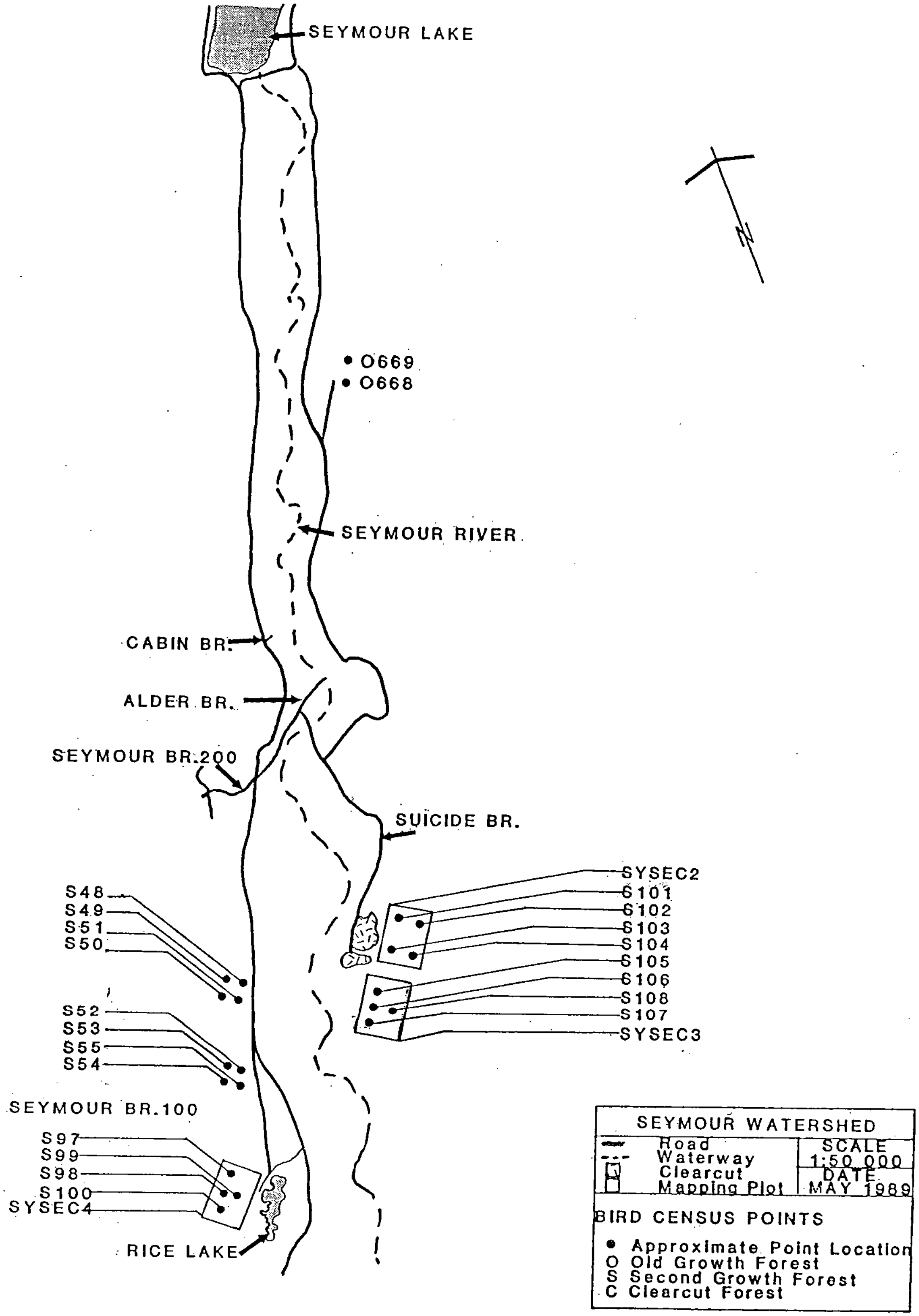
App. 1.1.1 Location of bird census points in the Coquitlam Watershed



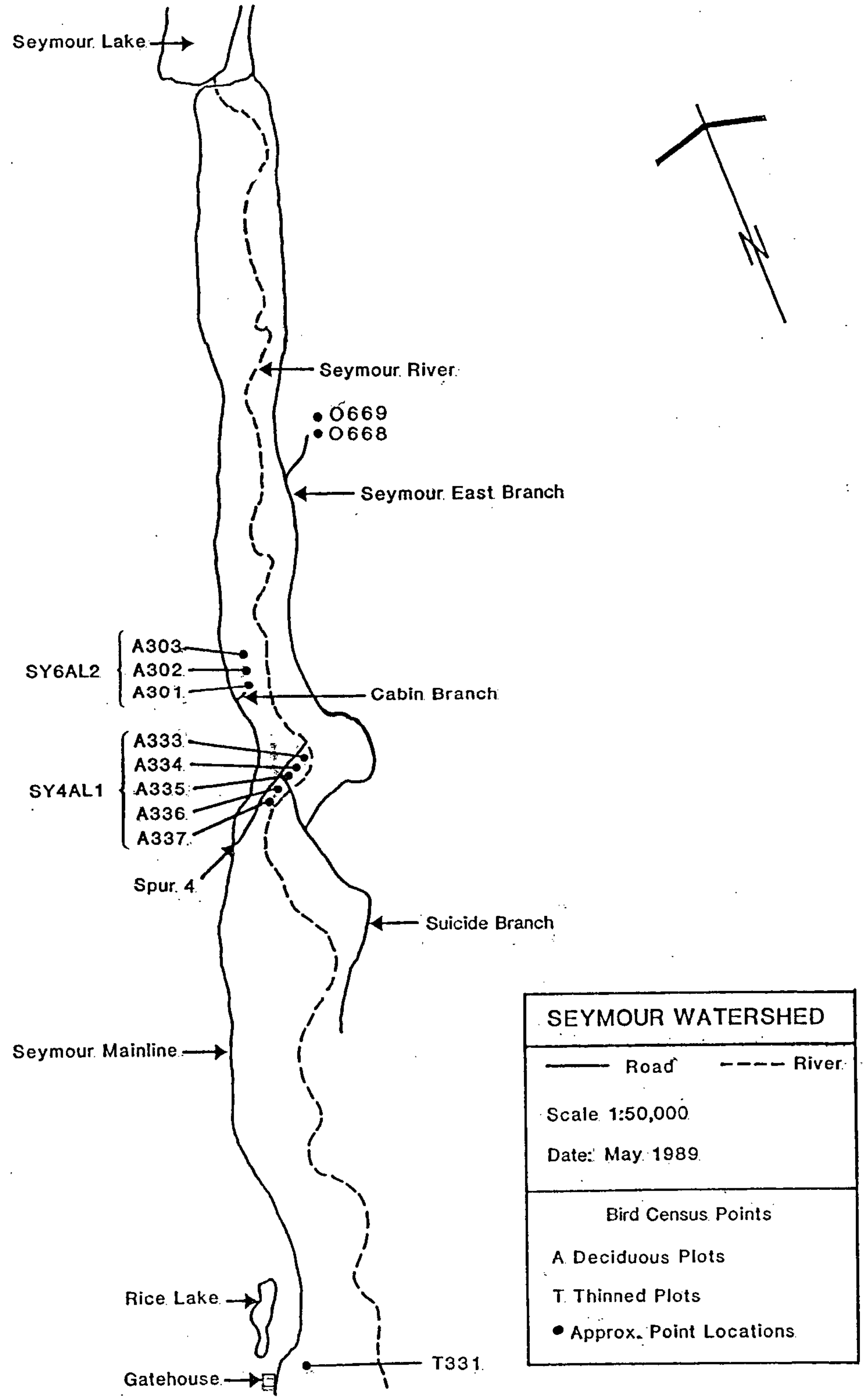
App. 1.1.2 Location of bird census points in the Capilano watershed (clearcut, second growth and old growth stands)



