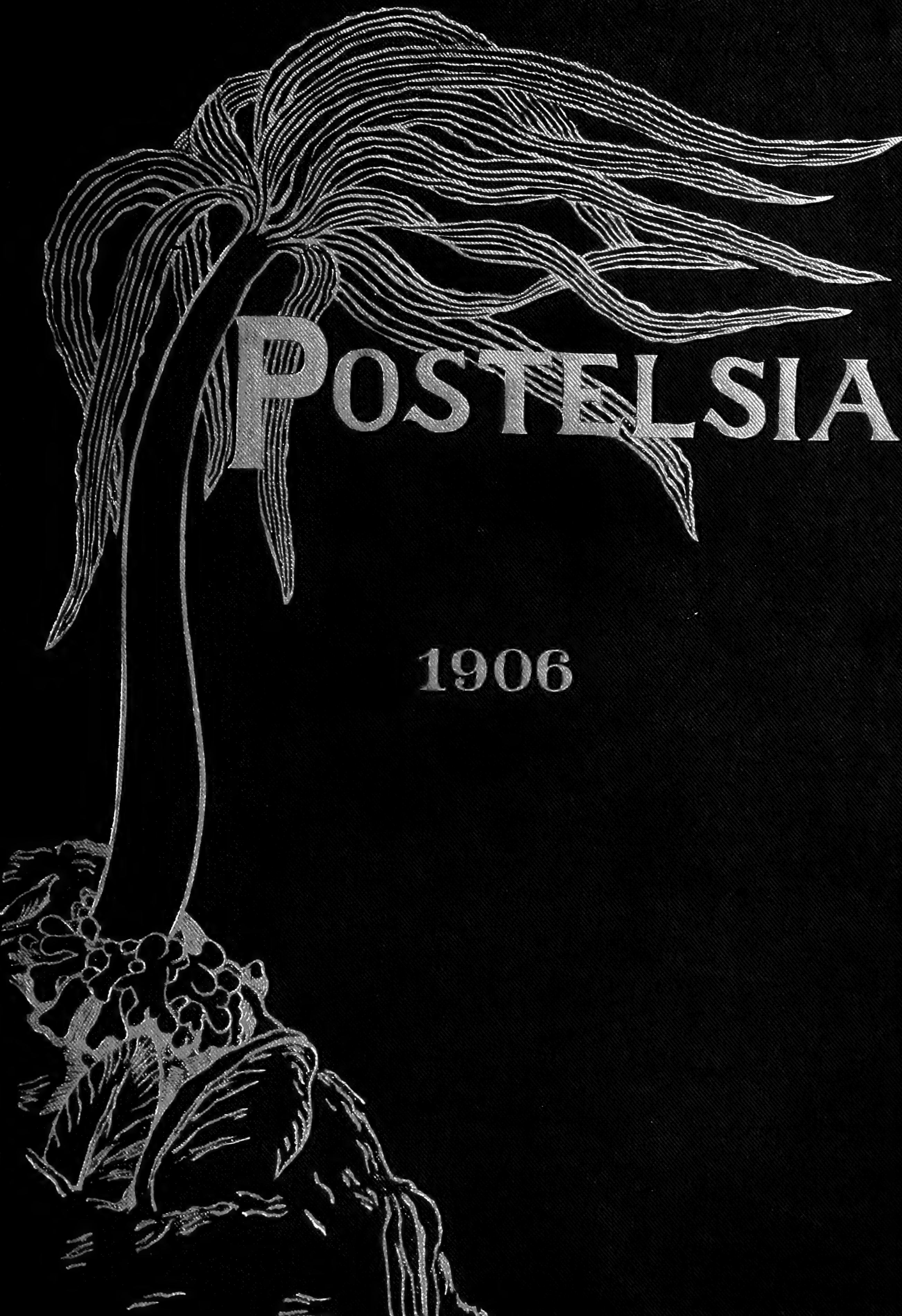
POSTELSIA



1906

Postelsia
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Postelsia
The Year Book of the Minnesota Seaside Station

1906

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The Contents

Word of Introduction

Conway MacMillan

Four years ago the first volume of *Postelsia* was published, with seven papers by members of the Minnesota Seaside Station. Now, seven other papers have been brought together in the hope that they will be of interest to those who have made the pilgrimage and sat in the Hall of the Energids. This little book will at least be a souvenir to those who know the Vancouver coast and love the memories of happy days and nights under the sheltering roof of the "Sea Palms" or beside the white water. To others, too, it is hoped that these papers will have some scientific and permanent value.

Observations upon Plant Distribution

Observations on Plant Distribution

In Renfrew District of Vancouver Island

C. O. Rosendahl

A. Introductory.

During the summer of 1901 the writer, in company with Mr. C. J. Brand of the Field Columbian Museum, began a collection of flowering plants and ferns of the west coast of Vancouver Island in the region surrounding the then newly established Minnesota Seaside Station.

The work, which was carried on from the 18th of June to the 15th of July, was largely floristic in character, the object being in the main to secure for general distribution sets of each species growing in the region. Owing partly to the labor thus entailed and partly to the great difficulty of penetrating the dense forests, the area covered in the few weeks was necessarily limited.

During the following summer, 1902, the writer again visited the region spending most of the time between July 18 and Aug. 15 in field work.

The region gone over in these two seasons' work is largely coastal, being mostly confined to the open rocky beaches in the vicinity of the above named seaside station, and the territory surrounding San Juan Harbor. Excursions were made inland for several miles in the San Juan and Gordon river valleys.

From this it may be seen that no extensive generalizations on plant distribution along the west coast of Vancouver Island will here be attempted, but that rather it will be the object in these pages to set forth a few main facts bearing upon plant ecology and plant floristics as revealed in the particular limited area defined above, not striving to enter into too detailed analyses and elucidations which can be undertaken only with the aid of fuller observations and extensive statistics relating to temperature, precipitation soil composition and the like.

Since the vegetation of a given region is the product of both past and present conditions, it follows that a survey of these in so far as it can be brought out through a brief account of position, geological formation, topography, rainfall and climate, will add materially towards facilitating the interpretation and explanation of its present plant associations and formations.

Position and extent. Vancouver Island is situated between latitudes 48° 15′ and 50° 45′ N. and longitudes 123° and 128° 30′ W. It is the southernmost and the largest of a long chain of islands strung out along the west coast of North America from Washington to farthest Alaska. It is separated from the main land on the southwest by the Straits of San Juan de Fuca, and on the east and northeast by Johnsons' Straits and the Straits of Georgia. The island is in round figures 450 kilometers long by 130 kilometers wide. The part of Renfrew district under consideration lies on the west coast opposite Cape Flattery and comprises the region of San Juan Harbor.

Geological formation. Geologically this chain of islands is a partially submerged extension of the coast range of the Pacific States. Vancouver, and this applies in main part for the other islands also, is essentially a mass of tilted gneissic rocks with here and there certain tertiary areas. It was subjected to heavy glaciations. The main course of the glaciers seems to have been northward through the Straits of Georgia, and westward, as shown by scourings on the rocks around Victoria, through the Straits of Fuca. The effect has been to leave in many places extensive gravel moraines and in others beds of boulder clay. On top of the sharply tilted slate rocks of the region of the Minnesota Seaside Station in certain places are such morainic remains, while in others again the rocks jut out bare, or have only such covering as countless generations of decaying trees and other vegetation have left behind. Along the shore, on the projecting points mostly, there is superimposed upon the slate rocks a late sandstone formation, while in the inlets there is usually a coarse grained beach deposit, formed from coarse sands and particles of the disintegrating slate. The west coast, being subjected in many places to unusually heavy wave action, is undergoing comparatively rapid changes. The geological formation of the valleys of the Gordon and San Juan rivers is not essentially different from that observed along the coast. The two streams have a somewhat rapid descent to the sea and some distance inland have cut deep yet narrow gorges in the solid volcanic rocks. In the lower portions of the San Juan Valley are evidences of extensive moraines.

Topography. Generally speaking the whole island can be said to be mountainous. From both ends there is a rapid rise towards the middle interior, culminating in Alberni district in snow capped peaks of over 1800 meters altitude, and near Comax, in Victoria Peak, 2280 meters high. Only in the northern portions are there found meadow lands and fairly level country. The rest is uneven and rough. The west coast has been referred to in writings as "stern and rockbound," and the application is wholly appropriate. Jagged shores and high and rocky promontories leave few places of approach. The east coast is more protected and also less rough.

Rainfall and Climate. No extensive data are at hand concerning the rainfall, hence it can be referred to only in general terms. This however can be said, that the precipitation on the west coast, from the northern extremity of the island to within 40-50 kilometers of the southern end, is unusually heavy. The region around Victoria and the extent of the coast referred to above, lie behind the Olympic Mountains of Washington and the moisture of the southwest winds has been largely condensed before these reach the island. According to observations made by Mr. Newton at Port Renfrew in San Juan Harbor, the rainfall for the year 1902 was 300 cm. This can hardly be considered as the average annual precipitation since the year, according to statements made by the natives, was more than ordinarily wet. Yet an average of 275 cm. may not be far from correct. This indicates that the place is one of the rainiest in temperate North America, being approached at Neah Bay across the straits in Washington, and perhaps equalled only at certain places in Alaska. By far the greatest amount of rain falls during the winter months, during which time there are few rainless days. Even during the summer it is unusual for a week to pass by without some precipitation. The rain falls usually in the form of steady continuous drizzle, which at times may develop into heavy downpours. Such a great amount of rainfall cannot but have far-reaching effects upon the floral population of the place, and this together with the equable climate brings about conditions favorable for the development and maintenance of dense and heavy vegetation. Snow is of rare occurrence in this part of the island, and if it falls it quickly disappears, because the temperature very seldom is known to reach the freezing point. The Japan current, with its warm waters sweeping along the west coast of North America, exerts a great equalizing influence upon the climate of the islands whose shores it washes, and is an important factor in the present floral development. Moisture and heat are thus seen to be present in quantities to give seasons with long periods of growth. These combined causes are responsible for the dense and stately forests that characterize the region.

This short survey of these fundamental factors and conditions which have to do with plant distribution in general, will perhaps suffice to give an idea of how they obtain in the region under consideration. It is then in line to consider their bearing upon the floral development in this limited designated area, with reference to the organization and division of the plant community into its most likely natural groupings and formations, and then further to enter into an analysis of the various associations with respect to their present interdependence and floristic composition rather than their historic origin and development.

B. Plant Distribution and Adaptation.

A territorial rather than a biologic basis is adopted for primary divisions and upon this is built the classification of groupings and formations which is thought best suited for the manner of treatment pursued in this work. The following synopsis will serve to give an idea of the entire scheme.

I. Marine formations.

a. Vegetation of the tidal area.

1. Algal formation.
2. Eel grass formation.

II. Formations of the beach.

a. Vegetation of sandy beaches.

1. Sand beach formation

a Large open beach.

b Small inlet beach.

b. Vegetation of rocky beaches.

1. Rock beach formation.

a Exposed rocky beach.

b Protected rocky beach.

III. Formations of the forest country.

a. Vegetation of the transition zone.

1. Salal formation.

b. Vegetation of the forest proper.

1. Coniferous forest formation.

a Forest of low altitudes fronting the sea (up to 100m.

b Forest of higher altitudes (100m. to 300m.).

c Forest of the river valleys.

2. River bed formation.
   a Banks and channel.
   b Rivers and streamlets.
3. Lake beach formation.
   a Front beach.
   b Mid beach.
   c Back beach.
4. Lake formation

I. Marine formations.

Vegetation of the tidal area.

1. Algal formation.

Marine vegetation, as built up along the shores of Vancouver Island, falls into two general categories as indicated in the above synopsis. Since it is not the province of this essay to deal with the former of these two, it will merely be alluded to in passing.

It is well known that this part of the west coast of North America shows an unusual development of forms belonging to the *Rhodophyceae* and especially the *Phaeophyceae*. Some of the larger kelps like *Nereocystis*, *Laminaria*, *Alaria*, *Egregia*, *Lessonia*, *Pterygophora*, etc., not only attain here great proportions but also occur in wonderful profusion. No attempt short of an exhaustive treatise can give an adequate idea of the multiplicity of types and the richness of the algal flora of the west coast of Vancouver Island.

2. Eel grass formation.

This formation as known along the shores of Vancouver Island is built up to a large extent of so-called eel grass or *Phyllospadix scouleri.* It occurs in great abundance over the jagged sandstone rocks exposed only at low tide, and in most of the numerous tide pools along the shore. Mixed with various species of algae it forms in some places a distinct zone covering the rocks (Plate I.). The zone varies in width with the slant of the shore, for in no case is the plant found in very deep water. Where it occurs in tide pools, it is found mostly in a fringe along the edge and the long blades float upon the water in such manner and quantities as to completely obscure the surface. The wanderer upon the beach at low tide must pick his way with care, for it is extremely difficult to tell whether the eel grass lies upon a flat rock surface or is spread out over some deep tide pool. In such pools which empty either only partly or else almost entirely with the outgoing tide, the grass is found attached both on the sides and at the bottom.

The manner of seed distribution of a plant which has adopted this habitat is one of considerable interest. Growing as the plant does in places subjected to heavy wave action and surf, it has become necessary to devise a scheme for holding the seed in place until the young plant has anchored itself by its roots. It is affected in the following manner. At the time of maturity the uni-carpellate fruits are oblong bodies with two emergences or projections towards the base. As they are washed about on the rocks, the softer outer tissue of these projections wears away so as to expose the harder, inner portions in the form of two fish-hook-like prongs. By means of these it is finally able to grapple on to some algal holdfast or other likely object, thus bringing the body to rest and permitting the germinating seed to attach its rootlets to the substratum.

Another representative of the eel grasses, but

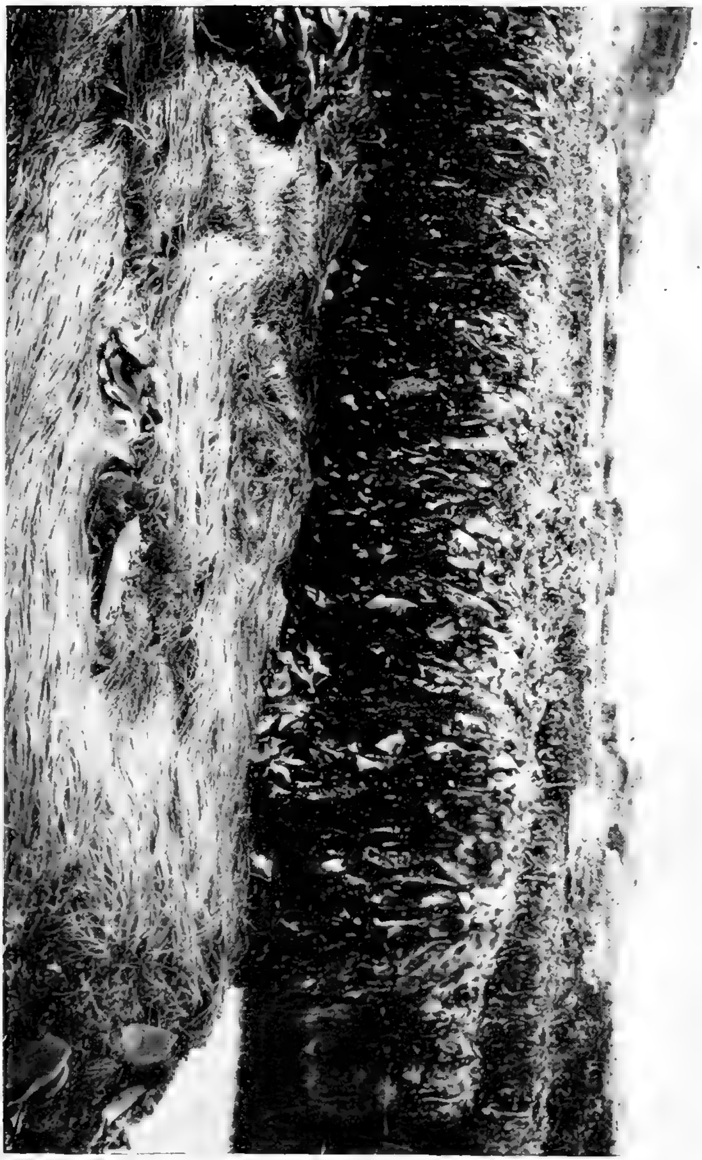

PLATE I.—Field of Phyllospadix scouleri.

not growing in the *Phyllospadix* association, is *Zostera marina*. It is found only in the sheltered coves of the inner San Juan Harbor and in these places it grows from a muddy or sandy bottom, where its blades at high tide reach up through the water somewhat after the fashion of *Vallisneria spiralis*. That it occurs to some extent on the Washington side of the straits is shown by the fact that not infrequently it is washed in after heavy winds from that direction. It does not grow in such great masses as *Phyllospadix scouleri*.

II. Formations of the beach.

The area occupied by the beach formations varies with the varying contour of the shore. In some places the distance between wave-washed rock and forest edge may be only a few meters, with scattered crevice plants established upon the narrow ground. In other places the intervening space may be a hundred meters or more wide, made up either of a sloping sand beach, smooth in front but riddled with drift wood towards the back, or formed of tilted strata supporting a crevice flora of varying aspect, which is succeeded as the forest is approached by a well established turf built up by a complex society of plants. Within this area the greatest variety of plant life of the region is to be met with, and it is here that the sharpest struggle is carried on. The two great factors, the forest and the sea, maintain by common consent as it were, this intervening skirmish place, each continually exerting powerful influences towards the other, which, as they commingle and permeate, give rise to a complexity of conditions made manifest in a highly complex plant population. Of conditions arising seaward and having a most direct bearing upon plant distribution over this area, are among others, ocean spray, wind currents, moisture, fogs and an equalizing influence of temperature. In like manner conditions arising landward, such as drainage, slope, texture and nature of the soil or rock, and the almost endless complexity of conditions physical, chemical and biological which the proximity of the forest gives rise to, all aid in giving color to this ground. The conditions here experienced although somewhat complex and many, still are uniform and constant. The forest, in a region where precipitation is uniform and large, is a stable organization. The sea with its tides, its currents, and its winds in its great entirety is unchangeable. Now and then some heavy storm may pile the driftwood farther into some cove, or sweep bare a projecting point, yet the main tension line between the two is of comparatively great stability.

As shown in the preceding synopsis, the vegetation of the sea strand is divided with reference to the substratum, into two general divisions of; a. vegetation of sandy beaches, and b. vegetation of rocky beaches.

a. Vegetation of sandy beaches.

1. Sand beach formation.

a Large open beach.

b Small inlet beach.

Since the sand beaches vary considerably with respect to size, slope and direction, it is natural to expect that the plant formation upon them will likewise vary. In some places the coves or inlets may be wide and open towards the direction from which prevailing winds blow. In such cases the distance from the waters edge to the forest is generally considerable and the gently sloping beaches are mostly bare in front but loaded with driftwood towards the back. If the inlet is sheltered from the wind, the sand beach is of less width, and driftwood is either absent or found only in small quantities. Other inlets are narrow and are simply openings of small ravines or gullies. These are drainage courses and frequently small streams find their way through them to the sea. From the fact that these streams drain from the humus-laden forest soil, a greater complexity of plant life is met with upon the sand beaches at the mouth of these ravines than upon other kinds referred to above. The humus contents of the soil is much greater than that of the larger, more open beaches, backed by no extensive natural drainage course. It is quite evident that conditions arising landward exert themselves more strongly here because they are concentrated as it were, into a smaller space. The result is the establishment of a group of plants numerous both as to individuals and species and among which the competition is sharp.

a. Large open beach.

Along the front border of the large open beaches, the association of plants almost universally met with is composed of the following species:-

Juncus lescurii	*Argentina anserina grandis*
Ammodenia major	*Trifolium heterodon*

This region of the beach is subjected to occasional flooding by high waves even in summer, and during the frequent winter storms bears repeated inundation.

Farther back upon what might well be termed the driftwood area of the beach, the vegetation consists of a mixed society of so-called weeds. The seeds of these hardy plants at first carried in by various agencies, have found lodgment in the tangle of logs and debris and it is largely through the aid of this barrier that a vigorous association has been built up and flourishes. The species most commonly established over such an area are:-

Elymus mollis	*Chamaenerion angustifolium*
Festuca jonesii	*Conioselinum gmelini*
Bromus secalinus	*Galium aparine*

Bromus pacificus	*Tanacetum huronense*
Ammodenia major	*Aster foliaceus*
Nabalus alatus	*Anaphalis subalpina*
	Sonchus asper

In very severe storms it may happen that there is great addition to, or a considerable shifting of the driftwood deposit and when this occurs, a readjustment of the society naturally ensues. New conditions arise and a response to these will show itself in new arrangements. The beach at the head of San Juan Harbor is a comparatively wide sandy waste. Its slope is very gradual and during high seas the waves wash nearly up to the forest edge. Vegetation is therefore extremely scanty and is confined to a narrow strip of the back beach where the most typical plants are the following xerophytes:-

Aira caryophylla	*Carex macrocephala*
Deschampsia caespitosa	*Artemisia suksdorfii*

b. Small inlet beach.

Upon the small sand beaches at the mouths of ravines it is perhaps more difficult to differentiate between the front and back regions of the beach than is the case with those already discussed although even there it must not be understood that any sharp demarcation line can be drawn. What mainly characterizes this type of beach is not alone the profusion of vegetation which they sustain but also the comparatively large number of species associated, for in no other habitat of the territory explored are so many species found to a given area as here.

This mixed herbaceous society, as the association may appropriately be called, for the reason that no one particular species seems to preponderate appreciably, contains a few vigorous annuals, yet the majority of the plants are strong biennials or perennials. The most common species of the society are:-

Elymus glaucus	*Lathyrus maritimus*
Elymus borealis	*Vicia gigantea*
Bromus pacificus	*Oenanthe sarmentosa*
Bromus sitchensis	*Heracleum lanatum*
Carex cryptocarpa	*Stachys ciliatus*
Scirpus microcarpus	*Scrophularia californica*
Alsine brachypetala	*Galium vaillantii*

This does not exhaust the list of plants which could be enumerated for this type of beach. It is however representative and will serve to give an idea of the composition of the society.

The interdependence and adjustments of individuals to each other in an association is shown by such plants as *Alsine brachypetala* and *Galium vaillantii* which, though largely shaded by the taller weeds and grasses, grow profusely, their weak stems finding ready support upon the rank growth about them.

b. Vegetation of rocky beaches.

1. Rock beach formation.

a. Exposed rocky beach.

By exposed rocky beaches are meant those that by their proximity to the water are sometimes subjected to the dashing ocean spray and occasionally to intermittent inundation by high waves. They lie exposed to the light and receive the full force of the wind currents.

Upon this unpromising rock substratum where hardly any soil finds lodgement are established a group of hardy xerophytes. Plants of this character are not of general distribution in the region because conditions for xerophytism are offered only by the more or less perpendicular rocky ledges and by the sharply tilted strata, between the crevices of which the water passes quickly downwards and out of reach. Among these chasmophytes, more or less well differentiated associations are to be made out.

Plantago society. This is made up principally of *Plantago maritima* (Pl. II.) although *Plantago major asiatica* is occasionally met with in this location. The thick narrow leaves of *Plantago maritima* show the adaptation of the plant to withstand dryness as well as the impact of spray and strong winds. On slightly less exposed places one meets with a *gramineus society.* The few hardy species which figure most prominently here are *Hordeum boreale*, growing in considerable tufts in the crevices, *Festuca rubra baikalensis* and *Agrostis exarata.* Closely associated with these plants, and growing under very similar conditions are *Potentilla villosa* and *Armeria vulgaris.* All these forms are able to maintain themselves in small dry crevices of the slate rock, and in spite of the precarious foothold flourish better than farther back where competition with other forms is more sharp.

b. Protected rocky beaches.

These are of two principal kinds. First, those protected by elevation and distance from the sea and second, those protected by projecting points or shelves of rocks. The former is characterized by a more or less scanty deposition of soil towards the front and by well established turf towards the back. On the patches of soil and in the crevices where soil has accumulated is found a group of plants which may well be designated as a society of rock perennials. The species abounding here are:-

Panicum unciphyllum	*Fragaria chiloensis*
Deschampsia caespitosa	*Trifolium heterodon*
Allium cernuum	*Prunella vulgaris*
Rumex salicifolius	*Castilleja acuminata*
Sagina occidentalis	*Achillea lanulosa*

Aster foliaceus

This association is succeeded in passing to-

PLATE II.—Field of Plantago maritima.

wards the forest by a turf building group of plants constituting a *gramineous-cyperaceous* society. It is composed chiefly of the typical turf builders, grasses, sedges and rushes, which by their rhizomes and roots bind and mat together the upper layers of the soil very firmly. The soil even down to the underlying rocks seems to be of purely organic origin as evinced by its color and consistency. It holds a great amount of moisture and in many places boggy spots and even small pools occur. In such the water is generally of a brownish color, due no doubt to the presence of a great amount of organic matter which is drained directly in from the heavy mould of the adjoining forest. The following species are generally found in this grass-sedge society:—

Calamagrostis aleutica	*Juncus effusus*
Calamagrostis hyperborea	*Juncus balticus*
Deschampsia caespitosa	*Juncus ensifolius*
Trisetum nutkaensis	*Juncus falcatus alaskensis*
Carex cryptocarpa	*Luzula comosa*
Carex flava rectirostrata	*Tofieldia intermedia*
Carex sitchensis	*Glaux maritima*

In the swampy places of the turf and along the edges of the pools the following species are frequently met with:-

Triglochin maritima *Hydastylus brachypus*
Eleocharis palustris *Veronica anagallis-aquatica*
Sisyrinchium idahoense *Mimulus langsdorfii*

Under the second division of protected rocky beaches, different conditions are met with. These beaches are generally shaded either by the projecting branches of adjoining trees or by the tilting of the strata in such a way as to exclude the direct rays of the sun. In a few places there is a considerable layer of soil upon the rocks, while in others there is hardly any; frequently they are covered with a layer of moss. (Pl. III.). Here are found often in great profusion most of the following species:-

Adiantum pedatum	*Sagina occidentalis*
Polypodium scouleri	*Ranunculus bongardii*
Polypodium falcatum	*Aquilegia formosa*
Montia siberica	*Tellima grandiflora*
Montia parvifolia	*Heuchera micrantha*

Veronica serpyllifolia

Polypodium falcatum and *Polypodium scou-*

PLATE III.--Field of Adiantum pedatum.

PLATE IV.—Field of Polypodium scouleri growing upon trunk of spruce.

leri are sometimes met with in this habitat yet they are more frequently found growing epiphytically on trees. (Pl. IV.)

III. Formations of the forest country.

a. Vegetation of the transition zone.

1. Salal formation.

Between the formations of the beach already considered and those of the forest proper, lies a well differentiated zone of vegetation which derives its distinctive marks from the strong development in it of the *salal* or *Gaultheria shallon*. Other shrubs and herbs go to make up its composition, yet the salal is the dominant species and attains here in this transition area between forest and beach its characteristic development. The zone exhibits such uniformity and continuity throughout that it is best considered as a distinct formation.

