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AN ECOLOGICAL STUDY OF GOOSE ISLAND, BRITISH COLUMBIA, WITH SPECIAL REFERENCE TO TERRESTRIAL MAMMALS

by

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ABSTRACT

A study of mammals on the Goose Island, British Columbia, was conducted in the summer of 1948. This group of islands represents a well isolated unit typical of many outer fringe islands along the coast. Over and above the qualitative examinations of the fauna, studies were undertaken to obtain some quantitative information upon the ecological distribution of terrestrial mammals.

The terrestrial mammalian fauna was represented by three species of small mammals, *Peromyscus maniculatus*, *Microtus longicaudus* and *Sorex obscurus*. Two species of bats also occurred, *Lasionycteris noctivagans* and *Myotis yumanensis*. A species of *Castor* once inhibited the islands.

Based on a snap trap procedure the relative abundance of *Peromyscus*, *Microtus* and *Sorex* was determined in four habitats occupied by all three species. The floral composition of these habitats was determined and reasons for the observed distributions postulated.

The extent and nature of eight additional habitats have been included as well as notes on pelagic mammals, *Myotis*, *Lasionycteris* and *Castor*.

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AN ECOLOGICAL STUDY OF GOOSE ISLAND, BRITISH COLUMBIA, WITH SPECIAL REFERENCE TO TERRESTRIAL MAMMALS.

INTRODUCTION

The Goose Islands lying off the British Columbia mainland coast comprise an outer unit in a complex insular pattern in which geographical barriers of salt water intensify generally to westwards.

The group, in its central location, small size and complete isolation was selected in 1948 as an area for field investigation by the University of British Columbia and the Provincial Museum. Mr. Patrick Martin and myself constituted the field party.

In view of the small area involved it was thought that four months allocated from May through August would enable the party to make representative collections of the avian and mammalian faunas, and to gather specimens of the flora. In addition, equipment was supplied for collecting specimens of marine vertebrates and invertebrates from the surrounding waters. In these respects the field party accomplished what it had set out to do. Some 400 specimens of birds and mammals were collected, prepared, and adequate notes maintained throughout the period. Over 1000 specimens of marine fishes and invertebrates were also collected for future study and a representative collection of plants was made.

The field work was initiated on May 13 and terminated at the end of August. Over and above the qualitative examination of the fauna, studies were undertaken to obtain some quantitative information upon the ecological distribution of the mammals and birds. To accomplish this, emphasis was placed upon the small mammal work in May and June in order to have the raw data collected before young animals of the year began to run. This enabled us to operate only four quadrats in each habitat occupied by small mammals, but had the advantage of dealing only with adult animals except in the case of Sorex obscurus, where the young were already out. Preliminary investigations revealed an equal amount of sign in the two types of coniferous forest occurring. For the purposes of small mammal study these types are included under one heading in the mammal quadrat work, and separately under floral analyses.

This paper is a presentation of the results obtained in the mammalian studies only; it includes the distribution of habitat types regardless of utilization by mammals. The major problem entails the floral analyses of the vegetated habitats occupied by small mammals, determination of relative abundance of these animals in each habitat and, where possible, the determination of factors responsible for the observed distributions. While investigations similar in part, to that presented here have been carried out on the

mainland in the eastern part of the continent (Townsend, 1935), to my knowledge no comparable studies have been conducted on the Pacific coast. It is hoped that this paper will act as a forerunner to more comprehensive and intensified studies on our coastal islands.

In acknowledgment I wish to thank Dr. I. McTaggart Cowan, under whose direction this research was conducted; Dr. W. A. Clemens, Head of the Department of Zoology, and Dr. G. C. Carl, Director of the Provincial Museum, for valuable suggestions and cooperation; Mr. George Hardy, Provincial Museum Botanist, and Dr. T. M. C. Taylor, Department of Biology and Botany, for identifications and suggestions pertaining to the flora; and Dr. P. A. Larkin for hours spent in statistical analyses and critical examination of the data.

In addition I wish to thank Mr. P. W. Martin for his invaluable assistance in the field, and the secretarial staff of the Provincial Museum for technical assistance in preparation of the manuscript.

I am especially indebted to the Department of Veterans' Affairs for the gratuities which made possible my attendance at the university.

GEOLOGICAL BACKGROUND

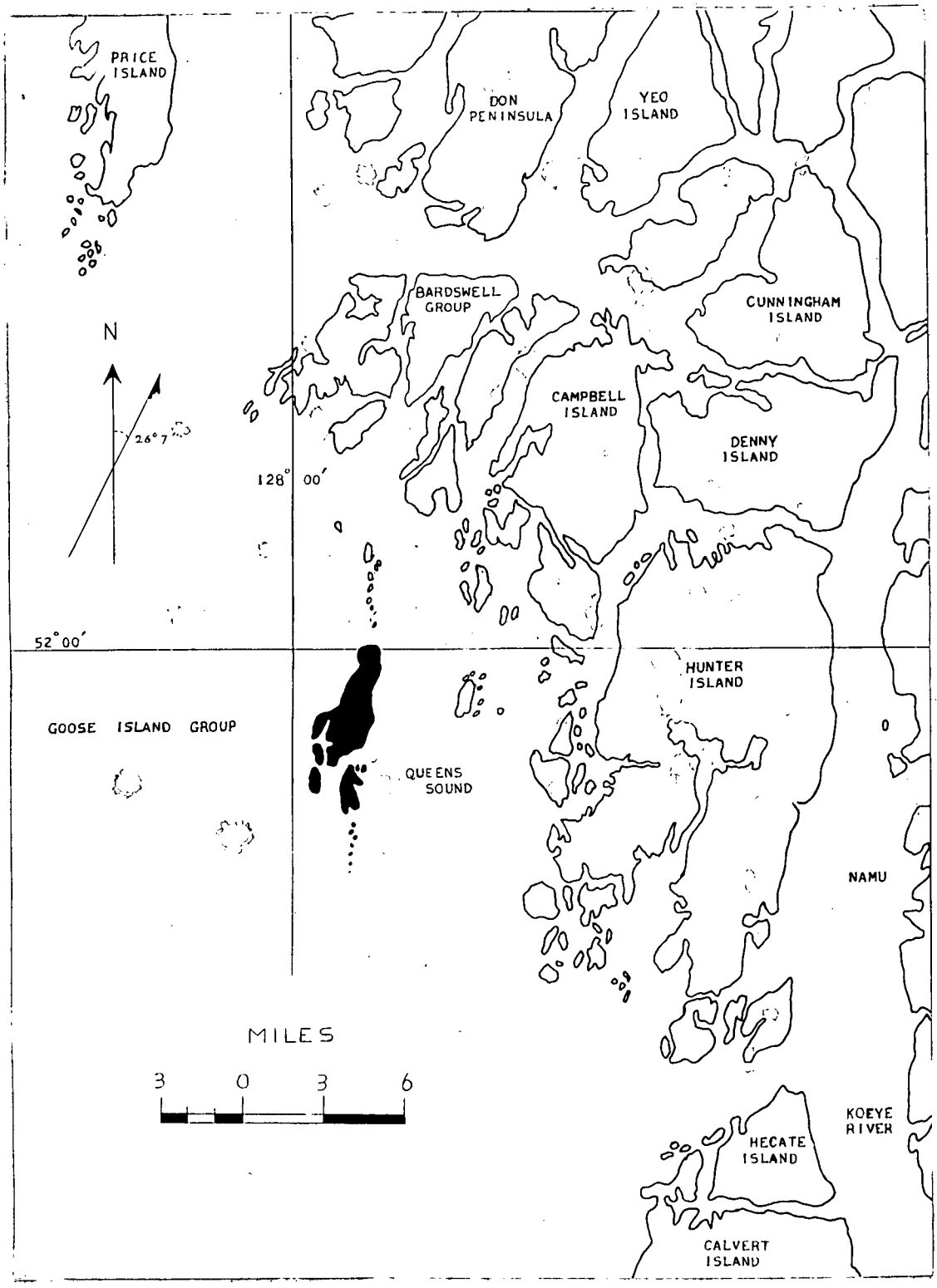
As far as I have been able to determine, no geological publications dealing specifically with the Goose Island group have been published. McCabe and Cowan (1945) reviewed the geological background of the area in question and of British Columbia in general, in a paper dealing with small mammals and the problem of insularity. From this review of the literature I quote here -- "Though it is not difficult, whether on the ground or from the results of research, to demonstrate the recent ice-coverage of almost any fraction of the British Columbia region, the most insidious criticism of the hypothesis in its biological implications remains unanswered. This is the allegation that, while the phenomenon in its broad sense is proved, the local estimates of elapsed time cannot be so perfect as to prove synchrony of the latest glaciation, -- to prove, that is that at any given moment throughout the region, coverage was so uniform as to displace, everywhere and at once, the vast majority of present forms of mobile vertebrate life." These workers go on to say, however, that the coastal range strip, with which we are mainly concerned, does show evidence of glacial uniformity and synchrony and that the evidence of recent climatic change is overwhelming. "The timbered zones show fresh and universal evidence of recent coverage. The chance that such degrees of change within the limited area could have been intermittent or localized is almost nil."

The Goose Island group then in all probability has become occupied by the vegetation it carries and the animal influents it harbours during that period of time which has elapsed since the retreat of the last or Vashon ice sheet. That these animals invaded directly or indirectly from the adjacent mainland seems logical from a geographic point of view and appears biologically sound in view of their close affinities to the mainland forms.

LOCATION AND GENERAL DESCRIPTION

The Goose Island group is located some twenty-three and one half miles off the British Columbia mainland coast, with a latitude and longitude of 51:58:00 degrees north, 128:27:00 degrees west at their approximate centre. They are the outermost island at this latitude (Fig. 1) bounded on the west by the open Pacific. To the east lies an arm of the sea eight miles in width known as Queen's Sound. This separates Goose Island from the nearest substantial land mass, Hunter Island. Deep channels approximately one mile in width separate the group at the north and south ends from the Broken Islands and the Gosling Rocks respectively, which are in turn completely isolated. The group consists of six main islands (Fig. 14). Goose Island upon which most of the investigations were conducted covers 4521.50 acres. The areas of the others are as follows:- Gosling Island, 773 acres; Duck Island, 263 acres; Swan Island, 168 acres; Gull Island, 16.40 acres; and Snipe Island, 6.39 acres.

FIGURE 1. - General Location and Isolating Factors of the Goose Island Group.

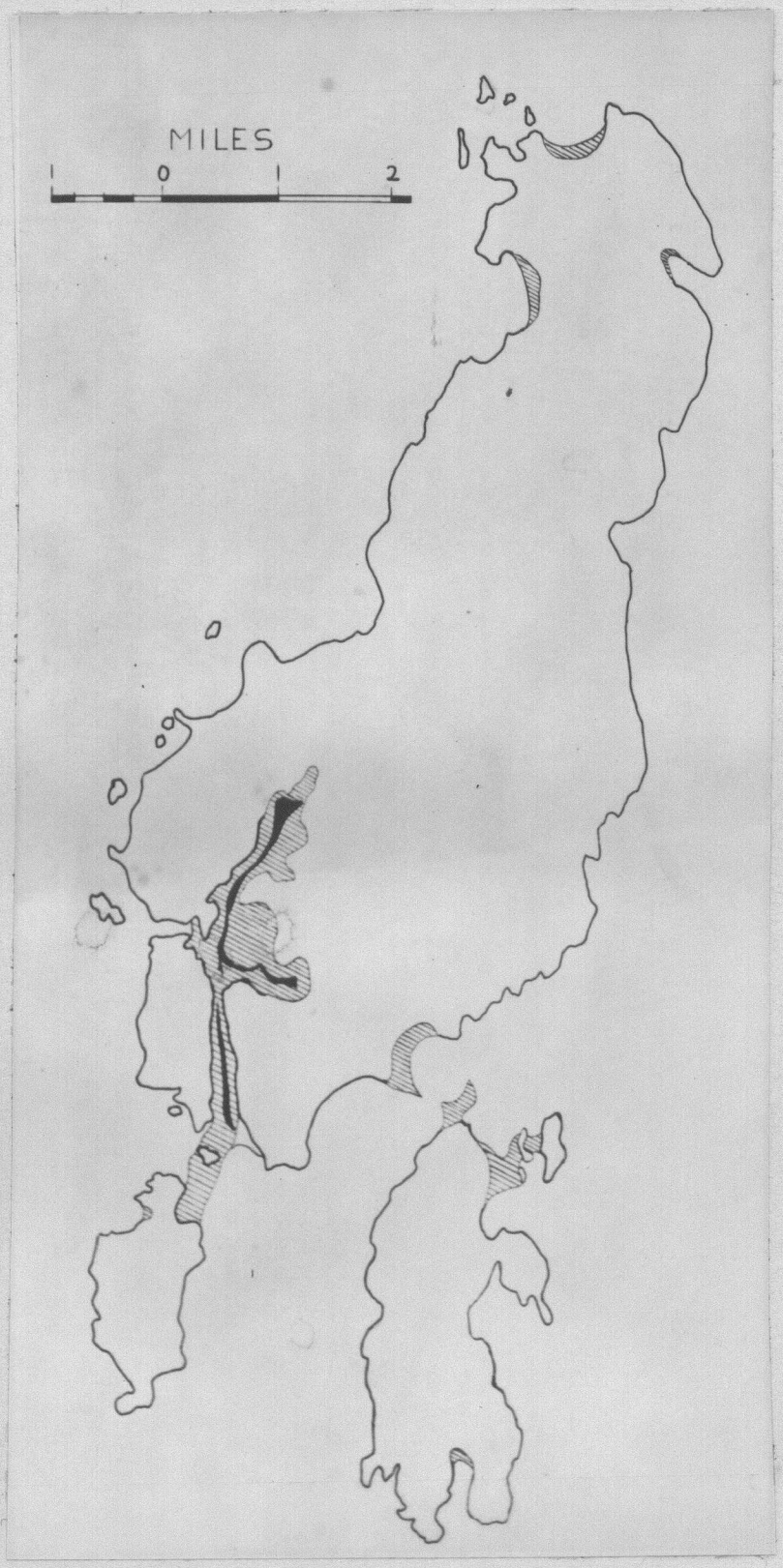

PRICE ISLAND
DON PENINSULA
YEO ISLAND
BARDSWELL GROUP
CUNNINGHAM ISLAND
N
26°7
CAMPBELL ISLAND
DENNY ISLAND
128° 00′
52° 00′
HUNTER ISLAND
GOOSE ISLAND GROUP
QUEENS SOUND
NAMU
MILES
3 0 3 6
KOEYE RIVER
HECATE ISLAND
CALVERT ISLAND

There is in addition considerable acreage of rocky sea shore, sandy and boulder beaches which are exposed in varying degrees with falling tides. These expanses connect all islands of the main group at low tide with the exception of Duck Island, which remains separated by a narrow channel but which may dry briefly during the periods of extremely low tides.