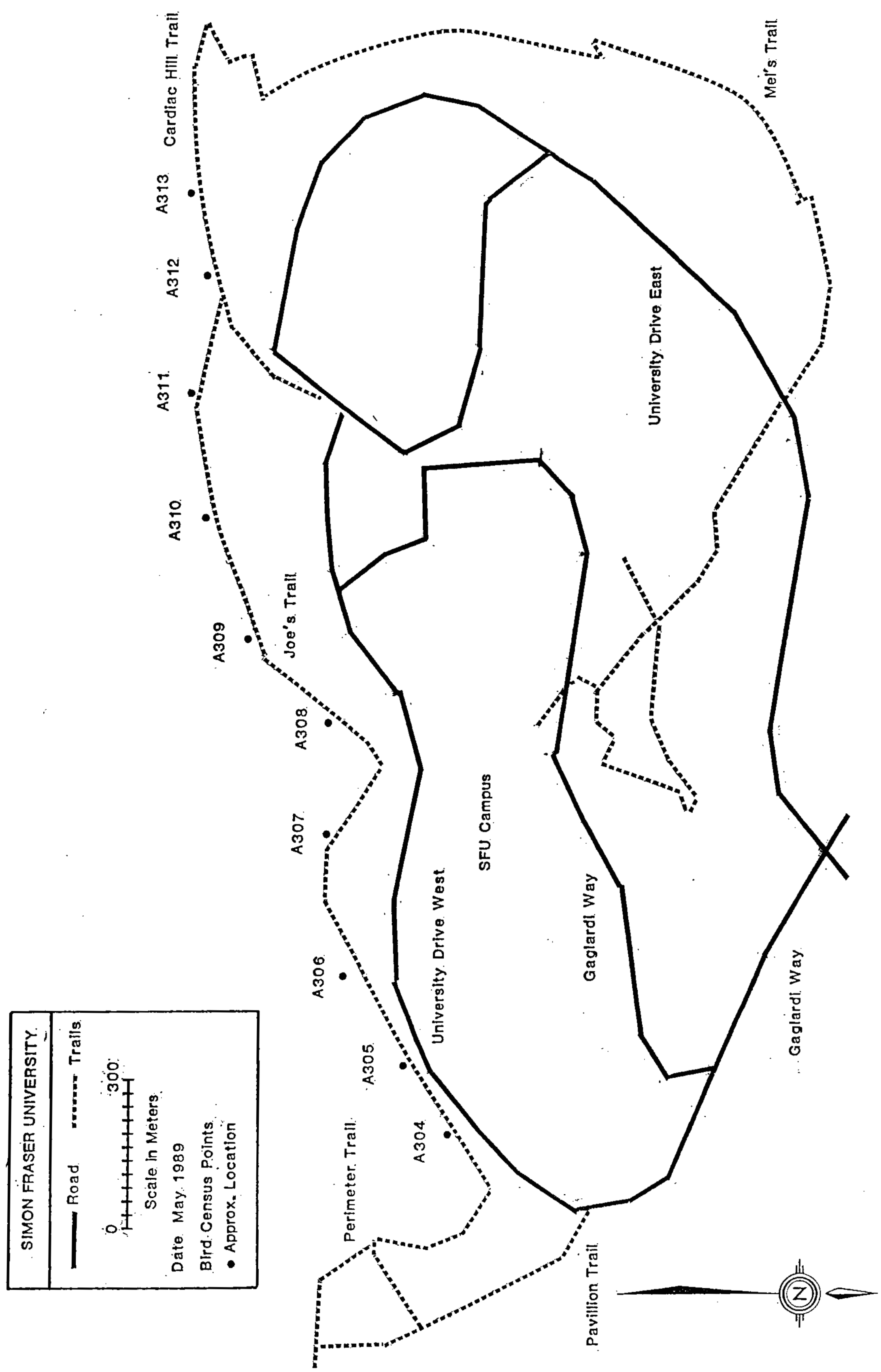
App. 1.1.3 Location of bird census points in the Capilano watershed (second growth and thinned stands)