Along the outer edge of the salal, generally in under the overhanging branches, are found a few shade-loving plants which occur more typically, it seems, in the forest. Most frequent of these are:-

Carex deweyana Unifolium bifolium dilatatum

Boykinia elata *Trientalis europaea arctica*
Linnaea borealis

These are most abundant where considerable moisture is present in the soil. The salal bushes along the edge are not as large and vigorous as those farther back since along the border of a formation or society are always to be found the less typically developed plants. In the middle region the salal assumes its charactercteristic growth and size (Pl. V.) and the inextricable tangle is here shown at its best. The stems which do not grow upright, branch freely in all directions and these intertwine in every conceivable way making passage through practically impossible. The matted manner of growth which the plant assumes along the forest edge is partly due to the fact that in this position it is exposed to the full impact of the winds and subjected to sea influences. Where it is not so exposed it has a much more open growth as is characteristically shown in well protected places and where, as it enters the forest proper, it thins out gradually. In this dense growth a few plants which evidently are willing to accept the

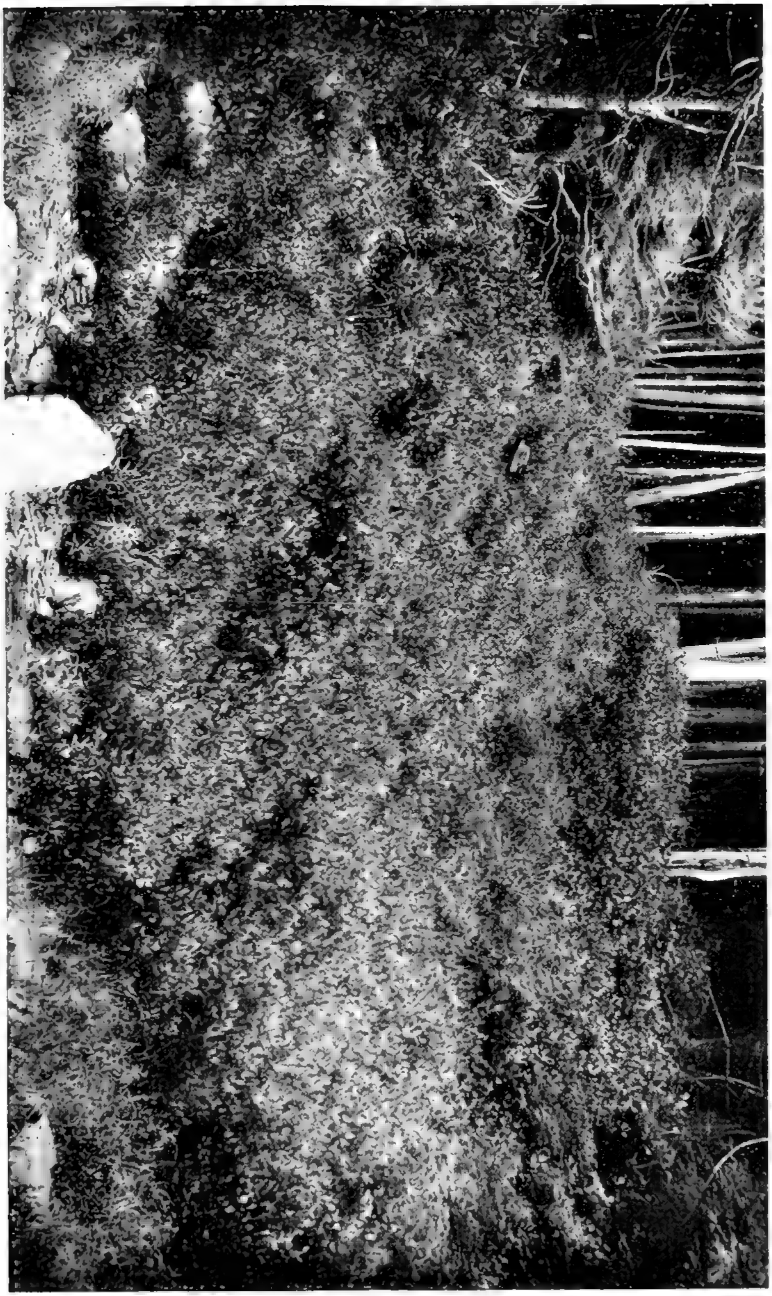

PLATE V.—Salal formation along the forest edge.

sharpest kind of competition have forced themselves in; only a few herbaceous forms appear:-

Epilobium glandulosum	*Vicia gigantea*
Elymus glaucus	*Boschniakia strobilacea*
Sanicula menziesii	

Boschniakia is a peculiar plant growing as a parasite upon the roots of *Gaultheria shallon*; it will be referred to again under another heading. The characteristic shrubby forms are:-

Rosa nutkana	*Rubus parviflorus*
Rubus spectabilis	*Aruncus aruncus*
Rubus ursinus	*Lonicera involucrata*

Well towards the back part of the formation larger shrubs frequently occur such as *Malus rivularis* and *Amelanchier alnifolia*: here too one meets with stunted forms of *Pinus contorta*.

b. Vegetation of the forest proper.

1. Coniferous forest formation.

This great formation of the region bears the stamp of ages and through the signs of antiquity which it presents are seen the promise of future endurance, except in so far as the advent of white man upon the island may have far reaching effects. The two great factors for the formation and perpetuation of forests, copious rainfall and sufficiently high temperature, both obtain on the west coast. The greatest density is attained in the lower reaches of the river valleys and along the lower slopes fronting the sea. Towards the higher interior, the density decreases. The same is also true of the low hills around Victoria and from thence up the west coast some 40-60 kilometers. In most places of Renfrew district the forest stands yet in its primeval grandeur, only here and there has the woodsman's ax made imprints. The possibilities of ravages by fire are well nigh precluded, and the evidences of undisturbed growth through long periods of time are everywhere apparent. It is not an uncommon sight to find trees three to five feet in diameter growing upon some fallen giant cedar of even greater dimensions, the combined ages of the two undoubtedly encompassing many hundred years. A large number of phenomena of this character observable in these forests is to be ascribed to the great and ever present amount of moisture and to the uniformity of temperature. Considering the formation according to its composition and after the manner of its subdivisions we have first to deal with

a Forest of low altitude fronting the sea (sea level to 100m)

The width of this zone varies with the degree of slope. In those places where the slope is abrupt, conditions that characterize the higher levels are sooner met with than where the rise is gradual. Elevation is apparently of more importance than distance from the sea. In sheltered places like within San Juan Harbor where wave action is not greatly felt, the forest approaches much nearer to the high tide mark than along the exposed shores. For this reason a great deal of the vegetation characteristic of the rocky beaches is eliminated and one sees frequently the branches of large trees reaching out over the water. No one particular species of tree seems to form the forest vanguard. *Picea sitchensis*, *Thuja plicata* and *Tsuga heterophylla* occur with about equal frequency, although in some places the hemlock and cedar yield to the spruce. When *Alnus oregana* occurs it is found almost invariably along the edge. It is seldom met with in this region except as a border tree. The fir, *Abies amabilis*, occurs frequently in the lower forest belt, and then stands in more or less exclusive groups or patches separated from each other by stretches of the more general forest. *Taxus brevifolia* is occasionally found as a small sized tree in the lower forest zone. *Picea sitchensis* is the most abundant tree of the lower elevations and seems to attain its typical development in the immediate vicinity of the sea. Trees with a diameter of 1-2.5 meters and 40-55 meters in height are not uncommon. *Thuja plicata* also reaches large proportion but is more typical of the higher places where it occurs in greater numbers and larger size.

Shrubby undergrowth.—Where the forest is very dense as for example along the river valleys, there is not very much underbrush. On the other hand where there is more space, typical shrubs and underbrush occur abundantly (Pl. VI.). This underbrush is made up chiefly of the following:-

Malus rivularis	*Vaccinium ovalifolium*

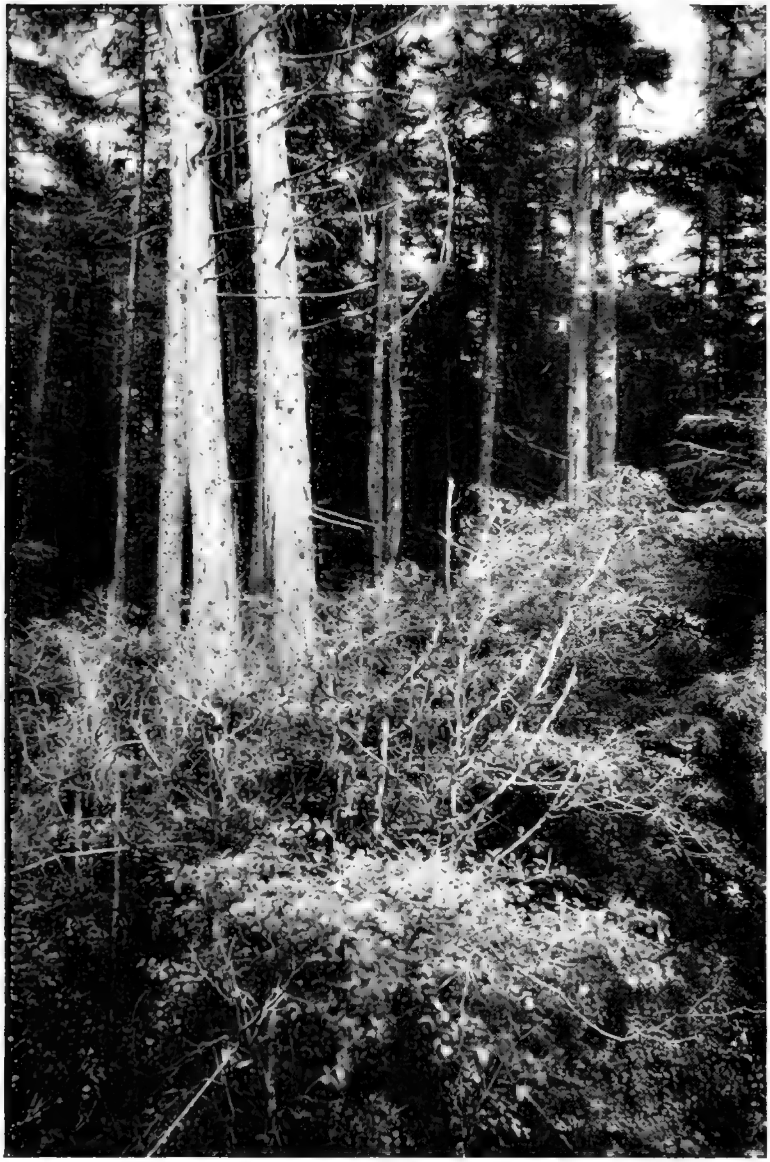

PLATE VI.—Underbrush in the forest of lower altitudes.

Menziesia urceolaria *Rubus spectabilis*
Vaccinium parvifolium *Gaultheria shallon*

Malus rivularis occurs generally in the form of a low shrub, 2-4 meters high, and in this form is found mostly towards the edge of the forest or in the salal zone. When, however, it appears in the denser parts of the forest it frequently assumes a liane like character of growth, its long slender stems, often 10-15 meters, finding support on the branches of adjoining trees and reaching upwards where they can obtain sufficient light. When so growing the stems often attain a greater diameter above than at the base.

Herbaceous undergrowth.—The rich humus-laden soil of the forest supports a shade-loving herbaceous vegetation which is quite characteristic. Mosses and liverworts occur in great profusion, covering logs and stumps and the lower portions of the growing trees. Several species of ferns are found in great abundance, of which *Lomaria spicant* and *Polystichum munitum* (Pl. VII.) are the most common. The latter attains great size and beauty in the damp deeply shaded places. *Dryopteris spinulosa* and

Asplenium filix-foemina are generally found along streams. *Equisetum telmateia* is of infrequent occurrence but attains large size, sterile plants being observed measuring from 1-1.5 meters in height. *Lysichiton camtschatcense*, (Pl. VII.) the only representative of the Araceæ in this region with its enormously long and broad leaves offers a marked contrast to the other types of vegetation and seems much out of place in a northern, coniferous forest. It grows typically in cool, moist, deeply shaded ravines. *Luzula campestris* occurs occasionally along streams. *Streptopus amplexicaulis* is common throughout the belt but is most frequent at the lower levels. *Listera cordata*, though somewhat rare, is found generally where the forest is very dense and where there is less of underbrush. *Razoumofskya tsugensis*, growing as a parasite on the branches and stems of the hemlock is most abundant in the low forest. *Ranunculus bongardii*, *Tiarella trifoliata* and *Boykinia elata* flourish on this forest floor where little or no direct sunlight falls. The latter two species are frequently found growing side by side, usually upon banks of streams.

PLATE VII.—Lysichiton camtschatcense with background of Polystichum and Lomaria.

b Forest of higher altitudes.

(100-300 meters.)

It is not to be understood that there is any sharp demarcation line or very natural division between what here is designated as forests of low and high altitudes. The forest of the lower level grades into that of the higher and as these higher levels are reached new conditions are met with under which the forest assumes a different look. The immediate effects of the ocean and the winds blowing over it are not so strongly asserted, although the subtler influences permeate even to great distances. That less moisture reaches these heights is well shown by the fact that heavy clouds of mist hang very low, often only half way up the slopes. That the moisture content of the soil is much less than below is self evident. The forest becomes more open. There are frequent small knolls or elevations which are covered only by shrubs and underbrush. Again swamps and Sphagnum bogs occur. The trees which are characteristic of the forest below are also to be found here but with altered rank, which, although it varies, is in general as follows:

Thuja plicata *Tsuga heterophylla*
Picea sitchensis *Pinus monticola*
and now and then *Taxus brevifolia*

The typical underbrush is much like that found nearer the sea, another species of Vaccinium, *Vaccinium ovatum*, is found now and then. Upon the more or less open knolls together with *Vacciniums* and *Menziesias*, small and stunted trees of *Thuja plicata* and *Tsuga heterophylla* frequently appear. *Lycopodiums* are met with on these ridges. The herbaceous undergrowth is rather scanty and consists only of a few grasses and sedges together with *Cornus canadensis* and *Lilium columbianum.*

Interior bogs and swamps.—Swampy places and Sphagnum bogs are of frequent occurence in the forest. As a general rule they are not large in size and sometimes the forest continues uninterrupted over the swampy area. In other places there are distinct openings or clearings usually in the form of modified Sphagnum bogs through which the forest is gradually encroaching but has not been able to establish itself. It is very likely that these places were originally typical Sphagnum bogs and that gradually through the ages as they build themselves up higher and became drier other plants wandered in until the present complex has been built up. Besides the various species of Sphagnum and other mosses, one finds here turf building types like *Agrostis aequivalvis*, *Carex livida*, *Carex sitchensis*, *Carex sterilis cephalantha*, *Carex howellii*, *Carex pauciflora*, *Eriophorum polystachyon*, *Scirpus caespitosus*, *Rynchospora alba*, *Juncus paucicapitatus*, *Juncus effusus*. A number of heaths occur typically in these places such as *Kalmia glauca*, *Ledum groenlandicum*, and *Oxycoccus palustris*. With them are generally associated *Empetrum nigrum* and *Myrica gale*. Particularly frequent are *Drosera rotundifolia*, *Gentiana douglasiana*, *Hypericum anagalloides*, *Sanguisorba media*, *Limnorchis stricta* and *Limnorchis graminifolia*. Of herbaceous species which are of less universal distribution one meets with,

Coptis asplenifolia	*Fauria crista-galli*
Plantago macrocarpum	*Apargidium boreale*

Along the border of these forest openings is generally a zone of low, bushy, in many cases stunted looking trees of *Thuja plicata* and *Tsuga heterophylla*. Now and then one encounters a peculiar adaptation of *Pinus contorta* to such a habitat. When this species occurs in these modified bogs it is generally found fringing the edge, although sometimes it has succeeded in establishing itself well out in the open. In either case, the tree does not attain any considerable height, (3-8 meters) and grows apparently very slowly. In appearance it offers a peculiar contrast to the other trees around as the branches are all clustered in a palm like crown at the top (Pl. XII.). Frequently one observes here the phenomenon of old cones adhering far down on the main stem. These have evidently been produced on adventitious shoot.

c Forest of the river valleys.

Under the conditions which these natural drainage courses call forth, the vegetation shows itself in a somewhat different aspect from that developed at similar altitudes but in closer proximity to the sea.

Both the San Juan and Gordon rivers find outlet into San Juan harbor about 3-4 kilometers apart. The former stream through alluvial deposits and the formation of an extensive sand bar at its mouth has shifted its outflow from its one time channel so that at low tide it flows into the Gordon a short distance above the mouth of the latter. Between the original outlet of the San Juan and the place where they at present both reach the harbor, there has been built up a considerable alluvial plain which now supports a very heavy forest mostly of spruce but with scattered trees of cedar and of hemlock.

The Gordon river valley widens out slightly in its lower part. The heavy timber of the slopes reaches down to the edge of the channel, except near the mouth of the river where narrow strips of meadow land are found on either side. Again the typical forest trees are *Picea sitchensis*, *Thuja plicata*, *Tsuga heterophylla*, and *Abies amabilis*. Here *Pseudotsuga Douglasii* is occasionally met with even in the lower reaches of the valley, and along the river bank occur *Acer macrophyllum* as well as one or two species of

Salix. The forest in the valley is built on a magnificent scale. The trees stand close and straight, often within arms length of each other, and frequently tower 60-90 meters in the air.

Shrubby forest undergrowth—The shrubby undergrowth does not play an important part in the general constitution of the forest, since it does not reach any degree of density except close towards and along the banks of the river. There it is largely made up of the following species:

Rubus spectabilis	*Vaccinium ovalifolium*
Rosa gymnocarpa	*Sambucus liosperma*
Gaultheria shallon	*Symphoricarpos occidentalis*
Vaccinium parvifolium	*Fatsia horrida*

The last named species, familiarly known as "Devils Club", occurs mostly along gullies and banks of streams.

Herbaceous undergrowth—The herbaceous flora although not numbering many species, is nevertheless characteristic and very profuse except where the densest shadow prevails. The species abounding almost throughout are:

Polystichum munitum	*Achlys triphylla*
Lomaria spicant	*Tolmiea menziesii*

Adiantum pedatum	*Tiarella trifoliata*
Erythronium grandiflorum	*Viola glabella*
Trillium grandiflorum	*Circæa alpina*
Disporum menziesii	*Newberrya congesta*
Trautvetteria grandis	*Monotropa hypopytis*

Somewhat different vegetation relations from those observed in the general valley are to be met with on Mt. Edinburgh which lies in this immediate region. Aside from differences due to much higher elevation (the mountain attains an altitude of 1000 meters) profound modifications of the original conditions have been brought about through disturbances by fire. At the base of the mountain much the same type of forest is to be observed which is characteristic of the rest of the valley. Giant specimens of *Pseudotsuga-taxifolia* are common at elevations up to 150 meters or thereabouts.

That a magnificent forest once clothed the mountain to its very summit is shown by the still standing charred stems and the fallen and burnt debris. To account for the fire which swept the upper slopes and summit is difficult in the face of climatic conditions obtaining during the years 1901 and 1902. During these summers no fire could ever have gained foothold or made progress. Only by supposing a remarkable reversion of climatic conditions and a "dry spell" of unusual length can a forest fire in this immediate region be explained. Some time was spent in exploring the river side of the mountain and in futile attempts to reach its summit. The whole burnt over area is one inextricable tangle of brambles and criss-crossed logs which make progress up the slopes extremely difficult and dangerous. The primeval aspect is here completely destroyed and the characteristic signs of age are gone.

The process of re-population is rapidly going on, and in much the same fashion to be observed in any burnt over region. In this waste the predominating plants are:

Rubus spectabilis	*Chamaenerion angustifolium*
Rubus parviflorus	*Epilobium glandulosum*
Rubus ursinus	*Galium triflorum*

Seedlings of *Picea sitchensis*, *Tsuga heterophylla*, and *Thuja plicata* are struggling for a place in the tangle.

At the higher elevations along the base of rocky ledges and in large crevices where there is enough soil to yield a foothold, the plants occuring most frequently are:

Polypodium falcatum	*Achlys triphylla*
Asplenium trichomanes	*Tiarella trifoliata*
Berberis nervosa	*Trientalis latifolia*

Mosses and lichens occur in considerable quantities upon the rocky ledges and shelves.

San Juan Valley. The vegetation of the two valleys differs only in smaller details. This finds its explanation in the slope and trend of the valley and in the nature of the soil. The fall of the river in the same distance is not as great as that of the Gordon and one finds often along the banks small grassy meadows and forest openings, especially in the lower portions where there is considerable alluvial deposit. Farther up the valley are frequent evidences of moraines and although the surface soil is made up of decaying vegetation as everywhere else in the region, the subsoil is a moraine deposit and dissimilar conditions are therefore experienced.

The direction of the harbor and the valley beyond being the same, it allows the strong winds from the straits to sweep unimpeded up through the valley. This accounts in a large measure for the somewhat different general aspect of the vegetation in the lower portions at least. On some ot the slight elevations and points of projecting sidehills, the trees have been blown down in places. In these openings, the shrubby undergrowth assumes much the same character as at the forest edge, and the herbaceous forms with the admittance of more light find opportunity for greater development. Nowhere, however, are such stately trees seen in such proximity to the harbor as in the Gordon valley. The spruce, *Picea sitchensis*, is by far the most abundant tree, but not being closely crowded by other tall-growing forms like *Thuja*, *Tsuga*, and *Pseudotsuga* it generally becomes much branched, and although of large diameter never attains great height. As the valley is ascended, the spruce loses its predominance and is largely supplanted by the cedar and the hemlock. *Tsuga heterophylla* in many places occurs in beautiful stands almost to the exclusion of all other kinds of trees. In the portion of the valley traversed, *Abies* and *Pseudotsuga* were less often met with than along the Gordon river watershed. *Acer macrophyllum* and *Alnus oregana* appear more frequently along the banks of this stream than along the other and occasionally trees of *Populus deltoides* and *Salix lasiandra* are seen.

With distance, the windfalls characteristic of the lower valley, disappear, and the shrubby undergrowth assumes the same tone and is of the same composition as that which we have learned to know for the other valley. The herbaceous undergrowth, because of the general less dense nature of the forest, is more profuse. In point of species, there is not much difference and naturally many of these are common to both places. The following species form the main bulk of this herbaceous forest undergrowth:

Polystichum munitum	*Asplenium filix foemina*
Lomaria spicant	*Dryopteris spinulosa*
Deschampsia caespitosa	*Poa elata*
Agrostis aleutica	*Carex laeviculmis*
Juncus paucicapitatus	*Alsine crispa*

Tiarella trifoliata	*Boykinia elata*
Tolmiea menziesii	*Mitella ovalis*
Viola glabella	*Moneses uniflora*
Mimulus moschatus	*Galium triflorum*

2. River bed formation

a Banks and Channel.

Gordon River Bed—During the summer months, the volume of the river decreases to such an extent as to leave exposed the banks from where the forest and its underbrush ceases, and also a considerable extent of the boulder-strewn channel bed. Two types of river banks can be distinguished here, viz; moist sandy banks and moist rocky banks. Both kinds are more or less shaded by the overhanging branches of the adjacent trees, yet it is self evident that much more light is admitted here than into the forest of the slopes on either side.

Upon the sandy banks are associated a few species, no one of which figures predominantly and all growing more or less scattered or in tufts. In this scanty society are most generally to be observed:

Bromus vulgaris *Anemone lyallii*
Juncus falcatus *Lathyrus nuttallii*
Stenanthium occidentale *Adenocaulon bicolor*
Valeriana sitchensis

In the part of the valley designated the gorge, the river flows between high rocky banks. In many places these are quite bare and smooth, while in others there are rifts and crevices in which soil has found lodgement. The water draining from the slopes beyond over these banks keep them continually moist and here a few hydrophytes flourish, most frequent of which are:

Parnassia fimbriata *Pinguicula vulgaris*
Chelone nemorosa *Campanula petiolata*

Where the banks are high and well shaded they are frequently moss covered, and in this mossy covering one often meets with a peculiar form of *Selaginella rupestris.* As is well known this species is found typically upon dry, exposed generally sandy rocks and grows in tufts. The form occuring along the Gordon river is loose, has long, slender stems and branches and twines among the moist moss.

Channel bed—Among the boulders of the river channel and in the hollows and crevices of the large rocks a few hardy types have gained a foothold . A few of these are perennials and as such must bear the yearly winter inundation. The forms most commonly noted in this habitat are:

Heuchera glabra *Cladothamnus pyroliflorus*
Viola sp. *Erigeron philadelphicus*
Chamænerion latifolium *Luina hypoleuca*
Arnica amplexicaulis

In no instance do these plants become closely associated into groups or societies but occur thinly and scattered where enough soil is present to sustain them. *Cladothamnus pyroliflorus* grows as a small shrub less than a meter high, upon the large rocks in the channel and also upon the rocky banks of the river. *Chamaenerion latifolium*, *Erigeron philadelphicus* and *Arnica amplexicaulis* grow in sand upon the boulder strewn channel bottom:.

San Juan river bed—Owing to the fact that the descent in this valley is more gradual, typical mud banks are found along the river sides.

Sparganiums, grasses and rushes are commonly found along these.

In many places, strips of meadow land are found on either side of the stream, the composition of which merits no special elucidation.

b Rivers and Streamlets—The two rivers which enter into consideration, the Gordon and the San Juan, are streams of considerable volume. The former is swift, falling 50 meters in the last 12 kilometers. Its waters are of unusual clearness and of low temperature. These factors are responsible for the fact that no higher plant life is developed in it, at least not throughout the extent explored.

The San Juan on the other hand especially in its lower reaches is a much slower flowing stream. Along it are found occasional sloughs and in these various aquatics like *Fontinalis*, *Sparganium*, *Nymphæa* and *Callitriche* are developed.

There are a large number of streams in the region, most of which are small brooks that find a rapid descent through the numerous gullies of the forest into the adjoining sea. Under these conditions no extensive development of higher forms of vegetation is to be looked for in their clear, cold waters. Aside from various species of algae, only a few Bryophytes like *Hypnum* and *Fontinalis* are of general occurrence. In occasional pools, *Callitriche palustris* is met with.

3. Lake beach formation

Vancouver Island possesses a number of lakes the largest of which is Cowichan with over 20 miles of water expanse. Most of the lakes, however, are of the character of mountain tarns. Of those lying in Renfrew district, only Lake San Juan was visited and the vegetation in and around it studied. This is a small body of water situated a few miles inland and off to one side of the valley bearing the same name. The lake is almost completely surrounded by high hills, its waters finding outlet into San Juan river through a narrow rift in the surrounding barrier. Its level above sea was not definitely ascertained but a rough estimate would place it at between 10 and 15 meters. One meets here with the peculiar condition of a far northern lake whose shore line is never subjected to ice disturbance and a low beach flora which does not have to bear the incessant impact of surf or strong winds, for so effectively hemmed in is the lake by the high and heavily timbered slopes that strong and lasting wind currents of prevailing direction do not obtain. Furthermore the expanse of water is not great enough to allow the shifting air currents that reach the lake to develop any surf action on this or that shore. The lake is fed by one fair sized stream and by a number of brooklets from the surrounding hills. The per cent of organic matter in its waters is necessarily comparatively large.

With regard to the topography and structure of the beach only a few words will be set down. For some distance along one end of the lake, the slope drops off rather suddenly in rocky ledges and here the beach is only a few meters wide. In front of gullies or ravines, the filling in has been greater and a wider beach is the result. On the side where the main stream that feeds the lake flows in, a considerable stream delta has been formed. The beach here is largely built up of sand and has a width of many meters (15-50 meters). Along the places where there are no natural drainage courses like those mentioned above, the building up of the beach has been more uniform and gradual and is formed by loam deposits carried down from the surrounding slopes by the washings of countless rains and also by decay of the vegetation that the beach supports. The soil therefore is largely of organic nature, of very dark color and of fine consistency. A grouping of the vegetation societies such as has been employed by various American writers on lake strand vegetation seems applicable here, according to which we consider first the front beach.

a Front beach

Equisetum fluviatile society—This society exhibits regular zonal distribution along the beaches where there is no considerable proportion of sand in the soil. It is therefore interrupted by the stream inlets. The society extends even out into the water but since it seems to attain its typical development just above the water line, it is classed as a part of the beach formation. Towards the front, it is made up almost entirely of *Equisetum fluviatile* and *Equisetum fluviatile polystachyon.* Farther back in some places *Hippurus vulgaris* and *Veronica scutellata* are also met with.

Juncus-Ranunculus society—This occurs on sandy front beach and extends from the water's edge back for only a short distance. It is made up of *Juncus paucicapitatus* and *Ranunculus intermedius.* The former in this situation has a different habit of growth from that which it assumes when growing in swampy places in the forest, where it is frequent. Upon the beach the plant is more or less spreading or prostrate and the inflorescence is considerably branched. In the forest on the other hand it grows more erect with much longer stems and inflorescence less branched. The other constituent of this society-*Ranunculus intermedius*-has a creeping habit of growth. Stems several decimeters in length are found creeping along and frequently striking root into the sandy soil. As far as my observations go these two prostrate types are the only tenants of the front sandy beach. They both grow only at slight elevation above the lake level.

b. Mid beach.

Within this zonal region of the beach, the lakeward and shoreward influences meet and commingle in such a way as to call forth the greatest complexity of conditions. As the forest is approached the influences of the lake decrease, and in like manner as the water is neared so those of the forest become of less weight. The optimum is therefore established somewhere in the middle zone. Besides the transitions in the societies undergone in passing from the front towards the back, one also notes changes in the longitudinal direction of the strand like those of the front beach in passing from low and mucky, to raised sandy beach and stream delta. This longitudinal transition results in the division of the midstrand vegetation into societies more or less distinct and conditioned by the soil composition. The sandy beaches show a greater variety of species than the low humus ones, but fewer individuals in a given area. This is largely due to the fact that there are more typical turf builders, sedges and the like, found growing in the latter habitat. Along the humus shores the mid beach area is largely tenanted by a *Carex-Comarum* society, which lakeward passes into the *Hippuris-Equisetum* front strand complex already spoken of The characteristic plants of the society are various species of *Carex* such as:

Carex howellii	*Carex sitchensis*
Carex exsiccata	*Eleocharis palustris*

In some places occur scattered examples of *Veronica scutellata. Comarum palustre* is found in considerable quantities among the sedges throughout, but reaches apparently its fullest development well toward the back.

Upon the sandy beaches and stream deltas of the mid beach region is established a somewhat complex herbaceous society of mostly perennial types. The composition varies but the most characteristic plants are:

Agrostis attenuata	*Lycopus communis*
Agrostis exarata	*Bromus vulgaris*
Elymus ciliatus	*Oenanthe sarmentosa*
Carex decidua	*Galium trifidum pacificum*

This group does not exhibit signs of stability.

This is especially to be observed upon stream deltas for the uneven stream deposits and the changing contour of these bars do not permit the various inhabitants to establish themselves with permanency. Where on the other hand, the beach does not undergo comparatively rapid changes, vegetation is not of such transient character and here too less hardy forms are able to compete for the ground and maintain themselves with varying success. The group as a whole is of more or less open growth. The various species of grasses enumerated grow in scattered tufts and do not build up a characteristic turf. The struggle here is not so much of species against species as that of the entire society against adverse edaphic conditions. That the different representatives share much alike in this fate is shown by the fact that no one species preponderates in any marked degree over the others.

c Back beach.