Over one hundred small reefs and islets are located in close proximity to the shores of the main group. The majority of these are little more than sea washed rocks, but some of the larger islets are vegetated. The group is approximately six and one-half miles long measured from north to south by two and one-half miles wide, measured from east to west. The largest island of the group is indented on the southwest side by a tidal mud and sand flat, referred to in this work as the lagoon. The lagoon varies in width from a few yards to half a mile and extends approximately one mile in a northerly direction. The flat is bounded on the west by low rocky sea shore and a narrow fringe of grass. On the northern and eastern sides lie flat grassy meadows which vary considerably in extent. The Goose Islands are, for the main part, bounded on the outer peripheries by rocky sea shore. The few sandy sea beaches that interrupt this continuity are illustrated in Fig. 2.

Viewed from a distance the islands appear heavily wooded, but closer investigation reveals that the main island of Goose, and part of Gosling Island are comprised of muskeg

FIGURE 2. - Illustrating Extent of Sandy Sea Beach (cross hatched) and Tidal Mud Flat (solid black). - The remainder of the shoreline is rocky sea shore.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surrounded by a fringe of coniferous forest varying in width from 25 to 300 yards. At some points on the east coast the muskeg extends through the forest to the rocky sea shore. The four remaining islands are timbered throughout. The extent and floral constitutents of the various habitats are discussed fully in the text.

Thus the Goose Island group supports well defined floral associations and habitat types characteristic of the outer fringe of islands at this latitude. It is, at the same time, a well isolated ecological unit surrounded by deep expanses of salt water which are subject to strong and treacherous tidal currents. Some of the smaller islets mentioned are well isolated in themselves.

CLIMATE

"It must be remembered that we have no data whatsoever for the true outermost shorelines, and that the excellent climate of that narrow strip is officially unknown." This statement by McCabe and Cowan (1945) still holds true. No records of climate are yet available for the Goose Island group and other outer fringe islands.

The climate was indeed excellent on the group in the summer of 1948. The small mammal work was carried out during a period of unvarying sunshine, the days repeating themselves identically in the climatic sense, thus eliminating a potential source of error that is all too prevalent, often unavoidable, and not often mentioned in works of this kind. The mainland coast and inner islands during that

summer suffered almost continual rain and cold. Prevailing winds carried widely dispersed cumulus clouds from the sea, over the outer fringe and to the mountains, where they shed their moisture on the coast and closely adjacent islands. During the occasions when precipitation did occur on the Goose Islands, the phenomenon of rain approaching across Queen's Sound against the wind presented an unusual sight.

Whether the conditions that prevailed were atypical is difficult to say in light of inadequate knowledge. If they were atypical, the effect, if any, upon the mammalian populations can be determined only by future studies after several years of observations have established annual mean precipitations, relative humidities, and temperatures.

For the purpose of this research however, the daily climatic constancy which existed at the time of operations was fortunate and constituted an exceedingly pleasant change from previous summers spent in the northern coastal areas.

FLORAL ANALYSES AND DESCRIPTION OF HABITAT TYPES

An initial inspection revealed the existence of eleven well defined vertebrate habitats on and about the islands, some of which may be regarded as distinct floral associations. These habitats are coniferous forest, meadow, muskeg, rocky sea shore, sandy sea beach, tidal mud flats, beach debris, coast littoral and pelagic waters.

Systematic floral analyses were carried out in the forest, meadow and muskeg habitats. The coniferous forest was subdivided into two sections for botanical study because of their diverse appearance. The remaining habitats, which were sparsely vegetated were not treated systematically.

Rough approximations of habitat size and occurrence were recorded in view of future refinement from aerial photographs which had supposedly been taken during the recent war. Unfortunately such photographs are not in existence and consequently the areas illustrated in Figures 2, 3, and 14 are diagrammatic representations indicating relative dispersion and position only.

Coniferous Forest

Two types of plant associations are included in the general heading of coniferous forest. One, the typical coast climax association of cedar, hemlock and spruce, the other, in which cedar and hemlock are in association with jackpine, yellow cedar and yew (Figs. 3, 6, 7). This stunted forest appears to form an ecotone between the spruce hemlock and muskeg association and also predominates in rocky areas on

Fig 3

FIGURE 3. - Distribution of Small Mammal Habitat Types on Goose Island - Cedar hemlock forest is white, ecotone type forest is solid black, muskeg is cross hatched and meadow is stipled, beach debris habitat is illustrated in Fig. 8.

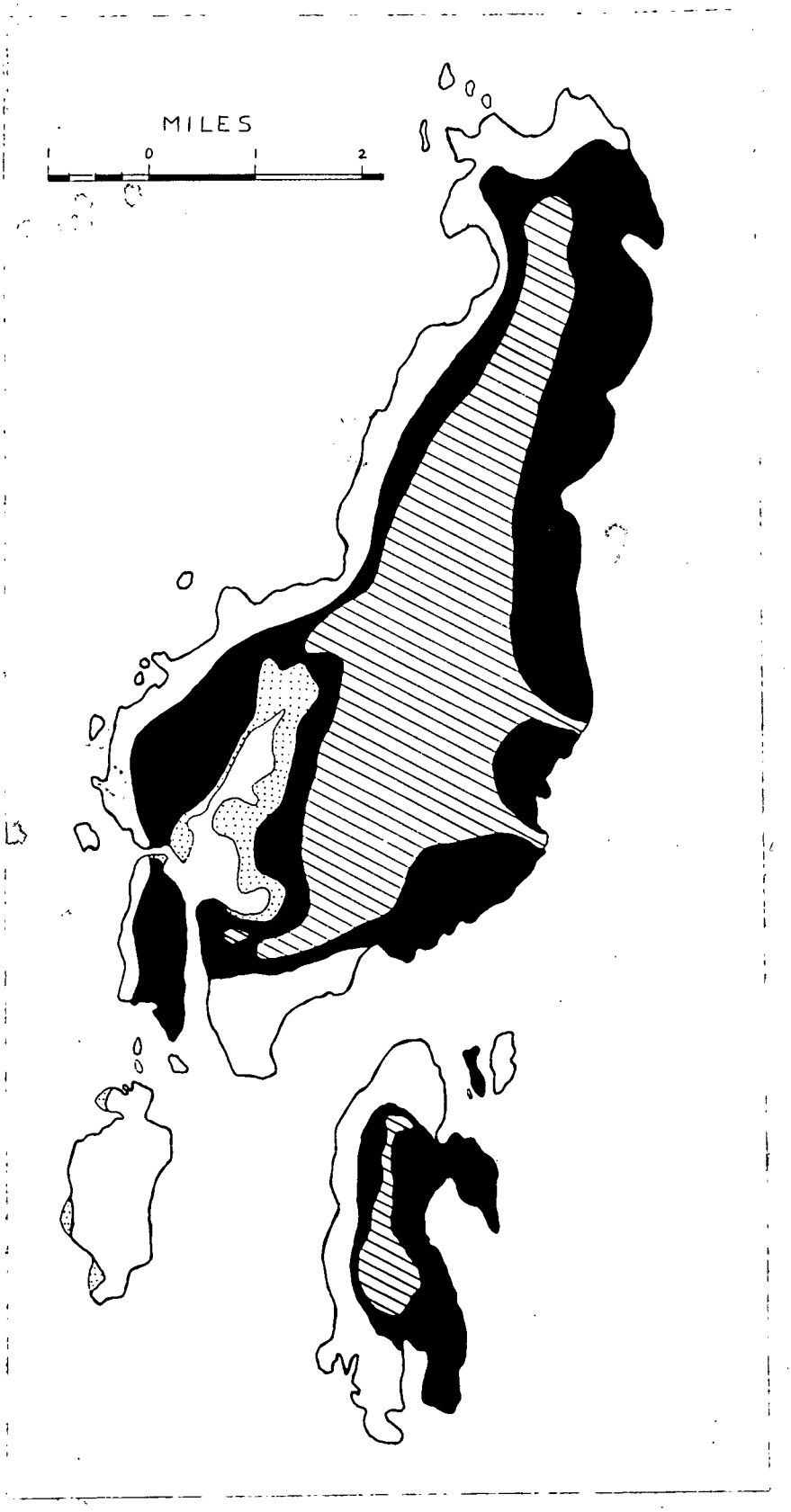
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FIGURE 4. - Cedar-Hemlock Association on Goose Island. - Showing a stand of *Calamogrostis* at the edge.

FIGURE 5. - Same Area from a Distance. - Showing beach Debris at the Edge.

the east coast of the island.

In view of the small area involved it seems unlikely that the cause or causes leading to this differentiation can be attributed directly to climate. It would seem rather, that they are due to prevailing ecologic factors coupled with normal plant succession towards a spruce-hemlock climax. A general gradient from the sea is apparent throughout most of the wooded areas, although the cedar-hemlock stands at the north and south ends of Goose Island are on relatively flat ground. Except for possible retaining effect by the contours of underlying rock formations, drainage seems reasonably adequate on the coastal slopes. The possibility of fire as an agent responsible for the diversification of coniferous types has been considered. Some ancient fire scars were observed in both types of forest, but in view of the length of time which has elapsed since fire swept the islands, and with almost identical floral distributions existing on other outer fringe groups, it seems more probable that the postulated soil factors, drainage and associated plant succession are the important causative agents here.

The general distribution of the cedar, hemlock, and associated spruce on these islands seems to substantiate McCabe and Cowan (1945) in their observations that the development of spruce is not reduced by outside exposure to the sea. In fact the distribution here seems to indicate the opposite. It has been pointed out (Dr. T. M. C. Taylor, Pers. Comm.) that a lack of seedling trees coupled with the

FIGURE 6. - Ecotone Type Forest on East Coast of Goose Island.

FIGURE 7. - Ecotone Type Forest at Edge of Muskeg.

heavy occurrence of sphagnum throughout the cedar-hemlock association on Goose Island may indicate a post climax condition. Another possibility accounting for the lack of seedlings in the narrow coniferous belt may be attributed to the almost complete utilization of available spruce cones by Peromyscus. This however does not account for the hemlock and red cedar which may not be utilized. The problem of plant succession cannot be discussed fully here. Whether the seral stages represented are progressing towards a cedar-hemlock climax or retrogressing to another type remains arbitrary. The outer islands present a fascinating source of study to the plant ecologist; that they have not been worked more thoroughly is surprising. The boundaries between the two types of forest are characterized by the gradual blending of indicative species over a short linear space, giving, from the distance, an appearance of abrupt change.

The floral composition of the coniferous forest was assessed by the Aldous method (1944). Strips 300 yards in length were chosen at random. Plots of 1/100 acre were spaced at 50 yard intervals on these strips and the coverage by plant species recorded on a mean basis as described in the foregoing reference. Twenty-four plots were run in each coniferous type. The coverage by species and the occurrence within each plot are recorded in percentage. (Tables I and II).

The methods of appraisal here are not intended as a refined treatment of floral composition but as a gross analysis

Table I.-- Percentage Occurrence and Cover by Plant Species in Cedar-Hemlock Forest on Goose Island, B.C., July 1948.

	Plant Species	Occurrence	Cover
1	Sphagnum sp.	100	56.8
2	Peligera canina	83.3	9.8
3	Maianthemum bifolium	75.0	18.2
4	Tsuga heterophylla	70.8	33.7
5	Menziesia ferruginea	66.6	7.5
6	Vaccinium	62.5	6.8
7	Gaultheria shallon	58.3	22.7
8	Thuja plicata	50.0	17.7
9	Rubus spectabilis	50.0	7.2
10	Polypodium hesperium	45.8	2.2
11	Struthiopteris spicant	45.8	4.3
12	Picea sitchensis	37.5	16.4
13	Prenanthes hastata	29.1	0.2
14	Streptopus amplexifolius	28.1	0.2
15	Tiarella trifoliata	25.0	1.2
16	Usnea sp.	16.6	8.3
17	Galium trifidum	12.5	0.6
18	Coptis asplenifolia	12.5	2.7
19	Lonicera involucrata	12.5	0.4
20	Vaccinium caespitosum	12.5	0.6
21	Fatsia horrida	12.5	1.6
22	Calamagrostis inexpansa	12.5	4.3
23	Aspidium spinulosum	8.3	0.4
24	Lysichiton americanum	4.1	0.2
25	Stereocaulon sp.	4.1	0.2
26	Malus rivularis	4.1	2.9
27	Rubus pedatus	4.1	1.2
28	Alnus sitchensis	4.1	0.2
29	Pteris aquilina	4.1	0.2
30	Conioselium gmelini	4.1	0.2
31	Vicia gigantea	4.1	0.2
32	Moneses uniflora	4.1	0.2

Table II.-- Percentage Occurrence and Cover by Plant Species in Ecotone Type Forest on Goose Island, B.C., July 1948.