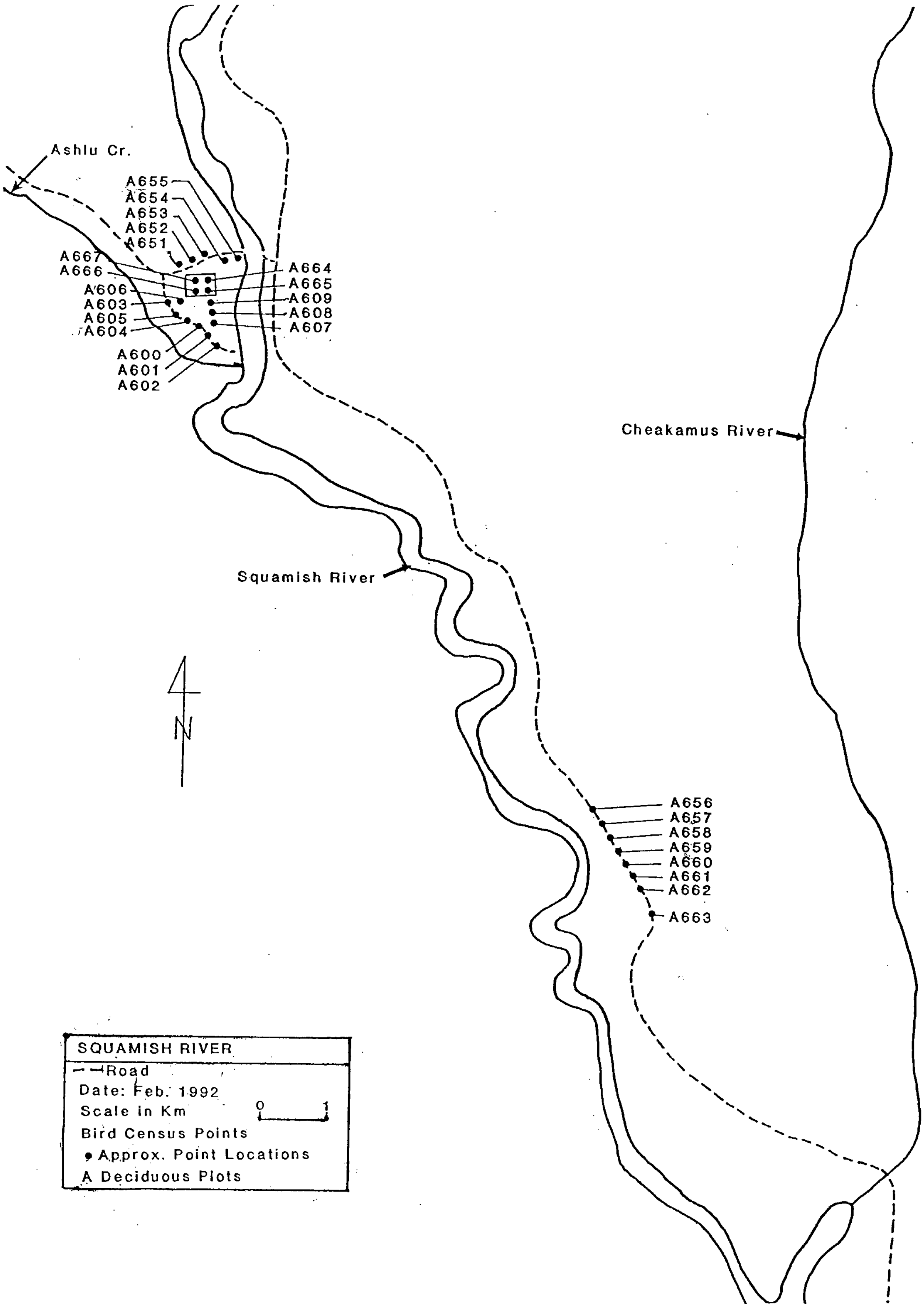
App. 1.1.4 Location of bird census points in the Seymour watershed (clearcut, second growth and old growth stands)



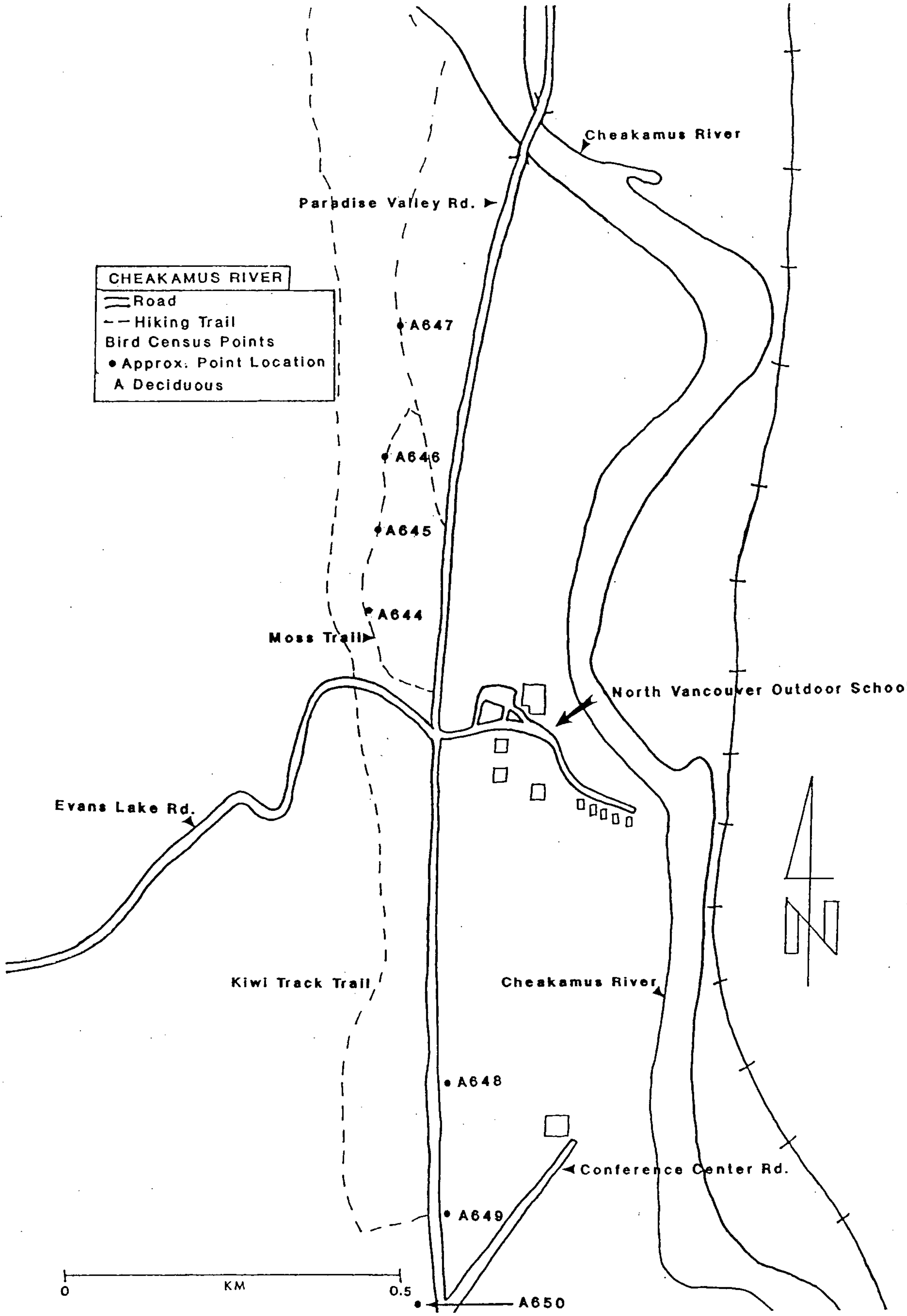
App. 1.1.5 Location of bird census points in the Seymour watershed (deciduous and thinned stands)