This zone at Lake San Juan can be separated, according to present topographic conditions, into a rocky and a non-rocky region. The characteristic rocky back beach is found only along one end of the lake. At the rate which this body of water is filling in, it is only a question of time when the three zones shall have been pushed so far out that what is now the back beach zone shall have yielded its place to the invading forest. The present tenants of the rocky ledges may be able to maintain their foothold even after the forest has become established in front, yet new conditions of light and illumination will eventually tend to bring about a change. The plants dwelling upon this type of rocky beach constitute a *Rosaceous* shrub society, of which the principal species are:

Spiraea menziesii	*Rubus spectabilis*
Rubus parviflorus	*Neillia capitata*

Together with these occur *Vaccinium parvifolium* and a few herbaceous forms like *Polystichum munitum*, *Adiantum pedatum*, etc.

In the non-rocky back beach, there are regions which correspond to those of the mid and front beaches with reference to elevation and soil composition. Along the sandier, elevated portion the composition is slightly more diversified than in the other places. The forest fringing zone is here made up mostly of the following shrubby types: *Rubus spectabilis*, *Cornus nuttallii*, *Salix sitchensis*, together with a few herbaceous species like *Elymus ciliatus*, *Cardamine angulata*, *Viola glabella*, and *Washingtonia divaricata*.

The remaining part of the backstrand exhibits general uniformity in its composition and is the least complex of all. Two species of willow predominate, *Salix sitchensis* and *Salix lasiandra*. The species of *Carex* observed in the mid strand societies force themselves in among the willows here and there but not in any considerable numbers.

The whole back strand zone in its main characteristics is a complex of shrubby forms. Herbaceous annuals and perennials occur but nowhere in such groupings or abundance as to materially change the tone. The zone passes almost directly into the typical forest of the surrounding hills and slopes. In natural groups or societies of vegetation there are no sharp lines of demarcation; one grades into another. Between some the transition is not as gradual as between others, and this fact is observable upon the shores of Lake San Juan. Towards the front the transitions are gradual. In the backstrand there is a sharp passing over from the fringe of willows to the wall of tall, coniferous trees of the forest proper.

The whole beach formation is however a plastic one. The different societies and groups are in a state of migration. The successive zones are continually, though slowly, moving lakeward as the filling in process goes on, each in turn by degrees coming to occupy the place once tenanted by other forms, all leaving their decaying generations behind, changing, building up and preparing the soil for the permanent occupation by the forest which is here the last link in the chain.

4. Lake formation.

The hydrophytic types which are here developed show much the same disposition of their various societies which is characteristic of more northern fresh water lakes. Not taking algal vegetation into consideration and beginning farthest out in the lake working shoreward one meets first with a zonally arranged society of

Myriophyllum spicatum:-This zone varies in width and is not continuous. Its usual depth is from 1-3 meters. Frequently in certain places of this society are found scattered plants of *Nymphæa polysepala.*

The next zone shoreward is formed by a *Potamogeton* society. This is principally composed of *Potamogeton natans* and *Potamogeton pusillus.*

In some of the small bays or inlets along the shore this zone attains a comparatively large width. Along projecting points on the other hand it frequently narrows down very much and often becomes discontinuous. *Potamogeton natans* is by far the largest element in this zone.

Of a still more interrupted character is a society that shoreward succeeds the one just mentioned and which is built up principally of *Nymphæa polysepala.* It develops typically in the bays or behind projecting spits of land. As a rule the plant occurs in dense patches where often the large heart shaped floating leaves crowd so close together as nearly to obscure the surface of the water. The depth at which it is anchored varies from 1-2 meters as a general rule. It seems to prefer a bottom of fine silt or mud where the proportion of sand is not considerable. Under these limiting conditions there are only a few places along the shore of the lake where it has been able to gain sufficient foothold to build up a characteristic society.

Other aquatic representatives occur but sparingly. At the time of the year when the place was visited only two other species were observed growing in the lake. These were *Callitriche palustris* and *Sparganium minimum.* They are found at intervals along shore, generally in shallow water, and do not seem to show any strong preference as to the nature of the bottom. Nowhere do they develop in any considerable quantity and must be regarded as outposts of the general lake flora.

Special adaptations—In forests of such high latitudes as that of Vancouver Island epiphytism is generally confined to the lower plants like lichens, liverworts and mosses. The last two groups are particularly abundant in the region under discussion. Not only are dead logs, branches, the lower portion of trees etc. covered with a layer of the bryophytic types, but frequently large masses of moss perch high up towards the tops of trees (Pl. VIII.) or hang in long festoons from the branches. The forest floor is carpeted in most places with a layer of *Marchantias*, *Jungermannias* and allied forms. The great amount of moisture however makes it possible for plants higher in the scale of development than Bryophytes to adopt the epiphytic mode of life. A characteristic epiphyte of the region is *Polypodium falcatum.* This fern is almost invariably found growing upon the stems and lower branches of *Alnus oregana*, in the mossy covering of which the creeping rhizomes find anchorage. Other ferns like *Polystichum munitum* and *Lomaria spicant* are occasionally found upon moss covered branches of large trees and in the old "Hexenbesen" of the hemlock. Not infrequently one finds *Vacciniums* and *Menziesias* flourishing high up in some giant cedar or spruce (Pl. IX.), the demands for nourishment of these small shrubs not being greater than the

PLATE VIII.—Epiphytic moss vegetation on spruce.

PLATE IX.—Thuja plicata with epiphytic Menzieseas and Vacciniums.

PLATE X.—Thuja plicata growing upon fallen tree.

PLATE XI.—Hemlock forest showing trees with "Hexenbesen".

moss laden crotches and branches can furnish. The ultimate fate of the countless seedlings of spruce, cedar and hemlock which one finds in this peculiar habitat and upon fallen trees is, however, in most cases different. They quickly outgrow the possibilities of their substratum and die. Now and then an individual by chance circumvents the impending fate in a manner which would be impossible in a climate less rainy than this.

In Plate X. is shown an example of how a seedling cedar from such an airy position has succeeded in juggling its young roots, evidently along the decaying branches of its host into the ground and has grown into a large tree, still holding between its massive roots, or more correctly its bifurcated stem, the decaying spruce log. Frequently seeds lodge upon high stumps from which elevated position the roots of the growing young trees reach down and into the soil. As the stump decays and falls away, it leaves the tree standing as it were on stilts.

Parasitism—It is not the intention under this head to discuss the numerous aspects of fungal life which the region presents, but only the occurrence and adaptation of a few parasitic or semiparasitic, flowering plants. The most characteristic and most common of these is the "Hexenbesen-forming" mistletoe of the hemlock. Wherever the west coast hemlock, *Tsuga heterophylla*, occurs it is frequently infested in patches by the parasitic plant *Razoumofskya tsugensis*. It occurs sometimes upon the main stem of the tree and in such cases generally destroys the timber value, but mostly upon the twigs and branches. Whatever part of the tree is attacked the result is alike apparent in an increase in thickness of the infested portion and a great proliferation and branching resulting in the characteristic faciations known as "Hexenbesen" (Pl. XI.). After a number of years there begins to gather debris and moss in the "Hexenbesen" with the result that the parasite finally dies out. The damage however is done to the branch and it is only a question of time before it dies and rots.

The method of seed distribution among this group of plants is so well known as to merit only passing comment here. The seeds at the time of maturity are covered with a mucilaginous substance. The bursting fruit shoots out the seed with considerable force and as the flying missile strikes a branch it adheres and is held in place. When such a seed, stuck on to a young hemlock branch, germinates, the young seedling finds the substratum it wants and quickly establishes itself. Where the hemlock forms a large element of the forest composition, there the advent of the parasite is especially dangerous, since the trees stand in such close proximity to each other as to facilitate the transfer of seeds from one to the other. The other coniferous trees of the region seem to be immune against this mistletoe, for is was never observed upon any other host than the hemlock.

Another plant, a representative of the Orobanchaceæ, which shows a peculiar parasitic habit, is *Boschniakia strobilacea*. This is of frequent occurrence in most places where the salal, *Gaultheria shallon*, abounds, for it grows as a parasite upon the roots of this shrub. It produces peculiar bulb-like almost spherical growths 2-6 centimeters in diameter upon the roots of its host, and from these the plant rises. The portion above ground varies from about 6-16 centimeters and is closely covered with brownish colored scale leaves or bracts which give the plant much the appearance of an old spruce cone struck base end into the ground. Almost the entire visible portion of the plant is inflorescence, a flower standing in the axil of each of the brown scale leaves. At maturity the comparatively large capsular fruits crowd close one upon each other over the entire flowering axis. The parasite appears to be most common where the host plant is found growing over steep slopes or embankments. In such position the roots of the salal are more easily reached and therefore the parasitism more readily established than where a thicker and firmer layer of soil has to be penetrated.

Saprophytism—Where there is such an abundance of decaying vegetable matter and where the soil is so largely humus as it is in the forests of this region, one would reasonably expect to meet frequently with the phenomenon of saprophytic adaptation. The contrary however is experienced. Of the group of holosaprophytic plants only two representatives were found and even these of very infrequent occurence. *Monotropa hypopitys* was met with in the valley of the Gordon and *Newberrya congesta* on the wooded slope back of San Juan harbor.

Of hemisaprophytic plants, which in northern forest are generally represented by many *Pyrola* species, only *Moneses uniflora* was found. It too occurs infrequently.

Statistics and Summary.

To aid in the composition and distribution of the plant population of the region as set forth in the preceding pages, the following catalogue and statistics are set down. The list includes only those Pteridophytic and Spermatophytic plants which have come under the observation of the writer and does not claim to be fully exhaustive and complete for the reason that investigation covers only a period of the year. Further field work both earlier and later in the season would undoubtedly add a few more species but not enough however to alter or affect the various groupings as brought out.

PTERIDOPHYTA

POLYPODIACEÆ

Polystichum munitum (Kaulf.) Underw. In the shady forest throughout. July 9. R. and B. 103.

Cystopteris fragilis (L.) Bernh. Schrad. Neues. Journ. Bot. 1: part 2. 27 1806. Mt. Edinburgh, Aug. 1905. F. K. Butters

Dryopteris spinulosa (Retz) Kuntze Rev. Gen. Pl. 813. 1891. Common along banks of streams in the forest. July 9, 1901. R. and B. 102.

Asplenium filix-foemina (L.) Bernh; Schrad. Neues Journ. Bot. 1: 26. Same habitat as the preceding. July 9. R. and B. 106

Phegopteris dryopteris (L.) Fee, Gen. Fil. 243.1850-52. Bugaboo Mine; Mt. Edinburgh, Aug. 1904-05. F. K. Butters.

Asplenium trichomanes L. Sp. Pl. 1080. 1753.

Frequent in rock crevices on Mt. Edinburgh. July 31. R. 852.

ADIANTUM PEDATUM L. Sp. Pl. 1095. 1753. Common throughout. July 7. R. and B. 90.

CRYPTOGAMMA ACROSTICHOIDES R. Br. App. Frankl. Journ. 767. 1823. Mt. Edinburgh, Aug. 1904. F. K. Butters.

PTERIS AQUILINA LANUGINOSA Bong. Veg. Sitch. 176. 1833. Growing abundantly along the forest edge. July 13. R. and. B. 128.

POLYPODIUM FALCATUM Kellogg. Growing infrequently on rocks, occurs mostly as an epiphyte upon the stem and branches of *Alnus oregana*.

POLYPODIUM SCOULERI Hook. and Grev. Hook Ic. Fil. 1: 56. 1829-1831. In crevices on the rocky beaches, mostly in exposed places. June 25. R. and. B. 42

LOMARIA SPICANT Desv. Newman Hist. of Brit. Ferns 89: 1844. Common throughout in the shady forest. July 7. R. and B. 89.

EQUISETACEÆ

EQUISETUM FLUVIATILE L. Sp. Pl. 1062. 1753.

Growing abundantly on the shores of lake San Juan. July 22. R. 807.

EQUISETUM FLUVIATILE POLYSTACHYON Bruck. Same habitat as the species. Aug. 7. R. 887.

EQUISETUM TELMATEIA Ehrh. Beitr. 2: 159, 1788. Common on rocky banks and in the forest. Only sterile plants noted at the time

LYCOPODIACEÆ

LYCOPODIUM CLAVATUM L. Sp. Pl. 1101. 1753. On less densely wooded knolls of the upper forest, July 19, 31. R. 783. 844.

LYCOPODIUM SELAGO L. Sp. Pl. 1102. 1753. Gordon River Valley. Aug. 8. 1905. F. K. Butters.

SELAGINELLACEÆ

SELAGINELLA RUPESTRIS (L.) Spring. in Mart. Fl. Bras. 1: Part 2. 118. 1840. On moist moss covered rocks along the Gordon river. July 31. R. 864.

GYMNOSPERMÆ

PINACEÆ

PINUS CONTORTA Dougl. in Loudon Arb. Brit.

4: 2292, 1838. Along the edge of the forest. Occasionally in Sphagnum bogs. June 25. R. and. B. 44.

Pinus monticola D. Don. Lamb. Pinus. 3: 1837. Common in the higher forest. July 13 R. and B. 135.

Picea sitchensis (Bong.) Carriere, Traite Comf. 260. 1855. Most common tree in the low forest. Aug. 14. R. 933.

Tsuga heterophylla Sarg. Sylva N. Am. Common forest tree throughout. Aug. 13. R. 926.

Tsuga pattoniana (A. Murray) Séneclauze, Conif. 21. 1867. Mt. Edinburgh, Aug. 1904. F. K. Butters.

Pseudotsuga taxifolia (Lambert) Britton, Trans. N. Y. Acad. Sci. 74. 1889. Frequent in the Gordon River Valley.

Abies amabilis (Loud.) Forb. Pinetum Wob. 125, pl. 44. 1839. Common in the low forest. Aug. 15. R. 934.

Thuja plicata D. Don. Cat. Hort. Cantab. ed. 6. 249. 1811. Most important timber tree of the region, reaching its greatest development between sea level and 200 meters. Aug. 11. R. 904.

Chamaecyparis nootkatensis Spach. Hist. Veg. 9. 333. 1842. Mt. Edinburgh and Gordon River Valley. F. K. Butters.

TAXACEÆ

Taxus brevifolia Nutt. Sylva 3: 86. 1849. Infrequent throughout the region. Aug. 1. R. 831.

ANGIOSPERMÆ

SPARGANIACEÆ

Sparganium androcladum (Engelm.) Morong. Bull. Torrey Bot. Club. 15: 78. 1888. Shores of Lake San Juan and banks of San Juan river. Aug. 7. R. 886.

Sparganium minimum Fries. Summa Veg. Scand. 68:560. 1846-1849. In Lake San Juan. Aug. 7. R. 880.

POTAMOGETONACEÆ

Potamogeton natans L. Sp. Pl. 126. 1753. In Lake San Juan. July 21. R. 790.

POTAMOGETON PUSILLUS L. Sp. Pl. 127. 1753. In Lake San Juan. Aug. 7. R. 898.

ZOSTERA MARINA L. Sp. Pl. 968. 1753. In sheltered places of San Juan Harbor. Found occasionally on the beach by the Minnesota Seaside Station after heavy southwest storms. Aug. 12. R. 919.

PHYLLOSPADIX SCOULERI Hook. Fl. Bor. Am. 2:171. 1838. Common in tide pools and on jagged rocks below the half tide mark. July 23. R. 814.

JUNCAGINACEÆ

TRIGLOCHIN MARITIMA L. Sp. Pl. 105. 1753. In moist turf on the rocky beaches. June 28. R. 67.

GRAMINEÆ

PANICUM UNCIPHYLLUM Trin. Gram. Panic. 242. 1826. On rocky beaches, crevices of the slate rocks. July 10. R. and B. 107.

AGROSTIS EXARATA Trin. Gram. Unifl. 207. 1824. On steep, rocky beaches. Straits of Fuca and on sandy shores of Lake San Juan. A very variable species. July 22, 25. R. 806,819.

Agrostis aequivalvis Trin. in Mem. Acad. Petersb. Ser. 6 2:362. 1845. In swampy places in the forest. July 12. R. and B. 121.

Agrostis attenuata Vasey. Bot. Gaz. 11:337. 1886. Sandy shores of Lake San Juan. Aug. 7. R. 892.

Calamagrostis hyperborea Lange Fl. Dan. t. 2942. Growing in patches upon the rocky beaches. July 1. R. and B. 77.

Calamagrostis aleutica Trin. in Bong. Veg. Sitch. 171. Along the edge of the forest. July 8. R. 768. A form of the species growing in the forest. July 23. R.

Holcus lanatus L. Sp. Pl. 1048. 1753. Occurring in clearings. July 13. R. and B. 132.

Aira caryophylla L. Sp. Pl. 66. 1753. On the wide, sandy beach in San Juan harbor. July 22. R. 788.

Deschampsia caespitosa (L.) Beauv. Agrost. 160. 1812. Common throughout and in various habitats. July 13. R. and B. 131. July 16, 21. R. 769,789.

PHLEUM PRATENSE L. Sp. Pl. 59. 1753. Introduced and growing spontaneously near the station buildings and elsewhere along trails and in clearings in the forest. C. E. B.

POA FLAVA L. Sp. Pl. 68. 1753. In moist sandy soil of the beach. July 18. R. 777.

PANICULARIA ELATA Nash, Mem. New York Bot. Gard. 1:54. 1900. Along trails in the forest. July 23. R. 812.

TRISETUM NUTKAENSIS (Presl.) Scrib. and Merrill. Frequent along the edge of the forest. July 13. R. and B. 11.

FESTUCA RUBRA L. Sp. Pl. 74. 1753. (Approaching variety *biakalensis* Griseb.) Growing as a crevice plant upon the rocky beaches. June 20. R. and B. 11.

FESTUCA JONESII. Vasey, Contrib. U. S. Nat. Herb. 1:278. 1893. Common on the sandy beaches. July 16. R. 765.

BROMUS SITCHENSIS Trin. in Bong. Veg. Sitch. 173. 1833. Growing abundantly on moist sandy beaches. July 11. R. and B. 114.

BROMUS PACIFICUS Shear, U. S. Dept. Agric.

Bull. 23:1900. Same habitat as the preceding July 18. R. 776.

Bromus secalinus L. Sp. Pl. 76.1753. Introduced along trails and roadsides. July 19. R. 787.

Bromus vulgaris (Hook.) Shear, U. S. Dept. Agric. Bull. 23:1900. Infrequent on the moist banks of the Gordon River. July 31. R. 856.

Hordeum boreale Scribn. & Smith, Bull 4. Div. Agrost. 28. 1897. Occurs as a crevice plant upon the rocky beaches. June 20. R. and B. 10.

Elymus glaucus Buckl. Proc. Acad. Sc. Phila. 99.1863. Frequent along the edge of the salal zone. July 11. R. and B. 116.

Elymus borealis Scribn. Circ. U. S. Div. Agrost. 27: 9. 1900. Growing on moist sandy beaches. July 16. R. and B. 115.

Elymus mollis Trin. Spreng. Neue Entdeck. 2.72. Common among driftwood upon some of the larger sand beaches. July 13. R. and B. 127.

Elymus ciliatus Scribn. Bull. U. S. Div. Agrost. 11: 57. pl. 16. 1898. Along shaded banks of streams in the vicinity of Lake San Juan. July 22. R. 801.

CYPERACEÆ

Eleocharis palustris (L.) R. and S. Syst. 2: 151. 1817. Frequent throughout, in various moist habitats. July 6. R. and B. 87. Aug. 7. R. 894 b.

Scirpus americanus Pers. Syn. 1:68. 1817. On moist sandy beaches at the mouth of small ravines. June 28. R. and B. 65.

Scirpus caespitosus L. Sp. Pl. 68. 1753. Grows abundantly in modified Sphagnum bogs. Aug. 11. R. 914.

Scirpus microcarpus Presl. Rel. Haenk. 1:193. 1830. On moist sandy beaches, together with *Scirpus americanus*. June 28. R. and B. 61.

Eriophorum polystachyon L. Sp. Pl. 52. 1753 Abundant in Sphagnum bogs. Aug. 11. R. 913.

Rynchospora alba (L.) Vahl. Enum. 2:236. 1806. In Sphagnum bogs. Aug. 2. R. 873.

CAREX PAUCIFLORA Lightf. Fl. Scot. 2:543. 1777. Same habitat as the preceding. Aug. 13. R. 932.

CAREX STERILIS Willd. Sp. Pl. 4:208. 1805. Frequent in boggy places in the forest. July 12. R. and B. 122.

CAREX STERILIS CEPHALANTHA Bailey, Bull. Torr. Bot. Club. 20:429. 1893. In Sphagnum bogs. Aug. 13. R. 931.

CAREX CRYPTOCARPA C. A. Meyer. Mem. Sav. Extr. Petersb. 1:226. 1831. Infrequent, on the smaller sandy beaches. June 20. R. and B. 9.

CAREX FLAVA RECTIROSTRATA Bailey, Bot. Gaz. 13: 84. 1888. Growing as a crevice plant on the rocky beaches. June 25. R. and B. 37.

CAREX SITCHENSIS Presc. ex Bong. Veg. Sitch. 51. As a crevice plant, and also along the edge of the forest bordering the rocky beaches.. June 25. R. and B. 37.

CAREX DEWEYANA Schwein. Ann. Lyc. New York 1:65, 310. 1824. Occurs occasionally in the salal society. July 18. R. 764.

CAREX DEWEYANA BOLANDERI Boot. Bot Calif. 2: 236. 1880. Grows as a crevice plant on the more or less perpendicular rocks along shore. Aug. 1. R. 832.

CAREX DECIDUA Boot. Proc. Linn. Soc. 1:255. 1845. Frequent on the sandy beaches of Lake San Juan. July. 21. R. 793.

CAREX MERTENSII Presc. ex Bong. Veg. Sitch. 51. Along forest trail. July 23. R. 809. On the banks of small mountain stream, Mt. Edinburgh. July 31. R. 851.

CAREX LAEVICULMIS Meinsch, Bot. Centralb. 4: 195. 1893. Infrequent along forest trails. Aug. 7. R. 879.

CAREX LIVIDA (Vahl) Willd. Sp. Pl. 4: 285. 1805. In boggy places in the forest. Aug. 2. R. 872.

CAREX HOWELLII Bailey, Mem. Torr. Bot. Club. 1:45. 1889. Occurs in Sphagnum bogs. Aug. 11. R. 916.

CAREX ARCTA Boot. Hook. Fl. Bor. Am. 2: 227. Along forest trails in the San Juan river valley. Aug. 7. R. 890.

CAREX EXSICCATA Bailey. Mem. Torr. Bot.

Club. 1:6. 1889. Very abundant in places on the beaches of Lake San Juan. Aug. 7. R.891

CAREX MACROCEPHALA Willd. ex Kunth Enum. Pl. 2:428. 1837. Common on the sandy beaches of San Juan Harbor. Aug. 15. R. 935.

ARACEÆ

LYSICHITON CAMTSCHATCENSE Schott. Oestr. Bot. Wochenbl. 7: 62. 1857. Common in moist ravines in the deeply shaded forest. July 25. R. 825.

JUNCACEÆ

JUNCUS EFFUSUS BRUNEUS Engelm. Trans. St. Louis Acad. 2:491. 1868. In moist turf on the open beaches. June 25. R. and B.39.

JUNCUS BALTICUS Willd. Ges. Naturf. Fr.Berlin. Mag. 3:298. 1809. Frequent in the same habitat as the preceding. July 6. R. and B. 86.

JUNCUS ENSIFOLIUS Wikstr. Vet. Akad. Handl. Stockh. 2:274. 1823. Grows most frequently as a crevice plant upon the rocky beaches. June 25. R. and B. 36.

JUNCUS PAUCICAPITATUS Buch. Bot. Jahrb. 12:307. 1890. Frequent in swampy places in the forest. July 12. R. and. B. 123. July 23. R. 811. On the beach of Lake San Juan. Aug. 7. R. 883.

JUNCUS FALCATUS E. Meyer, Syn. Luz. 34. 1823. Banks of the Gordon river. Aug. 1. R. 840.

JUNCUS FALCATUS SITCHENSIS Buch. Bot. Jahrb. 12:428. 1890. Growing in moist crevices on the rocky beaches. June 26. R. and B. 50.

JUNCUS LESCURII Bolander, Proc. Acad. Sc. Calif. 2:179. 1863. Frequent on the sandy beaches, near high tide mark. June 24. R. and B. 30. July 18. R. 778.

LUZULA PARVIFLORA Desv. Journ. de Bot. 1: 144 1808. Infrequent along banks of small streams in the forest. July 9. R. and B. 104.

LUZULA COMOSA E. Meyer Syn. Luz. 18. 1823. On the open beaches, in moist turf. June 24. R. and B. 34.

LILIACEÆ

TOFIELDIA INTERMEDIA Rydberg, Bull. Torr.

Bot. Club. 27:528. 1900. In moist turf along the beach. June 25. R. and B. 45.

ALLIUM CERNUUM Roth. ex Roem. Arch. 1:Part 3.40. 1798. Frequent on the rocky beaches. June 24. R. and B. 32.

LILIUM COLUMBIANUM Hanson. Journ. Linn. Soc. 14:243. 1874. Frequent on the open ridges of the higher forest region. July 19. R. 785.

UNIFOLIUM DILATATUM (Nutt.) Greene, Man Bot. San. Fran. Bay. 316. 1894. In the shady forest and also along the outer edge of the salal society. June 25. R. and B. 38.

ERYTHRONIUM GRANDIFLORUM Pursh. Lindl. Bot. Reg. 1786. Frequent in the dense forest of the Gordon River valley. Aug. 1. R. 836.

DISPORUM MENZIESII Nichols, Dict. Gard. 1:485. Frequent in the same habitat as the preceding. Aug. 1. R. 837.

STREPTOPUS AMPLEXIFOLIUS (L) DC. Fl. France, 3: 174. 1805. Frequent on the banks of streams in the forest. June 6. R. and B. 85.

STENANTHIUM OCCIDENTALE A. Gray, Proc.

Amer. Acad. 8:405. Rare along the Gordon River. July 3. R. and B.

TRILLIUM OVATUM Pursh. Fl. Am. Sept. 1:245. 1814. Higher forest of Gorden River valley. Common on Mt. Edinburgh. Aug. R. 839.

IRIDACEÆ

SISYRINCHIUM IDAHOENSE Bicknell, Bull. Torr. Bot. Club. 26:445. 1899. Growing in moist turf on the beach and also in crevices. June 21. R. and B. 14.

HYDASTYLIS BRACHYPUS Bicknell, Bull. Torr. Bot. Club. 27:379. 1900. Same habitat as the preceding. June 26. R. and B. 48.

ORCHIDACEÆ

LIMNORCHIS STRICTA (Lindl.) Rydb. Mem. New York Bot. Gard. 1:105. 1900. In Sphagnum swamps and boggy places of the forest throughout. July 7. R. and B. 97. July 19. R. 780.

LIMNORCHIS GRAMINIFOLIA Rydb. Bull. Torr. Bot. Club. 28:627. 1901. Frequent in Sphagnum swamps with the preceding species. Aug. 11. R. 912.

LISTERA CORDATA R. Br. Ait. Hort. Kew. Ed. 2, 5:201. 1813. In densely shaded places in the forest where undergrowth is scarce. July 13. R. and B. 125.

GOODYERA MENZIESII Lindl. Gen. et Sp. Orch. 402. Mt. Edinburgh. Aug. 1905. F. K. Butters.

SPIRANTHES ROMANZOFFIANA Cham. and Schlecht. Linnæa 3:321. 1828. Mt. Edinburgh. Aug. 1905. F. K. Butters.

MYRICACEÆ

MYRICA GALE L. Sp. Pl. 1024. 1753. Abundant in Sphagnum bogs. Aug. 11 R. 918.

SALICACEÆ

SALIX SITCHENSIS Sanson; ex Bong. Mem. Acad. Petersb. 2:162. 1833. Frequent along the shores of Lake San Juan. July 22. R. 799.

SALIX LASIANDRA Benth. Pl. Hartw. 355. 1839-1857. On the banks of streams in San Juan river valley. Aug. 7. R. 900.

BETULACEÆ

ALNUS OREGANA Nutt. Silv. 1:28. 1842. Mostly along the edge of the forest, infrequent along the banks of the Gordon and San Juan rivers. July 13. R. and B. 134.

LORANTHACEÆ

RAZOUMOFSKYA TSUGENSIS Rosend. Minn. Bot. Stud. III. Part 2. 271. 1903. Parasite on *Tsuga heterophylla*. July 25. R. 826.

POLYGONACEÆ

RUMEX SALICIFOLIA Weinm. Flora, 4:28. 1821. Infrequent on the exposed rocky beaches. July 18. R. 763.

RUMEX ACETOSELLA L. Sp. Pl. 338. 1753. Frequent along trails and roadsides. July 9. R. and B. 100.

CARYOPHYLLACEÆ

ALSINE CRISPA (C. and S.) Holzinger, Contrib. U. S. Nat. Herb. 3:216. 1893. Introduced and frequent along trails in the forest. June 25. R. and B. 41.

ALSINE BRACHYPETALA (Bong.) Howell. Fl. North West. Am. 1897. On the beach of moist sandy inlets or coves. June 26. R. and B. 53.

SAGINA OCCIDENTALIS Wats. Proc. Am. Acad. Sc.