Plant Species	Occurrence	Cover
Gaultheria shallon	100	38.1
Sphagnum sp.	100	55.2
Thuja plicata	91.7	40.2
Tsuga heterophylla	83.3	16.9
Maianthemum bifolium	79.1	3.9
Struthiopteris spicant	75.0	7.9
Coptis asplenifolia	75.0	4.3
Menziesia ferruginea	66.7	5.4
Vaccinium ovalifolium	62.5	3.1
Carex sitchensis	58.3	6.0
Charaecyparis nootkatensis	45.8	15.2
Calamagrostis inexpansa	41.7	2.1
Pinus contorta	37.5	14.8
Ledum groenlandicum	37.5	3.9
Linnaea borealis	33.3	1.7
Caltha biflora	33.3	4.4
Lysichiton americanum	33.3	1.7
Picea sitchensis	20.8	11.9
Taxus brevifolia	16.7	3.9
Empetrum nigrum	16.7	1.9
Rubus spectabilis	16.7	0.8
Pteris aquilina	16.7	1.9
Coptis asplenofolia	16.7	1.9
Polypodium hesperium	12.5	0.6
Streptopus amplexifolius	12.5	1.7
Stereocaulon sp.	8.3	0.4
Cladonia sp.	8.3	1.4
Usnea sp.	8.3	0.4
Lycopodium selago	8.3	0.4
Malus rivularis	4.1	0.2
Sanguisorba sitchensis	4.1	0.2
Drosera rotundifolia	4.1	0.2
Peltigera canina	2.0	1.0

indicating the relation of the plant species involved regarded from a cover point of view rather than by numbers of individual plants occurring.

The Muskeg Habitat

Comparatively small areas of muskeg are located on Gosling Island but the study of this habitat was confined to Goose Island proper. Here the main part of the interior is comprised of this type (Figs. 3, 8, 9). The island resembles a shallow saucer or catch basin with rising timbered coastal slopes levelling off and depressing generally towards the centre forming a shallow rim around the island. The topography of the interior is marked by numerous rocky outcroppings, ridges and low hills of varying size forming a series of secondary catch basins. The low lying ground is characterized by pot holes and a general coverage of sphagnum moss and lichens. From this understory other plants have established themselves. Stunted jack pine, many of them dead, are dispersed over the area. The higher ground, hills and ridges are wooded with the ecotone type forest.

The presence of this muskeg is probably due to hydrophytic conditions resulting from the damming effect of the catch basins, in other words, inadequate drainage. This is borne out by the fact that in periods of heavy precipitation the pot holes become filled with water, the muskeg because generally very wet and the several small streams draining the interior come in spate carrying the great excesses over

FIGURE 8. - Muskeg at South End of Goose Island. May, 1948.

FIGURE 9. - Muskeg in Central Goose Island. May, 1948. - Note the dead *Pinus contorta* debris in pothole.

the coastal rim to the sea. The streams in a short while are almost dry again, mere trickles which are almost stationary. The pot holes however retain the water for a much greater length of time, depending upon the intensity and humidity of the prevailing westerlies.

A line intercept method was used in assessing the floral composition of the muskeg. Here again the raw data were collected from a cover point of view only. Two stout upright wires were used to spread a taut horizontal line 100 inches long. Each 100 inches was regarded as a plot, one inch representing one percent. Total cover of the species occurring was measured in inches along the line regardless of overlap. For example, in a given plot 100 percent cover of sphagnum moss could be recorded along with 100 percent of some higher growing species that chanced to intercept the total length of the line. If still higher growing species occurred, the three cover levels could, theoretically, show a percentage of 300 for the plot.

Twenty-four plots spaced at 100 yard intervals were selected at random running transversely across the muskeg from forest edge to forest edge.

Table III lists the species occurring in terms of percentage of cover and occurrence in plots.

Table III.-- Percentage Occurrence and Cover by Plant Species in Muskeg on Goose Island, B.C., July 1948.

Plant Species	Occurrence	Cover
Cladonia sp.	95.8	63.8
Sphagnum sp.	91.6	67.0
Myrica gale	91.6	12.7
Juniperus communis	72.5	17.2
Ledum groenlandicum	58.3	3.1
Sanquisorba sitchensis	58.3	4.9
Empetrum nigrum	50.0	5.5
Carex limnosa	50.0	1.7
Scirpus caepitosus	41.7	4.4
Chamaecyparis nootkatensis	37.5	5.3
Pinus contorta	33.3	4.7
Lycopodium selago	29.2	2.4
Tofieldia intermedia	25.0	0.7
Drosera rotundifolia	25.0	0.5
Eriophorum chamissoris	25.0	0.5
Carex stylosa	20.8	0.6
Caltha biflora	16.7	1.5
Kalmia polifolia	12.5	0.2
Rynchospora alba	12.5	0.8
Gaultheria shallon	8.3	0.2
Coptis asplenifolia	8.3	0.6
Linnaea borealis	8.3	0.1
Rubus pedatus	8.3	0.2
Thuya plicata	4.2	0.04
Alnus sitchensis	4.2	1.1
Struthiopteris spicant	4.2	0.5
Habenaria leucosthchys	4.2	0.04
Coptis asplenifolia	4.2	0.04
Gentiana propinqua	4.2	0.1
Pinquicula vulgaris	4.2	0.1
Carex sitchensis	4.2	0.04
Plantago macrocarpa	4.2	0.04
Calamagrostis inexpansa	4.2	0.04
Deschampsia caepitosa	4.2	0.04
Stereocaulon sp.	4.2	0.2
Bare Rock	4.2	0.8

The Meadow Habitat

The meadow habitat on the Goose Islands is limited to a few acres bordering the shores of the lagoon and to three small areas on the south western isle. (Figs. 3, 9a, 10). The meadows on the main island, where the floral assessment was done, are continuous but vary in width from a few feet to between 50 and 100 yards. Narrow necks of meadow penetrate into the coniferous forest at several points, chiefly where rills draining the interior occur.

Numerous fresh and brackish-water pot holes are located in the area. They represent a striking series of transitional stages in soil formation. Those nearer the shore contain a permanent supply of fresh water and harbour hydrophytic plants. Others, devoid of plant life, lose their water in dry spells exposing mud bottoms often two and three feet below the general level of the meadows; some of these become caked after long exposure (Fig. 11), while others become partially or wholly filled by accumulating debris from the annually dying vegetation. These areas become vegetated by the plant life of the meadow. Salicornia (sp.) is dominant on those immediately bordering the sea which are washed periodically by salt water (Fig. 12). Others have become vegetated completely by Plantago maritima leaving only patterns of irregular darker green patches to mark what had once been a pot hole. On some of these, the "harder" grasses of the meadow are encroaching.

FIGURE 9a. - Goose Island Meadows in May, 1948.

Figure 10. - Same area in July, 1948.

FIGURE 11. - Dry Pothole on the Goose Island Meadows. July, 1948.

FIGURE 12. - Edge of Meadow at Salt Water on Goose Island. July, 1948. - Note *Salacornia* sp. Encroaching on Sand.

The gradual transitional stages from pot hole to meadow represented here may well bear further investigation by a competent agronomist or plant ecologist.

A point sample method of range assessment (Clarke, 1942) was used in this habitat. The point sample unit improvised in the field, of wire and cardboard, carried 18 points. Each unit was considered a plot and 56 such plots were selected at random over the meadow for a total of 1000 points, 10 points only being included in the last plot. Seventy-one percent of the 1000 points struck bare ground. The percentage composition is calculated on the remaining 29 percent in which the points actually struck the root of a plant. In cases where beds of sphagnum or cladonia occurred, all points striking the mass were included. Simultaneous strikes were recorded where certain species of grass were growing up through the moss accounting for a total percentage greater than 100.

The results here are not viewed from the cover stand point, but as an indication of the floral composition of the meadow from relative numbers of different plant species occurring, as illustrated in Table IV.

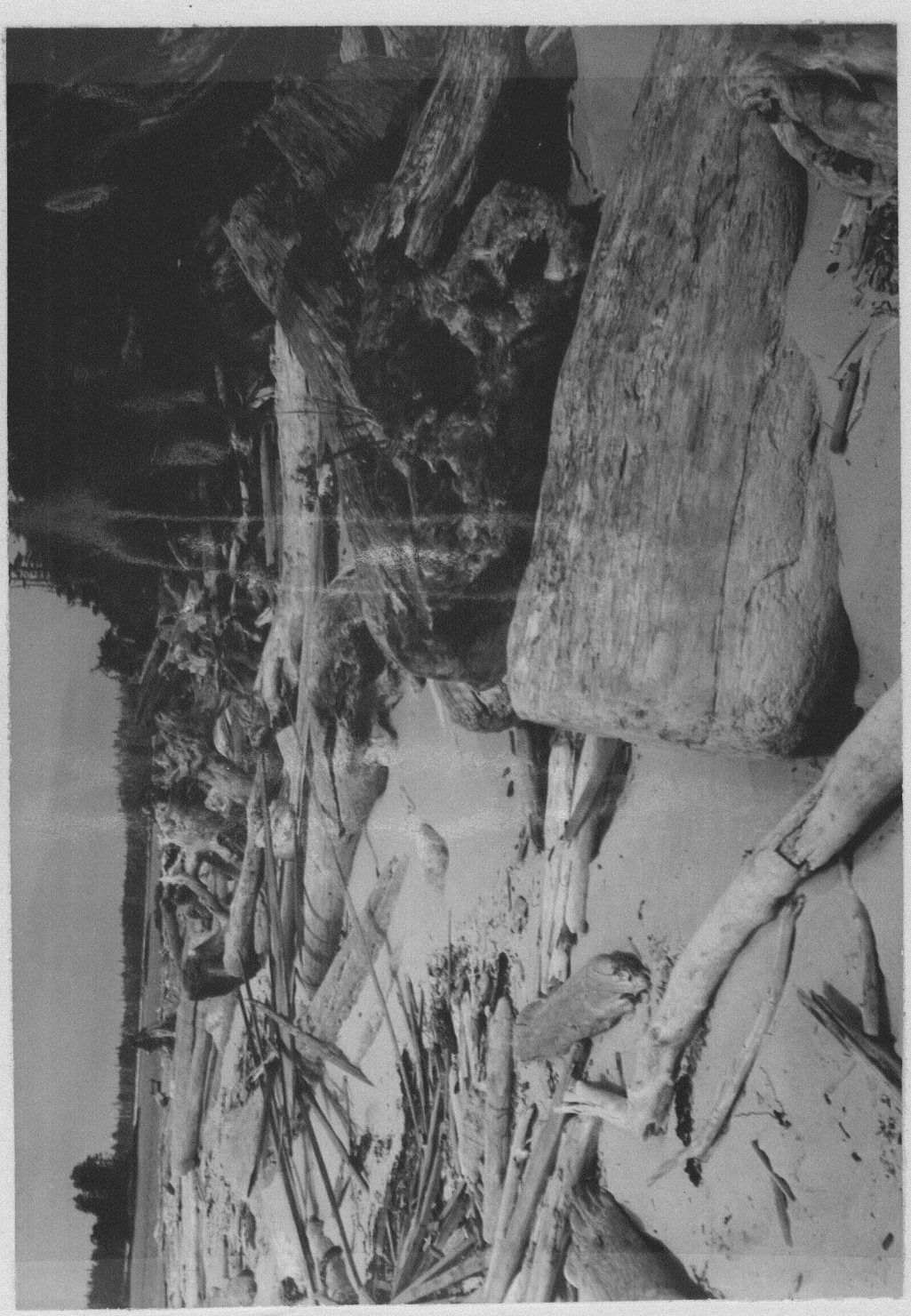
The Beach Debris Habitat

On many stretches of the British Columbia coast, where the tidal drifts permit, a welter of debris composed mainly of the logs, roots, and stumps of dead coniferous trees is found piled up on the sea beaches. The units making up these jams become lodged. Additional debris accumulating through

Table IV.-- Percentage Composition of Meadow by Plant Species on Goose Island, B.C., July, 1948.

Plant Species	Composition
Sphagnum sp.	30.0
Cladonia sp.	15.5
Trigolochin maritima	13.1
Deschampsia caespitosa	7.9
Salicornia ambigua	6.6
Juncus balticus	6.2
Carex bauxbaumii	5.5
Empetrum nigrum	5.2
Plantago maritima	4.1
Fetuca rubra	4.1
Eriophorum chamissonis	3.4
Potentilla anserina	2.8
Plantago macrocarpa	2.4
Hordeum nodosum	2.1
Achillea millefolium	2.1
Ledum groenlandicum	1.7
Glaux maritima	1.7
Carex limnosa	1.0
Elymus arenaria	1.0
Castilleja miniata	0.6
Calamagrostis inexpansa	0.6
Gaultheria shallon	0.6
Agrostis exarata	0.3
Sisyrinchium idahoense	0.3
Cochlearia officinalis	0.3
Mianthemum bifolium	0.3
Atriplex patula	0.3

FIGURE 13. - Beach Debris Habitat on Goose Island, B. C. July, 1948.