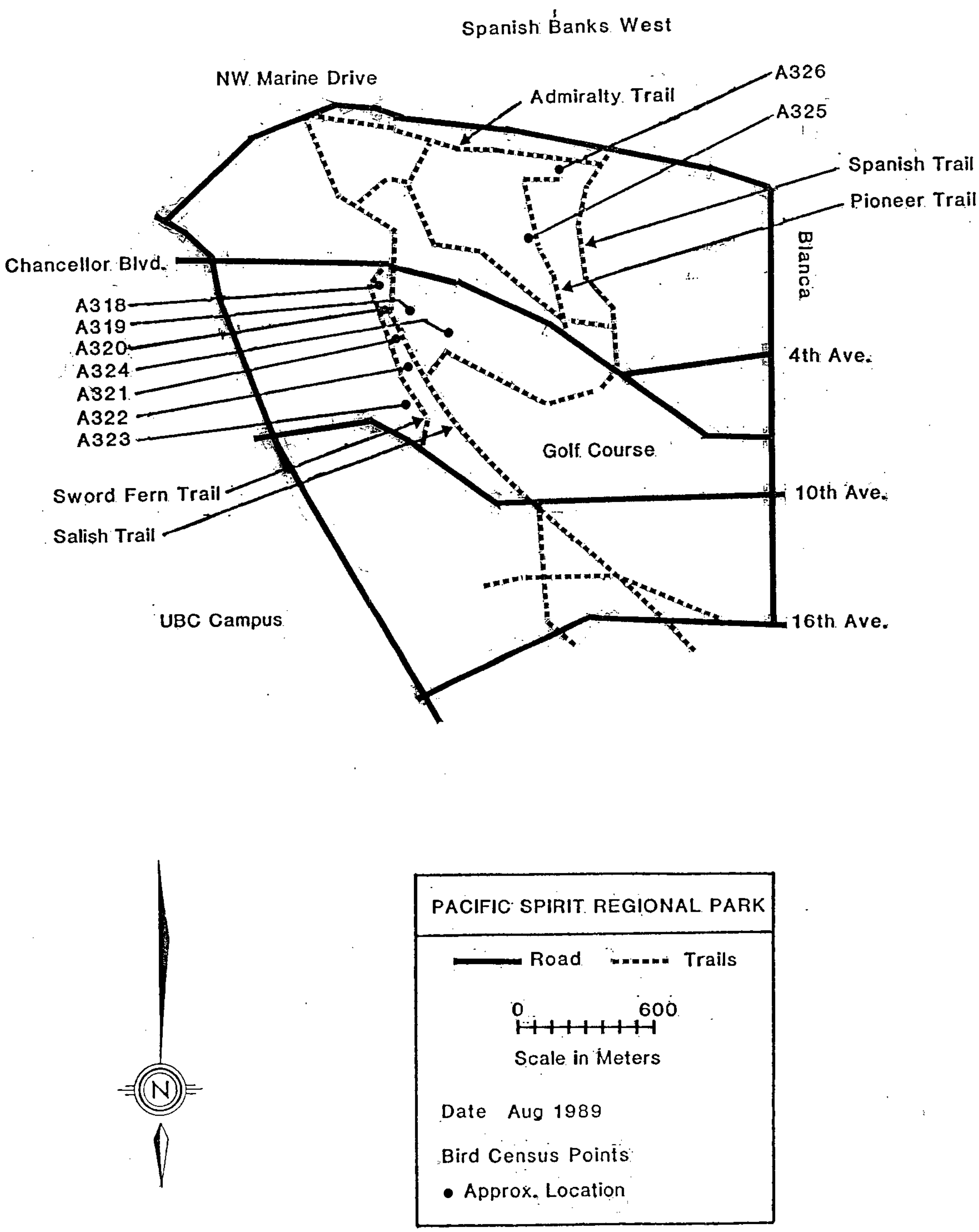
App. 1.1.6 Location of bird census points at Simon Fraser University (deciduous stands)



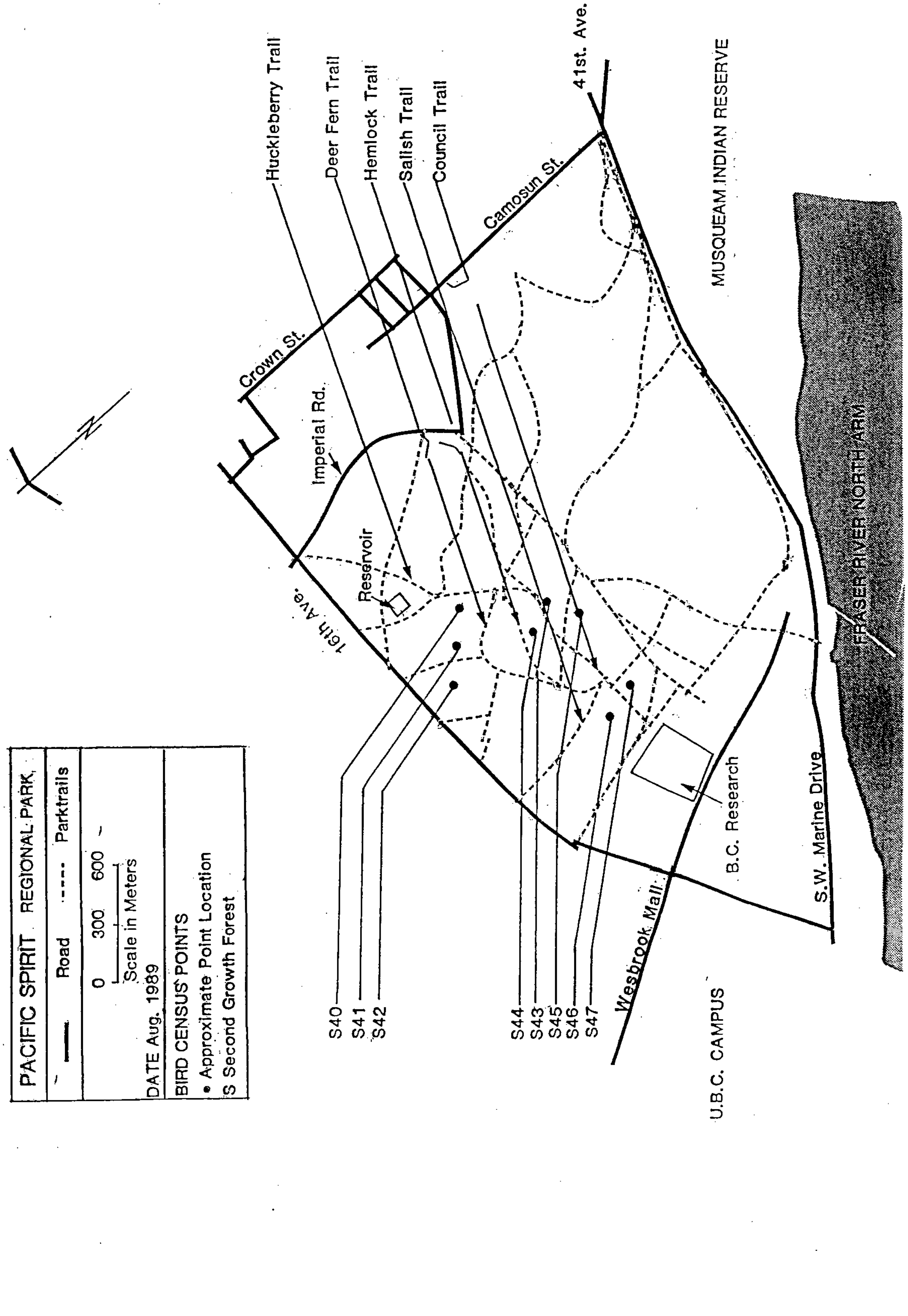
App. 1.1.7 Location of bird census points along the Squamish River