10:334.1875. In moist crevices on the rocky beaches. June 27. R. and B. 62.

Ammodenia major (Hook.) Heller. Catalogue of N. Am. Pl. Common among driftwood on the sandy beaches. July 12. R. and B. 126.

PORTULACACEÆ

Montia siberica (L) Howell. Erythea 1:38, 1893. Frequent on the moist, moss covered ledges of the protected rocky beaches. June 27. R. and B. 60.

Montia parvifolia Greene Fl. Fran. 181.1891. Same habitat as the preceding. June 18. R. and B. 8.

NYMPHÆACEÆ

Nymphæa polysepala (Engelm.) Greene, Bull Torr. Bot. Club. 15:84,1888. San Juan Lake. Aug. 7. R. 893.

RANUNCULACEÆ

Coptis asplenifolia Salisb. Trans. Linn. Soc. 8:306.1807. Frequent in Sphagnum swamps and boggy places in the forest. July 19. R. 781.

ACTÆA RUBRA Willd. Enum. Hort. Berol. 561. Hodag Lake, Aug. 8. 1905. F. K. Butters.

AQUILEGIA FORMOSA Fisch. ex DC. Prod. 1:50. 1824. Common as a crevice plant on the rocky beaches. June 25. R. and B. 23.

ANEMONE LYALLII. Britton, Ann. New York Acad. Sc. 6:227. 1891. Infrequent on the banks of the Gordon river. July 31. R. 849.

TRAUTVETTERIA GRANDIS Nutt. Torr. and Gray Fl. N. Am. 1:37. 1840. Frequent in the shady forest of the Gordon river valley. July 3. R. and B. 82.

RANUNCULUS BONGARDI Greene, Erythea 3:54. 1895. Common on moist rocky banks. June 23. R. and B. 22.

RANUNCULUS INTERMEDIUS (Hook.) Heller. Bull. Torr. Bot. Club. 25:580. 1898. Low sandy beaches of Lake San Juan. Aug. 7. R. 884.

BERBERIDACEÆ

BERBERIS NERVOSA Pursh. Fl. Am. Sept. 1:219. 1814. Frequent on the burnt over region of Mt. Edinburgh. Aug. 1. R. 843.

ACHLYS TRIPHYLLA DC. Syst. 2.35.1821. Frequent in the deeply shaded forest of the Gordon river valley. Aug. 1. R. 847.

PAPAVERACEÆ

DICENTRA FORMOSA DC. Syst. 2:109.; Prod. 1.125. 1824. Mt. Edinburgh, Alt. 2500 ft. July, 1904. Holway & Butters.

CRUCIFERAE

CARDAMINE ANGULATA Trin. Hook. Bot. Misc. 1:343.1830. Infrequent on the sandy back-strand at Lake San Juan. July 22. R. 805.

ARABIS HIRSUTA (L.) Scop. Fl. Carn. Ed. 2, 2: 30.1772. In crevices of rocks along the beach. June 20. R. and B. 12.

DROSERACEÆ

DROSERA ROTUNDIFOLIA L. Sp. Pl. 281.1753. Infrequent as a crevice plant on the moist rocky beaches. July 13. R. and B. 130. Abundant in Sphagnum bogs throughout Aug. 13. R. 927.

SAXIFRAGACEÆ

BOYKINIA ELATA (Nutt.) Greene, Fl. Francis. 190. 1891. Common on moist stream banks. June 27. R. and B. 58. July 5. R. and B. 84.

TIARELLA TRIFOLIATA L. Sp. Pl. 406. 1753. Occurs with the preceding. June 26. R. and B. 46.

TIARELLA LACINIATA Hook. Fl. Bor. Am. 1:239. 1833. Mt. Edinburgh. Aug. 1904. F. K. Butters.

SAXIFRAGA NOOTKANA Ser. ex DC. Prod. 4:40. 1830. Mt. Edinburgh, Aug. 1904. F. K. Butters.

HEUCHERA MICRANTHA Dougl. ex Lindl. Bot. Reg. 1302. 1830. On dry exposed rock ledges along the beach, infrequent. July 25. R. 816.

HEUCHERA GLABRA Willd. ex Roem. and Schult. Syst. 6:216. 1820. Frequent on the rocky banks of the Gordon river. July 31. R. 856.

TELLINA GRANDIFLORA (Pursh.) Dougl. ex Lindl. Bot. Reg. m. 1178. 1828. On moss covered ledges of the protected beaches. July 1. R. and B. 76.

MITELLA OVALIS Greene, Pittonia 1:32. 1887. Found infrequently along the trails in the San Juan valley. Aug. 7. R. 878.

TOLMIEA MENZIESII T. and G. Fl. N. Am. 1:582. 1840. Same habitat as the preceding. Aug. 7. R. 897.

PARNASSIA FIMBRIATA Banks; ex Kon. and Sims, Ann. Bot. 1:391. 1805. On the moist rocky banks of the Gordon River. July 31. R. 860.

RIBES BRACTEOSUM Dougl. Hook. Fl. Bor. Am. 1:233. 1833. Frequent along the banks of small streams. July 9. R. and B. 105.

RIBES LACUSTRE (Pers.) Poir, Encyc. Suppl. 2:856. Mt. Edinburgh. Aug. 1904. F. K. Butters.

ROSACEÆ

NEILLIA CAPITATA (Pursh.) Greene, Pitt. 2:28. 1889. Common on the rocky backstrand of Lake San Juan. July 22. R. 798.

SPIRÆA MENZIESII Hook. Fl. Bor. Am. 1:173. 1833. Associated with the preceding plant. July 22. R. 797.

ERIOGYNA PECTINATA (Pursh.) Hook. Fl. Bor. Am. 1 : 255. 1833. Mt. Edinburgh, Alt. 3000 ft. Aug. 1904. F. K. Butters.

ARUNCUS ARUNCUS (L.) Karst. Deutsch. Fl.

779 (1880-83). Occurs occasionally along the forest edge. June 28. R. and B. 66.

MALUS RIVULARIS (Dougl.) Roem. Syn. Rosifl. 216. Mostly along the forest edge in the salal society, occasionally in the forest. June 25. R. and B. 72.

SORBUS OCCIDENTALIS (S. Wats.) Greene Fl. Fr. 54. Hodag Lake, Alt. 1000 ft. Aug. 1905. F. K. Butters.

AMELANCHIER ALNIFOLIA Nutt. Journ. Phil. Acad. Sci. 7:22. Frequent along the forest edge. July 6. R. and B. 88.

RUBUS PARVIFLORUS Nutt. Gen. 2:308.1818. Common on the open beaches along the forest edge. June 18. R. and B. 3.

RUBUS URSINUS C. and S. Linnæa 2:11.1827. A low, running shrub, common along the border of the salal. June 23. R. and B. 26.

RUBUS SPECTABILIS Pursh. Fl. Am. Sept. 1:348. 1814. Common throughout the region, popularly known as the salmon berry. July 18. R. 761.

FRAGARIA CHILOENSES (L) Duch. Hist. Nat. Frais. 165. Common on the rocky beaches, occuring mostly as a crevice plant. June 24. R. and B. 29.

COMARUM PALUSTRE L. Sp. 502.1753. Frequent on the mid and backstrand of San Juan Lake. Aug. 7. R. 899.

POTENTILLA VILLOSA Pall. ex Pursh. Fl. Am. Sept. 1:353.1814. In dry crevices on the exposed rocky beaches. June 18. R. and B. 4.

ARGENTINA ANSERINE GRANDIS (T. and G.) Rydberg. Mem. Dept. Bot. Columbia Univ. 2:161. Common on low sandy beaches. June 18. R. and B. 5.

GEUM MACROPHYLLUM Willd. Enum. 1:557.1809 Frequent along the forest edge fronting the harbor beach. July 22. R. 795.

SANGUISORBA MEDIA L. Sp. Pl. ed. 2:169.1762. Common in Sphagnum bogs. Aug. 11. R 911.

ROSA NUTKANA Presl. Epim. 203. Frequent among the salal along the forest edge. June 18. R. and B. 2.

ROSA GYMNOCARPA Nutt; Torr. and Gray Fl. N. Am. 1:461.1840. Common along the banks of the Gordon river. July 3. R. and B. 80.

LEGUMINOSÆ

Lupinus latifolius Agardh. Syn. Gen. Lupin. 18. Mt. Edinburgh. Aug. 1904. F. K. Butters.

Trifolium heterodon Torr. and Gray Fl. N. Am. 1:318.1840. Occurs on both sandy and rocky beaches. June 21. R. and B. 13.

Vicia gigantea Hook. Fl. Bor. Am. 1:157.1833. Frequent on the higher portions of the beach. June 26. R. and B. 54.

Lathyrus maritimus Bigel. Fl. Bost. ed. 3: 286.1824. On moist sandy beaches. June 26. R. and B. 52.

Lathyrus nuttallii Wats. Proc. Amer. Acad. 21:450.1886. Occurs infrequently on the banks of the Gordon river. July 3. R. and B. 81.

CALLITRICACEÆ

Callitriche palustris L. Sp. Pl. 969.1753. In San Juan Lake and slow streams of the San Juan valley. Aug. 7. R. 885.

EMPETRACEÆ

Empetrum nigrum L. Sp. Pl. 1022.1753. Common in Sphagnum bogs. July 27. R. 827.

ACERACEÆ

ACER MACROPHYLLUM Pursh. Fl. Am. Sept. 1:267.1814. Noted but not collected. Frequent along the banks of both the San Juan and Gordon rivers.

ACER GLABRUM Torr. Ann.Lyc. New York 2:172, 1828. Gordon River valley, Aug. 1905. F. K. Butters.

GUTTIFERÆ

HYPERICUM ANAGALLOIDES Cham. and Schlecht. Linnæa 3:127.1828. In boggy places in the forest. July 9. R. and B. 101.

VIOLACEÆ

VIOLA GLABELLA Nutt. Torr. and Gray Fl. N. Am. 1:142.1840. Frequent in the forest of the river valleys. Aug. 1. R. 838. Aug. 7 898.

VIOLA SP. A small form growing on the boulders and rocky banks in the Gordon River channel. Aug. 1. R. 857.

ONAGRACEÆ

CHAMÆNERION ANGUSTIFOLIUM (L.) Scop. Fl. Carn. ed. 2, 1:271.1772. On sandy and rocky beaches. Common on the burnt over slopes of Mt. Edinburgh. July 7. R. and.B. 94.

CHAMÆNERION LATIFOLIUM (L.) Sweet, Hort. Brit. ed. 2, 198.1830. Frequent in the rocky channel of the Gordon river. July 31. R. 841.

EPILOBIUM ADENOCAULON Housskn. Oester. Bot. Zeitschr. 29:119. Growing abundantly on the slopes of Mt. Edinburgh. July 31. R. 854.

EPILOBIUM GLANDULOSUM Lehm ex Hook. Fl. Bor. Am. 1:206. 1833. 2:14. Occurs along the forest edge, infrequent. July 9. R. and B. 112.

CIRCÆA ALPINA L. Sp. Pl. 9.1753. Occasionally along the trail in the Gordon river valley and on the slopes of Mt. Edinburgh. This plant seems to correspond in every respect with Circæa alpina L. Most of the collections from the island and surrounding mainland are recorded as Circæa pacifica Asch. and Magn., but in this instance there is no adequate reason for such separation. Aug. 1. R. 834.

HALORRHAGIDACEÆ

Myriophyllum spicatum L. Sp. Pl. 992.1753. In Lake San Juan. Aug. 7. R. 888.

Hippuris vulgaris L. Sp. Pl. 4.1753. Occurs on the front strand of Lake San Juan. July 22. R. 791.

ARALIACEÆ

Fatsia horrida Benth. and Hook. f. Gen. 1:939. Frequent along creeks in the Gordon River valley. Aug. 1. R. 833.

UMBELLIFERAE

Sanicula menziesii Hook. and Arn. Bot. Beech. Voy. 142. Growing in the salal society, infrequent. July 18. R. 762.

Washingtonia divaricata (Nutt) Britt.; Britton and Brown Ill. Fl. N. Am. 2: 531. 1897. Shaded banks of streams, San Juan River valley. July 22. R. 804.

Oenanthe sarmentosa Presl. ex DC. Prod. 4:138. Along banks of streams. July 22. R. 803. Sandy beaches July 19. R. 779.

Conioselinum gmelini (Ch. and Schlect.) C. and R. Monograph N. Am. Umbel. Contrib.

U. S. Nat. Herb. 7:1900. Common among driftwood on the sandy beaches. Aug. 9. R. 901.

HERACLEUM LANATUM Michx. Fl. Bor. Am. 1:166.1803. Common among the shrubs of the forest edge. July 1. R. and B. 75.

CORNACEÆ

CORNUS CANADENSIS L. Sp. Pl. 117.1753. Frequent on the higher ridges in the forest. July 7. R. and B. 95

CORNUS OCCIDENTALIS (T. and.G.) Coville Contrib. Nat. Herb. 4: 117. 1893. On banks of streams in the region of San Juan Lake. Aug. 7. R. 800.

PYROLACEÆ

PYROLA SECUNDA L. Sp. Pl. 396. 1753. Mt. Edinburgh. Alt. 3500 ft. July,1904. F. K. Butters.

MONESES UNIFLORA (L.) Gray, Man. 273. Along trails in the forest of the San Juan valley. Aug. 7. R. 876.

MONOTROPA HYPOPITYS L. Sp. Pl. 387.1753. Gordon River valley, infrequent.

NEWBERRYA CONGESTA Torr. ex Ann. Lyc. New York 8:55.1867. In the densely shaded lower forest of the Gordon River valley. Aug. 1. 835.

ERICACEÆ

MENZIESIA URCEOLARIA Salisb. Par. Lond. pl. 44.1806-7. (Menziesia ferruginea Pursh). Common as a forest undershrub throughout. June 26. R. and B. 47.

KALMIA GLAUCA Ait. Hort. Kew. ed. 1.2:64. Common in Sphagnum bogs. Aug. 11. R. 917.

GAULTHERIA SHALLON Pursh. Fl. Am. Sept. 1:288.1814. Common as underbrush throughout, most abundant along the forest edge. June 26. R. and B. 56.

VACCINIUM OVALIFOLIUM Smith; ex Rees Cyclop. 36:n. 2. Frequent in the forest throughout. June 29. R. and B. 69.

VACCINIUM PARVIFOLIUM Smith. in Rees' Cyclop. 36: n. 3. Occurs with the preceding, but more abundantly. June 29. R. and B. 68.

VACCINIUM OVATUM Pursh. Fl. Am. Sept. 1: 290.1814. On some of the open ridges of the higher forest, infrequent. July 9. R. and B. 99.

VACCINIUM MYRTILLOIDES Hook. Fl. Bor. Am. 2:32.1833. Mt. Edinburgh, Alt. 1200 ft. F. K. Butters.

OXYCOCCUS PALUSTRIS Pers. Syn. 1:419.1805. In Sphagnum swamps and boggy places in the forest. July 19. R. and B. 782.

CLADOTHAMNUS PYROLIFLORUS Bong. Veg. Sitch. 37. Grows as a small shrub on the rocky banks of the Gordon River. July 31. R. 865.

PRIMULACEÆ

TRIENTALIS EUROPÆA ARCTICA Ledeb. Fl. Ros. 3:25.1846-1851. On moist moss covered rocks along the forest edge. June 22. R. and B. 16.

TRIENTALIS LATIFOLIA Hook. Fl. Bor. Am. 2:121.1833. Frequent on the slopes of Mt. Edinburgh. July 31. R. 853.

GLAUX MARITIMA L. Sp. Pl. 207.1753. In moist turf along the beach. June 28. R. and B. 63.

PLUMBAGINACEÆ

ARMERIA VULGARIS Willd. Enum. Hort. Berol.

333. Frequent as a crevice plant on the open rocky beaches.

GENTIANACEÆ

Gentiana douglasiana Bong. in Mem. Acad. Petersb. 2:156.1833. Common in Sphagnum bogs. July 7. R. and B. 96.

Gentiana sceptrum Griseb. Gen. et Sp. Gent. 293. Hodag Lake, Aug. 1905. F. K. Butters.

Fauria crista-galli (Menzies) Makino, Tokio Bot. Mag. 18: 15. 1904. Growing abundantly in a few Sphagnum bogs in the region. Aug. 2. R. 873.

Menyanthes trifoliata L. Sp. Pl. 145.1753. Hodag Lake, Aug. 1905. F. K. Butters.

HYDROPHYLLACEÆ

Romanzoffia sitchensis Bong. Mem. Acad. Petersb. 2: 156, 1833. Mt. Edinburgh, Alt. 1500 ft. Aug. 1904. F. K. Butters.

LABIATÆ

Stachys ciliatus Dougl. ex Benth. Lab. Gen. et Sp. 539. On moist sandy beaches. June 29. R. and B. 71.

Prunella vulgaris L. Sp. Pl. 600.1753. Frequent on the rocky beaches. June 18. R. and B. 1.

Lycopus communis Bicknell. ex Britton. Man. 803. 1901. Growing on the sandy beach of Lake San Juan. Aug. 7. R. 881.

SCROPHULARIACEÆ

Scrophularia californica Cham. and Schlecht. Linnæa 2:585.1827. On moist, sandy beaches. June 26. R. and B. 55.

Chelone nemorosa Dougl. ex Lindl. Bot. Reg. t. 1211. Infrequent on moist moss covered rocks along the Gordon River. July 31. R. 868.

Pentstemon menziesii Hook. Fl. Bor. Am. 2:98.1833. Mt. Edinburgh, Alt. 3500. ft. July, 1904. Holway & Butters.

Mimulus langsdorfii Donn. ex Sims. Bot. Mag. pl. 1501. In moist crevices of the rocky beaches. June 18. R. and B. 6.

Mimulus moschatus Dougl.; ex Lindl. Bot. Reg. 1118. Along forest trails in the San Juan River valley. Aug. 7. R. 895.

Veronica anagallis-aquatica L. Sp. Pl. 12.

1753. In pools on the elevated portions of the beaches. June 25. R. and B. 40.

VERONICA SCUTELLATA L. Sp. Pl. 12.1753. On low shores of Lake San Juan. July 22. R. 792.

VERONICA SERPYLLIFOLIA L. Sp. Pl. 12.1753. On the rocky beaches along the forest edge. July 25. R. 818.

CASTILLEJA ACUMINATA (Pursh) Spreng. Syst. 2:775. As a crevice plant on the exposed beaches. Very abundant. June 23. R. and B. 24.

LENTIBULARIACEÆ

PINGUICULA VULGARIS L. Sp. Pl. 18.1753. On the moist rocky banks of the Gordon River July 31. R. 862.

OROBANCHACEÆ

BOSCHNIAKIA STROBILACEÆ A. Gray. Pacif. Rail. Rep. 4:118. Parasitic on the roots of *Gaultheria shallon* and frequent throughout the region. July 9. R. and B. 189.

PLANTAGINACEÆ

PLANTAGO MAJOR ASIATICA Decaisne DC.

Prod. 13:695.1849. In dry crevices on the exposed rocky beaches. Aug. 9. R. 903.

PLANTAGO MARITIMA L. Sp. Pl. 114.1753. Same habitat as the preceding. June 22. R. and B. 21.

PLANTAGO MACROCARPA Cham. and Schlecht. Linnæa 1:166.1826. Frequent in Sphagnum bogs. Aug. 11. R. 910.

RUBIACEÆ

GALIUM APARINE L. Sp. Pl. 108.1753. On sandy beaches near the forest edge. July 22. R. 808.

GALIUM TRIFLORUM Michx. Fl. Bor. Am. 1:80. 1803. Common in the river valley and on the slopes of Mt.Edinburgh. July 31. R. 846.

GALIUM VAILLANTII DC. Fl. Fr. 4:263. On moist sandy beaches, among tall weeds. July 11. R. and B. 117.

GALIUM TRIFIDUM PACIFICUM Wiegand Bull. Torr. Bot. Club. 24:400.1897. Frequent on the mid-strand of Lake San Juan. Aug. 7. R. 882.

CAPRIFOLIACEÆ

SAMBUCUS LEIOSPERMA Leiberg, Biol. Soc. Wash. 11: 40. 1897. A common shrub in the river valleys. July 22. R. 794.

LINNÆA BOREALIS L. Sp. Pl. 631.1753. In the underbush along the forest edge. June. 22. R. and B. 20.

SYMPHORICARPOS RACEMOSUS Michx. Fl. Bor. Am. 1:107.1803. Banks of the Gordon River July 31. R. 866.

LONICERA INVOLUCRATA (Rich.) Banks; ex Spreng. Syst. 1: 759. Frequent in the salal society. July 1. R. and B. 73.

CAMPANULACEÆ

CAMPANULA PETIOLATA DC. Monograph Campan. 278. Growing on the rocky banks of the Gordon river. July 31. R. 861.

CAMPANULA ROTUNDIFOLIA arctica Lange. Fl. Dan. 14. 8. t. 7211. Mt. Edinburgh, July, 1904. F. K. Butters.

VALERIANACEÆ

VALERIANA SITCHENSIS. Bong. Veg. Sitch. 145. Infrequent on the banks of the Gordon river.

COMPOSITÆ

SONCHUS ASPER (L) All. Fl. Ped. 1:222. 1785. Introduced and growing on sandy beaches Aug. 12. R. 920.

APARGIDIUM BOREALE T. and G. Fl. N. Am 2:474.1841. Common in Sphagnum bogs of the higher forest. July 8. R. 767. July.28. R. 830.

NABALUS ALATUS Hook. Fl. Bor. Am. 1:294. 1833. On the rocks at the edge of the forest. July 8. R. 766.

HIERACIUM ALBIFLORUM Hook. Fl. Bor. Am. 1:298.1833. Along the forest edge, San Juan Harbor. July 22. R. 796.

ASTER FOLIACEUS Lindl. DC. Prod. 5:228. Common on rocky ledges along the beach. July 25. R. 817.

ASTER MAJOR (Hook.) Porter. Mem. Torr. Bot. Club. 5:325. Among rocks in the Gordon River channel. July 31. R. 842.

ERIGERON PHILADELPHICUS L. Sp. Pl. 863.1753. On the rocky banks of the Gordon River. July 31. R. 859.

ANAPHALIS SUBALPINA (Gray) Rydberg. Mem. New York. Bot. Gard. 1:415.1900. Common among driftwood on sandy beaches. Aug. 9. R. 902.

ADENOCAULON BICOLOR Hook. Bot. Misc. 1:19. 1830. On the sandy banks of the Gordon river, July 31. R. 867.

ACHILLEA LANULOSA Nutt. Journ. Acad. Sci. Phila. 7:36. In crevices of the rocky beaches. July 23. R. and B. 25.

TANACETUM HURONENSE Nutt. Gen. Am. 2:141. 1814. On the driftwood beaches. July 24. R. and B. 31.

ARTEMISIA SUKSDORFII Piper. Bull. Torr. Bot. Club. 28:42.1901. Common on the sand beach of San Juan Harbor. July 31. R. 870.

ARNICA MACOUNII Greene. Pittonia 4:160.1899-1901. In the rocky channel of the Gordon River. July 3. R. and B. 83.

LUINA HYPOLEUCA Benth. ex Hook. Ic.Pl. t. 1139. 1873. On rocks in the channel of the Gordon River. July 31. R. 863.

This catalogue gives a total of 253 species and varieties for the region covered. An examination will reveal the fact that the *Pterid-ophyta* are represented by 18 species, 12 of which come within the family *Polypodiaceæ*. The genera *Polystichum*, *Lomaria*, *Pteris*, and *Dry-opteris* constitute the principal part of the Pter-idophytic vegetation.

The *Gymnospermæ* are represented by 2 families of the *Coniferæ* and present 8 genera and 10 species. The great bulk of the Van-couver Island vegetation falls within this division and 4 or 5 species preponderate heavily: these are *Picea sitchensis Thuja plicata*, *Tsuga heter-ophylla*, *Abies amabilis*, and *Pseudotsuga taxi-folia*.

Two hundred and twenty-two species belong to the *Angiospermæ* of which 79 are *Mono-cotyledons* and 143 *Dicotyledons*,. The former class presents 42 genera in 10 families: the latter 119 genera in 42 families. The characteristic northern preponderance of grasses, sedges, and rushes is shown by the fact that the family *Gramineæ* yields 24 species. The *Cyperaceæ* come second with 22 species and the *Juncaceæ* fifth with 9 species. The latter being exceeded in point of number of species by three dicotyledonous families, the *Rosaceæ* with 18, the *Compositæ* with 14 and the *Saxifragaceæ* with 12. Since grasses, sedges and rushes nearly always build compact groups or societies with numerous individuals, it follows that a considerable array of species of these types means a considerable occupation of the available ground.

Among the dicotyledonous families, aside from those mentioned above, the *Ericaceæ* show 9 species, the *Scrophulariaceæ* 9, the *Ranunculaceæ* 7 and so on in decreasing number. Of the 52 angiospermous families 18 are represented by but a single species each.

In giving the above figures the writer is well aware that the attempts to convey an idea of the aspect of vegetation and the floral composition of a given region by means of statistics, and percentages especially, are often misleading and many times prove good as useless. This is partly due to the fact that statistics and percentages, based on a bare enumeration of families, genera and species do not incorporate the right elements of proportion and color, and futhermore do not allow for the item of error due to the various conceptions of species and genera. Only in so far as they are general can figures in this connection be relied on, and only in so far as they can be co-ordinated with other explanations do they explain.

Summary and Conclusion.

In the light of the above generalization, the main facts to be gained from the cited figures can be summed up as follows:—

a. That the pteridophytic flora is poor in number of species for a region showing almost tropical conditions as regards moisture, yet shows great density and profusion.

b. That the gymnospermous flora forms the all important group and constitutes the great mass of the island vegetation.

c. That of the two classes of Angiosperms, the Monocotyledons occupy a more important position than the Dicotyledons. This relegation of the Dicotyledons to a secondary place is not without bearing upon other and interesting biological phenomena. For there can be little doubt that the dearth of insects of almost all kinds is largely conditioned by the comparative lack of entomophilous flowers. And again the disparity in the insect population may be the chief cause for the scarcity of song birds, but further pursuance of these suggested thoughts would be digression here.

In conclusion it can be said in general, that the flora of Vancouver Island, in so far as it can be judged by observations confined to a limited area of the same, is typically boreal: with an admixture of more arctic forms than the latitude, the elevation above sea level, and present climatic conditions would indicate. This is perhaps best illustrated by the fact that several species which grow only a few feet above sea-level on the island are identical with forms found in the Canadian Rockies at altitudes of 4000–7000 ft. and at higher latitudes. The infiltration of southern forms is slight. The greatest complexity of plant life is shown in the beach formations. The coniferous forest is the principal formation of the region and has reached through favorable climatic and edaphic conditions it present enormous development. June, 1904.

The Conifers of Vancouver Island

The Conifers of Vancouver Island

FRED K. BUTTERS

One of the most natural phytogeographical regions of North America is the great coniferous forest which extends along the Pacific Ocean from central California to Kadiak Island in the Gulf of Alaska. The equable climate and heavy rainfall of this region have developed here the densest and most luxuriant forest to be found outside of the tropics.

To the east are continuous high mountain ranges which seldom stand more than one hundred and fifty miles from the sea, and are often much nearer. East of the mountains semi-arid conditions prevail except where other high mountains cause a local increase in the precipitation, as in the Selkirk Mountains of British Columbia, the ranges of northeastern Washington, northern Idaho and western Montana, and the Sierra Nevada of California.

As Vancouver Island occupies a somewhat central position in this great Pacific forest, and as the climate and topography of this island is typical of the whole region, a discussion of its conifers is not without general interest.

The main facts brought out in the following discussion have been obtained from observations during four summers spent in the vicinity of the Minnesota Seaside Station in southwestern Vancouver. Additional data as to geographical distribution have been obtained from Macoun's Catalogue of Canadian Plants and Sargent's American Sylva, together with an examination of the specimens in the herbarium of the University of Minnesota and some personal observations made in the mountains of the upper mainland of British Columbia. The formal specific descriptions are largely adapted from Sargent's Sylva.

The topography of Vancouver Island is everywhere hilly and in the central portion it is very mountainous with numerous summits which reach the level of perpetual snow. As is usual in regions of rugged topography, there is very considerable local variation in climate. Stations at sea level have a mean temperature of 45° to 50° F.

The west coast, being under the immediate influence of the ocean, has cool summers and very mild winters, with exceedingly heavy rainfall which is heaviest in winter, but abundant even in summer. There are limited areas along this coast where frost is very rare, or almost unknown, but in most places there are two or three weeks of frosty weather each winter.

As the summer clouds and fogs are generally low-lying and are intercepted by hills fifteen hundred to two thousand feet high, the interior of the island has much hotter and dryer summers than the west coast, while the winters are somewhat more severe than in that region.

Mountains of moderate height even near the coast have a climate much like the interior of the island. In winter their climate is more severe than that of the adjacent lowlands, and there is a very heavy snowfall, but in summer as they stand above the comparatively thin layer of sea-cooled air, with its fogs and frequent rains, they are much warmer and drier than the lowlands. Above three thousand feet the usual alpine changes in the climate begin to appear, and above five thousand feet there is considerable perpetual snow.