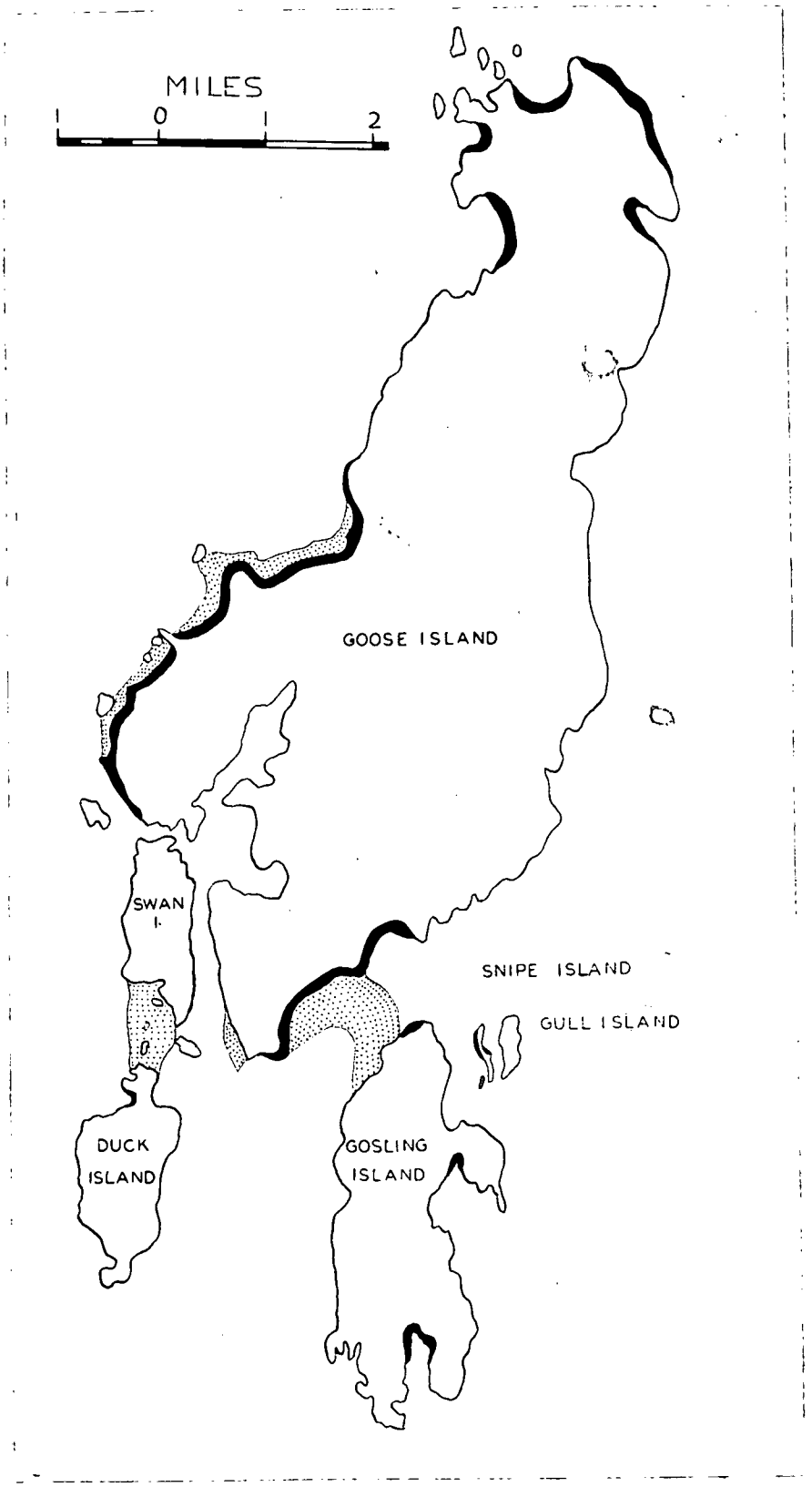


the years often extends the mass from the high water line to the forest edge, and sometimes into the forest proper for short distances. In many cases the logs are piled to a height of fifteen to twenty feet, depending upon the ferocity of the gale and the state of the tide upon which they were borne. Interlocking units, shifting sands, and encroaching plants of the forest edge and high beach combine with other agents such as rock and mud in anchoring the accumulating mass until it often becomes a permanently fixed and integral part of the shoreline. These coastal log jams form a distinct habitat type utilized by certain species of birds and small mammals.

The beach debris habitat on the Goose Island group occurs on all sides of the islands where conditions are favourable (Figs. 13, 14,). It seldom exceeds a width of 25 yards, and the debris in most cases is composed of from one to three layers varying in depth to four feet.

Along the forest edge of this habitat, Gaultheria, Alnus and Rubus, have encroached to a considerable extent, where the substratum is composed of sand. Here also, the older debris carries thick mats of sphagnum moss below which the decaying wood has furnished bases for small cedars and hemlocks and lesser plant life. Lower down the beaches, in the central line of the habitat, but still above high tide mark, irregularly occurring stands of Lathyrus, Atriplex and Vicia grow up among the debris. The former often spreading back over the logs, intertwining with the woody plants already

FIGURE 14. - Distribution of Beach Debris and Boulder Beach on Goose Island, B. C. 1948. - Beach Debris in solid black, boulder beach stippled.


MILES
0
1
2
GOOSE ISLAND
SWAN I.
SNIPE ISLAND
GULL ISLAND
DUCK ISLAND
GOSLING ISLAND

established to form dense thickets over the logs along the high beach. Beneath these thickets, between and under the logs, are mazes of passages, runways and chambers admirably suited as a dwelling place for mice.

The outer margin of the beach debris which is washed regularly by the tides, is devoid of plant life.

Where the logs have "hung up" on rocky sea shore plant life is generally much less abundant. In some areas however, the spaces between the larger units have become filled with smaller debris and cast up sea weed, forming suitable bases for plants. Newly established jams bear no plant life. Some of these may be temproary and will disappear under the onslaught of winter storms.

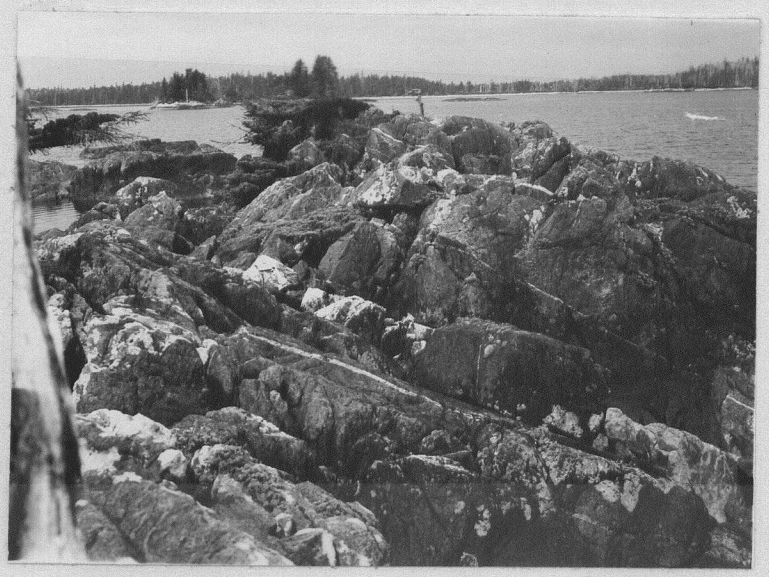
The development of permanent beach debris habitat depends upon a multitude of factors, time, nature of the bases, prevalence and intensity of storms, tidal drift, exposure and so on. It is obvious then, that many types, all differing in certain aspects, are to be found along the coast and shores of the coastal islands in British Columbia; this holds true on the Goose Island group as well.

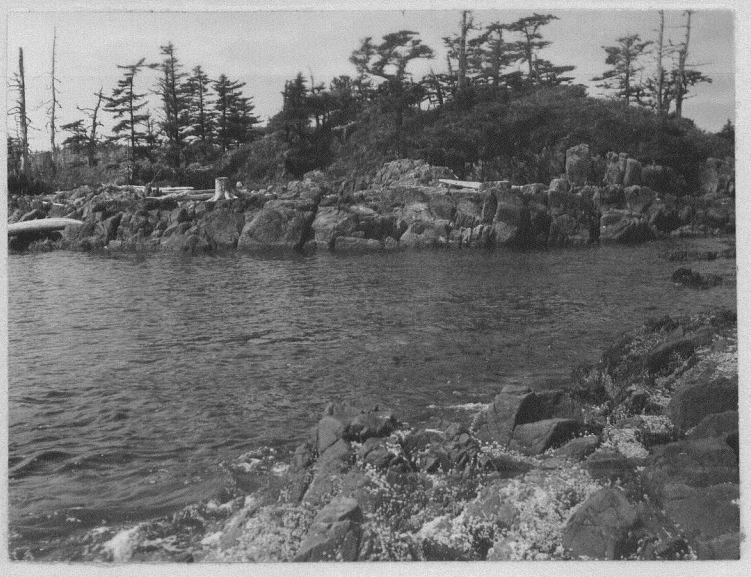
The Rocky Sea Shore

As previously indicated rocky sea shore forms a large part of the outer shoreline of the Goose Island group (Figs. 2,15,16).

The margin of rock between the sea and the forest is generally narrow and precipitous, seldom exceeding twenty or thirty feet in width.

FIGURES 15 and 16. - Typical Rocky Sea Shore on Goose Island, B. C. 1948.





The vegetation is sparse, Potentilla villosa dominating, with Fragaria chiloensis also present. Here and there an occasional twisted spruce helps break the monotony of lichen encrusted rock. Nearer the forest edge, where there is shelter and an accumulation of soil in the crevices, such plants as Tellima grandiflora, Montia sarmentosa, Trientalis sp., Erigeron salsuginosus, Barbarea vulgaris, and Castilleja sp. are found.

The percentage composition of flora on the rocky sea shore of the Goose Islands is not presented here.

The floral analyses of the foregoing habitats was conducted in July at the approximate mean of the four months spent upon the islands. In consequence some earlier and later appearing varieties of plants were gone or had not appeared when the work was being conducted. These of course, do not appear in the plot results. In addition, some of the less abundant plants did not chance to fall within a plot. Time did not permit the continued running of plots until every possible variety was represented, as had been planned, but a fairly representative collection was made in May and June.

I do not maintain that the collection of plants is complete, but I do feel that the work here presented has accomplished its intended objective, in that it gives an indication of the type, diversification and, in most cases, the relative abundance of the characteristic flora on the various habitats discussed.

The plant collection from the Goose Islands is housed

FIGURES 17 and 18. - Boulder Beach between Goose and Gosling Island, B. C. 1948.

at the Provincial Museum in Victoria, B.C.

The marine flora of the sandy sea beach, boulder beach, coast littoral and pelagic waters, being beyond the scope of this paper, is not presented here.

Boulder Beach

The boulder beach occurring upon the group is located for the main part between the south end of Goose and the north end of Gosling Island. A considerable stretch is located on the west coast of Goose Island, while short stretches lie between Gosling, Snipe and Gull Islands (Figs.14,17,18).

Sandy Sea Beach and Tidal Mud Flat

Figs. 2, 19 and 20 illustrate the extent of these habitats on the group. All expanses shown are true sandy beaches except portions of the lagoon. Here there is a considerable amount of soft mud (Figs. 2, 21, 22) occurring along the central depressions and generally mixed with the sand on the flats at the head. The area here appears to be in a stage between tidal mud flat and sandy sea beach with sand predominating.

MAMMALIAN POPULATIONS

Discussion of Methods, Procedures and Application

It is generally conceded that up to, and including the present time no satisfactory methods of accurately measuring per unit densities of small mammals has been devised. Various workers, Dice, Blair, Bole, Stickle, and many others have devoted much time to the subject. The conflicting nature of the results obtained by these workers in the

FIGURES 19 and 20. - Sandy Sea Beach on Goose Island, B. C. 1948.

use of the snap trap and the live trap quadrat have cast serious doubts upon the validity of either method. Many contributions published have accomplished valuable objectives in pointing out the pitfalls and difficulties encountered in the censuring of small mammal populations (Dice, 1938). Stickle (1947), in an experimental comparison of the two methods arrived at the conclusion that live trapping, mark and release, yields more accurate figures than does snap trapping. She indicates that the latter method results in population figures three times as great as those obtained by the live trap procedure. The experiment, in this respect, indicated also that the use of live traps appreciably shortened the range of operations of the mice on the quadrat in question. When the live traps were removed from a large quadratand a smaller central area of that quadrat snap trapped, it was revealed that the previously marked mice had come from distances greater than the calculated range based on the live trap data. In view of the fact that per unit densities arrived at by the live trap methods are based upon this calculated range, the results so obtained must be regarded as questionable approximations with a tendency to indicate fewer animals per unit area than actually occur. When large quadrats are used it is probable that errors of exaggeration resulting from snap trap procedures are no more extensive in one direction than those resulting from live trap methods are in another. The utilization of both methods combined, may yield a calculated mean representing

FIGURES 21 and 22 - Sandy Sea Beach in Lagoon on Goose Island, B. C. - Note wet areas in background demarking areas of tidal mud flat.

more truthful figures than does the sole use of either one.

When smaller quadrats are used, in which the linear ranges of the mice in question are undoubtedly greater than the dimensions of those quadrats, it is obvious that per unit area density estimates based solely on the area covered by traps will result in exaggerated figures. Some correction then, must be made to compensate for that part of the rangesof the mice which chance to lie outside of the plot upon which they were taken. Such was the case in the work conducted on the Goose Islands. In consequence, the unit area density figures presented here are open to question and are presented only as points of interest and comparison with the percentage calculations upon which the relative abundance of small mammals is based in this paper.

Potentially the live trap method has greater possibilities than has snap trapping. The latter method kills the mice as they are taken and consequently the calculation of individual ranges is impossible. The removal of a number of animals from a given area also gives rise to sources of error.

The major objection to the use of live traps in this type of research is the influence which these traps exert upon the range of individual mice. Several methods of eliminating this effect have been suggested. Basically all of the methods operate on the same principle, that of closing a trap or group of traps on a quadrat or adjacent quatrats thus allowing the mice to wander further afield and into

traps they otherwise would not have visited. Most of these methods involve a large number of traps and subsequent man hours. In addition the ranges arrived at will still remain directly proportional to the spacing of the traps as long as a set pattern is used. For these reasons and others, they are impractical. It is generally acknowledged that seasonal movements and other variable factors affecting mammalian populations necessitate the completion of an investigation within a short space of time.

A live trap method employing an expanding quadrat and possibly involving relatively fewer traps has been postulated by Cowan (1949, Pers. Comm.). Beginning at a central area of suitable dimension in a given habitat, a number of live traps are set in close proximity. The mice taken are marked and released and on succeeding nights the traps are set further and further from the central area. Eventually a point or points should be reached at which the originally marked animals are no longer being taken. Howard (1949) has suggested a similar method, in which, stated generally, the traps are lifted from the central area after a sufficient number of animals have been marked and released. A peripheral line of traps is then set around the central area at a distance greater than the expected range of the individuals of the species in question. On succeeding nights this line of traps is moved closer to the central area until marked mice are being retaken.

In dense cover types where a short cruising range may be expected these methods may well prove effective and yield data

from which per unit area densities can be calculated with reasonable accuracy. In open cover types, however, they may necessitate the use of far too many traps. Until they have been subjected to field trials their practicability and accuracy remain unknown.