App. 1.1.8 Location of bird census points along the Cheakamus River



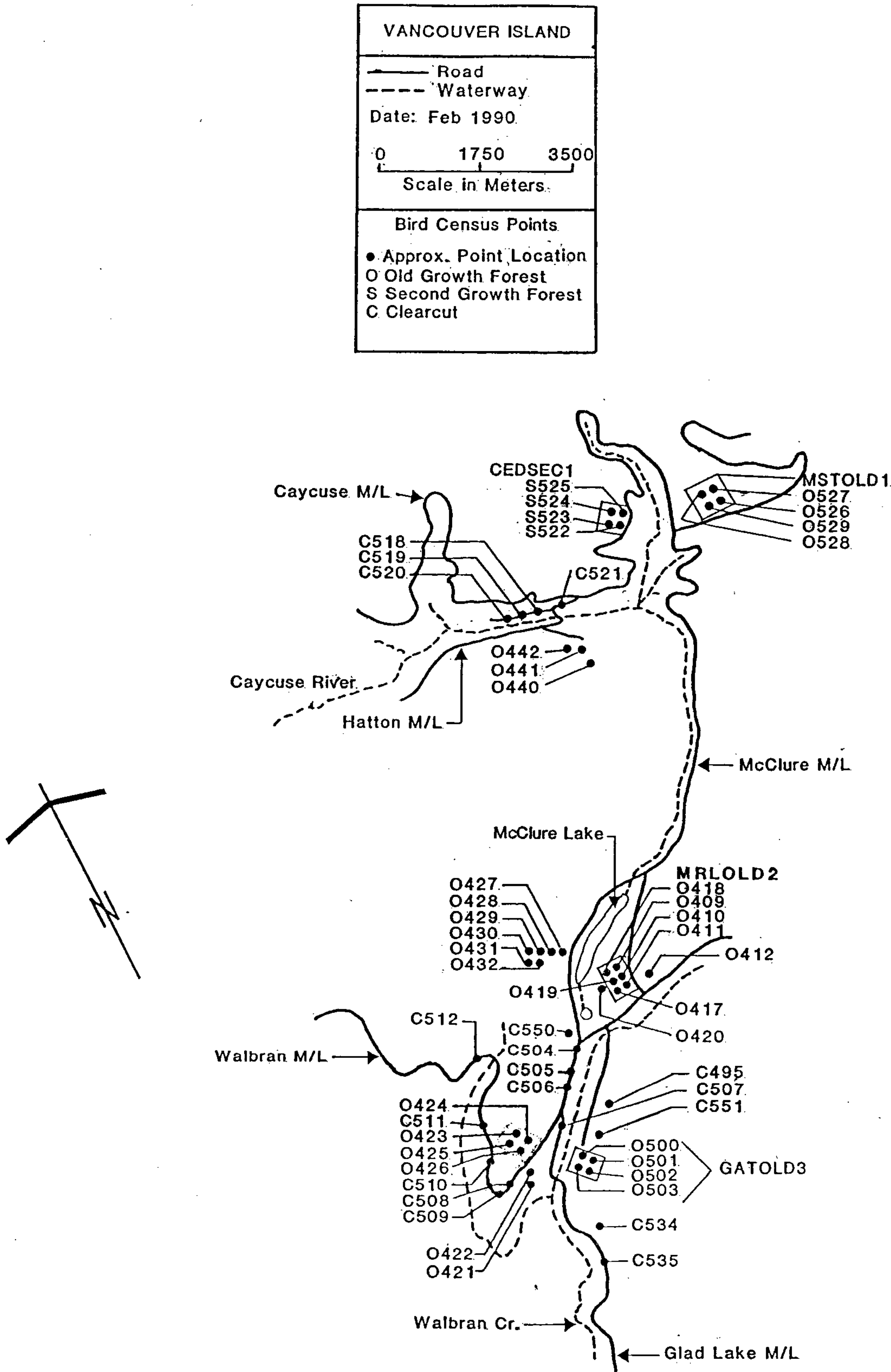
App. 1.1.9 Location of bird census points in Pacific Spirit Regional Park (deciduous stands)