Temperature conditions upon the east coast are intermediate between those of the west coast and those of the interior, but during the occasional cold waves of the winter the temperature of the east coast is often lower than that of the more sheltered interior. The rainfall upon the east coast is less than in the interior. It is especially light in the southeast peninsula in the vicinity of Victoria, as that part of the island is sheltered from the moist southwest winds by the lofty Olympic Mountains of northwestern Washington.*

* The following statistics are obtained from the Report of the Department of Agriculture of the Province of British Columbia for 1902.

	Latitude.	Mean temp. for year.	Mean temp. of warmest month.	Mean temp. of coldest month.	Maximum for 1902.	Minimum for 1902.	Number of months with mean above 50°.	Number of months with mean below 40°.	Rainfall.	Snowfall.
WEST COAST										
Clayoquot.	49°10′	48.9°	56.9°	41.3°	81°	18°	6	0	146.56 in.	20 in.
Cape Scott	50°48′	46.3	55.3	36.9	81	16	3	3	135.76 "	0 "
INTERIOR										
Alberni...	49°15′	50.4	67.6	35.8	94	13	6	3	62.68 "	36 "
EAST COAST										
Nanaimo..	49°11′	48.9	62.7	37.1	90	7	6	2	40.36 "	28 "
Victoria...	48°24′	49.1	59.7	38.0	86	12	5	2	30.57 "	16 "

	Alaska west of long. 140°.	Alaska—South-eastern coast.	Vancouver Island.	Lower mainland of British Columbia and western Washington.	Coast of Oregon and northern California.	Cascade Mountains of Oregon.	Sierra Nevada.	Eastern Washington, Selkirk Mountains and western ranges of Idaho and Montana.	Eastern and southern Rocky Mountains.
Taxus brevifolia......	—	—	+	+	+	+	+	+	—
Pinus contorta........	—	+	+	+	+	+*	*	*	*
Pinus monticola......	—	—	+	+	—	+	+	+	—
Abies sitchensis.......	+	+	+	+	+	—	—	—	—
Abies Mertensiana....	+	+	+	+	—	+	+	+	—
Abies heterophylla....	+	+	+	+	+	+	—	—	—
Abies taxifolia.......	—	—	+	+	+	+	+	+	+
Abies grandis.........	—	—	+	+	+	+	—	+	—
Abies amabilis.......	+	—	+	+	—	+	—	—	—
Abies lasiocarpa......	—	+	—(?)	+	—	+	—	+	+
Thuja plicata........	—	+	+	+	+	+	—	+	—
Cupressus nootkatensis	—	+	+	+	—	+	—	+	—
Juniperus communis..	?	+	+	+	—	+	+	+	+
Juniperus scopulorum.	—	—	+	+	—	+	—	+	+

* Pinus contorta var. Murrayana.

TABLE I. THE GEOGRAPHICAL DISTRIBUTION OF THE CONIFERS OF VANCOUVER ISLAND.

All parts of Vancouver Island are heavily forested except the southeastern peninsula and the higher mountain summits of the interior. The densest forests are to be found in the vicinity of the west coast, where the climatic conditions are particularly favorable to the growth of trees.

Only thirteen species of conifers are known to occur spontaneously on the island, viz.:-

TAXACEÆ

Taxus brevifolia

PINACEÆ

ABIETINEÆ

Pinus monticola
Pinus contorta
Abies (Picea) sitchensis
Abies (Hesperopeuce) Mertensiana
Abies (Tsuga) heterophylla
Abies (Pseudotsuga) taxifolia
Abies grandis
Abies amabilis

CUPRESSINEÆ

Thuja plicata

Cupressus nootkatensis

Juniperus communis var. siberica

Juniperus scopulorum

It is highly probable that further exploration of the higher mountains of the interior will reveal from one to three other species. of *Abietineæ*, as several members of this tribe which occur as alpine trees in the mountains of the adjacent mainland have not yet been found in Vancouver.

No conifer is endemic to the island, and most of the species recorded above are of very wide distribution as may be seen from Table I. on page 139. It will be noted from this table that the species gradually die out northward. No species occurs in Vancouver Island which does not extend southward at least into Oregon either along the coast, or in the Cascade Mountains. Nearly all the species extend eastward across the mountains of the interior of Washington and British Columbia to the Selkirk Mountains and other western ranges of the Rocky Mountain system. Very few of them are found in the Rocky Mountains south of Montana. Several species extend southward into the forests of the Sierra Nevada as alpine and subalpine trees. One noticeable fact is that nearly all these trees are able to withstand considerably more severe winter conditions than they undergo in Vancouver Island. Several of them occur far north along the Alaska coast, while others occur in the interior mountain districts where the winters are long and severe.

In this connection it should be noted that the geographical distribution of species appears quite incompatible with the theory that the present plants of the region are post-glacial immigrants either from the south or from the north, though it is quite probable that the plants of the northern part of the region have emigrated there from the more southern parts. As it appears impossible that there should have been an extensive post-glacial migration across the Cascade Mountains, the only logical alternative is that the present Pacific coast forest, at least its southern half, represents the survival of the pre-glacial forests of the region. In western Vancouver, while many of the valleys have been glaciated, the ridges facing the ocean show no signs of glacial action, and there appears to be no reason why such ridges may not have been forested during the entire glacial period, just as the hills of the Alaska coast are forested now, while the valleys are often filled with glaciers.

In this way fragments of the forests probably survived at many points along the coast of British Columbia, Washington and Oregon, and perhaps also at points in the interior, and from these remnants the present forests have evidently been formed.

In Vancouver Island the conifers are, with a few exceptions, widely distributed. The two Junipers are local, one in the dry southeastern district near Victoria, and the other as an alpine shrub on the high mountain summits. *Abies Mertensiana* is sub-alpine and apparently does not descend appreciably below three thousand feet.

The forest of the lowlands of the west coast is composed chiefly of spruce, western hemlock, and cedar, with a smaller proportion of *Abies amabilis*, yew and white pine, while *Pinus con-*

torta is common in certain peculiar situations. These are the trees which can flourish with the lowest summer temperatures provided that the season of growth is sufficiently long. It is notable that the three principal species of this formation all extend far north along the Alaska coast, and the spruce and hemlock are the last trees to disappear in that direction. The final limit of the forest in the vicinity of Kadiak island seems to be due to the lack of a sufficiently long season of growth, rather than to the winter cold which is not severe.

The Douglas fir, on the other hand, is essentially a tree which needs considerable summer heat, though it will withstand more severe winters than the spruce. It is not found anywhere in Alaska, and although it is very abundant in the interior of Vancouver Island and even on the mountains overlooking the west coast, it does not flourish on the lowlands close to the ocean and the occasional specimens which occur there are small, and offer a marked contrast to those which have developed in the more favorable climate of the interior.

Points concerning the local and general distribution of some of the other species will be considered in connection with the respective species.

In general it can be said that the conifers of Vancouver Island occupy at present the regions which are best adapted climatically to the individual species, and this can often be shown by a comparison of their local occurrence with their general geographical range. While some species may be slowly increasing their range, the whole Pacific coast forest region appears to be in a remarkable state of stability, and except where it has been interfered with by man, there is very little tendency for one species to replace another. The result is that over very wide areas the forests are practically identical in composition wherever the same climatic conditions obtain. Even where the forests have been burned or cleared the land becomes rapidly reforested with the same species wherever the burning or clearing is not sufficiently thorough and widespread to destroy the source of seed supply.

In the following pages descriptions are given of all the species of conifers known to occur in

Vancouver Island, with notes concerning their distribution in the forests of the southwestern parts of the island. Brief descriptions are given also of those conifers which from their general range will probably be found in the mountains of the island. For a key for the recognition of the genera from non-fruiting specimens see page 205.

FAMILY TAXACEÆ

Trees or shrubs with diœcious or very rarely monœcious flowers, the staminate often cone-like, terminal or axillary, solitary or in few-flowered clusters, composed of an axis bearing stamens, with or without sterile basal scales; pollen sacs commonly two on each stamen, rarely three to eight. Pistillate flowers usually solitary, axillary, seldom cone-like, composed of a longer or shorter axis, bearing one to many one-(or rarely two-) ovuled carpels, sometimes with sterile basal scales resembling the carpels, or the whole flower reduced to a single ovule terminating a short scale-bearing axis; ovules generally naked, projecting, often much exceeding the carpels, erect or more or less inverted. Seeds usually naked, drupaceous or with a hard testa surrounded by a more or less free, cup-like, fleshy aril.

A family comprising about ten genera and one hundred species, mostly inhabitants of the southern hemisphere, and of southeastern Asia and the adjacent islands. Besides the following, only the closely allied genus, Torreya, occurs in extra-tropical North America.

Taxus Linnæus, Sp. Pl. 1040.1753.

Flowers diœcious, the staminate solitary, axillary, short-stalked, with basal scales; stamens six to fourteen, peltate, each with six to eight coherent pollen sacs. Pistillate flower in the axil of the uppermost scale of a short scale-bearing, axillary branchlet, solitary, consisting of an axis bearing three pairs of decussate involucrate scales, and a single terminal, erect, naked ovule sessile upon an annular accrescent disc which in fruit becomes a fleshy cup-shaped aril nearly inclosing the woody seed.

Evergreen trees or shrubs with spirally inserted short-petioled, flat, linear leaves, which by the twisting of the petioles come to lie distichously on the lateral branches. About seven species, inhabitants of the north temperate zone, differing somewhat from one another in leaf characters and considerably in habit of growth, but otherwise so slightly that they have all been described as subspecies of the typical species, *Taxus baccata* L., the European yew.

Taxus brevifolia, Nuttall, Sylva, 3:86.1849. Yew.

A small or moderately large tree with long, slender, erect-spreading or horizontal branches; leaves above dark yellowish-green, below paler, linear, abruptly mucronate, 1.5-2.5 centimeters long, about 1.5 millimeters wide, with slender petioles 1-3 millimeters long; branchlet bearing the pistillate flower 3-5 millimeters long in fruit, clothed with numerous very small, round-obtuse scales; seed ovoid, about 5 millimeters long, vaguely 2-4 angled above. Northern British Columbia to central California, eastward to to western Montana.

A slow-growing tree with a trunk seldom over eight decimeters thick, or often a large shrub of irregular growth. The bark of the trunk is thin and purple in color and falls away in scales, so that in old trees it is marked with broad, shallow depressions. It, however, always maintains a very smooth surface. Despite this fact, in the damp Vancouver forests the trunk and branches of the yew are nearly always covered with a very heavy growth of mosses and lichens, often to a much greater extent than those of other trees with rougher bark.

Fruiting specimens of this tree may be readily identified by the peculiar fruits looking, when half-grown, like minute green acorns, and when ripe, conspicuous on account of the thick, fleshy, bright red aril which almost covers the seed. On account of the twisting of the petioles, the leaves of this tree appear two-ranked, although they are inserted spirally. The same character occurs to a greater or less extent in several other conifers of the region, but in none of them is it as perfectly developed as in the yew. In this respect it is most closely approached by the western hemlock, from which it may be readily distinguished by its sharp-pointed leaves, those of the hemlock being rounded or blunt. Moreover the foliage of the yew differs from that of the other conifers of this region in that it contains no resin and therefore is not at all aromatic, but has a purely bitter taste.

The wood of the yew is hard, strong, fine-grained and durable, but on account of the comparatively small size of the trees it is little used.

The seedling has two seed-leaves.

FAMILY PINACEÆ

Resinous trees or shrubs with monœcious or diœcious axillary or terminal flowers either solitary or forming inflorescences. Staminate flowers usually cone-like with an elongated axis bearing the stamens and usually some sterile basal scales; stamens often leaf-like; pollen sacs two to many on each stamen. Pistillate flower cone-like, composed of an elongated axis bearing two to many fertile carpels, with or without similar sterile scales; ovules one to many on each carpel, erect or inverted, provided with two integuments, seldom exceeding the carpels and usually concealed by the latter. Seeds often winged, with a woody or leathery testa, without a fleshy outer covering, concealed between the scales of the woody, fleshy or berry-like cone.

A family comprising about twenty-five genera and three hundred species, most abundant in temperate regions. Four sub-families are recognized: the *Araucarieæ*, trees of the southern hemisphere, the *Taxoideæ*, trees of southern and south-western North America, southeastern Asia and Tasmania, and the two sub-families, *Abietineæ* and *Cupressineæ* described below.

SUB-FAMILY ABIETINEÆ

Leaves spirally arranged. Pistillate cones with two kinds of scales, borne in pairs, spirally arranged upon the axis, each pair consisting of a carpel or bract scale (commonly referred to as the bract), bearing in its axil the usually larger placental scale (commonly referred to as the scale) which in turn bears two inverted ovules on its upper side.

Trees with linear or acicular foliage leaves, "needles", which may be obviously spiral in their arrangement, or may be apparently two-ranked as a result of the twisting of the petioles, or may be crowded together into fascicles borne on special dwarf branches.

The *Abietineæ* are widly distributed through the boreal regions, the north temperate zone, and the adjacent mountainous parts of the tropics. From five to nine genera and about 130 species are recognized. Almost two-thirds of the species, representing all but one of the genera, inhabit the Pacific slopes of North America and Asia.

The following is a synopsis of the North American genera of *Abietineæ*.

A. Shoots of two sorts, long and dwarf; leaves of dwarf shoots fascicled.

a. Only scale-leaves borne by the long shoots; foliage leaves persistent, in fascicles of 2-5 (rarely 1 or 6). Cones ripening the second year; cone-scales more or less thickened at apex. *Pinus*

b. Foliage leaves deciduous, borne singly on the long shoots; those of the dwarf shoots forming large fascicles. Cones ripening in one season; cone-scales thin. *Larix*

B. Twigs of only one sort, leaves evergreen, not fascicled; cones ripening in one season.
Abies

Pinus Linnæus, Sp. Pl. 1000.1753. in part.

Evergreen trees with two kinds of leaves, the primary scale-like, not green, deciduous, scattered and spirally arranged upon the long shoots of the plant, each having in its axil a dwarf shoot which bears a fascicle of 2-5 (rarely 1, 6 or 7) acicular foliage leaves surrounded by a sheath of scale-leaves. Flowers monœcious, the staminate with basal involucre-like scales, fascicled at the base of the young shoots of the year; stamens numerous, spirally arranged; anther sacs two, parallel, longitudinally dehiscent, surmounted by a transverse, sub-orbicular crest, or by a knob; pollen grains with two bladder-like appendages. Pistillate flowers solitary or clustered, lateral or subterminal; the scales much longer than the bracts; cones ripening at the close of the second season or later, woody, variously shaped, often very large, the scales more or less thickened and callous at the tips. Seeds destitute of resin vesicles, usually winged. A genus of about seventy species, widely distributed throughout the north temperate zone and adjacent mountainous parts of the tropics. The greater number of species is found in the warmer parts of the range, over one-third of the known species occurring in southwestern North America. The extensive pine forests of more northern regions are composed of comparatively few species. Only two pines are known to occur in Vancouver Island, while a third may grow in the more mountainous parts of the island.

Two sections of the genus *Pinus* are recognized.

Section 1. *Pinaster.* Endlicher, Synops. Conif. 166.1847. emended.

Apophysis of the cone-scale much thickened, more or less pyramidal with a central umbo. Foliage leaves in fascicles of one to five, usually with a persistent sheath of scales.

Leaves in groups of two. *Pinus contorta*

Pinus contorta Dougl., Loudon, Arb. Brit. 4:2292 1838. Scrub Pine.

A small tree with stout branches often form-

PLATE XII.—Pinus contorta growing in Sphagnum swamp.

ing a round or irregularly flattened top, or often dwarf and shrubby; foliage leaves in clusters of two, dark green, semi-cylindrical with concave inner faces, 3-6 centimeters long, about 1 millimeter wide, acute, and very minutely serrulate; cones often clustered, oval or subcylindrical, not deciduous; cone-scales hard, woody, thin, the exposed end slightly thickened and armed with a long slender somewhat recurved, finally deciduous spine; seeds about 2 millimeters long, with thin wings about 1 centimeter in length. Along the coast from Alaska to northern California and eastward to the Cascade range. Farther east it yields gradually to the variety *Murrayana*, which is one of the most abundant trees in the more arid forest regions of the interior from northern British Columbia to Colorado and the mountains of southern California.

In western Vancouver Island, this species is found as a low contorted shrub along the edge of the forest next to the ocean, and as a small irregular, flat-topped, slow-growing tree in the sphagnum bogs of the forest region. It seldom reaches a height of ten meters and it is often much smaller. It begins to flower and to bear fruit when it is only a few centimeters high. The ripe cones usually persist in an unopened condition and are frequently seen attached to the older branches and even to the trunks of the trees. The bark of the older trunks is thick, rough and furrowed both vertically and horizontally.

The variety *Murrayana*, the lodge-pole pine of the interior, is a straight, slender, narrowly conical, thin-barked tree, often 30 meters high, with leaves wider than those of the type. Intergrading forms connect these extremes.

Section 2. *Strobus*. Spach. Hist. Nat. Veg. Phaner. 11:394. 1842. emended.

Apophysis of the cone-scale not pyramidal, furnished with a terminal umbo. Foliage leaves in fascicles of five, with a usually deciduous sheath of scales.

Cones 12-25 centimeters long, cylindrical, ends of the scales little thickened, wing of seed longer than the seed. *Pinus monticola*

Cones 4-8 centimeters long, their scales much thickened, terminating in short, incurved triangular tips. *Pinus albicaulis*

Pinus monticola Douglas ex Lambert gen. Pinus. Ed. 1.3: pl. 87. 1837. White Pine.

A tree 30 meters or more in height, with comparatively slender spreading branches; foliage leaves in fascicles of five, triangular, rigid, minutely serrulate, bluish-green, glaucus,5-10 centimeters long; cones cylindrical, 12-30 centimeters long, their scales but slightly thickened at the end, tipped with a small umbo, widely spreading after the discharge of the seeds; seeds about 1 centimeter long, with wings about 3 centimeters in length. Vancouver Island and the southern mainland of British Columbia, southward and eastward to Montana, Idaho and the Sierras of central California.

A large tree with a trunk from one to two meters in diameter. Young trees have pale gray bark, which is often covered with small balsam blisters similar to those which commonly occur on young balsam fir trees. With age the bark becomes thicker, reddish-brown and rugose. The arge cones fall after the seeds are scattered and are conspicuous objects beneath the trees. Throughout the greater part of its range, *Pinus monticola* grows at high altitudes, reaching up to ten thousand feet in California, but in southwestern Vancouver Island it grows sparingly throughout the coast forest and is often abundant a short distance back from the shore at an altitude of about five hundred feet. Even at this altitude the summer fogs are much lighter than upon the shore, and the summer days are generally warmer. Trees close to the ocean are usually somewhat stunted in growth.

Pinus albicaulis Engelmann, Trans. St. Louis Acad. 2:209. 1863.

A small alpine tree with stout flexible branches; foliage leaves in fascicles of five, stout, rigid, dark green, acute, 4-7 centimeters long; cones dark purple, oval or subglobose, horizontal, sessile, 4-9 centimeters long; cone-scales much thickened, terminating in stout incurved triangular tips; seeds 1.5 centimeters long, falling without any attached wing. In the high mountains of British Columbia south of latitude

53°; thence southward to Wyoming and the Sierras of southern California.

This tree is not reported from Vancouver Island, but as it grows in the adjacent Coast ranges of the mainland, it may occur in the high mountains of the northern and central parts of the island.

Larix Adanson. Fam. Pl. 2:480. 1763.

A genus differing from *Pinus* chiefly in the cones, which ripen the first year and have unthickened scales, and in the leaves, which are deciduous, scattered and spirally arranged on the long shoots of the tree, crowded and forming many-leaved fascicles on the dwarf shoots. Three species occur in North America, none of which is reported from Vancouver Island. One, *Larix laricina* (Du Roi) Koch., a swamp-inhabiting tree of northeastern North America, finds its western limit in the Rocky Mountains of northern British Columbia and the Yukon region; one, *Larix occidentalis* Nuttall, is a large tree of the semi-arid region east of the Cascade Mountains; the third, *Larix Lyallii* Parlatore, an alpine tree occurring near timber line in the mountains of southern British Columbia, Alberta and the adjacent parts of the United States, may possibly be found in the high mountains of northern Vancouver Island.

Abies. Adanson. Fam. Pl. 2:480. 1763.

Evergreen trees without special dwarf leaf-bearing shoots. Leaves flat or more or less quadrangular, sessile or short-petioled, spirally arranged but often twisted so as to appear more or less two-ranked. Flowers monœcious, terminal or in the axils of leaves of the previous season's growth; the staminate pedicelled, composed of numerous spirally arranged stamens, with basal involucred scales; anther sacs two, surmounted by an orbicular or knob-like appendage; pollen grains with or without bladder-like appendages. Fruit a more or less woody cone, maturing in one season, its scales not thickened nor callous at the tips, the upper and lower scales of the cone commonly smaller than the others and sterile. Seeds winged.

A genus of about fifty species, natives of the boreal and north temperate regions and the adjacent mountainous parts of the tropics. About eighteen species occur in western America and about the same number in eastern Asia. The species may be grouped into several fairly distinct sections which are often recognized as genera. The relationship of these sections is, however, so complicated and the genera as currently recognized are so unsatisfactory that it seems best to include them all under the genus Abies. *

Synopsis of American sections of Abies.

A. Twigs roughened by the persistent leaf bases (sterigmata), cone-scales persistent, longer than the bracts.

a. Leaves sessile, quadrangular or flattened, resin ducts of leaves lateral, cones axillary or terminal. *Picea*

b. Leaves with a single median resin duct, petioled, cones terminal.

aa. Leaves quadrangular, without palisade tissue. *Hesperopeuce*

bb. Leaves flat, with palisade tissue. *Tsuga*

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* See note on page 207.

B. Twigs with or without sterigmata, leaves flat, petioled, furnished with lateral resin ducts, cones axillary, pendulous, cone-scales persistent, shorter than the bracts. *Pseudotsuga*

C. Twigs without sterigmata, marked with circular leaf scars, cones axillary, erect, cone-scales deciduous from the persistent axis. *Eu-Abies*

Section 1. *Picea*. Link. Abhand. Akad. Berlin. 179.1827. 1830. as genus. Spruce.

Leaves quadrangular or flattened, seldom twisted so as to appear two-ranked; leaf bases becoming woody and persistent as prominent sterigmata; resin ducts of leaves lateral, two or sometimes only one or none; leaves stomatiferous on all four sides, or in species with flat leaves mainly on the morphologically upper side. Flowers terminal, or in the axils of the upper leaves of the growth of the previous year. Staminate flower with a short, or occasionally a long slender pedicel; anther sacs opening longitudinally, surmounted by an orbicular toothed crest; pollen grains with bladder-like appendages. Pistillate flower erect, short-stalked, with bracts

PLATE XIII.—Tideland spruce

at first exceeding but soon exceeded by the scales. Fruit a woody pendulous cone; cone-scales longer than the bracts, persistent after the fall of the seeds; seeds without resin vesicles.

About sixteen species, inhabitants of north temperate and boreal regions, most abundant in western North America and eastern Asia.

Leaves flattened, whitish on upper side, bright green on under side, branchlets glabrous. *Abies sitchensis*

Leaves quadrangular, blue-green, branchlets pubescent *Abies Engelmanni*

Abies sitchensis (Bongard) Lindley and Gordon, Journ. Hort. Soc. Lond. 5:212.1850. [*Picea sitchensis* (Bongard) Carriere]. Tideland Spruce.

A large tree with a thick, strongly buttressed trunk; leaves flattened, acute or acuminate, silvery white and stomatiferous on the morphologically upper side, bright green on the morphologically lower side; branchlets glabrous; cones pendant, cylindrical-oval, 6-10 centimeters long, 2.5 -4 centimeters thick; their scales thin, lustrous, pale brown, oblong-oval, erose-denticulate above the middle. Near the coast from the shores of the Gulf of Alaska to northern California.

This spruce is the most characteristic tree of the Pacific coast forest, growing throughout almost the entire length of the region, but never occurring far from the ocean. It cannot endure extremes of summer heat or winter cold, but under the peculiar conditions which obtain along the Alaska coast, it reaches the extreme limit of tree growth in that direction. It forms one of the largest trees in the forests of western Vancouver Island. Specimens sixty meters high, with trunks two meters in diameter are not rare and not infrequently these dimensions are considerably exceeded. Under adverse circumstances it can, however, maintain life for a long time with very little increase in size, and curiously dwarfed specimens have been found growing in crevices in the rocks of the upper beach near the Minnesota Seaside Station.* In one case a tree less than a foot in height was found to have an age of ninety-eight years. The western hem-

* MacMillan, C. Note on some British Columbia Dwarf trees. Bot. Gaz. 38:379. 1904.

lock and white cedar are also sometimes similarly dwarfed, but less frequently and less perfectly than the spruce.

This spruce is readily distinguished from the other forest trees of the region by its bark, its foliage and its cones. The moderately thin bark varies from grey-brown to bright red-brown in color. That of young trees is moderately smooth, reddish-brown, and sometimes shows resin vesicles like those of balsam firs. The surface of the bark becomes cracked in older trees and drops off in the form of scales which leave shallow, concave scars. The bark does not become deeply furrowed nor shredded. The leading shoot of a young tideland spruce is very stiffly erect and fast growing. The twigs of the lateral branches are usually somewhat drooping. The leaves may be somewhat two-ranked, or may project equally in all directions about the stem. They are generally slightly twisted so as to bring the dark green lower side upwards towards the light. The leaves differ greatly in form and size even on the same tree, being sometimes narrow and sharply acuminate and sometimes, especially on vigorous well-lighted branches, large, wide and almost obtuse. The cones are borne on the upper branches of the tree. The unripe cones are pale yellow or ruddy, the ripe cones a glistening grayish-brown. They fall soon after the discharge of the seed and are conspicuous beneath the trees. The bracts of the mature cones are fairly conspicuous, about one-half the length of the scales, oblanceolate, serrate above, slightly acuminate. The scales are very thin and flexible. The seeds are small and long-winged. The seedling has usually five needle-like somewhat glaucous seed-leaves.

The wood of the tideland spruce is light, soft, and straight-grained. It is used considerably for lumber.

Abies Engelmanni Parry. Trans. St. Louis Acad. 2:122.1863. [*Picea Engelmanni* (Parry) Engelmann.] Engelmann Spruce.

A large tree, or in high alpine situations a shrub; leaves soft and flexible, strong-smelling, blue-green, quadrangular, with stomata on all sides; branchlets pubescent; cones oblong, cylindrical or oval, their scales truncate or acute at the apex, or obovate and rounded, erose-dentate or entire; seeds black, about half as long as their broad oblique wings.

Not reported from Vancouver Island, but possibly occurring on some of the higher mountains. This is the common spruce of the interior, occurring in the Rocky, Selkirk and Cascade Mountains of British Columbia and southward to New Mexico, Arizona and Oregon. It can be readily distinguished from the tideland spruce by its pubescent twigs and quadrangular leaves, which have a strong disagreeable odor. The cones of the two species are very similar, and despite the difference in foliage, mistakes in identification appear not to be rare.

Section 2. *Hesperopeuce* Lemmon, Report California State Board Forestry. 3:126.1890. as genus.

Leaves narrowly linear, slender-petioled, inserted upon small persistent, woody sterigmata, spirally arranged, spreading, stomatiferous on all sides, without palisade tissue, with abundant hypodermal sclerenchyma, and with a single median resin duct close to the hypoderm. Staminate flower axillary or terminal, subglobose with an elongated drooping pedicel; stamens short-stalked, globose; anther sacs opening transversely, surmounted by a short gland-like skin; pollen grains with bladder-like appendages. Pistillate flower sessile, terminal at the end of a short, leafy branchlet, the bracts exceeding the broad scales. Fruit a woody, pendulous or erect cone; cone-scales much larger than the bracts, persistent after the fall of the seeds; seeds furnished with resin vesicles.

This subgenus includes only the following species which is often included under *Tsuga*, from which it differs in the form and structure of the leaves, the pollen grains with bladder-like appendages, and the long bracts of the pistillate flower.

Abies Mertensiana (Bongard) Lindley and Gordon, Journ. Hort. Soc. Lond. 5:211.1850.

[*Abies Pattoniana* Jeffrey ex A. Murray. 1853.]

[*Tsuga Mertensiana* (Bongard) Sargent].

[*Tsuga Pattoniana* (Jeffery) Sénéclauze].

Mountain Hemlock. Patton Spruce.

PLATE XIV.—Upland forest. Mountain hemlock in foreground

An alpine tree with slender, often drooping branches and short, stout, erect branchlets; leaves crowded, extending out from the twigs in all directions, not flattened, stomatiferous on all sides, 1-2 centimeters long, obtusely pointed at the apex; cones 2-8 centimeters long, oblong cylindrical, sessile at the end of short leafy branchlets, pendulous or erect, purple or sometimes pale yellow-green; cone-scales oblong-ovate, longer than broad; seeds about 3 millimeters long with large resin vesicles and long wings. From Alaska southward along the mountain ranges to the southern Sierra Nevada and eastward in the high mountains of the interior of British Columbia, Idaho and Montana.