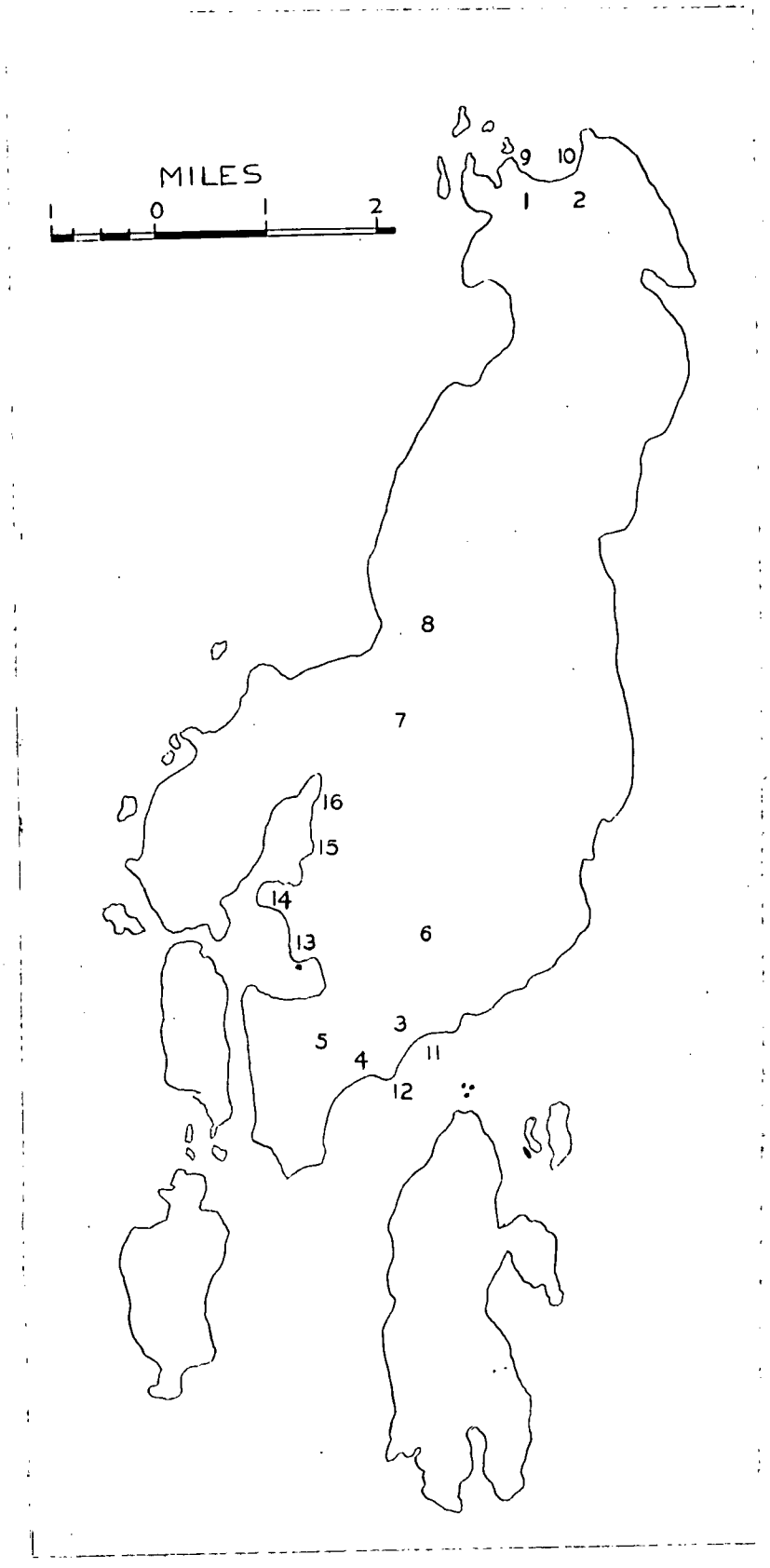
In the present study snap traps only were available. These I utilized to the best of my ability fully realizing the limitations imposed by variable factors and by the inadequacies of the available equipment.

The three species studied by use of snap trap quadrat represented the only terrestrial mammals found occupying the Goose Islands (apart from bats). These animals are Peromyscus maniculatus, Microtus longicaudus and Sorex obscurus.

Investigations by quadrat were confined to the main island (Fig. 23) and commenced on May 22, terminating on June 7 when the first young Microtus were observed running.

Four quadrats, 70 yards long by 20 yards wide, were run for three consecutive days and nights in each of the four habitats occupied by these mammals. Each quadrat contained 39 traps baited with walnut and set at five yard intervals in lines of three running transversely. Thirteen such lines constituted the complement for each quadrat. All traps were set in niches deemed most likely to catch mice while still conforming to the five yard interval. No trap was set within five yards of the outer margin of the quadrat in which it was placed. The margin formed by this five yard strip when considered in per acre calculations, figuratively disperses the

FIGURE 23. - Location of Mammal Quadrats on Goose Island. - Numbers 1,2,3,4, coniferous forest; numbers 5,6,7,8, muskeg; numbers 9, 10,11,12, beach debris; numbers 13,14,15,16, meadow.

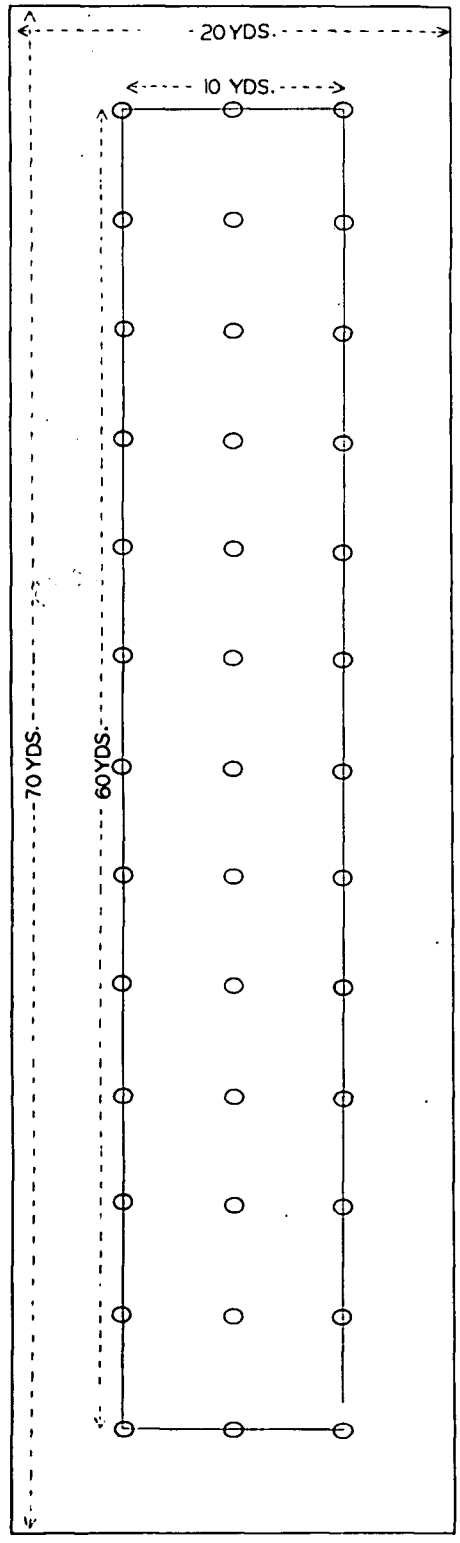

MILES
1
0
1
2
9
10
1
2
8
7
16
15
14
13
6
3
5
4
11
12

animals taken, over an area less, by 400 square yards, than three times the area actually enclosed by traps. This area is arbitrary and based on an expected exaggeration of roughly three times the per acre density figure that would have resulted had live traps been used. The 400 square yard difference is regarded as compensatory for the range shortening effect of the hypothetical live traps. The standard quadrat used on Goose Island is diagrammatically illustrated in Fig. 24. In calculation of per acre densities, the total number of individuals taken in a given habitat in three nights of trapping on four standard plots was considered. For example, Peromyscus taken in all beach debris plots totalled 65 of both sexes. The total area enclosed by four plots = 70x20x4 = 5600 square yards. There are 4840 square yards in one acre. The calculated density = $\frac{4840}{5600}$ x 65 = 56.1. One acre of beach debris habitat then, is considered to be utilized by an estimated 56 Peromyscus. Similar calculations were utilized for each species in each habitat.

I wish to stress again, at this point, that the density figures so calculated are presented as a basis for comparison and interest only. The discussions are based upon the number of individuals of a species taken in the different habitats by a constant, unbiased trapping procedure. The results are presented in percentage and the raw data have been treated by analysis of variance (Snedecor, 1938). Taken at the .01 level of probability it has been indicated that:--

1. The observed differences in the total number of individuals of all species cannot be ascribed to chance. In other words

FIGURE 24. - Standard Trapping Quadrat used on Goose Island.


70 YDS.
60 YDS.
10 YDS.
20 YDS.

the productivity of the various habitats in relation to all species differs due to some product of the habitats.2.The differences observed in the number of individuals of different species taken in different quadrats cannot be ascribed to chance, but suggests that some species "do better" than others in different quadrats. 3. That one species does better in one habitat than it does in another. Consequently, the observed distribution of individuals of different species for specific habitat types is not due to chance, but to intrinsic characteristics of either the species, the habitat, or both.

A source of error of course, still exists in possible differential wandering of individuals of a given species in different habitats. It is assumed from the trapping results obtained that this constitutes for practical purposes, a negligable factor contributing to the relative distributions observed here.

Five small islets were trapped off in an attempt to measure the reliability of the quadrat methods utilized in arriving at per acre densities on the main island.

Islets were selected which bore habitats comparable to those on the main island and which were small enough to be completely covered by the traps available. Unfortunately two of the islets first selected were so trampled by operators setting traps that no valid results were obtained. Another islet while bearing old sign, yielded no mice or shrews when trapped. The fourth bore no sign and subsequent trapping

proved that it was uninhabited by small mammals. The remaining islet bore no beach debris and harbored no Microtus. In addition the meadow, muskeg, and coniferous forest present were not laid out in distinct patterns as they were on Goose Island proper. In all a measured 3600 square yards constituted its total area. Fifty percent of this was in sparse spruce-hemlock forest with a sub climax of Gaultheria. Thirty percent was in muskeg, represented by a strip along the east shore which was vegetated predominantly by sphagnum moss and ledum. Two small headlands at the north and south were covered by Calamogrostis which also bordered the ledum stand at the sea thus representing approximately 20 percent of the total area as meadow habitat.

The islet was well isolated by approximately 400 yards of sandy sea beach to the west, and by a deep rocky gorge about 30 yards in width on the east. Large expanses of sandy sea beach to the north and deep water to the south completed the isolation. The gorge and sandy sea beach were inundated at all times except during periods of extremely low tide.

An untrapped headland at the southern extremity was effectively blocked by a buffer line of traps covering a neck of land about 30 feet in width. Traps were arranged to indicate the direction of travel of any small mammal caught crossing the line.

The islet was saturated by traps spaced at five yard intervals and trapping was continued for a twelve day period which commenced June 9 and was terminated June 20. No

animals were taken after June 16 and the total population inhabiting the area was considered trapped off.

A total of ten Peromyscus was caught represented by seven males and three females. Seven Sorex taken were represented by four males and three females. Statistically, in both cases there was no significant preponderance of either sex, indicating in the case of Sorex, that population dynamics may not have been comparable to those on the main island.

The densities calculated from the data gathered on the islet indicated 13 Peromyscus per acre, as compared to 18 per acre on the main island, and nine Sorex per acre as compared to 13 on the main island. The figures for the small islet may be regarded as reasonably accurate. I have little doubt that every small mammal vulnerable to trapping was caught. I am equally confident that no influx had taken place.

The agreement observed between main island and islet population densities may justify, to some extent, the arbitrary methods utilized in the areas where an influx from outside the plots presented such a grave source of error. Limited replications, differences in absolute sex ratios, varied habitat dispersion and the strong possibility that the unequal size of the land masses had exerted differences in reaction imply, however, a need for caution.

The data presented here serve in directing attention to the existing possibilities of testing small mammal census

methods on British Columbia's coastal islands.

Outline of Mammalian Fauna observed on the Goose Islands

The terrestrial mammalian fauna of the Goose Islands at the time of study was restricted to five species of small mammals. These were Peromyscus maniculatus, Microtus longicaudus, Sorex obscurus, Lasionycteris noctivagans and Myotis yumanensis.

That a species of Castor had once inhabited the islands was apparent from evidence in the form of dam shells and cuttings. No fresh sign or live animals was observed. The species is assumed as Castor canadensis.

Marine mammals recorded during the time of study included Balaenoptera physalus, Megaptera novaeangliae, Phocoenoides dalli, Eunetopias jubata, Callorhinus and Phoca vitulina. That other species occur is highly probable but none was observed.

Marine mammal studies were confined to observations of date, place of occurrence and are presented as such in this paper; no discussion of distribution is presented. For some inexplicable reason, mink and otter apparently do not occur upon the Goose Islands. No indication of their presence, immediate, or in time past was found by our field party. Local fishermen, trappers and Indians state flatly that they have never seen individuals of either species on the islands, or in immediately adjacent waters. No record exists in British Columbia Game Department fur return files (H.Rose, Pers.Comm.) and the island is not included on a registered

trap line as many other coastal islands are.

With the proximity of large mink populations on the Broken Islands, and Bardswell group, and in light of numerous records of otter from these neighboring islands, it is puzzling indeed that some record of occurrence has not been made. The Goose Islands are utilized by salmon and cod fishermen the year 'round and by local sportsmen in the fall. A scarcity of human observers does not appear to be the answer.

Ample food for both species in the form of crabs and shore fishes abounds in the coast littoral of the Goose Islands.

DISTRIBUTION OF SPECIES OF MAMMALS OF GOOSE ISLAND IN TERMS OF HABITAT OR FLORAL ASSOCIATIONS

Castor canadensis

Beaver populations had apparently been restricted to the mature coniferous forest and muskeg habitats where sufficient water was available. No evidence was found in other habitats. Rivulets bordered by grasses and intruding into the coniferous forest from the meadows of the lagoon were dammed at the forest edge.