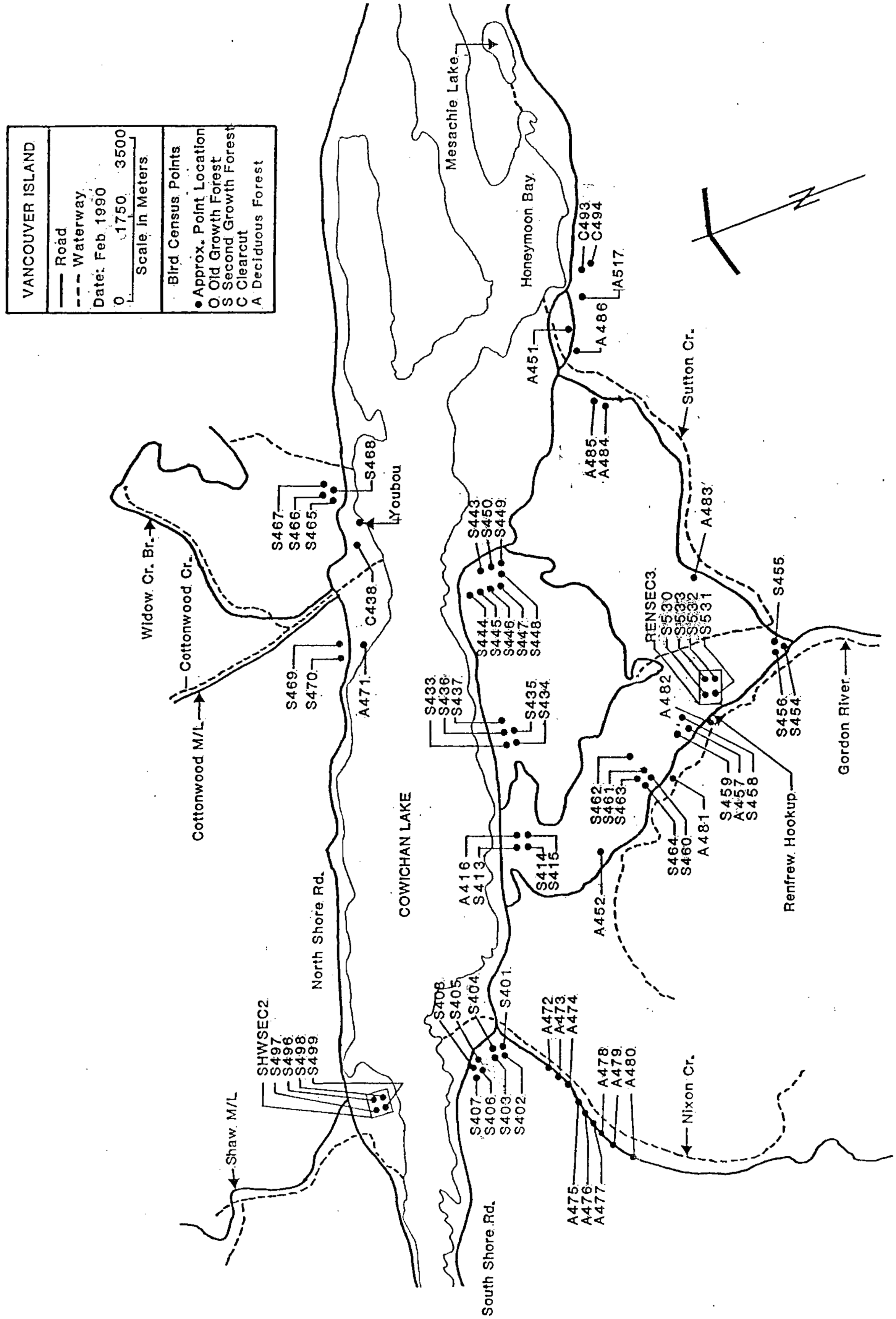
App. 1.1.10 Location of bird census points in Pacific Spirit Regional Park (second growth stands)