This tree usually occupies alpine regions near the limit of tree growth. It has been found on some of the higher mountains of southern Vancouver Island. On Mt. Edinburgh, near Port Renfrew, it occurs only close to the summit, not descending below three thousand feet. In the extreme northern part of its range it descends to sea-level and occurs in Alaska almost as far northwest as the tideland spruce and as it is able to withstand much more severe winter cold than the latter tree, it reaches farther inland in the northern part of its range. This tree differs entirely from the true hemlocks in its appearance. Its stout twigs with their thick, bluntly pointed, closely packed leaves projecting in every direction from the stem, gives it the appearance of some species of balsam fir, and the likeness is emphasized in many cases by the erect cones which, however, are not axillary, but terminal on short lateral leafy branchlets.

Sargent (*) has pointed out that both this tree and the following grow in the vicinity of Sitka, and that the *Pinus Mertensiana* of Bongard, collected on Baranoff island, is undoubtedly this species and not the following, as has been generally assumed.

Section 3. *Tsuga.* Carrière. Traité Conif. 185. 1855. in part, as genus.

Leaves flat, narrowly linear, slender petioled, inserted upon small persistent woody bases, spirally arranged and apparently two-ranked by the twisting of the petioles; leaf with stomata

* Sargent C. S. Sylva. 12:75. 1898.

on the under side, palisade tissue above and a single median resin duct between the vascular tissue and the lower epidermis. Staminate flower axillary or terminal, subglobose, with an elongated drooping pedicel; stamens short-stalked, globose; anther sacs opening transversely, surmounted by a short, gland-like spur; pollen grains without bladder-like appendages. Pistillate flower terminal, erect, short-stalked or subsessile, the scales exceeding the bracts. Fruit a woody, pendulous, or rarely erect cone; cone-scales much larger than the bracts, persistent after the fall of the seeds; the outer coat of the seeds furnished with resin vesicles.

Six closely related species, natives of temperate North America, Japan and the Himalayas

Abies heterophylla Rafinesque, Atlantic Journal. 1:119. 1832.
[*Tsuga heterophylla* (Rafinesque) Sargent].
[*Tsuga Mertensiana* (Gordon *not* Bongard) Carrière] Western Hemlock.

A large tree with slender, usually pendulous branches and very slender pubescent twigs; leaves distichous, flat, dark green and conspicuously grooved on the upper side, pale below, rounded at the apex, 5-20 millimeters long, with long and short leaves intermingled on the same twig; cones oblong-oval, sessile, 2-3 centimeters long, their scales thin, flexible, longer than broad, often abruptly contracted below the middle; seeds about 3 millimeters long, with few resin vesicles and long narrow wings. Alaska to central California, eastward to the Rocky Mountains of British Columbia and Montana.

Enduring without injury greater extremes of both heat and cold than the tideland spruce, the western hemlock ranges higher on the mountains and much farther into the interior than the latter tree. It is not, however, so well adapted to the short cold summers of the Alaska coast, and does not extend as far westward as the spruce. It is one of the most abundant trees of southern Vancouver Island, forming everywhere a large, and often the predominant element in the mixed forest of the low country near the coast. It is usually a somewhat smaller tree than the tideland spruce when the two are growing together under similar circumstances. Its bark is at first thin and somewhat scaly, but on old trees it becomes from one to two inches thick, deeply furrowed and rugged. The foliage is easily recognized. The growth of the current season is of a very bright fresh green color, the older leaves are dark and glossy on the upper side, glaucous beneath. The leaves are small, flat and very unequal in size, and the longer and shorter leaves are intermingled. The leaves are petioled, and as in the yew, they are twisted so that they lie almost in one plane. Young trees of this species can be distinguished even at a considerable distance by their peculiar drooping leading shoots which are in marked contrast with the stiffly erect leading shoots of the spruce and balsam fir. The small, drooping terminal cones are very abundant. Before maturity they are greenish tinged with purple; when mature they are of a soft grayish-brown color. The wood of this tree is superior to that of other species of hemlock. It is used for piles and lumber. The bark is rich in tannin and is used for tanning.

Section 4. *Pseudotsuga.* Carrière, Traité Conif. ed. 2. 256. 1867. as genus.

Leaves flat, narrowly linear, slender petioled, spirally arranged, but somewhat two-ranked by the twisting of the petioles; leaf scars concave, transversely elliptical, not prominent, or raised on more or less prominent woody sterigmata; leaf grooved above, with a prominent midrib below, stomatiferous on under side, furnished with two lateral resin ducts. Staminate flower axillary, oblong-cylindrical, with a short pedicel which finally becomes considerably elongated; stamens short-stalked, globose, their anther sacs opening obliquely, surmounted by a short spur; pollen grains without bladder-like appendages. Pistillate flower in the axil of one of the upper leaves of the growth of the previous season, short stalked, with aristate, two-lobed bracts, much exceeding the scales. Fruit a woody pendulous cone; cone-scales not deciduous from the axis; bracts much exserted, long acuminate and with two prominent lateral lobes, the lower bracts showing a gradual transition to the form of ordinary foliage leaves; seeds without resin vesicles, winged.

Three closely allied species, two of western North America, one of Japan.

Abies taxifolia (Lambert) Poiret, Lamark. Dict. 6:523. 1804.

[*Pseudotsuga taxifolia* (Lambert) Britton] Douglas Fir, Red Fir, Douglas Spruce.

A large tree with a massive trunk; leaves 1.5-3.5 centimeters long, flat, petiolate, usually rounded and obtuse at the apex; cones oval-cylindrical, 4-11 centimeters long, with woody, broadly ovate scales, and much exserted, deeply lobed bracts; seeds about 5 millimeters long, with narrow oblique wings about 1 centimeter long. From central British Columbia and Alberta southward to central California and along the Rocky Mountains to Texas, Arizona and Mexico.

The Douglas fir is one of the largest forest trees of America, being exceeded in height and massiveness of stem only by the Sequoias. It reaches its maximum development in western Washington and southwestern British Columbia, where trees of this species are often sixty meters high, with scarcely tapering trunks two or three meters in diameter at the base. The bark of this tree, at first smooth and thin, becomes in old specimens, three decimeters thick and very deeply fissured, falling off in scales which often collect at the base of a large tree in a mound a meter or more high. The foliage has the general appearance of that of a spruce, but the spray is more often somewhat flattened, and is much softer to the touch than that of the spruces. The leaves are short-petioled and flattened and, unlike the spruces and hemlocks, are persistent in drying. They are inserted on woody mounds of elliptical outline, which vary considerably in prominence in different specimens, so that sometimes a twig from which the leaves are removed is as rough as in *Tsuga*, and sometimes as smooth as in *Abies*. The cones of the Douglas fir are very characteristic, like spruce cones in their general appearance, but more woody and marked by the very long, exserted, three-pointed bracts. The cones fall from the trees soon after they have discharged their seeds.

The Douglas fir is very abundant in Vancouver Island, except close to the sea along the west coast, where it is rare and seldom reaches large size. A few miles inland, however, it grows to magnificent proportions.

Section 5. *Eu-Abies*

Leaves linear, flat or rarely tetragonal, sessile or short-petioled, spirally inserted, but on lateral branches usually twisted into a somewhat two-ranked arrangement, without sterigmata, leaving circular scars when they fall from the twig, persistent in drying, furnished with two lateral resin ducts. Bark of young tree usually smooth and with numerous resin vesicles, that of older trees often thick and rugose. Flowers axillary. Staminate flower composed of numerous short-stalked stamens, pendulous, oval or oblong, with a slender, often much elongated pedicel; anther sacs opening transversely or obliquely, surmounted by a short knob-like projection or a more or less orbicular crest; pollen grains with bladder-like appendages. Pistillate flower short-stalked, erect, usually situated upon the topmost branches of the tree, the bracts much exceeding the scales. Fruit an erect cone, the bracts longer or shorter than the scales; cone-scales deciduous from the axis which persists for a long time. Seeds with conspicuous resin vesicles, winged.

A group of about twenty-five somewhat diverse species, mostly inhabiting the mountainous regions of the north temperate zone and the adjacent tropics. Over half the species occur on the Pacific slopes of North America and Asia. Only two species of *Eu-Abies* are reported from Vancouver Island, but it is highly probable that a third species occurs there, and the presence of a fourth species is possible.

Bracts of mature cone shorter than the scales, leaves flat.

Resin ducts of leaves within the parenchyma, leaves blue-green and glaucous, cones medium sized.

Abies lasiocarpa

Resin ducts of leaves close to the lower epidermis.

Bracts of cone oblong or obcordate, with an abruptly acuminate apex. Cones medium sized.

Abies grandis

Bracts of cone oblong-ovate or rhomboidal, gradually narrowed into a long slender tip. Cones very large. *Abies amabilis*

Bracts of mature cone longer than the scales, exserted, leaves tetragonal or flattened and grooved above. *Abies nobilis*

Abies lasiocarpa (Hooker) Nuttall, Sylva. 3: 138. 1849. Balsam Fir.

A tree with thin, smooth, pale gray bark, becoming somewhat thickened and roughened with age; leaves crowded, spreading, blue-green, flat, grooved above, usually rounded at the apex, acute on cone-bearing branches, 1-4 centimeters long, stomatiferous on both sides, with resin ducts enclosed by the mesophyll; cones purple, oblong-cylindrical, 6-10 centimeters long, the scales two to three times as long as the erose, obtuse or truncate, abruptly acuminate bracts; seeds about 5 millimeters long, with broad purple wings. Coast mountains of Alaska, east to the Rocky Mountains, and south to Oregon, Colorado and Arizona.

This tree has not been reported from Vancouver Island, but as it occurs in the coast ranges of the mainland and in the Olympic Mountains, it will almost certainly be found on the high mountains of the interior of the island. It is an alpine tree, growing with *Picea Engelmanni* and *Tsuga Mertensiana.* It has usually a remarkably narrow, spire-like form, but near timber line it is frequently reduced to a matted shrub less than a meter high.

Abies grandis Lindley. Penny Cycl. 1:30. 1833. White Fir.

A tall, somewhat slender tree with leaves dark glossy green above, silvery white beneath, two-ranked and somewhat remote on sterile lateral branches, more crowded on leading shoots and fertile branches, rounded, notched, or sometimes pointed at the apex, 2-5 centimeters long; cones cylindrical, 5-8 centimeters long, 2.5-4 centimeters thick; cone-scales thick, two to three times as long as the obcordate, laciniate, abruptly mucronate bracts: seeds about 1 centimeter long, with wide wings about 1.5 centimeters long. Along the coast from Vancouver Island to northern California, eastward to Montana.

This tree is reported from Vancouver Island by G. M. Dawson (*). It apparently does not occur in the vicinity of Port Renfrew.

Abies amabilis (Loudon) Forbes. Pinetum Woburn. 125. pl. 44.1839. White Fir.

A tall tree with a straight, slender trunk and pale bark; leaves dark glossy green above, silvery white beneath, flat, grooved on the upper side, rounded, notched or sometimes acute at the apex, short petiolate and twisted at the base, somewhat two-ranked except on leading and fertile branches, 1.5-3 centimeters long; cones oblong, dark greenish purple, puberulous, 8-15 centimeters long, about 5 centimeters wide; cone-scales broad cuneate, exceeding the oblong-ovate acuminate bracts; seeds about 12 millimeters long, with wide oblique wings. Southern British Columbia, Washington and Oregon, along the Cascade mountains and westward to the ocean. Largely subalpine.

This is the common balsam fir in southwestern Vancouver Island where it grows abundantly from sea level up to the summits of the

* Dawson, G. M. Can. Nat. N. S. 9:326.

highest mountains. Near the sea it often forms groves of almost pure growth, the trees standing close together, and having very tall slender trunks, about a meter in diameter at the base, and often unbranched up to a height of thirty meters or more. At an altitude of three thousand feet it is a comparatively small tree often clothed with branches to the base. The bark of young trees is thin, very smooth and almost white, with numerous balsam blisters. In old trees it is apt to become thickened, dark and somewhat rough. The foliage appears very different on the upper and lower branches of the tree. Except on fertile and leading shoots the leaves are twisted into a somewhat two-ranked arrangement. The leaves on the under side of the twigs spread laterally, exposing the lower side of the stem. On the lower branches the leaves along the upper side of the twig are small and appressed, so that the spray appears flat. On the upper branches, however, the leaves along the upper side of the twig are long and spreading and the spray is bushy and semi-circular in section. The leaves are very persistent and in some cases remain upon the tree for over twenty years. This tree may be distinguished from *Abies grandis* by its much larger cones, with ovate-oblong bracts which taper to a narrow point (those of *Abies grandis* are truncate and abruptly mucronate), and by its shorter, more crowded leaves.

The distribution of this tree is somewhat peculiar. In western Vancouver it occurs at all altitudes, reaching its best development, however, close to the sea level. In the western part of the Olympic peninsula it also occurs at low altitudes, but elsewhere it is confined to the mountain slopes, ranging in the Cascade Mountains from about one thousand to six thousand feet above sea level. It appears to be a tree of great hardiness, flourishing under a variety of climatic conditions, but unable to endure the hot and dry summers of the lowlands about Puget Sound. That its geographical range should be the most limited of any conifer found upon Vancouver Island must be due to the slowness of its distribution owing to its heavy seeds which remain attached to the cone-scales until after they have fallen. The ground beneath old trees is commonly well covered with seedlings, but they are rarely seen at any distance from the parent trees.

Abies nobilis (D. Don) Lindley, Penny Cycl. 1:30.1833.

A tree with large cones, the spatulate bracts of which are much exserted, and blue-green leaves, tetragonal and grooved along the upper sides, occurs in western Oregon and northward into the Olympic Mountains, and along the Cascade range to Mt. Baker. It is not reported from Vancouver Island, and probably does not occur there.

SUB-FAMILY CUPRESSINEÆ

Foliage and floral leaves opposite or in whorls, or the foliage leaves very rarely scattered on sterile shoots; often heterophyllous. Flowers solitary; staminate flower consisting of an axis bearing four to eight whorls of stamens, each stamen having three to five pollen sacs; pistillate flower consisting of an axis bearing one to few whorls of fertile carpels, often with other whorls of specialised sterile scales above or below the carpels; carpel bearing one to many erect ovules near its base; the upper side of the carpel outgrowing the lower side in ripening, and displacing the original apex so that in fruit it appears as a boss upon the back of the cone-scale. Fruit a woody cone, or drupaceous or berry-like.

Evergreen trees and shrubs of wide geographical distribution. The following genera occur in Vancouver Island and the adjacent regions.

Cones woody, elliptical, scales overlapping, *Thuja*

Cones woody, spherical, scales peltate *Cupressus*

Cones fleshy and drupaceous or (in all American species) berry-like. *Juniperus*

Thuja. Linnæus, Sp. Pl. 1002.1753.

Aromatic trees with distichous branchlets, flattened twigs, and imbricated, appressed dimorphic, scale-like leaves, the lateral leaves of the twigs conduplicate, carinate, overlapping the flat leaves of the dorsal and ventral ranks, or on leading shoots all four ranks similar, slightly carinate, with spreading tips. Flowers monœcious, minute. Staminate flower consisting of two or three pairs of decussate stamens borne on a short axis; stamens peltate, anther sacs two to four, longitudinally dehiscent. Pistillate flower of four to six pairs of decussate, erect, oblong scales, the central or lower ones fertile, each bearing at its base two to four erect orthotropous ovules. Fruit ripening the first season, woody or leathery; cone-scales oblong, with a small boss on the back near the tip, the fertile scales largest, each bearing one to four seeds.

Four species, two of North America and two of eastern Asia. Only the following occurs in western North America.

Thuja plicata D. Don. ex Lambert, Pin. 1824. Cedar.

A large tree with short horizontal branches often pendulous at the extremities, distichous branchlets and deciduous spray; leaves 2-6 millimeters long, scale-like, usually acute, eglandular or conspicuously glandular, dimorphic on all

PLATE XV.—Cedar growing over fallen log of same species.

but leading shoots; wood dull red, very fragrant; cone 12-15 millimeters long, usually with six fertile scales each bearing two or three seeds; cone-scales conspicuously mucronate; seeds about 5 millimeters long, with lateral wings. Alaska to northern California, eastward to the Rocky Mountains of British Columbia and Montana.

Thuja plicata is abundant throughout the Vancouver forest especially at low altitudes. It is one of the largest trees of the region. Although it is not as tall as the spruce and Douglas fir, it exceeds them in trunk diameter, which is not infrequently five meters at the base. Its trunk tapers rapidly, however, while those of the spruce and fir are almost columnar.

This tree may be readily distinguished from all the other conifers of the region, with the single exception of *Cupressus nootkatensis*, by its small, scale-like leaves and flat spray. Its bark is smooth and cinnamon red in young trees, becoming gray and shredded with age, and separating from the trunk in long strips. The wood is of a dull reddish brown color and contains much volatile oil which gives it its characteristic odor. It is coarse-grained and splits readily, and is much used in the manufacture of shingles. The oil is antiseptic and preserves the wood from decay so that sound cedar logs of very great age are often found lying among and under the living trees of the forest.

Thuja seedlings, as is common among the *Cupressineæ*, have spreading, acicular leaves which are very unlike the adult foliage. These leaves are 3-10 millimeters long and are arranged in decussate whorls of three or occasionally of four. Not infrequently one of the leaves of a whorl is displaced slightly above the others, and this seems to be uniformly true in the case of a leaf in the axil of which stands a lateral branch. Foliage of the mature form generally appears on some of the side shoots produced during the second year's growth of the seedling, but the leading shoot maintains the juvenile form of foliage for several years.

Cupressus. Linnæus, Sp. Pl. 1002. 1753.

Evergreen trees with small, scale-like, decurrent leaves, and monœcious flowers. Staminate flower terminating a leafy branch, consisting of an axis bearing numerous decussate pairs of stamens; stamens orbicular, subpeltate, with two to six pollen sacs. Pistillate flower terminal on a short leafy branch, consisting of an axis bearing whorled or decussately opposite carpels; carpels subpeltate, the middle or upper ones fertile, bearing one to many ovules. Fruit globose, woody, the scales peltate with thick distal ends formed principally from the greatly enlarged upper side of the carpel, and bearing a prominent central boss, the original apex of the carpel.

A genus of about eighteen species divided into two sections, *Eu-Cupressus* and *Chamæcyparis.* Only the latter is represented in northwestern North America. Four species of *Eu-Cupressus* occur in California and Arizona.

Section *Chamæcyparis.* Spach. Hist. Veg. Phan. 11: 329. 1842. as genus.

Branchlets distichous, twigs somewhat flattened, leaves four ranked, dimorphic, those of the lateral ranks conduplicate, folded over the almost flat leaves of the dorsal and ventral ranks, or on leading shoots the twigs terete, leaves similar and with slightly spreading tips. Carpels opposite, decussate, one-to five-ovuled. Fruit ripening the first season.

This section differs from *Eu-Cupressus* in its *Thuja*-like foliage, its few-ovuled carpels, and in the fact that its fruit ripens the first season. It has frequently been recognized as a distinct genus, but the differences are not as marked as those which exist between the subgenera of *Juniperus*, and do not appear sufficient to give generic rank to this group.

Five species of North America and Japan.

Cupressus nootkatensis Lambert, Pinus. 2:18. 1824.

[*Chamæcyparis nootkatensis* (Lambert) Spach. Hist. Veg. 11:333. 1842.] Yellow Cypress. Yellow Cedar.

A tree with horizontal branches, stout, distichous, terete or slightly flattened twigs, and deciduous spray; leaves four-ranked, scale-like acute or acuminate, 2-10 millimeters long, usually eglandular, dimorphic on the smaller twigs; cones spherical, 7-12 millimeters in diameter, dark reddish-brown, glaucous, with four to six scales, each furnished with a prominent, erect, pointed boss; seeds two to four on each scale, about 5 millimeters long, with large lateral wings. Southern Alaska to Oregon, mostly at high elevations in the Coast and Cascade Mountains. Common in southeastern Vancouver Island at elevations above one thousand feet.

A tree of moderate size resembling *Thuja plicata* in foliage. The two can be readily distinguished by the fruit, and with little difficulty by a close examination of the foliage. The branchlets of this tree are much less flattened than those of *Thuja plicata*, the leaves of the four ranks are more nearly alike in form, and all the leaves, especially those of the leading shoots, are more pointed than in that tree. Both species have aromatic foliage, but their odors are entirely different. The smell and taste of the foliage of this *Cupressus* approximate much more closely to some of the species of *Juniper* than to *Thuja*.

The seedlings of this species, like those of *Thuja plicata*, have spreading acicular leaves arranged in whorls of three or four. They retain this juvenile form much longer than the seedlings of *Thuja*, and it is not uncommon for young plants 20 centimeters high to show little trace of the mature form of foliage.

The wood of this cypress is light yellow, very even grained and fragrant. It is one of of the finest woods produced in this region, and should be as valuable as the red cedar of the eastern United States.

Juniperus. Linnæus, Sp. Pl. 1038.1753.

Trees or shrubs with aromatic wood. Leaves spreading, linear subulate, or scale-like and appressed. Flowers minute, usually diœcious, axillary or terminal on short axillary branches. Staminate flower consisting of an axis bearing opposite or ternately whorled peltate stamens, each with two to five pollen sacs. Pistillate flower consisting of an axis bearing three to six opposite or ternately whorled carpels, often with modified sterile scales at the base. Fruit fleshy, berry-like or drupaceous.

A genus of about thirty species which form three well-marked sections. Of these the two following are represented in America.

Section *Oxycedrus.* Endlicher, Syn. Conif. 8. 1847.

Leaves ternately whorled, linear-subulate, spreading, jointed to the stem. Flowers axillary, the staminate solitary, with numerous minute sterile scales below the opposite stamens. Scales of the pistillate flowers ternately whorled; ovules three, alternate with the scales of the distal whorl, their tips enlarged and exserted. Fruit with one to three free seeds. Eight or ten species. Only the following with its varieties is found in North America.

Juniperus communis Linnæus, Sp. Pl. 1040. 1753.

Juniper.

A small tree, or a more or less dwarf shrub, often forming dense mats about one meter high and four meters or more in diameter; leaves 5-20 millimeters long, 1-2 millimeters wide, ternately whorled, spreading almost at right angles to the stem, linear lanceolate, sharply acuminate, dark green on the lower side, white glaucous above; scales of pistillate flower ternately whorled, the distal whorl becoming fleshy and coalescent in fruit; fruit ripening the third year, subglobose, bright blue, one to three seeded. Throughout the cooler parts of the northern hemisphere.

Juniperus communis L. var. *sibirica* (Brugsdorf) Rydberg. Contr. U. S. Nat. Herb. 3:533. 1896.

[*Juniperus nana* Wildenow.]

[*Juniperus communis* L. var. *alpina* Wahlenberg.]

A dwarf trailing shrub with leaves 5-10 millimeters long, 1.5-2 millimeters wide, less acute than in the type.

This is the common form of *Juniperus communis* in the northern parts of its range and in alpine regions. Although the extreme forms of the species and of this variety appear very distinct, there are so many intermediate forms that it appears better not to separate them specifically.

The alpine variety is reported by Macoun from Mts. Benson, Mark and Arrowsmith, and doubtless occurs commonly among the higher mountains of Vancouver Island. It is very abundant in the high ranges of eastern British Columbia.

Section *Sabina.* Haller ex Ruppins, Fl. Jen. ed. 2, 336.1745 as genus.

Leaves mostly scale-like, appressed, or in young plants and especially in vigorous shoots of old plants spreading, acicular, not jointed at the base. Flowers terminal on short leafy branches. Pistillate flower of two or three whorls of scales, the distal whorl usually sterile, each of the scales of the other whorls bearing one or two erect ovules at its base.

Juniperus scopulorum Sargent. Sylva of N. A. 13:93.1902. Red Cedar.

A small tree with an irregularly round-topped head; twigs slender; leaves opposite, acute, entire, glandular, scale-like and closely appressed; scales of pistillate flower opposite, the three distal pairs becoming fleshy and completely coalescent in fruit; fruit usually two-seeded, ripening the second year, bright blue, about 1 centimeter in diameter; seeds ovate, acute, prominently grooved and angled. The eastern foothills of the Rocky Mountains, westward to the coast of British Columbia, Washington and Oregon.

This is the western red cedar closely resembling the eastern *Juniperus virginiana L.* It differs from the latter in its stouter branchlets and in having fruit which ripens the second year, while that of *Juniperus virginiana* ripens the first year.

This is evidently the tree which is reported in Macoun's (*) Catalogue under the name of *Juniperus occidentalis* Hooker, as occurring on rocky points of Vancouver Island and small islands in the Gulf of Georgia. I have seen no specimens of *Juniperus scopulorum* from Vancouver Island, but specimens which I have examined from San Juan Island, Washington, belong to this species. †

* Macoun, J. Cat. Can. Pl. 1:463.1883.

† Two species of arborescent savin-leaved Junipers occur in the northwestern United States and it is possible that both are found in the interior of British Columbia. One, considered by Sargent to be the *Juniperus occidentalis* of Hooker, is a tree with stout, terete twigs; leaves usually in threes, but occasionally even on the same plant in twos, minutely serrulate, conspicuously glandular; fruit large, its flesh filled with resin glands. This species is distributed generally at high altitudes from Idaho and eastern Washington southward through the basin region to the California Sierras. It does not

A Key to the Genera of Conifers found in northwestern North America, based upon their foliage. *

1. Foliage of linear or acicular leaves, i. e. "needles."
   - A. Foliage leaves, or some of them, borne in fascicles on dwarf branches.
     - a. Leaves not deciduous, all the foliage leaves borne in fascicles of 2-5. *Pinus* p. 153.
     - b. Leaves deciduous, arranged spirally upon the long shoots of the season's growth and in crowded fas-

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occur west of the Cascade Mountains. The other is the species described above. These two species have been badly confused by collectors. It does not appear entirely certain which of these is Hooker's *Juniperus occidentalis*, which was founded by him upon two non-fruiting specimens collected by by Douglas "from the higher parts of the Columbia, at the base of the Rocky Mountains." Hooker states that his species has four-ranked leaves, but his note after the description indicates that he had the Idaho-California species, especially as he states that there is a large gland on each leaf constantly exuding a transparent resin which concretes in drops upon the foliage,—a character which is often very prominent in that species, whereas the leaf gland of Juniperus scopulorum Sargent, is small and not resin-secreting.

*This key is based upon the foliage of the mature plants. During the first few years of the plant's growth its foliage often differs entirely from the mature form. No attempt has been made to include these seedling characters.

cicles on dwarf branches on the older parts of the tree.

Larix p. 161.

B. Foliage leaves all spirally arranged upon the ordinary branches, often twisted so as to appear two-ranked.

a. Leaves non-resinous, with little odor when bruised and with a purely bitter taste. Leaves mucronate, twisted so as to appear two-ranked

Taxus p. 147.

b. Leaves resinous, aromatic or strong smelling when bruised; taste other than purely bitter. *Abies* p. 162.

C. Foliage leaves in whorls of three.

Juniperus (Sect. *Oxycedrus*) p. 201.

2. Foliage wholly or largely of closely appressed opposite or whorled scales.

A. Spray not flattened, scale-leaves not heteromorphous, leaves of strong growing twigs sometimes acicular.

Juniperus (Sect. *Sabina*) p. 203.

B. Spray flat (i. e. the twigs of a branch all in the same plane), scale-leaves heteromorphous, four-ranked, those of the upper and lower ranks almost flat, those of the lateral ranks abruptly folded over the others.

Thuja p. 191. and *Cupressus* (Sect. *Chamæcyparis*) p. 197.

Note on the Taxonomy of the genus *Abies*.

The genus *Abies* as here defined has the limits assigned to it by Tournefort * and Adanson. †

Table II. shows seventeen of the chief points of disagreement between species of this genus and the occurrence of these characters in those sections of the genus which contain any American species. Below is given a summary of the number of these points in which species of the same or different sections agree with one another.

Picea.	Hesperopeuce.	Tsuga.	Pseudotsuga.	Eu-Abies.
Picea..............14–17	7½‡–11	5–9½	5½–7	2–8½
Hesperopeuce....7½–11	16–17	11–13	4½–6½	3½–8½
Tsuga.............5–9½	11–13	15–17	7½–10½	3½–10½
Pseudotsuga.......5½–7	4½–6½	7½–10½	16–17	6–13
Eu-Abies..........2–8½	3½–8½	3½–10½	6–13	10–17

* Tournefort. Institutiones. 585. pl. 353, 354. 1700.

† Adanson, Fam. Pl. 2:480. 1763.

‡ The agreement of a constant character with an individually in-

Shape of leaf.	PICEA Flat or quadrangular.	HESPEROPEUCE quadrangular.	TSUGA flat	PSEUDOTSUGA flat	EU ABIES flat or quadrangular.
Vascular bundles of leaf..	1—(rarely 2)	1	1 or 2	1	2 or 1 / 2
Resin ducts of leaf........	2 lateral	1 median	1 median	2 lateral	2 lateral
Palisade tissue of leaf.....	—	—	+	+	+
Stomata..................	above or on all 4 sides	4 sides	below	below	below / 4 sides
Petioles..................	—	+	+	+	+ or —
Sterigmata...............	+	+	+	+	
Leaves persistent on drying..................	—(rarely +)	—	—	+(rarely—)	+
Staminate flower.........	terminal and axillary	terminal and axillary	terminal and axillary	axillary	axillary
Stamen tip..........	orbicular	spur	spur	spur	spur or somewhat orbicular
Dehiscence of stamen ...	longitudinal	transverse	transverse	oblique	transverse or oblique
Appendages of pollen grain.................	+	+(small)	—	—	+
Position of cone..........	axillary, or terminal and axillary	terminal	terminal	axillary	axillary
Orientation of cone.......	pendent	pendent or erect	pendent or somewhat erect	pendent	erect
Cone-scale longer than bract..................	+	+	+	—	+ or — or +
Cone-scales persistent	+	+	+	+	—
Seeds with resin glands...	—	+	+	—	+

TABLE II COMPARISON OF THE SECTIONS OF ABIES.