Lasionycteris noctivagans

Few observations were recorded for silver-haired bats on Goose Island. In all cases this species was seen only in the immediate vicinity of the upper mature coniferous canopy. Mature coniferous forest afforded the only available roosting sites for species of bats on these islands.

Myotis yumanensis

This small species of bat was observed for the most part in the immediate vicinity of the coniferous forest. On several occasions however it was seen foraging over the coast littoral, sandy sea beach and meadow habitats.

Peromyscus maniculatus

Peromyscus were found occupying every habitat bearing cover which occurred upon the Goose Islands. Individuals of this species were more evenly distributed throughout the habitats than were Microtus and Sorex. Of the 136 adult Peromyscus taken in the course of the quadrat works 46.79 percent were caught in beach debris, 25.5 percent were taken in the coniferous forest, 17.38 percent in the muskeg and 10.29 percent in the meadow (Fig.25).

Calculated per acre density estimates for this species based on the methods previously discussed are as follows:-- Beach debris, 56; mature coniferous forest, 25; muskeg, 18; and meadow habitat, 12.

Microtus longicaudus

Microtus were taken in all vegetated habitats with a strong preference for meadow indicated. Thirty adult

animals taken were distributed as follows:-- 13.33 percent in beach debris, 06.67 percent in coniferous forest, 10 percent in musket and 70 percent in the meadow habitat (Fig. 25).

Per acre densities of this species were estimated at 4 in beach debris, 2 in the mature coniferous forest, 3 in the muskeg, and 18 in the meadow habitat.

Sorex obscurus

Sorex were also caught in every habitat bearing vegetation. Fifty adult animals were taken on the quadrats: 27.78 percent of these were in beach debris, 11.11 percent in the mature coniferous forest, 11.11 percent in the muskeg, and 50.00 percent in the meadow habitat (Fig. 25).

Calculated density estimates indicated 13 Sorex per acre in the beach debris, 5 in the mature coniferous forest, 5 in the muskeg, and 23 in the meadow habitat.

Balaenoptera physalus

Six fin-back whales were observed, the first on May 30. Two were observed together on June 13, one on June 15, and two at widely separated points on June 26.

The animals observed on May 30 and June 15 were in the littoral waters of Goose Island, the remainder were observed in pelagic waters approximately 14 miles to the west at the edge of a shallow area termed the Goose Island banks.

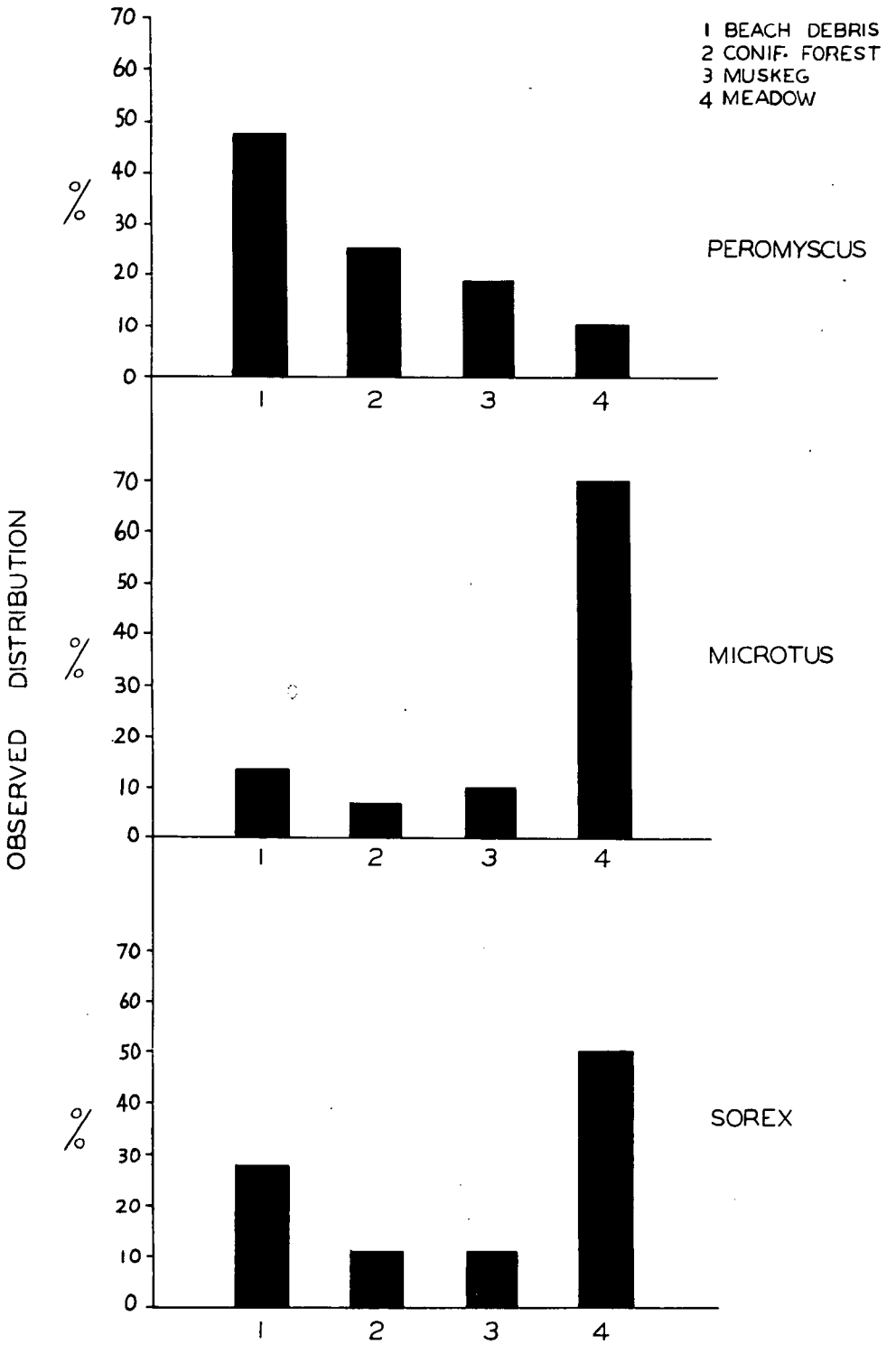
Megaptera novaeangliae

One humpback whale was observed in coast littoral waters on July 31.

Phocoenoides dalli

Dall's porpoise was first observed on June 25. Prior to

FIGURE 25. - Relative Abundance of Small Mammals in Four Habitat Types on Goose Island B.C.,Summer,1948.


1 BEACH DEBRIS
2 CONIF. FOREST
3 MUSKEG
4 MEADOW
OBSERVED DISTRIBUTION
%
PEROMYSCUS
MICROTUS
SOREX
0
10
20
30
40
50
60
70
1
2
3
4

that date none had been seen despite a constant vigil maintained in view of collecting specimens. One June 26, a school of eight was seen in the littoral waters on the east side of Goose Island. From July 8 until we left the islands at the end of August, several schools, numbering from three to twenty individuals occurred almost daily in Queen's Sound.

These animals remained close to the east side of the Goose Islands in the early and mid morning period. At this time they appeared playful and disported readily in close proximity to the prow of the boat. Later in the day, the schools appeared to break up and proceeded to the central part of the sound. At this time they generally avoided the boat and were more difficult to approach.

Advantage was taken of these habits in securing specimens and photographs.

Despite comparable time spent in pelagic waters only one occurrence was recorded for the species in that habitat. A school comprised of eight individuals was observed 18 miles to the south of Goose Island in an area termed the South bank. All other observations were made in coast littoral waters. No animal of the 140 Dall's porpoise recorded in the course of this work differed in size to the extent that it could have been placed in a separate age class. That is to say, the animals observed were apparently all adults.

Eumetopias jubata

Four sea lions observed in the coast littoral waters of Goose Island in May were probably wandering animals from nearby Whitefliff reef where a rookery harboring between 30 and 40 individuals is situated. A single observation of the species in pelagic waters was made on June 26 at the south bank. This animal, a large bull, was robbing cohoe salmon from trolling gear of fishermen operating in the area.

Callorhinus ursina

Two small female fur seals were seen on May 18. One animal was observed in pelagic waters approximately 18 miles south west of Goose Island. This individual was swimming actively and appeared to be migrating. The second observation was made in coast littoral waters, where an animal was seen resting on the water approximately two miles west of Gosling rocks.

Phoca vitulina

Adult hair seals were present in the coast littoral waters of Goose Island throughout the period of study. None was observed in pelagic waters.

A female and two pups were seen in the lagoon at high tide on August 11, and a yearling female was collected by Martin in the same area on August 12. The stomach of this specimen contained the remains of small fish identified as a species of perch.

GENERAL DISCUSSION OF THE OBSERVED DISTRIBUTION OF TERRESTRIAL MAMMALS UPON THE GOOSE ISLANDS

Castor canadensis

A series of ancient washed out beaver dams was found on the west central muskegs of the island. These had, at one time, blocked the rivulets connecting various pot holes to a considerable extent, apparently forming bodies of relatively shallow water to supply the needs of the species.

Along the eastern shores of the lagoon, the streams draining the muskeg and passing through the coniferous forest had been dammed forming several small, deep beaver ponds in the coniferous forest. Unlike the dams of the muskeg, the coastal structures have withstood the ravages of time, due probably to the more substantial materials available for their construction in this habitat, or perhaps, to a later period of occupancy.

It was impossible to determine accurately to what extent these animals were distributed in the two habitats occupied. A limited number of suitable dam sites existed in the coniferous fringe. The central muskegs probably presented a larger area of sub optimal range, and may at one time have supported a widely dispersed population of considerable size. Individuals of such a population would have been forced to forage some distance for the hemlock, red cedar and jack pine which comprised their chief sources of food judging from the cuttings observed.

The coniferous habitat utilized appears to have been the more nearly optimal range for this species upon the Goose Islands.

Food was available closer at hand, escape facilities were probably enhanced by deeper waters. The dams were more substantial and probably less subject to "wash outs" than those on the muskeg appeared to be. From the evidence it appeared that the sites at the coniferous forest edge had been occupied more recently than had those of the interior, indicating perhaps, that the species had made their last stand in this habitat.

Factors leading to the disappearance of beaver from the Goose Islands present a problem that may never be fully solved. In the lack of willow, poplar and other conventional beaver foods, it may be argued that the habitats occupied do not represent adequate beaver range. The precarious tenure of a species on marginal range need not be elaborated here. Suffice it to say that such populations are more vulnerable to a catastrophe of climatic or biological nature than are those inhabiting optimal range.

Beaver sign, to a greater extent than was found upon the Goose Islands has been observed on many of the coastal islands. Martin and myself found considerable fresh and old sign on Princess Royal, Hunter and other islands in 1948. In 1936 H.M.Laing and myself found evidence of still extant populations on Calvert Island, as did McCabe (1948). The abundance of sign presents two possibilities; first that a large population once existed on optimal or near optimal range represented by the habitats on these islands, and second, that these habitats represent marginal range occupied

by small populations which are forced to re-establish over periods of time, leaving in their wake an abundance of lasting sign that is difficult to age accurately. In these respects, until an adequate study has been made, I am inclined to agree with McCabe and to regard the coastal islands on the whole as marginal range for beaver.

This marginal concept holds true especially for the Goose Islands, where area, fresh water and deciduous growth are much more limited than on the inner islands.

Man may have been instrumental, directly or indirectly, in the disappearance of beaver from the Goose Islands. About 1904 when Mr. Max Lohbrunner (1948, Pers. Comm.) first visited the islands, he observed a number of emaciated dogs digging for clams on a beach at low tide. In his opinion these animals were in the final stages of starvation; ribs showing, their feet torn and bleeding, the animals were reported to have an air of desperation about them. They had, apparently, been abandoned on the islands by Indians who come annually to fish in surrounding waters. Certainly it can be inferred that beaver would rate more highly to a starving dog than would clams. In light of the limited escape facilities and restricted habitat on so small an island, it is conceivable that these carnivores may have been a factor contributing to the disappearance of beaver there. In addition it is entirely possible that some trapper or trappers located the beaver and subsequently trapped them off. Here again the marginal aspects of the area would facilitate

annihilation.

In any event, the beaver apparently are gone, no record of a living animal from the Goose Islands appears to exist. The local trappers, fishermen and sportsmen interviewed have never seen them there and the B.C.Game Department has no records of their occurrence.

From Mr. Lohbrunner's reports it may be safely assumed that beaver occupied the islands some time prior to 1904. Why they have failed to re-establish themselves over a period of time approaching 46 years must be left to conjecture. If the coastal islands to the east are marginal range which once forced an extensive wandering of individuals when populations were unmolested by man, it is possible that augmented trapping along the mainland coast and inner islands annually reduces the number of surplus animals, thus eliminating a possible population pressure that may have led to the original occupancy and additional restocking. On the other hand the original stock may have arrived accidently and subsequently disappeared due to such inadequacies of the environment as land mass, food, and so on. In this case any future occupancy is left purely to chance, may possibly be temporary, and seems to furnish a more plausible explanation for the length of time which has elapsed since beaver lived upon the Goose islands.

Lasionycteris noctivagans

Population studies of Lasionycteris and Myotis were confined to nightly observations and to some field collecting.

The silver-haired bat was recorded only five times in a period of almost continual nightly observations extending from May 23 to July 21. One specimen was taken, an adult male collected on June 12 which constituted the first observation. Four observations were subsequently recorded, the last on June 30.

In all cases this species appeared earlier in the evening than did Myotis. It fed at a high level usually above the upper canopy of the mature coniferous forest. The only apparent food was a species of small white moth which became active in the late afternoon.

The prevailing westerly winds that often blew throughout the night during the summer months probably influenced the activities and distribution of this species and may account for the lack of an appreciable population upon the Goose Islands.

Myotis yumanensis

In the same period of observation maintained for Lasionycteris 24 observations of the Little brown bat were recorded. Five specimens were collected, 4 adult females and 1 immature male. A female taken June 1 carried an embryo 13 mm. in crown-rump measurement. Myotis were observed just on May 23 and were still present on the last day of observations, July 21.