1.2 Vancouver Island

Page

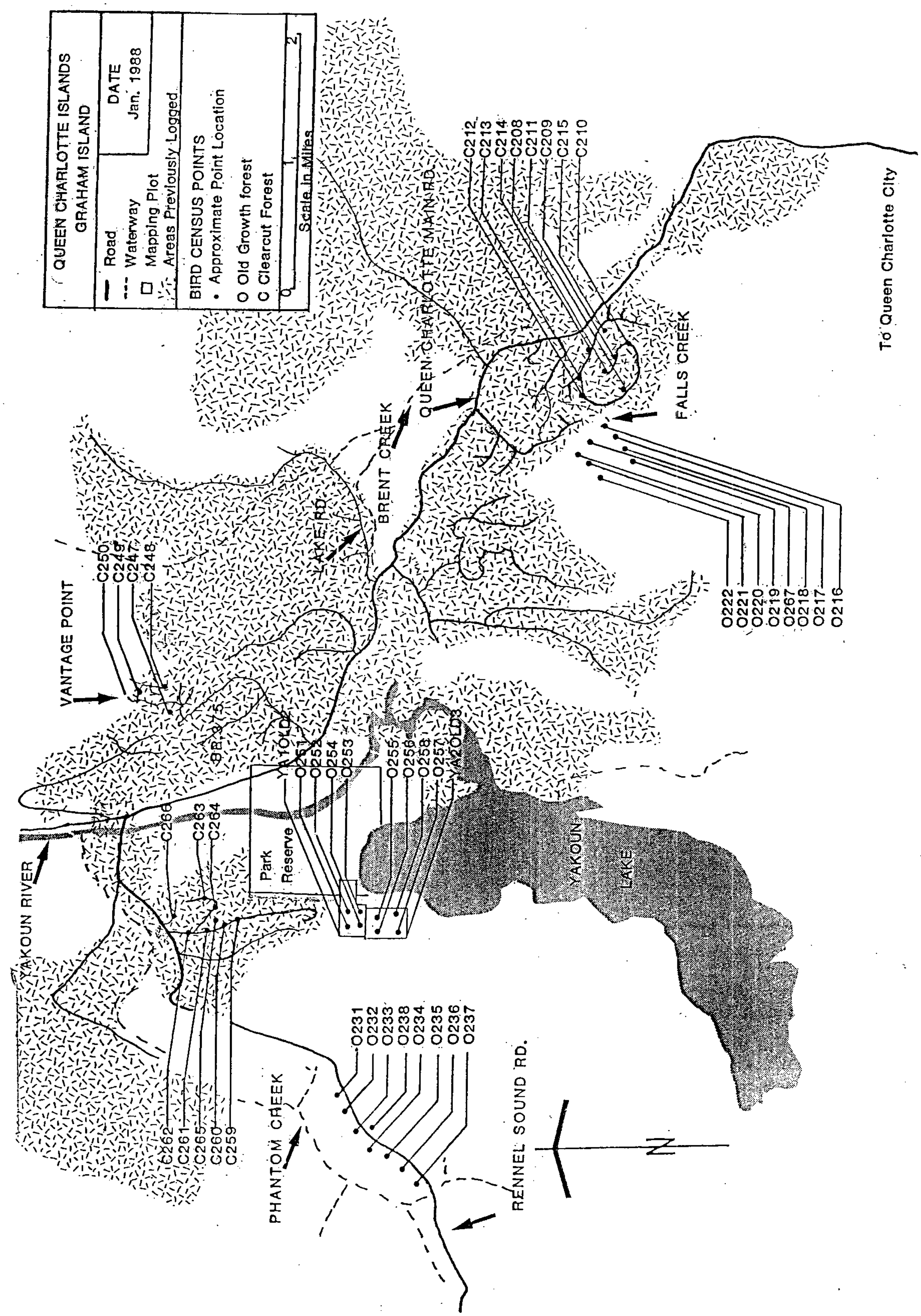


App. 1.2.1 Location of bird census points at McClure Lake

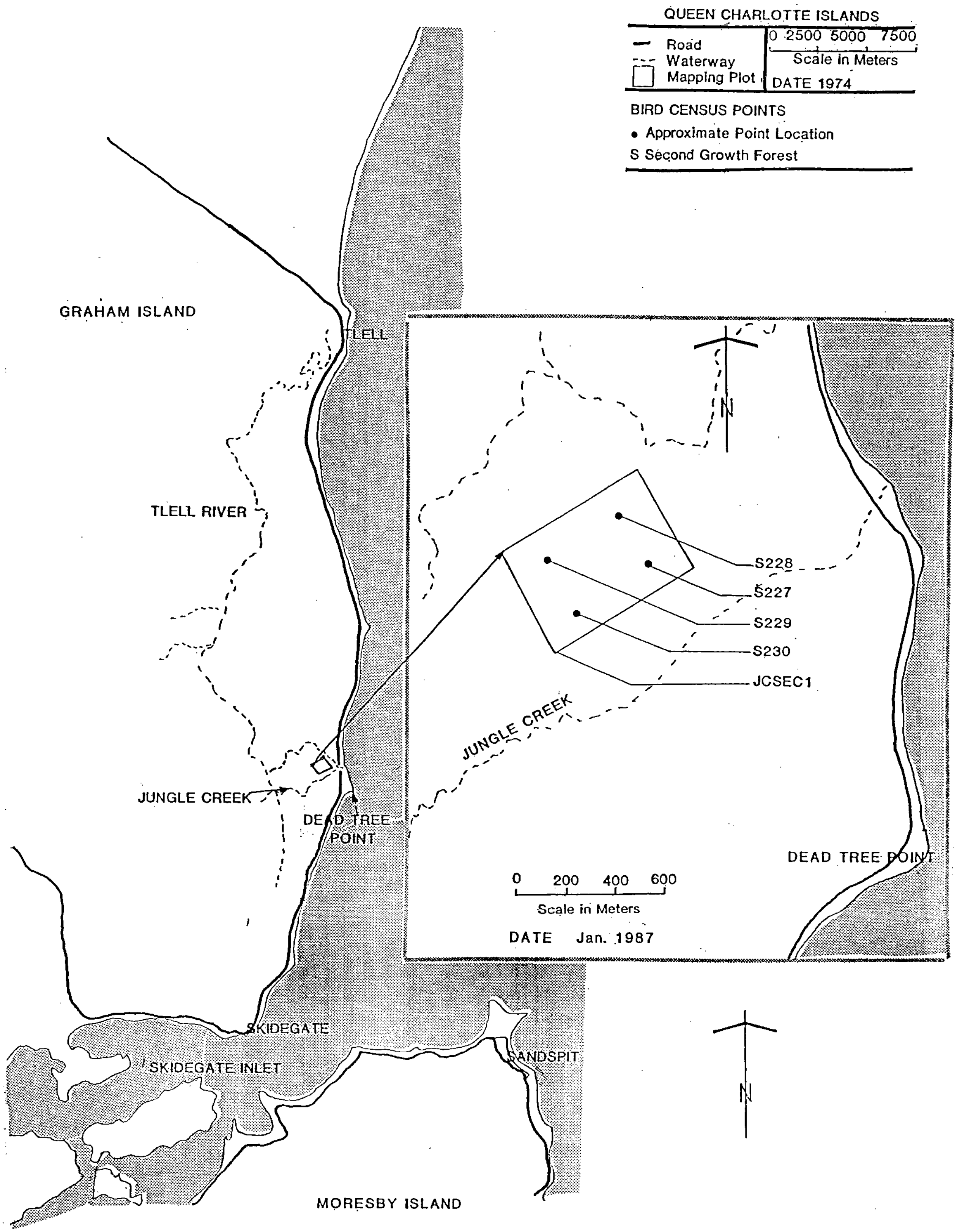


App. 1.2.2 Location of bird census points at Cowichan Lake

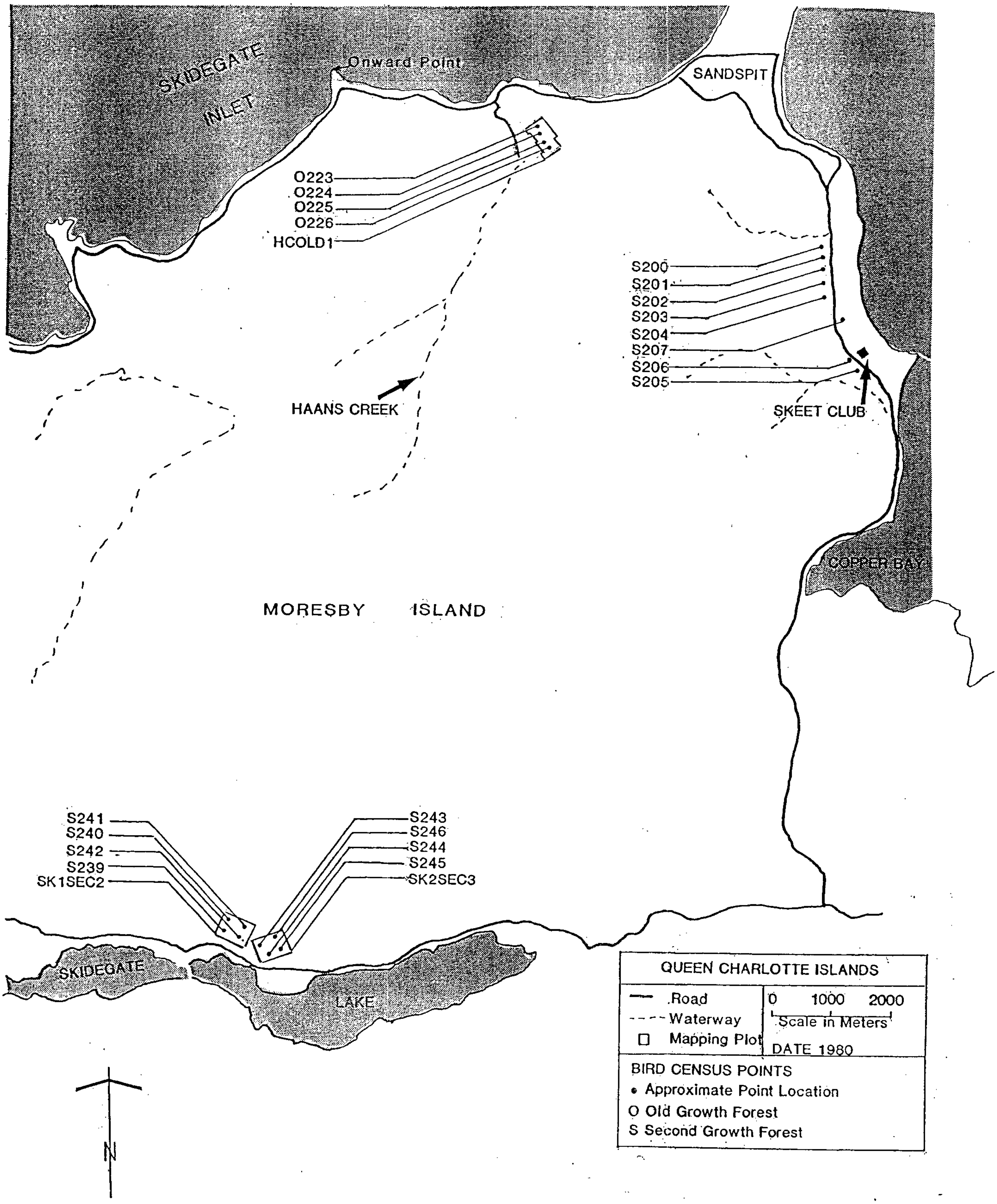
1.3 QUEEN CHARLOTTE ISLANDS