It is to be noted that no section is in complete internal agreement, even *Hesperopeuce* which is monotypic, varying in the position of the cones in different individuals.

Tsuga and *Pseudotsuga* are both small and uniform groups of species, but *Tsuga* shows considerable variety in the vascular bundle of the leaf, and in *Pseudotsuga* the leaf insertion, which has long been considered a very important character taxonomically, varies greatly even in the same species, so that in this respect, some specimens of *Abies* (*Pseudotsuga*) *taxifolia* agree with *Tsuga*, and others with *Eu-Abies*.

Picea shows great variation in the shape and structure of the leaf, but is otherwise very uniform, while *Eu-Abies* which likewise has great variation in leaf form, shows also considerable variation in the staminate flower, and in the relative length of the scales and bracts of the

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constant one, such as the terminal cones of *Tsuga* with the terminal or axillary cones of some species of *Picea*, is counted as one half agreement. When, however, some individuals of a species differ from others, as different individuals of *Abies mertensiana* differ in the position of the cones, it is considered an occasional complete agreement, and is reckoned as 0–1.

cone. Indeed there is considerably more variation within *Eu-Abies* than between *Pseudotsuga* and the more closely related species of *Eu-Abies.*

Hesperopeuce stands almost intermediate between *Picea* and *Tsuga*, and similarly *Pseudotsuga* stands between *Tsuga* and *Abies*, but the artificiality of uniting *Hesperopeuce* and *Pseudotsuga* with *Tsuga*, as was done by Eichler in Engler and Prantl's Pflanzenfamilien, is seen when the two former sections are compared with one another. There are scarcely two more unlike sections in the entire genus.

The section *Keteleeria*, embracing one or more peculiar Chinese trees, stands also in many respects intermediate between *Abies* and *Tsuga*, but it differs from all the other sections in its peculiar staminate inflorescence.

Although the general relationship of the sections seems best expressed by the arrangement adopted in the body of this article, with *Picea* at one extreme and *Eu-Abies* at the other. there are several peculiar points to be noted. Thus in the form of the pollen grains, *Tsuga* and *Pseudotsuga* stand together as contrasted with all the other sections. In the position of the cones, *Eu-Abies* and *Pseudotsuga* have lateral cones, *Tsuga* and *Hesperopeuce* terminal, and *Picea* stands intermediate with usually lateral but sometimes truly terminal cones. In the presence of resin vesicles upon the seeds, *Hesperopeuce* and *Tsuga* agree with *Eu-Abies*, while *Pseudotsuga* and *Picea* agree in their absence.

Botanical opinion has varied greatly as to the generic value of the various groups of the *Abietineæ*. Many botanists, including Linnæus and Parletore, in De Candolle's Prodromus, have embraced all the species of this tribe in the single genus *Pinus*. On the other hand, all the sections of *Abies* mentioned above have been recognised as genera together with *Larix*, *Cedrus*, *Pseudolarix* and several segregates from the true pines. It is to be noted that several of the groups like *Picea* and *Tsuga* were described as genera at a time when the *Abietineæ* of western North America and eastern Asia —over two-thirds of the species—were poorly understood and many of them almost or quite unknown. In the light of further knowledge of these forms, it has been necessary to greatly modify the original definition of the groups, while the distinctions between them have become much more vague and indefinite than they were formerly supposed to be.

In the light of these facts, it has seemed best to give *Abies* its wide significance, recognising as sections of this genus several groups of plants which are currently considered genera. *Larix*, *Pseudolarix* and possibly *Cedrus* also, are regarded as small genera very closely allied to *Abies*, but differing from it in a somewhat more marked manner than the sections of *Abies* differ from one another, while *Pinus* is a second large and complicated genus clearly distinct from *Abies*.

Hepaticæ of Vancouver Island

Hepaticæ of Vancouver Island.

Alexander W. Evans.

Apparently the first *Hepaticæ* recorded from Vancouver Island were those collected by Dr. David Lyall in 1858 and 1859. These are listed in Mitten's "Bryologia of the Survey of the 49th Parallel of Latitude"* and include three species, *Jungermannia ventricosa*, *Madotheca navicularis, and Frullania Tamarisci.* The first two of these species are now known to be abundant on the island. *Frullania Tamarisci*, on the other hand, has not been subsequently collected in the Pacific Coast region, and it is probable that Lyall's specimens would now be referred to the closely related *F. nisquallensis*.

In 1875 and again in 1887 much larger collections were made by Professor John Macoun, and these were supplemented by a series of specimens collected by Dr. G. W.

* Jour. Linn. Soc. Bot. *8*: 12—55. *pl. 5—8*. 1865.

Dawson in 1885. These three collections are reported upon by Pearson in his "List of Canadian Hepaticæ," published in 1890.* Fifty-five species in all are here recorded from Vancouver Island. Certain of these records, however, should be omitted or revised, in some cases because based on doubtful determinations, in other cases because the quoted specimens were not collected upon Vancouver Island itself but upon one of the neighbouring islands. Making the necessary subtractions forty-four species are left, about which there can be but little doubt.

In 1893 a third collection was made by Professor Macoun and sent to Professor L. M. Underwood for determination. The report of this collection appeared nine years later in Macoun's "Catalogue of Canadian Plants," Part VII.† It is supplemented by the earlier records made by Pearson and raises the number of Vancouver Island hepatics to sixty-six. Making the necessary subtractions the number of species should be reduced to fifty-seven.

* Montreal. Geological and Natural History Survey of Canada.

† Ottawa. Geological Survey of Canada.

At the suggestion of Professor Conway MacMillan, in 1901, 1902, and 1903, important collections were made in the vicinity of Port Renfrew by Miss Gertrude Gibbs, Mr. S. A. Skinner and Miss Daisy Hone, respectively. These were sent to the writer for determination. The first of these collections proved to be of especial interest and included two new species, *Odontoschisma Gibbsiæ* and *Scapania americana*. Both of these species have already been described and figured, the *Odontoschisma* by the writer* and the *Scapania* by Dr. C. Müller, of Freiburg in Breisgau.† No records of the remaining species in the collections have as yet been published.

The list which follows is based on the Port Renfrew specimens but it includes a revision of the lists published by Pearson and Macoun. A very few species collected by Professor William Trelease, Mr. J. M. Macoun, and others are added. Through the kindness of Professor Macoun it has been possible to

* Bot. Gazette *36:* 341. pl. 19, *f. 29—34.* 1903.

† Bull. de l'Herb. Boissier II. *3:* 44. 1903. Nova Acta Leop.—Carol. Akad. *83:* 201. *pl. 19b.* 1905.

examine many of the specimens referred to in his catalogue, including all of the more doubtful ones.

RICCIACEÆ

1. *Ricciocarpus natans* (L.) Corda. Lost Lake, Cedar Hill, Victoria (Macoun). P. 28, M. 2.*

MARCHANTIACEÆ

2. *Targionia hypophylla* L. Pier's Farm and Parson's Mountain, near Victoria (Macoun). M. 2. Specimens from Vancouver Island are also cited by Underwood† and by Howe, P. 36.‡

3. *Asterella gracilis* (Web. f.) Underwood. Comox; Goldstream, near Victoria (Macoun.) P. 27, M. 2. Also noted by Underwood§ and by Howe. Another species of this genus, *Asterella tenella* (L.) Beauv., is also cited by Pearson, p. 27. The specimens which he quotes,

* Throughout the paper these abbreviations refer to the pages of Pearson's "List" and Macoun's "Catalogue", respectively.

† Bot. Gazette *20:* 70. 1895.

‡ The page-references after Howe's name relate to his "Hepaticæ and Anthocerotes of California." Mem. Torrey Club *7:* 1899

§ L. c. 61.

however, were collected by Macoun on Salt Spring Island, in the Gulf of Georgia, and not on Vancouver Island itself. These specimens differ from the true *A. tenella* of eastern North America; they are referred by Underwood to *A. gracilis*, but according to Stephani they represent the type of a new species, which he names *Fimbriaria Macounii.*

4. *Conocephalum conicum* (L.) Dumort. Comox (Macoun). Port Renfrew (Miss Gibbs). M. 4.

5. *Marchantia polymorpha* L. Goldstream and Cedar Hill, near Victoria (Macoun). Broughton Strait (Trelease). Port Renfrew (Miss Gibbs). P. 27, M. 5.

METZGERIACEÆ

6. *Riccardia latifrons* (Lindb.) Parson's Mountain, Sea's Farm and Cedar Hill, near Victoria; Comox; Nanaimo (Macoun). Port Renfrew (Miss Gibbs, Skinner). P. 26, M. 7.

7. *Riccardia multifida* (L). S. F. Gray. Goldstream, near Victoria; Comox (Macoun). Port Renfrew (Miss Gibbs, Miss Hone). P. 26,

M. 8. The specimen from Nanaimo, which Macoun cites, should be referred to *R. sinuata.*

8. *Riccardia palmata* (Hedw.) Carruth. Comox (Macoun). P. 26, M. 7. The Cedar Hill specimen, quoted by Macoun, represents a form of *R. latifrons.*

9. *Riccardia sinuata* (Dicks.) Trevis. Nanaimo (Macoun). M. 7 (as *Aneura pinnatifida*). The specimens cited by Macoun belong to *R. multifida.* The widely distributed *R. pinguis* is also recorded from Vancouver Island by Pearson and by Macoun. A specimen from Comox, however, kindly sent for examination, is a sterile *Pellia.*

10. *Metzgeria conjugata* Lindb. Goldstream, near Victoria; Qualicum; Comox (Macoun). Blankensop Bay (Dawson). Port Renfrew (Miss Gibbs, Skinner). P. 27, M. 6.

Four other species of *Metzgeriaceæ* have been reported from Vancouver Island by Macoun, but all must be considered more or less doubtful. These four species are the following: *Pellia epiphylla, P. endiviæfolia, Blasia pusilla, and Fossombronia pusilla.* The *Blasia* is not mentioned in the catalogue but is distributed in Canadian Hepaticæ, No. 96. These specimens are correctly determined, but the label reads "on earth along roadsides in Gaspe; also at Sproat Lake, near Alberni, Vancouver Island, Aug. 12th, 1887." It is not quite certain, therefore, where they were collected. The three remaining species were all determined from sterile specimens. A second species of *Fossombronia*, *F. longiseta*, is noted by Pearson, p. 25. His specimens, however, came from Salt Spring Island and not from Vancouver Island itself. See M. 9.

JUNGERMANNIACEÆ

11. *Gymnomitrium obtusum* (Lindb.) Pearson. Mt. Benson, near Nanaimo; Pier's Farm, near Victoria; Mt. Mark, near Qualicum (Macoun). M. 10. The specimens of *G. concinnatum*, P. 25, M. 10, should apparently be referred to this species.

12. *Marsupella emarginata* (Ehrh.) Dumort. Goldstream, near Victoria; Mt. Benson, near Nanaimo; Mt. Mark, near Qualicum

(Macoun). Port Renfrew (Miss Gibbs). P. 25, M. 11.

13. *Marsupella sparsifolia* (Lindb.) Dumort. Nanaimo; Mt. Arrowsmith (Macoun). P. 25, M. 12.

14. *Nardia crenulata* (Smith) Lindb. Victoria; Shawnigan Lake (Macoun). M. 13.

15. *Nardia obovata* (Nees) Carr. Port Renfrew (Miss Gibbs).

16. *Nardia scalaris* (Schrad.) S. F. Gray. Near Nanaimo (Macoun). Port Renfrew (Miss Gibbs). P. 24, M. 12. Macoun's specimens are also quoted by Howe, P. 91.

17. *Gyrothyra Underwoodiana* M. A. Howe. Port Renfrew (Miss Gibbs, Skinner).

18. *Jungermannia atrovirens* Schleich. Mt. Quest and Goldstream, near Victoria; Union Mines, near Comox; Shawnigan Lake (Macoun). Most of the specimens listed under *J. pumila* (M. 15) and *J. riparia* (P. 20, M. 15) should be referred to this species.

19. *Jungermannia lanceolata* (L). Sea's Farm, near Victoria (Macoun). M. 15.

20. *Jungermannia sphærocarpa* Hook.

Near Victoria (Macoun). M. 14. The specimens cited from Shawnigan Lake belong to *J. atrovirens*.

21. *Jamesoniella autumnalis* (D.C.) Steph. Union Mines, near Comox (Macoun). P. 20, M. 13. The specimens from the same locality, referred by Macoun to *Jungermannia pumila*, also belong here.

22. *Lophozia alpestris* (Schleich.) Evans. Parson's Mountain, near Victoria (Macoun). The specimens from Mt. Mark, which are cited by Pearson and Macoun, belong rather to *L. ventricosa*.

23. *Lophozia Flœrkii* (Web. f. & Mohr) Schiffn. Mt. Benson, near Nanaimo; Mt. Mark, near Qualicum; Mt. Arrowsmith (Macoun). Port Renfrew (Skinner). P. 22, M. 21.

24. *Lophozia incisa* (Schrad.) Dumort. Esquimalt, near Victoria; Comox (Macoun). Port Renfrew (Miss Gibbs). P. 22, M. 15.

25. *Lophozia inflata* (Huds.) M. A. Howe. Port Renfrew (Skinner, Miss Hone).

26. *Lophozia Kunzeana* (Hüben.) Evans.

Victoria (Macoun). These specimens are listed under *L. barbata* by Macoun, P. 20.

27. *Lophozia lycopodioides* (Wallr.) Cogn. Port Renfrew (Skinner).

28. *Lophozia porphyroleuca* (Nees) Schiffn. Sea's Farm, near Victoria (Macoun). These specimens are referred to *L. excisa by* Macoun, p. 19.

29. *Lophozia ventricosa* (Dicks.) Dumort. Without definite locality (Lyall). Parson's Mountain, near Victoria; Union Mines, near Comox; Mt. Mark, near Qualicum (Macoun). Port Renfrew (Skinner). P. 23, M. 16.

30. *Sphenolobus ovatus* (Dicks.) Schiffn. Port Renfrew (Skinner). The closely related *Diplophyllum argenteum* and also *Sphenolobus Hellerianus* are recorded by Pearson from Vancouver Island, pp. 16 and 17. According to Macoun's Catalogue, however, the specimens which Pearson cites were collected in other parts of British Columbia.

31. *Plagiochila asplenioides* (L.) Dumort. Near Victoria; Mt. Arrowsmith; Mt. Mark, near Qualicum; Union Mines, near Comox

(Macoun). Port Renfrew (Miss Gibbs). P. 19 (under *P. porelloides*), M. 24.

32. *Mylia Taylori* (Hook.) S. F. Gray. Port Renfrew (Miss Gibbs, Skinner, Miss Hone).

33. *Lophocolea cuspidata* (Nees) Limpr. Cedar Hill and Sea's Farm, near Victoria; Comox (Macoun). Port Renfrew (Miss Gibbs). M. 26. The specimens from the same localities, cited under *L. bidentata* by Pearson and Macoun, should also be referred to *L. cuspidata*.

34. *Chiloscyphus polyanthus* (L.) Corda. Sea's Swamp, near Victoria; Mill Stream, near Nanaimo; Comox (Macoun). Port Renfrew (Miss Gibbs). P. 18, M. 26. A second species of this genus, *C. pallescens*, is quoted by Pearson and also by Macoun from Comox (as *C. adscendens*). Unfortunately these specimens have been lost, so that the citation cannot be verified.

35. *Harpanthus Flotowianus* Nees. Comox (Macoun). This species is not accredited to Vancouver Island by either Pearson or Macoun.

36. *Geocalyx graveolens* (Schrad.) Nees.

Goldstream, near Victoria; Comox (Macoun) P. 13, M. 28.

37. *Cephalozia bicuspidata* (L.) Dumort. Mt. Finlayson, Cedar Hill, Goldstream, and Sea's Farm, near Victoria; Comox (Macoun). Port Renfrew (Miss Gibbs, Skinner, Miss Hone). P. 19 (as *C. extensa*), M. 29.

38. *Cephalozia divaricata* (Smith) Dumort. Parson's Mountain, Cedar Hill, and Sea's Farm, near Victoria; Comox (Macoun). P. 10, M. 30.

39. *Cephalozia leucantha* Spruce. Port Renfrew (Miss Gibbs, Skinner).

40. *Cephalozia lunulæfolia* Dumort. Parson's Mountain, Cedar Hill, and Goldstream, near Victoria; Comox (Macoun). Port Renfrew (Miss Gibbs, Skinner). M. 28 (as *C. media*). The Vancouver Island specimens, quoted by Pearson and Macoun under *C. catenulata* and *C. pleniceps*, belong in part to *C. bicuspidata* and in part to the present species.

41. *Odontoschisma Gibbsiæ* Evans. Port Renfrew (Miss Gibbs, Skinner). The only known locality.

42. *Kantia trichomanis* (L.) S. F. Gray. Victoria; Comox (Macoun). Port Renfrew (Miss Gibbs, Skinner, Miss Hone). Broughton Strait (Trelease). M. 32.

43. *Bazzania triangularis* (Schleich.) Lindb. Union Mines, near Comox (Macoun). Port Renfrew (Miss Gibbs, Skinner, Miss Hone). P. 8, M. 33.

44. *Lepidozia filamentosa* (Lehm. and Lindenb.) Lindenb. Port Renfrew (Miss Gibbs).

45. *Lepidozia reptans* (L.) Dumort. Near Victoria; Comox (Macoun). Alert Bay (Dawson). Port Renfrew (Miss Gibbs, Skinner). P. 8, M. 34. A third species of *Lepidozia*, closely allied to *L. setacea*, has also been collected at Port Renfrew. Unfortunately the specimens are all sterile so that they cannot be definitely determined.

46. *Blepharostoma arachnoideum* M. A. Howe. Port Renfrew (Miss Gibbs). The only other known stations for this interesting species are in Mendocino County, California. See Howe, p. 141.

47. *Blepharostoma trichophyllum* (L.) Dumort. Port Renfrew (Miss Gibbs, Skinner).

48. *Herberta adunca* (Dicks.) S. F. Gray. Port Renfrew (Skinner).

49. *Ptilidium californicum* (Aust.) Underw. and Cook. Sea's Farm, near Victoria; Mt. Benson, near Nanaimo; Union Mines, near Comox (Macoun). Carmanah Bay (J. M. Macoun). Broughton Strait (Trelease). Port Renfrew (Skinner). P. 7, M. 37.

50. *Diplophylleia albicans* (L.) Trevis. Mt. Benson, near Nanaimo; Mt. Arrowsmith (Macoun). Carmanah Bay (J. M. Macoun). Port Renfrew (Miss Gibbs, Skinner, Miss Hone). P. 15, M. 37.

51. *Diplophylleia plicata* (Lindb.) Evans. Port Renfrew (Miss Gibbs, Skinner).

52. *Diplophylleia taxifolia* (Wahl.) Trevis. Mt. Benson, near Nanaimo (Macoun). Carmanah Bay (J. M. Macoun). P. 16, M. 38.

53. *Scapania americana* C. Müll. Freib. Port Renfrew (Miss Gibbs). The only known station.

54. *Scapania Bolanderi* Aust. Near Vic-

toria; Nanaimo; Mt. Mark, near Qualicum; Mt. Arrowsmith; Comox (Macoun). Alert Bay (Dawson). Broughton Strait (Trelease). Port Renfrew (Miss Gibbs, Skinner, Miss Hone). P. 13, M. 39, Müller, 186.*

55. *Scapania dentata* Dumort. Without definite locality (Macoun). Port Renfrew (Miss Gibbs). Müller, 106.

56. *Scapania Evansii Bryhn.* Mt. Arrowsmith (Macoun). Müller, 120.

57. *Scapania nemorosa* (L.) Dumort. Parson's Mountain, near Victoria (Macoun). M. 39. The specimen from Mt. Arrowsmith, quoted by Pearson and Macoun, is referred by Müller to *S. Evansii;* the specimen from Goldstream, quoted by Macoun, seems to belong rather to *S. undulata.*

58. *Scapania uliginosa* (Swartz) Dumort. Mt. Arrowsmith (Macoun). Carmanah Bay (J. M. Macoun). P. 14, M. 40, Müller, 88.

59. *Scapania umbrosa* (Schrad.) Dumort.

* The doubtful specimens of *Scapania* have been submitted to Dr. Müller. The numbers refer to the pages of his monograph of the genus.

Sea's Farm, Parson's Bridge, and Goldstream, near Victoria; Mt. Mark, near Qualicum; Comox (Macoun). Port Renfrew (Miss Gibbs). P. 15 (as *S. convexa*), M. 41, Müller, 283. The specimen from Mt. Mark is also cited by Howe, p. 154.

60. *Scapania undulata* (L.) Dumort. Goldstream, near Victoria; Mt. Arrowsmith; Comox (Macoun). Port Renfrew (Miss Gibbs). P. 14, M. 40, Müller, 133.

61. *Radula Bolanderi* Gottsche. Victoria; Comox (Macoun). Alert Bay (Dawson). Port Renfrew (Miss Gibbs, Skinner). P. 4, (as *R. spicata*), M. 42. Another specimen from Alert Bay, cited by Pearson and Macoun under *R. tenax*, also belongs here. *R. Bolanderi* is also quoted from Vancouver Island by Howe, p. 159.

62. *Radula complanata* (L.) Dumort. Sea's Farm, near Victoria; Mt. Benson, near Nanaimo (Macoun). P. 10, M. 42.

63. *Porella navicularis* (Lehm. and Lindenb.) Lindb. Without definite locality (Lyall). Victoria; Comox (Macoun). Alert Bay (Daw-

son). Victoria (Röll).* Broughton Strait (Trelease). P. 6, M. 43.

64. *Porella platyphylla* (L.) Lindb. Near Victoria (Macoun). This species is not accredited to Vancouver Island by either Pearson or Macoun but is cited by Howe.†

65. *Porella rivularis* (Nees) Trevis. Near Victoria (Macoun). Victoria (Röll).* P. 7 (as *P. platyphylloidea*), M. 44.

66. *Porella Roellii* Steph Craigflower, near Victoria; Mt. Benson, near Nanaimo; Nanaimo River (Macoun). P. 7 (as *P. Bolanderi*), M. 44. Specimens from near Victoria, collected by Macoun, are also cited by Howe, p. 166.

67. *Frullania Bolanderi* Aust. Victoria; Sea's Farm, near Victoria (Macoun). P. 2 (as *F. Hallii*), M. 45. In all probability the specimens from Cedar Hill, which Pearson and Macoun refer to *F. eboracensis*, represent *F. Bolanderi*. Unfortunately these specimens seem to have disappeared.

68. *Frullania californica* (Aust.) Evans.

* Hedwigia *32:* 401. 1893.

† Bull. Torrey Club *24:* 522. 1897.

Parson's Mountain, near Victoria; Comox; Nanaimo (Macoun). Port Renfrew (Miss Hone). P. 3 (as *F. Asagrayana*, var. *californica*), M. 47, Howe, 174.

69. *Frullania franciscana* M. A. Howe. Port Renfrew (Miss Gibbs.)

70. *Frullania nisquallensis* Sulliv. Victoria; Mt. Mark, near Qualicum; Comox (Macoun). Carmanah Bay (J. M. Macoun). Broughton Strait (Trelease). Port Renfrew (Miss Gibbs, MacMillan, Skinner). P. 3, M. 47, Howe, 177.

ANTHOCEROTACEÆ

71. *Anthoceros fusiformis* Aust. Goldstream, near Victoria; Nanaimo (Macoun). Alert Bay (Dawson). P. 28, M. 48.

It will be seen that the Port Renfrew collections add fourteen species to the hepatic flora of Vancouver Island. It is probable, however, that many interesting forms are still to be discovered, since more than one hundred species have already been reported from the entire province of British Columbia.

Of the seventy-one species already recorded from the island, fifty-four are common to Europe, forty-three to New England, forty-six to Alaska and forty-three to California. Of the seventeen species which do not grow in Europe, two (*Diplophylleia plicata* and *Scapania Bolanderi*) have been found in Asia, one (*Scapania Evansii*) has a rather wide American distribution, while the remainder seem to be confined to the Pacific Coast regions of North America. These include the following: *Gyrothyra Underwoodiana*, *Odontoschisma Gibbsiæ*, *Lepidozia filamentosa*, *Blepharostoma arachnoideum*, *Ptilidium californicum*, *Scapania americana*, *Radula Bolanderi*, *Porella navicularis*, *P. Rœllii*, *Frullania Bolanderi*, *F. californica*, *F. franciscana*, *F. nisquallensis*, and *Anthoceros fusiformis*.

Some Western Helvellineæ

Some Western Helvellineæ

D. S. Hone

The *Helvellineæ* listed here were collected in the western United States and Canada during various expeditions to the Minnesota Seaside Station. The specimens were preserved in 2 per cent formaline and 70 per cent alchohol, or were dried. All the species described are in the collection of the museum and herbarium of the University of Minnesota.

The following works have been consulted: Schrœter's generic classification as outlined in Engler and Prantl, Die Naturlichen Pflanzenfamilien. 1^2: 1894; Dr. H. Rehm's work in Rabenhorst's Kryptogamenflora. Pilze. 1^3: 1896; Cook's Mycographia, 1879; Massee's Monograph of the Geoglossaceæ, Ann. Bot., 11:225-307. 1897; also his British Fungus-Flora 4: 1895; Phillip's Gyromitra gigas (Krombholz) Cooke. Journ. Bot., 31:129-132. 1893, and

British Discomycetes. 1893; Krombholz, Schwämme, Part 3. 1834.

Of the seven species listed, four belong to the *Geoglossaceæ*, two to the *Helvellaceæ*, and one to the *Rhizinaceæ*.

I wish to thank Dr. E. J. Durand of Cornell University and Dr. H. Rehm of the University of München for their suggestions and exchange of material which aided in making my determinations. I also thank Dr. E. M. Freeman and Miss J. E. Tilden for their kind supervision of the work.

GEOGLOSSACEÆ

1. *Spathularia clavata* (Schaeff.) Sacc. Michelia 2:77. 1880.

Laggan, Alberta, Canada. Aug., 1903 Hone 259.

Laggan, Alberta, Canada. Aug., 1905, Holway.

On ground among moss under spruce and balsam trees at about 7,000 feet elevation.

Cæspitose, gregarious, erect; pileus yellowish to flesh-colored; stipe lighter tan, pruinose;

spores needle-shaped, multiseptate, 45-58 x 2 mic.

2. *Mitrula musicola* Henning. Oefvers. af K. Vet.-Akad. Förh. 1885.

Laggan, Alberta, Canada, Aug., 1903. Hone 257.

Growing upon *Webera nutans* Schreb. in moist spruce and balsam woods at about 7,000 feet elevation.

Cæspitose, erect; pileus yellowish to tan-colored, obtuse, slightly Morchella-like, with a tendency to be ribbed or rugose, glabrous, about 4 mm. long; stipe lighter colored to whitish, glabrous, solid, about 10 mm. long; spores elliptical, bent, non-septate, colorless, in two rows in ascus, up to 10-12 x 2-3 mic.; paraphyses filiform, up to 2 mm. broad.

This seems to be *M. musicola* Henning rather than *M. rehmii* Bresad. on account of its smaller size and only slightly rugose pileus. Dr. Rehm considers that it is either *M. musicola* Henning or *M. gracilis* Karst., but he prefers the former.

3. *Mitrula laricina* (Villars) Massee. Monogr. Geog. Ann. Bot. 11:271. 1897.

Minnesota Seaside Station, Port Renfrew, Vancouver Island, B. C., July 1903. Butters.

Growing in wet humus on bank of brook.

Pale yellow, erect; pileus club-shaped, inflated, pruinose, gelatinous-cartilaginous, 2 cm. in width; stipe yellowish to whitish, brittle, hollow, glabrous, erect, 3 cm. long by 3 mm. wide; spores elliptical, obtuse, hyaline, up to 12x3 mic.; paraphyses slender, septate, up to 2 mic. wide.

4. *Cudonia circinans* (Pers.) Fr. Summa Veg. Scand. 348. 1849.

Laggan, Alberta, Canada. Aug., 1905. Holway.

On ground among mosses, common in spruce and balsam woods at about 7,000 feet elevation.

Gregarious, erect; pileus with free margin, involute, glabrous, variable in color, tan to dingy yellow; stipe even, twisted, having ribbed appearance when dried, up to 4 cm. in height, 5 mm. in width

RHIZINACEÆ

5. *Rhizinia inflata* (Schaeff.) Karst. Rev. Mon. 112. 1885.
 Minnesota Seaside Station, Port Renfrew, Vancouver Island, B. C. Dec. 1903. J. E. Tilden.

Growing on the ground.

Prostrate, undulate, irregular in outline, brownish black; spores oblong, acute with a knob on each end, containing two oil globules, hyaline, 30-60 mic. x 8-10 mic.