This species appeared later in the evening than did Lasionycteris. It fed generally below the canopy of the coniferous forest, flying low along the edge of through

clearings in the trees. On several occasions when no wind prevailed it was observed at distances up to 150 yards over the sea, skimming low over the water and about exposed reefs, feeding apparently upon flying insects of some kind. The white moth utilized by Lasionycteris was also taken by this species. On other occasions myotis were observed over the sandy sea beaches and neighbouring meadows about the lagoon.

Compared to the mainland and inner island populations Myotis was poorly represented upon the Goose Islands. This was probably due to wind effect as in the case of Lasionycteris. Myotis populations on Goose Island however, are apparently much higher than those of the larger bat. This seems to indicate that this little bat is influenced less by wind than is the high flying, open feeding Lasionycteris. The low flying habit coupled with the ability or preference to hunt through the forest as well as above it or along the edge, probably has an effect upon the distribution of this species. Previous observations along the coast and coastal islands, seem to substantiate these conclusions. Areas affected by heavy prevailing winds are inhabited by much smaller populations of bats than are the sheltered areas, and species of Myotis appear to be much more generally distributed throughout coastal British Columbia than is Lasionycteris.

Peromyscus maniculatus

It is generally conceded that males of this species and closely related forms range farther in their nightly wanderings than do females. No methods of measuring this alleged difference was possible in this research. No significant difference at the .05 level of probability was observed in the sex ratio of total animals trapped. Seventy-five were males and 61 were females. If one is to accept the generalization postulated above, the observed sex ratio would indicate a preponderance of females. However, the species has never been studied critically in this respect on the British Columbia coast where the ecological conditions vary greatly from those of eastern North America, where most of the Peromyscus studies have been conducted. In view of the fact that an insignificant preponderance of males in the total catch is generally reflected in each habitat and in each plot within these habitats, I see no alternative other than to accept the figures at face value and to assume that they represent the distribution of sexes throughout this species in all habitats on the Goose Islands. In other words, the observed difference, a preponderance of 14 males, may be regarded as the result of a greater range in the male of the species. Statistically, however, no significance can be attached to this observed difference so a balanced sex ratio is accepted and regarded as normal for populations of Peromyscus maniculatus inhabiting the Goose Islands.

The apparent preference of this species for the beach debris may be attributed to a number of ecological factors. The beach affords a wide variety of foods at the season this study was made. An abundance of vegetative foods was growing

on the high beach. Lathyrus, Potentilla and Vicia being utilized by Peromyscus. Cuttings were found about which the droppings of this species were observed; and traps set in such places invariably yielded mice. Additional food in the form of amphipods, crabs, limpets and a host of beetles and other insect life was also in abundance. While no direct evidence indicated the utilization of amphipods as food by Peromyscus they do form a potential supply in this habitat. Limpet and crab remains were found wherever the habitat favored their occurrence and these may be regarded as a regular part of the diet of coastal Peromyscus.

The availability of dry home sites is ideal on the high beach, and while no predation apparently exists, escape facilities in the maze of interwoven logs may possibly have fulfilled some inherent need of the species here. Dry sphagnum in abundance may have been utilized for nesting material. Most species of mammals indulge in activities which may be interpreted as play. I believe this activity in Peromyscus takes the form of unimpeded romps over open stretches of ground. Tracks in the sand and previous observations would so indicate, at any rate. If this is true, the beach affords running grounds of unsurpassed excellence.

This combination of abundant and varied food supply, availability of nesting sites, materials, and escape facilities, open ground for play coupled with the general dryness at this season, probably accounts for the apparent preference of Peromyscus maniculatus for beach debris habitat

on the Goose Islands.

Fresh sign in the form of droppings was very abundant in the beach debris. Old sign was lacking. Mouse dropping, of course, in the wet coastal belt, must be well sheltered in order to last more than a few hours. The high relative humidity will cause deterioration in a very short time even when such droppings are protected from direct rainfall. Careful examination in the dryer recesses however, sometimes reveal droppings -- which, when compared to the more recent material may often be identified as winter sign. When such droppings are accompanied by runways, grass cuttings and lasting sign of this nature it is often possible to state definitely whether or not the sign was made during the previous winter. No winter sign was found in the beach debris habitat, indicating that the population present in May and June may well be absent at other seasons of the year. The abundance of fresh sign substantiates the trapping results obtained here. Myriads of fresh tracks in the sand, fresh droppings and runways of Peromyscus were much more in evidence than in the other habitats studied. While I do not profess to know how much sign one mouse leaves in a given length of time, I do maintain that, by careful examination an experienced operator can very often distinguish between an area greatly utilized by mice and one which is not. That Peromyscus utilized the beach debris to a far greater extent than the other habitats at this time of the year seems quite apparent.

The trapping data, again substantiated by sign, indicated that utilization of coniferous forest by Peromyscus was less by half than it was in the beach debris. Winter sign, however, in the form of cone cuttings was very abundant on the forest floor while fresh sign was difficult to find. That a heavier population had previously occupied this habitat appeared obvious. Three possibilities immediately come to mind in this respect. First, that the annual increment of young animals born in the summer and fall months is forced into less favorable habitats by population pressure, and that the observed populations represent, in part, those which have survived the winter. Second, that a much higher population had recently occupied all habitats, representing a possible population peak which had recently entered a decline resulting in heavier populations surviving in more optimal range represented by beach debris. The third possibility is that habitats bordering the sea become untenable during winter periods of high tides, great storms and limited growth, in which case the coniferous forest and muskeg become more optimal.

The concept of recent population decline may possibly be validated by the universal dispersal of winter sign observed throughout the coniferous and muskeg habitats. These habitats covered a far greater area than did the meadow and beach debris and it is difficult to attribute the amount of evidence in these areas solely to the populations observed in the limited areas of suitable peripheral habitat.

In considering the high reproductive potential of the rodents involved, however, it is entirely possible that the annual increment of young could, in a season of high productivity, universally "flood" the areas of forest and muskeg to the extent indicated by the winter sign observed. On an island where the limiting factors appear negligible in the summer months, it seems logical to assume that a large part of the evidence found can be attributed to the annual increment. The possibility that such evidence may have been augmented by a recent decline in total population remains. To what extent this factor influenced the amount of evidence found cannot be measured from the available data.

From a purely physical point of view the beach debris and meadow habitat must become untenable to small mammals during the winter months. At this season, probably from November through March, the prevalence of high tides accompanied by terrific winds and storms undoubtedly inundates the peripheral habitats for a large part of the time. Summer tides failed to flood the areas in question, but came within a very few feet of doing so. High winter tides coupled with increased ground swell plus arrested growth, almost certainly eliminates the beach debris of Goose Island as regular winter range for small mammals.

The coniferous forest in many respects appeared to be adequate range for Peromyscus. Home sites and escape facilities in the form of fallen logs, dead trees and windfall are plentiful, as is open ground for running. General

dryness and variety of food, however, do not compare favorably with beach debris in the summer months. In winter the Peromyscus apparently feed largely upon seeds cut from the shed cones of Picea which are in abundance upon the forest floor at that season. The relative dryness of the two habitats is apparently reversed, the forest then affording more suitable ecological niches than do the sea washed habitats along the coast.

From these discussions it may be concluded that ecological changes occurring with the major seasonal variation probably results in a reversal of optimal conditions in Peromyscus range on the Goose Islands, leading to a population movement from one habitat to a vastly different one. The evidence indicates that the spring movement from interior to peripheral habitats occurs sometime during the month of April. The autumnal movement is probably more gradual, beginning in late summer and early fall with increasing population, and climaxed in or about the month of November with the onslaught of winter tidal and storm conditions. In periods of low winter tides and relative calm, the possibility of Peromyscus foraging from the forest edge to the beaches to supplement their diet with marine invertebrates is very real. That a population occupies the peripheral habitats regularly, however appears extremely unlikely.

Heavier winter populations of Peromyscus were also indicated in the muskeg habitat. An abundance of winter sign prevailed under the thick cover afforded by stands of Myrica

Ledum, dwarfed Thuja and plants of similar nature. Fresh sign was scarce and only 17.38 percent of the Peromyscus taken in the quadrats was caught in this habitat. The arguments presented in discussing the higher winter populations in mature coniferous forest apply to the muskeg as well. The degree of utilization however, may vary with the number of young produced annually. In years of low reproduction the coniferous forest may provide adequate winter range for the total population. In years of high productivity this habitat may prove inadequate to support all of the animals, thus forcing them to forage into the muskeg which must, in the winter season,present an extremely wet and inhospitable environment despite ample seed bearing plants. Regarded from another point of view, the populations may move in two stages, first, to the coniferous forest, and then, on depletion of the Picea seed supply, to the muskegs for food. This theory is strengthened by the fact that the evidence of winter populations using the muskeg is represented by droppings only, while in the coniferous forest cone cuttings were dominant. The inference here, of course, is that the presence of droppings indicates more recent utilization than do the cuttings in the forest.

The perpetual wetness of the muskegs, despite a superficial dryness in periods of drouth, appears to be the limiting factor to stable Peromyscus populations in this habitat. All of the animals taken were caught near intrusions of coniferous forest,indicating that the muskeg proper was

used primarily as a food foraging area by this species in the summer months. In the winter this utilization was probably intensified by increased populations inhabiting the forest which accounts for the general abundance of winter sign found. In light of these discussions it seems that the populations recorded as utilizing the muskegs were in actuality based in the coniferous forest edge.

Utilization of meadow by Peromyscus was small; only 10.29 percent of the quadrat catch was taken in this habitat. Sign in the form of cuttings or droppings was almost completely lacking, and winter sign was nil. All of the Peromyscus taken were caught in natural runways formed by rills that traversed the meadows from coniferous edge to sea shore. None was taken in the heavy grasslands proper, despite the prevalence of Microtus runways. Food and homesites appeared adequate to support much greater utilization than the take indicated. The meadows however, were basically wet and populations of large Microtus offering possible inter specific competition may in themselves account for the low populations observed. I have no specific data regarding tolerance between the two species. Many of the Peromyscus taken in all habitats bore tail scars, indicative of fighting. No intensity of scarring was apparent in meadow Peromyscus over those in other habitats where Microtus did not abound, indicating intraspecific intolerance rather than one of an interspecific nature.

Microtus were taken in some instances in rill sets that

also caught Peromyscus which leads to the assumption that a certain amount of intermingling of species takes place. No Peromyscus catch in the confined Microtus runways through heavy grass, however, seems to indicate that a considerable degree of avoidance might prevail and that Peromyscus confine themselves to routes in which wide berth can be given.

Any Peromyscus utilizing the meadow permanently are forced to the forest and muskegs during the winter months. The presence of large logs and other debris on the meadows and extending up to the forest edge indicates that the area must be flooded at some time to a depth of two or three feet at least. No such flooding occurred during the four months spent on the islands, although the higher summer tides came within a few inches of doing so.

The Peromyscus utilizing the meadow in summer probably had home sites in the coniferous forest edge as was the case in the muskegs. During the winter months these animals were forced to forage in the coniferous forest and muskegs as were those from the beach debris.

Microtus longicaudus

As in the case of Peromyscus a balanced sex ratio is indicated throughout the Microtus populations inhabiting Goose Island. While differential wandering between sexes is a possibility with this species also, the figures obtained are accepted on the same bases presented for the former.

The occurrence of Microtus is apparently correlated with that of suitable grasses. The low returns recorded from

beach debris, coniferous forest and muskeg habitat indicates a distinct lack of some ecological requirement or requirements in each. These are easily explained for beach and forest where the minimum amount of grasses occurring yielded the only Microtus taken. Where no grasses occurred no Microtus were taken and no indication of their presence was observed. Grasses in these two habitats were confined to sporadic stands and intrusions along the edges. In the muskegs however, grasses occurred regularly though not in the thick stands observed on the meadows. Ample cover was provided by sphagnum mosses and other muskeg inhabiting plants. The deciding factors appeared to be the availability of suitable nesting sites and the density of the grasses. Perhaps the firm soil base of the meadow habitat is preferred to the soggy mass of ancient sphagnum which forms the base of the muskeg. Fresh burrows were numerous on the meadows, but none was found on the muskeg. The preferred summer habitat then is obviously meadow, where fresh cuttings, droppings and burrows substantiate the trapping returns. This preferance may be attributed to an optimal ecological combination of heavy grass stands affording maximum food, cover, nesting materials plus suitable bases for burrowing and nesting sites.

In the winter months the Microtus populations must leave the meadows due to flooding conditions primarily, and possibly through lack of suitable foods when the grasses are dead. No evidence of winter utilization of coniferous forest was found, but old droppings and runways were prevalent upon the muskegs. That a reversal of optimal conditions concerning Microtus

occurs between the meadow and muskeg habitats in spring and fall is indicated. Though some Microtus may utilize the coniferous forest in winter leaving little or no sign; the apparent evidence points to muskeg as the preferred winter habitat. The arguments presented in discussing population movement in Peromyscus are applicable here in many respects and are not pursued further.

Microtus are well adapted to a wet habitat, they swim readily for short distances and dig shallow burrows in wet soil along the banks of rills and small streams. Long runways are constructed through the grass along which these animals travel with amazing rapidity despite their short legs. Side runways off the main thoroughfares lead to feeding stations where the cuttings are found; in other cases the grasses are cut and carried to burrows or other points of cover where they are eaten.

Several species of grasses and sedges were being utilized by Microtus upon the islands. As specimens collected were unfortunately destroyed I am unable to present the data here. The stomachs of all Microtus examined, however, contained a green finely masticated mass of vegetable food. I found no evidence of these animals eating insects, but some specimens of Microtus and Peromyscus were partially devoured in the traps. Sorex were responsible in part for this, but in many cases rodents had apparently been guilty; whether Microtus or Peromyscus was undetermined.