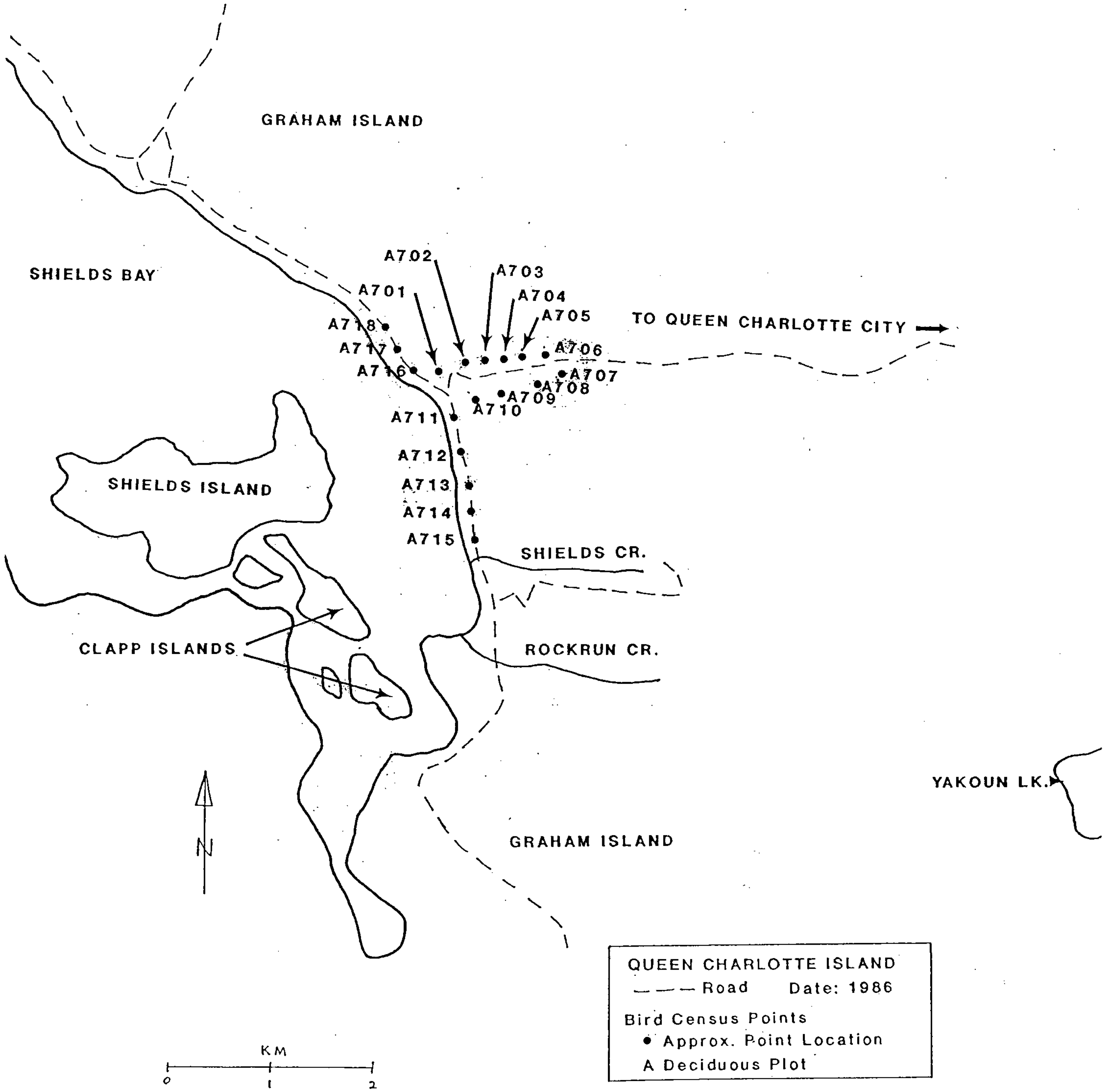
App. 1.3.1 Location of bird census points at Yakoun Lake



App. 1.3.2 Location of bird census points at Jungle Creek



App. 1.3.3 Location of bird census points on Moresby Island



App. 1.3.4 Location of bird census points at Shields Bay