Conditions prevailing on the Goose Islands in respect to

Microtus, prevail as well in many areas visited on other coastal islands and on the mainland. That Microtus longicaudus is an animal of the meadows and muskegs generally holds true in coastal British Columbia

Sorex obscurus

A significant preponderance of adult male Sorex was observed in all habitats except the coniferous forest. Here the sex ratio of 2 males to 1 female is not statistically significant due to the small number of animals taken, and consequently warrants no further discussion. The highly significant preponderance of males in the total adult catch, (40 males: 14 females) however, requires explanation.

A review of field data collected on the Queen Charlotte Islands in British Columbia (Guiguet, 1946) and in Algonquin Park, Ontario (M. Jackson, Pers.Comm.) reveals that the observed adult sex ratio in two species of Sorex studied remained balanced until the first young were taken in the traps. After this time, (herein referred to as the datum point) a preponderance of males was observed in both cases, indicating a sex ratio of 2 to 1. When the Goose Island work was initiated young Sorex had already left the nest and while no data on the pre-datum point sex ratio were obtained it seems reasonable to assume that the phenomenon previously observed had been repeated and so accounted for the preponderance of males observed in Sorex on these islands.

The basic factors leading to the apparent unbalanced sex ratio after the young are observed, remain, as yet

obscure. Present studies being conducted at the University of British Columbia by Miss Mary Jackson may clarify the issue. From the evidence to date it appears that a lower viability in breeding adult females may be the answer in part.

Some species of shrews apparently die after one breeding season in which they breed twice (Asdell, 1946). A post partum heat occurs requiring extensive coitus to effect fertilization. It may be argued that at this time the females are sedentary and the males extremely active, resulting in a larger catch of the latter sex. In the populations studied on the Queen Charlotte Islands no pregnant females were caught after the datum point, which seemed to indicate that the populations there may have bred only once up to the end of August when trapping was discontinued. Only one pregnant female was taken on the Goose Islands and this animal was caught early in May indicating that the same conditions prevailed there in this respect. Since an equal number of males and females were taken prior to the datum point, and since the great majority of these females were lactating or carrying embyos, it seems illogical to attribute the observed preponderance of males to differential wandering -- otherwise this preponderance should have been apparent in the pre datum period of trapping as well. If the males in actuality wander farther throughout the year than do the females, it is obvious that trapping returns indicating a balanced sex ratio should be interpreted as reflecting a preponderance of females, other factors remaining constant. In this respect the post-datum sex ratio should probably be

interpreted as indicating a more evenly balaced sex ratio at that time. The situation in respect to the observed number of females before and after the datum point does not alter. The fact remains that significantly fewer females are observed after the young appear.

A change in susceptibility to trapping between sexes due to the effects of breeding, seasonal advance or both may be a factor influencing the observed sex ratios. It is entirely possible that females after breeding become more cautious, undergo changes in diet or suffer some similar reversal in habit which may result in a smaller catch.

Diurnal activity manifested by trapping returns revealed that for every 2 males taken only 1 female was caught. On the Goose Islands only 9 adult Sorex in the total catch of 54 were taken by day. On this basis greater diurnal activity in the male cannot be considered as a factor influencing the observed sex ratio.

If a complete annual turnover in population occurs on the death of the adults at some time between the end of the breeding period and the following spring, it is not unlikely that the female, due to the drain imposed by the bearing and nursing of young, would, in a species of such high metabolic rate, succumb earlier than does the male. It appears highly probable therefore, that the underlying cause or causes leading to an observed preponderance of males after the young begin to run is tied in closely with breeding activity. Just which aspects of breeding are involved remain unknown and require further investigation.

The observed distributions of Sorex populations upon the Goose Islands is difficult to explain satisfactorily. The factors contributing to the suitability of an environment for a given species depend largely upon available food, climate, humidity, cover and a variety of such conditions which man is often unable to measure accurately. In the case of Sorex practically nothing is known of these requirements.

In analyzing the distributional data gathered in respect to this species it appears obvious that the refinements of technique in the assessment of Sorex range were inadequate.

It has been postulated that a micro-environment of high humidity is probably an essential requirement for the survival of these animals. Based on observations of captive specimens, the only degree of success in maintaining individuals occurred when they were kept in terraria under humid conditions (Dr. I.McT.Cowan, Pers. Comm.). On the Goose Islands, from gross inspection, the meadow, muskeg and coniferous forest must all be classified as humid. The beach debris on this basis was comparatively dry. Yet the concentrations of Sorex occurred in meadow and in beach debris. From these observations it may be assumed that, first, humidity is of secondary importance in determining distribution, or second, that the apparent humidity of the four habitats observed by gross analysis was not reflected in the micro-habitats; this implies that the methods of appraisal were inadequate. I believe the latter to be the correct assumption.

In considering available food as a factor, the insecti-

vorous nature of Sorex must be kept in mind. I have no record of these animals utilizing vegetative materials as food. Certainly the morphological aspects are those of the insectivore. Through necessity, the appraisal of the relative abundance of insect life throught the habitats occupied by Sorex was also one of gross examination. A varied abundance was observed in the beach debris; forest and muskeg harbored noticeably fewer insects while the meadow habitat, though examined more minutely in the course of point sampling, appeared least productive of all. The highest concentration of shrews however, occurred in the meadows. It was assumed that despite an apparent lack of insects there must have been sufficient food to support the populations observed. Consequently the relative abundance of insects apparent in the different habitats cannot be used as a factor in explaining the observed distribution of Sorex.

Assuming that food supply and conditions of humidity were comparable and adequate in all habitats, exposure to sunlight may be considered. In this respect beach debris, muskeg and meadow appeared equal, yet the distribution of Sorex varied greatly in all three. In addition this factor may be of little direct consequence to such nocturnal species.

Interspecific intolerance is eliminated as an influencing factor on the basis that Sorex were constantly taken in the same traps which caught Peromyscus and Microtus. Apparently no competition existed for food while competition in other respects remains unknown.

On this basis of gross examination, the cover type of

the meadow represented by lush stands of grass was the only observed difference that could be considered as a contributing factor in the observed distribution of this species on the Goose Islands. In view of inadequate knowledge pertaining to the micro-ecological factors associated with gross observed differences in habitat however, no reasons for the observed distribution of Sorex can be postulated here with any degree of confidence. Further investigations into the life history and behavior patterns of these diminutive animals are indicated.

Sorex inhabiting the peripheral habitats must necessarily have left those areas in winter as did the rodent species. The evidence left by shrews is minute and subject to rapid disappearance, consequently traces of their occupation in the winter months were obliterated. The seasonal activity of annual young may be assumed to parallel that of the other two species, although the complete annual turnover in population may result in fundamental differences.

Theories on the Original Occurrence of Insular Mammals in British Columbia

Any investigator having travelled for hours over stretches of cold Pacific seas to reach a small islet, invariably, upon finding it occupied by small mammals, begins to speculate upon the manner in which those animals have negotiated the formidable expanses over which he has just travelled in a modern vessel.

From these speculations four main theories have developed. Two of these require substantiation by a more complete geolo-

gical picture of the coast as it was during, and at the close of the last glacial period, another requiring a more detailed knowledge of tidal currents, while the remaining may rest forever in the field of conjecture.

These four theories are, in the order presented:

1. That residual populations lived through the ice age in unglaciated insular areas and surived to repopulate the glaciated portions as the ice withdrew.

2. The concept that the retreat of the ice left temporary ice bridges that may have been vegetated, over which the ancestors of the present populations migrated.

3. The "slide" theory postulated by McCabe and Cowan (1945) in which evidence of ancient and recent land slides are pointed out. These slides bearing acres of vegetation were borne off on the tides carrying with them mammals and other forms of life, which ran ashore when the rafts eventually lodged -- possibly on distant islands.

4. The theory of human transportation. Large populations of Indians inhabiting the coast and moving seasonally to fish on insular groups, may well have transported certain species of mammals to those groups where they have subsequently become established.

The complexity and variation of the islands and channels along the British Columbia coast may be forcibly brought to the reader's attention by a glance at any map of the area. That any one or all of the postulated factors may have been instrumental in distributing the animals as they appear to-day

is highly probable. In cases where it is practically certain from geological evidence that an island was completely below the sea, arising only after the disappearance of the ice, the concepts of residual population and ice bridge are eliminated. In other cases however, this appears to be the only plausible theory. Recent investigations by the University of British Columbia on outer isolated islets of the Queen Charlotte group reveal small mammal distributions that can be logically explained only on this basis. The indigenous caribou of Graham Island is another case in point.

McCabe and Cowan (1945) point out the plausibility of the floating slide as an agent of distribution. On considering the geological history of the Goose Islands this appears to be the most logical explanation for the presence of small mammals there. The group has long been utilized by the Bella Bella Indians as a summer fishing grounds; that the animals present may have been transported in canoes loaded with household materials is a possibility, certainly a very real one in the case of the ubiquitous Peromyscus. In the case of Sorex and Microtus, however, the reality lessens. Where larger mammals are involved the plausibility of the aboriginal as an agent of dispersal decreases. Bears are alleged by many to have arrived upon the Queen Charlottes in this manner, transported as pets while young. The mountain goats inhabiting Pitt Island are said to have been taken there from the mainland in comparatively recent times by some Indian chieftain. These two allegations to-day are little

more than rumour, whether their status will ever assume a more definite rating is very doubtful.

As one views the range in degrees of speciation manifest by morphological characters throughout the insular races of a given species (Peromyscus maniculatus), the question of invasion is immediately presented. The possibility that such invasion or series of invasions could attain sufficient magnitude to effect phenotypical expression seems remote in such well isolated groups as the Goose Islands. In the closer network of the inside islands as well, the nature of the separating channels discourages such a concept.

It will ultimately be shown, as our knowledge accumulates, that some of the factors postulated above are more logically applicable to one island, or group of islands than they are to another. For the main part however, the insular complex lying along these shores is made up of well isolated units presenting unsurpassed opportunities of study in the field of isolation and speciation.

Summary and Conclusions

1. The Goose Island group represents a well isolated ecological unit typical of many outer fringe islands along the British Columbia coast.

2. Eleven major vertebrate habitats occur upon the islands -- Beach debris, coniferous forest, muskeg, meadow, rocky sea shore, boulder beach, tidal mud flat, sandy sea beach, coast littoral, pelagic and fresh water habitat. The latter is not discussed in the foregoing paper.

3. The terrestrial mammalian fauna is represented by three species of small mammals -- *Peromyscus maniculatus*, *Microtus longicaudus* and *Sorex obscurus*. Two species of bats also occur -- *Lasionycteris noctivagans* and *Myotis yumanensis*. A species of *Castor* once inhabited the islands.

4. The small populations of bats occurring were confined chiefly to the environs of the coniferous forest. The small numbers representing both species are attributed to the effect of wind.

5. *Peromyscus maniculatus* was the most evenly distributed and most abundant species of terrestrial mammal present. Sixty-three percent of the total catch was comprised of this species. Distribution by habitat appeared as follows: Beach debris, 46.79 percent; coniferous forest, 25.54 percent; muskeg, 17.38 percent; and meadow, 10.29 percent. The availability and variety of food, nesting sites, and the relative dryness of the habitats appeared to be the major factors accounting for this distribution.

6. *Microtus longicaudus* was restricted to areas in which

grasses occurred. This species was the least abundant of the three terrestrial forms present, representing approximately 14 percent of the total catch. The catch was distributed as follows:- Beach debris, 13.33 percent; coniferous forest, 06.67 percent; muskeg, 10 percent; and meadow, 70 percent. Density of grass cover and the nature of ground bases in the habitat types are considered as major factors contributing to this distribution.

7. Sorex obscurus represented 23 percent of the total take of terrestrial forms. Of this species 27.78 percent were taken in beach debris, 11.11 percent in coniferous forest, 11.11 percent in muskeg and 50 percent in the meadow. The factors leading to this distribution are obscure. In gross analyses the only apparent factor is density of the grass cover.

8. Sex ratios based on snap trapping were indicated as 1:1 in Peromyscus maniculatus and Microtus longicaudus. A 3:1 ratio, males predominant, was observed in Sorex obscurus. This ratio seems to be correlated with the appearance of running young and is considered due to mortality in females and, or other undetermined changes associated with breeding.

9. Peripheral habitats bordering the sea, represented by beach debris and meadow, are preferred summer range for the terrestrial forms. Winter sign correlated with trapping data indicates that a reversal of optimal conditions with change of season results in population movements from peripheral to interior habitats, the latter represented by coniferous forest and muskeg. This seasonal movement is preceded by the annual

increment of young from peripheral habitats due to population pressure. In the latter case, due to lack of durable sign, the activities of Sorex obscurus are assumed.

10. Limpets and small crabs form regular items in the summer diet of coastal Peromyscus.

11. Predation as a factor influencing small mammals was non existant in the summer months of 1948 on Goose Island.

LITERATURE CITED

Aldous, S. E. 1944. A deer brouse survey method. Journ. Mammalogy 25 (2): 130-136.

Asdell, S. A. 1946. Patterns of mammalian reproduction. Comstock Publ. Co., Ithaca, New York.

Clarke, S. E., Campbell, J. A. and Campbell, J. B. 1942. An ecological and grazing capacity study in southern Alberta. Dom. Can. Tech. Bull. 44.

Dice, L. R. 1938. Some census methods for mammals. Journ. Wldlf. Mgmt. 2 (4): 119-130.

Guiguet, C. J. 1946. Unpublished field records.

Howard, W. E. 1949. Dispersal, amount of inbreeding, and longevity in a local population of prairie deermice on the George Reserve, southern Michigan. Misc. Publ. Mus. Zool. Univ. Mich. 43.

McCabe, T. T. and Cowan, I. McT. 1945. Peromyscus maniculatus macrorhinus and the problem of insularity. Trans. Roy. Can. Inst.

McCabe, T. T. 1948. Beaver on the northern British Columbia islands. Can.Field-Nat. 62 (2): 72-74.

Snedecor, G. W. 1938. Statistical methods. Collegiate Press Inc., Ames, Iowa.

Stickle, L. F. 1946. Experimental analysis of methods for measuring small mammal populations. Journ. Wldlf.Mgmt. 10 (2): 150-159.

Townsend, M.T. 1935. Studies on some of the small mammals of central New York. Roosevelt Wildlife Annals. 4 (1).