HELVELLACEÆ

6. *Helvella infula* Schaeffer. Icon. Fung. pl. 159. 1763.
 Laggan, Alberta, Canada. Aug. 1903. Hone 260.
 Balton, Lake MacDonald region, Colo. U. S. A. Aug. 1903. Polley 63.
 Laggan, Alberta, Canada, Aug. 1905. Holway.

On ground in spruce and balsam woods.

Alberta specimens were found at about 7,000 feet elevation.

Solitary or gregarious, cæspitose, small to large; 4 cm. to 8 cm. high; pileus cinnamon brown to brownish black above, whitish beneath; stipe light tan to whitish, finely pubescent; spores elliptical, obtuse, smooth, 18-24 mic. x 8-12 mic.; paraphyses clavate, septate, branched, brownish, about 4 mic. wide.

Certain of these specimens contain an abundance of *Sphæronamæmella helvellæ* Karst. to which the dense pubescence of the stipe is due. I also find the spermatia to be ultimately uniseptate as I found in all Minnesota specimens. Karsten's descriptions (Hedwig. 23:18. 1884), however, give "spermatia simplicia."

7. *Gyromitra phillipsii* Mass. Brit. Fungi. Fl. 4:478. 1895.

Balton, Lake MacDonald region, Colo., U. S. A. July, Aug. 1903. Polley 64.

Growing upon water-soaked logs and stumps.

Gregarious or solitary, small to very large, from 15 cm. to 60 cm. in height and up to 60 cm.

in diameter; pileus very irregular, wrinkled and contorted, waxy, very brittle, pearly-white beneath, grayish to brownish above; stipe lacunated towards the base, hirsute at base and brownish, towards the top pearly-white and glabrous, hollow, irregular; spores elliptic, continuous, obtuse, hyaline, smooth, with commonly two small oil drops one at each end, or one large central drop, 12-16 x 6-7 mic; paraphyses clavate, septate, rarely branched, up to 10 mic. at tip.

The material described here was collected by Miss Jessie Polley and all data and field notes were obtained directly from her. No complete specimen was preserved, but large portions were broken off from both stipe and pileus and preserved in 2 per cent formaline.

There is a decided difference between the figures of *G. gigas* as figured by Krombholz and by Cooke. The former shows the sporidia to be elliptical (pl. 20. fig. 1-5), and he describes them as "spores magnis ovalibus." Also, "Die Sporen selbst sind gross und vollkommen oval." The latter, on the other hand, figures fusiform spores (Mycogr. fig. 327) and gives dimensions

32 x 10-12 mic. Dr. Rehm, (Krypt. Fl. 1:1193. 1896) describes *G. gigas* as follows: "Sporen breit spindel-förmig, einzelig mit einen grossen, centralen und je einem kleinen Oeltropfen in den Ecken, dann an jeden Ende mit einem warzenförmigen Anlängsel, farblos, 30-40 mic. lang., 12-14 mic. breit" (p. 1174. f. 5).

Schrœder's and Massee's descriptions agree with Rehm's.

Although the Colorado material agrees in all respects with that identified by Phillips as *G. gigas*, (Journ. Bot. 31:129. 1893), it does not seem to be identical with Kromholz' plant, *Helvella gigas* (*G. gigas*), differing in color, size, and size of spores. Also, his specimens were collected in April and May, while the Colorado form occurred in August. Likewise, the habitat is different, the one growing upon wood, the other upon the ground.

Therefore, I agree with Massee in his interpretation (Fl. 4:478. 1895), considering that this specimen is identical with that of Phillips. "I consider the plant noted by Phillips as a previously undescribed species remarkable for tis great size as also for its very small spores."

Renfrewia

Renfrewia parvula, a New Kelp From Vancouver Island.

ROBERT F. GRIGGS

The kelp described below was discovered at the Minnesota Seaside Station, Port Renfrew, B. C., in August, 1905. It is quite common in the vicinity of the station but has escaped observation largely because of its small size which caused it to be mistaken for a juvenile form of some other species. When first recognized as distinct it was thought to be a *Laminaria* but was soon seen to be distinct from that and all other genera of kelps. No more fitting name could be given to the new genus than one derived from Renfrew, the District of the island in which the station is located where so much work has been done on algæ, especially the kelps.

I desire here to express my thanks to Miss Josephine E. Tilden of the University of Minnesota for assistance rendered in looking up literature on the related forms.

RENFREWIA GEN. NOV.

Holdfast simple, discoid, without haptera arising on the stipe; sori extremely irregular; tissues little differentiated; lamina plane, entire, without proliferations, unbranched. This genus is separated from *Laminaria* because of its simple discoid holdfast without haptera which together with its small size and evident simplicity of structure marks it as one of the most primitive of kelps. The absence of branching haptera arising around the primitive discoid holdfast and taking its place does not seem at first thought a very striking character. But it signifies a difference in the structure of the plant fully as profound as the absence of a stipe which was considered sufficient ground for the separation of *Hedophyllum*; or a folding and irregular growth in the lamina which differentiates *Pleurophycus* from *Laminaria.* There are two species previously described as *Laminarias* which have simple holdfasts, *Laminaria solidulgula* Agardh and *Laminaria yezzœnsis* Miyabé. The relations of these to the present species as well as its relation to other

PLATE XVI.—A series of representative forms of Renfrewia.

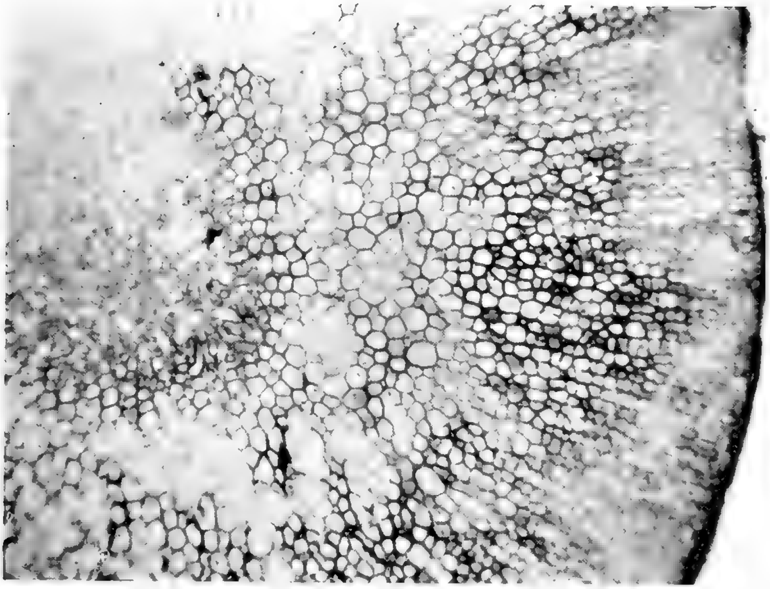
genera can best be considered after the description of this, the type species of the new genus, has been presented.

Renfrewia parvula n. sp.

Plant very variable in shape, size and proportions, but in texture and anatomy very constant; laminæ thin (less than 1 mm.) and more delicate in texture than any other kelp of the region except *Nereocystis* (which they resemble somewhat closely), yellowish-brown; cryptostomata absent even on young plants; stipe terete below, more rigid than the lamina but very much weaker than in *Laminaria saccharina* which is most nearly similar to it of the species found at Port Renfrew. Lamina oblong, in mature specimens varying from 25-90 millimeters in width, as much as 50 centimeters long, but varying greatly according to the violence of wave action, at the base usually cuneate and very gradually merging into the stipe but in broad short-stiped specimens sometimes rounded; stipe varying from 2.5-20 centimeters in length without apparent relation to the age of the plant or any other condition unless it be depth of water; holdfast, the simple primitive disc enlarged, without any trace of hapteres arising higher up on the stipe, though often in the disc itself showing local secondary growth, manifesting itself as radial thickenings and even closely appressed branches (Plate III., Fig. 2), as is also the case in *Cymathere triplicata* but not so conspicuous as in that plant. The largest holdfast collected measures about 20 millimeters in width; often they are much smaller not exceeding 8 millimeters. Mucilage ducts are absent from both stipe and lamina.

Fruiting habits very variable; sometimes very small apparently young specimens are found in fruit. I have specimens with well developed sori the dimensions of which are as follows: (a) (Plate XVI., Fig. 10) lamina 8x3.3 centimeters, sorus orbicular, about 25 millimeters in diameter, stipe 35 millimeters, holdfast 7 millimeters; (b) (Plate XVI., Fig. 2) lamina 12.5 x 2 centimenters, sorus elliptical, 37 x 13 millimeters, stipe 4 centimeters, holdfast 7 millimeters. On the other hand I have several large specimens which have not yet begun to differentiate the sorus: one of these (Plate XVI., Fig. 11) measures 23x6 centimeters with a holdfast 13 millimeters. There seems to be scarcely any localization of the sorus into a definite region of the lamina as in most kelps, but almost any portion may develop gonidangia. Sometimes the sorus occupies a small oval patch with fairly definite margins, near the base of the lamina; again it may cover almost the whole lamina leaving only a narrow margin all around. But more often it is irregular in shape especially at the distal end. Very often instead of bearing a single fruiting area the lamina has a series of parallel stripes of fructiferous tissue separated by similar sterile stripes; these may number as many as five. Both sides of the lamina are fertile but there is no close correspondence between the sori of the two as may be seen from Plate XVI., Figs. 3,5,6. I have a single specimen (Plate XVI., Fig. 6) in which there are two sori, one distal to the other, as in *Nereocystis*. The lower is a large oval area, 27x5 centimeters, then comes a region 10 centimeters long which is sterile except for a few small dots of fertile tissue, and distal to this there is the second sorus which is more irregular in outline and measures 10x2 centimeters. One might suppose from this specimen that we have here a regular succession of sori of different ages from the base to the tip, which renders fruiting continuous. But I think that such is not the case in *Renfrewia* for this is a single specimen among more than a hundred examined. and the few small dots of fructiferous tissue between the two sori seem to indicate that instead of two distinct sori, we have only an unusual case of irregularity. Moreover, as nearly as can be determined without sectioning, for the specimen seems too valuable to mutilate, both of the patches are of the same age.

Because of the low level at which it grows, juvenile forms are difficult to obtain and the search made for them was rather meagerly rewarded. A complete series was not found, the smallest being 5 centimeters long with others larger connecting with the mature forms. Since the



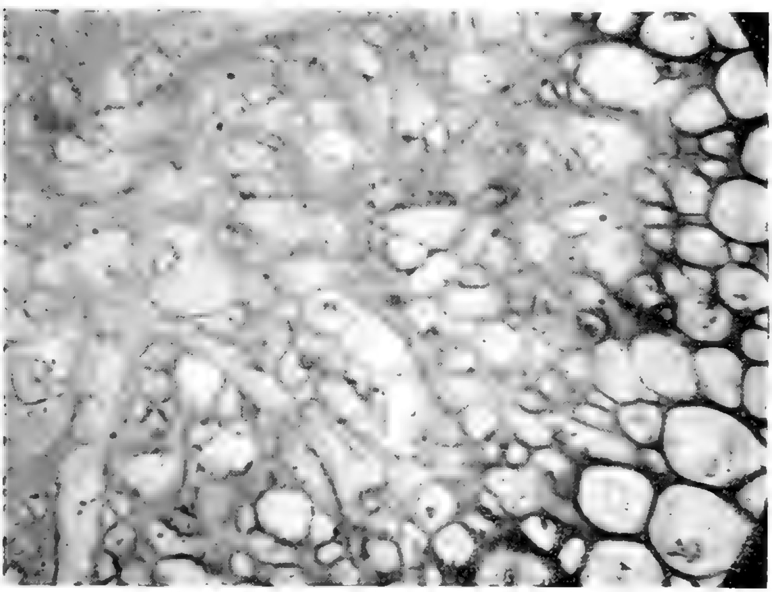
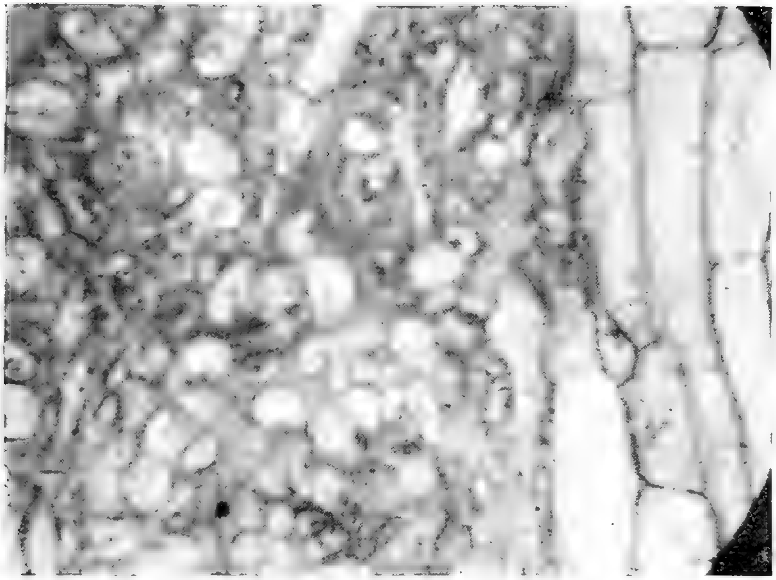


PLATE XVIII.—1 and 2. Photomicrographs of stipe of Renfrewia.

plant maintains through life a form very near the primitive type of kelp structure, there is not in this case the interest attached to the tracing out the development of a complex adult form like Egregia from the simple juvenile form that there is in the more specialized forms The young forms are very much like the older except in size and the tissues of the adult are already developed in plants as small as the smallest in the writer's possession. As in other kelps the juvenile forms of this species may be recognized quite readily at least when no smaller than 5 centimeters. At that time they are clearly differentiated from most species by the absence of the characteristic marks which distinguish other genera. They are most similar to *Nereocystis* and the similarity does not disappear, though they become easily distinguishable, until the laminæ of that genus begin to divide. In smaller specimens they may be distinguished by the beginning of the pneumatocyst of *Nereocystis* which is discernable in plants of about 3 centimeters. In specimens smaller than that it seems doubtful to me whether the two can be separated for there is no anatomical character and the texture which usually comes to one's assistance in such cases, is not sufficiently different to form a basis of separation. The only other kelp whose juvenile forms are likely to be confused with those of the present species is *Cymathere triplicata* which is similar to this in structure of the holdfast, a character which separates them from most other kelps when still very young. But in *Cymathere* the lamina is much narrower and thinner and the folds begin to appear when they are 2-3 centimeters in length.

HISTOLOGY. The thallus of *Renfrewia* is composed in general of the same tissues as the other kelps. The central portion of the body is composed of pith-web sharply delimited from the surrounding cortex which exteriorly shades into the smaller, more active cells of the hypodermis and epidermis. Since the histology of several of the kelps has been so thoroughly worked out by recent investigators, mostly at the Minnesota Seaside Station, it will be unnecessary to give a detailed account

Postelsia



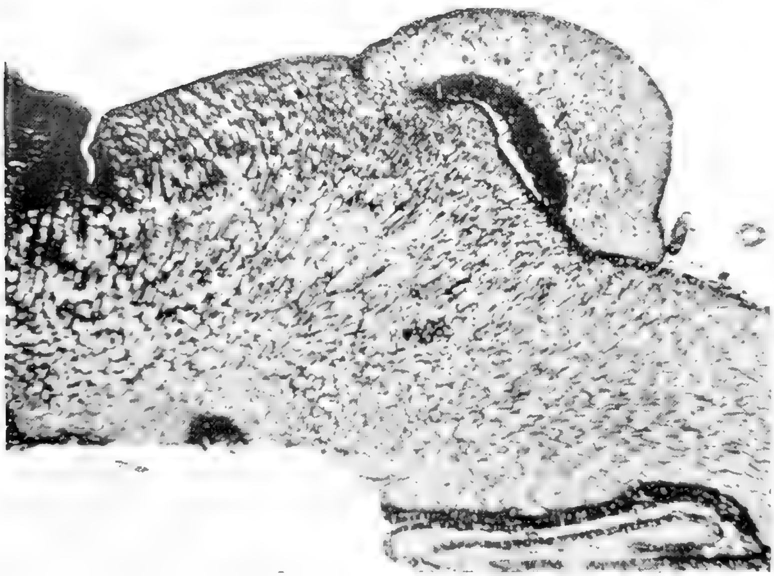


PLATE XVIII.—1. Longitudinal section of stipe.

2. Radial section of holdfast showing secondary branch.

of that of the present species and only a few features need be considered. As far as it goes the histology bears out the gross anatomy in indicating a primitive position for the present species.

Stipe. The pith-web is much simpler than that of most of the kelps. It is made up of anastomosing hyphæ as is usual; but they are shorter, composed of shorter cells, with less mucilaginous matrix between them than most species, e. g. *Laminaria bongardiana* which was studied for comparison. These hyphæ are sometimes so poorly developed that in both cross and longitudinal sections (Plate II.) of the stipe the pith appears to be composed of small spherical cells with only a few longer hyphæ, contrasting strongly with *Laminaria* whose stipes show very many long hyphæ and but few round openings where others have been cut across. The development of thick walled supporting tissue (sclerenchyma) from the cortex is also less marked in *Renfrewia* than in most kelps though there is some variation in this respect. Sometimes there is no thickening discernable in the walls of the inner cortical cells.

HOLDFAST. The holdfast is made up of thin walled cells continuous with the cortex of the stipe. They are arranged in radial lines centering in the base of the center of the holdfast, i. e. the original position of the primitive disc. Into this mass of cortical tissue extends the cylinder of pith from above, which gradually narrows and vanishes downwards. As described above, regions of local increase in thickness are often present. Sometimes this local growth may even be so active as to give rise to a branch which grows out from the main disc but is so closely appressed to it as to be unnoticeable except in section. (Plate III., figs. 2,3).

The lamina (Plate III., fig. 1) being thinner than in most of the kelps, is but a few (14-18) cells thick. The pith-web is extremely thin and there is no sclerenchyma. In the fruiting area nothing unusual was observed.

HABITAT. *Renfrewia parvula* grows in the sublitoral zone in the tide pools and recesses never uncovered even at the lowest tides. It

Postelsia

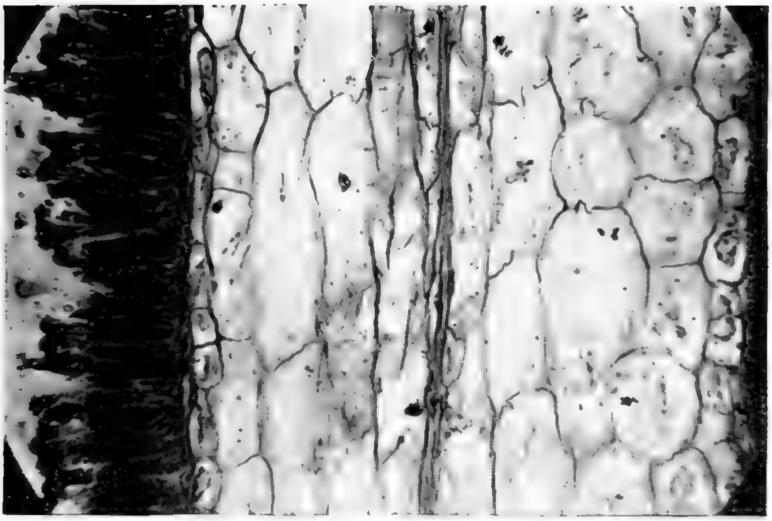


PLATE XIX—1 Cross section of fruiting lamina showing paraphyses and gonidangia

2 A typical holdfast.

is generally to be found along with *Cymathere* in situations where the surge is weak but is not quite so much restricted to quiet waters as is *Cymathere.* From this position, close to the emergent zone, it extends out an unknown distance into deep water where wave action is a minimum. That it grows out in very deep water is rather confidently inferred from the circumstances of its appearance at Port Renfrew. The shallow water specimens collected in various tide-pools and recesses were all comparatively short and badly eroded away so that even the smallest specimens found were quite imperfect.

Besides these, others were found in the wash at "Dictyoneuron Cove" which bore a very different character—so different that it seems advisable to distinguish them as a variety of the typical form which, on account of the character given below, may be designated *Renfrewia parvula perlonga* var. nov. Though truncated by wear at the tips, the plants all maintained a much greater length than the typical forms, often more than a meter, while the longest specimen measures 1.3 meters. The width of the widest specimen (6.5 centimeters) is slightly greater than the average of shallow water forms but not so great as the widest. Others are extremely narrow, measuring for example, 3x 118 centimeters (Plate I., fig. 13) i. e. forty times as long as wide though lacking both holdfast and tip. The stipe is similar to the shallow water forms but averages longer and the merging of stipe and lamina is much more gradual. The texture and histology of the plant are the same as the typical form. In the variety the long narrow laminæ and the irregularity of the sorus together with the similar texture, increase its resemblance to isolated laminæ of *Nereocystis* for which they have doubtless been mistaken many times as they are quite abundant at "Dictyoneuron Cove." growing just outside in the deep water.

The sorus is similar to that of the specific form. Sometimes it is a large patch covering the larger portion of the lamina, measuring 100x4 centimeters, or it may be broken up into several very narrow longitudinal stripes. In one specimen the sorus is divided by a sterile portion of the lamina into two, and in several others it is almost divided.

In contrast with the other kelps found in the wash not a specimen of the variety out of about forty seen, had a holdfast. Nearly all were cut off below the blade sharply as though bitten off by some kelp eating fish. All the other kelps including even *Lessioniopsis*, which clings so securely that it will support a a man's weight, and *Dictyoneuron*, which grows out so far in deep water that its habitat at Port Renfrew has never been discovered, are torn up "by the roots" and washed in whole as often as in fragments. This absence of holdfasts is the more significant because of their weakness and the ease with which they would be torn loose.

The striking difference in the length of the laminæ in shallow water specimens and those washed up from inaccessible depths shows more plainly the nice adjustment of strength of tissue and clinging power than any other kelp of the locality. Where wave action is strongest in the immediate sublitoral zone the tips are kept worn very short so that the plant presents very little surface to the waves and consequently the strain on the holdfast is slight and it is not torn loose. But where the wave action is less violent the tip is not nearly so rapidly frayed and consequently attains a greater length, while the strain on the holdfast remains nearly constant. The anatomical means by which this equilibrium is maintained is extremely simple. As in all the kelps the growing point is situated at the junction of the stipe and lamina. From this region new tissue is progressively pushed farther and farther out on the lamina by the formation of still newer tissue behind. When first formed it is tough and tenacious but with age its strength gradually weakens so that the tip of the lamina is able to withstand but a small strain, while the basal portion is quite strong. Thus the length of the plant is kept balanced with the force of the waves so as to prevent its being torn out by the roots as is the fate of most other kelps.

The nearest relatives of the present genus are obviously *Laminaria* and *Cymathere*. *Phyllaria* also is similar in appearance but has numerous cryptostomata on the lamina which are wanting in *Renfrewia* even when young. *Cymathere* differs in the folded lamina. The various species of *Laminaria* have forking secondary hapteres. Evidently the lack of hapteres, mucilage ducts and strengthening tissue, together with the simplicity of its body, mark this as one of the most primitive of kelps representing a form close to the original ancestor from which all kelps, with the possible exception of the aberrant *Chorda* and *Adenocystis*, have been derived.

The two species with simple holdfasts, previously described as *Laminarias* are both distinct from the present species.

Laminaria solidungula J. G. Agradh. (De Laminariaceis Sym. Of. p. 8. 1867.) which is very completely described by its author, presents several points of divergence. It is considerably larger than *Renfrewia parvula* and has well developed mucilage ducts. Its habit of growth is very peculiar. It is a perennial and has a constriction in the lamina marking the end of each year's growth, while I know of no reason for supposing that *Renfrewia parvula* is a perennial. Though this habit of growth may on closer study be considered of generic importance, it seems best for the present to consider this plant as *Renfrewia solidungula* (J. G. Agardh).

Laminaria yezzœnsis Miyabé (Rep. Marine Resources Hokkaido 3. On the Laminariaceæ and Laminaria Industries of Hokkaido, p. 41 t. 12-13.) is a large plant (1.25 millimeters) with an almost orbicular lamina digitately divided. It appears to be congeneric with my plant and should therefore be considered under the name *Renfrewia yezzœnsis* (Miyabé).

The type specimen is deposited at the University of Minnesota, with cotypes in the collection of the author and the herbarium of the Ohio State University. Specimens will be distributed by Miss Tilden in her "American Algæ."

As a summary a synopsis of the species of

Renfrewia may be presented. Lamina ligulate by the persistence of the lamina of the preceding year, with a succession of oval sori, obovate, up to 15 centimeters wide (at least), mucilage ducts well developed. *Renfrewia solidungula.*

Lamina not ligulate, oblong, entire, cuneate at base, variable, not more than 10 centimeters wide, and 50 centimeters long, no mucilage ducts; sori very variable in shape and size, yellow-brown, of delicate texture. *Renfrewia parvula.*

Texture and anatomy like the above but much longer, to 40 times as long as wide, tapering more gradually to the base.

Renfrewia parvula perlonga

Lamina suborbicular, digitately divided, 125 centimeters long. *Renfrewia yezzœnsis.*

EXPLANATION OF PLATES

Plate XVI. A series of representative forms of *Renfrewia* stretched on a glass plate and photographed by transmitted light to show the sori which are nearly invisible by reflected light. The light portions of the laminæ are sterile; the darker patches are sori on one side of laminæ; the darkest portions are places where sori on both sides overlap. Reduced to about one-fourth natural size. Figures 1-11 *Renfrewia parvula.* Figures 12-13.

Renfrewia parvula perlonga.

Figure 1. A short-stiped form with a small sorus.

Figure 2. A plant with a lamina 12.5x2 centimeters with sorus already developed.

Figure 3. A plant with a stipe 20 centimeters long, sorus showing a decided tendency to split into longitudinal stripes.

Figure 4. A small plant with sorus divided into three longitudinal stripes.

Figure 5. The type specimen with large well developed sorus.

Figure 6. Specimen with the sorus divided into two by a band of sterile tissue.

Figures 7 and 8. Two juvenile forms measuring about 5 centimeters each, though figure 8 represents an abraded plant older than figure 7.

Figure 9. Small plant with the sorus partially divided transversely.

Figure 10. Specimen with orbicular sorus at base of lamina.

Figure 11. Large plant measuring 23x6 centimeters which has not yet begun to develop a sorus.

Figure 12. Plant with five longitudinal stripes of fertile tissue.

Figure 13. A very long narrow plant 3 x 118 centimeters.

Plate XVII. Photomicrographs of the stipe.

1. Radial view of portion of cross section showing the tissues from the pith outward. B. & L. obj. $\frac{2}{3}$, oc. 1.

2. Portion of above showing in detail the pithweb and the innermost portion of the cortex. B. & L. obj. $\frac{1}{6}$, oc. 2.

Plate XVIII.

1. Longitudinal section of the stipe showing the pith-web with elongated cells of the inner layers of the cortex. B. & L. obj. $\frac{1}{6}$, oc. 2.

2. Radial section of a holdfast showing an appressed secondary branch. Leitz obj. 1, B. & L. oc. 2.

Plate XIX.

1. Cross section of the lamina with one side in fruit showing the elongated paraphyses with the shorter blacker gonidangia. B. & L. obj. $\frac{1}{6}$, oc. 2.

2. A typical holdfast enlarged about three times. At the lower side of the figure there is a branch like that shown in Figure 3.

A Study of Tide-pools on the West Coast of Vancouver Island

A Study of Tide-pools on the West Coast of Vancouver Island

Isabel Henkel

During the summer of 1903, the writer spent the month of July at the Minnesota Seaside Station, near Port Renfrew, on the west coast of Vancouver Island, and at this time the notes for this paper were taken.

The shore of this coast is remarkable for its extreme rockiness, and for the varieties of erosion produced by the waves and the tides. Fairly well back from the shore, the rocks stand in vertical cliffs, with flat rock in front sloping gently to the water's edge. Plate XX. fig. 1. is a good illustration of the shore line.

The principal rock formations are sandstone, conglomerate, and shale. From a comparison of the rocks at points where the series is complete, it is seen that the shale lies at the bottom, the conglomerate overlies the shale, and the sandstone overlies the conglomerate. It happens, however, in many places, that the conglomerate or the shale forms the surface rock, the strata overlying having been eroded. Plate XX. fig. 2. shows the heavily wooded cliff known as "The Point." The horizontal rock forming the floor leading to the sea is graywacke.

In all classes of rock are depressions of varying shape and depth, sometimes exposed by the tide, and sometimes covered. They possess characteristic fauna and flora, and are called tide-pools. The typical pools lie in the sandstone, because of the extreme softness of the rock, which renders the work of erosion easy. They are also abundant in shale, but are few in number in conglomerate.

The pools in sandstone occur generally in strata which are nearly horizontal, so that the pool resembles a depression in a floor. Sometimes the lower part of the pool has been worn away more than the upper part, leaving the uneroded strata as a projecting rock shelf, which affords a hiding place for sea-urchins, star fish, and other animals.

The greatest number of small pools was

PLATE XX—1. Sculpturing of shore cliffs.
2. Cliffs with seaward platform.

found in a gently-sloping sandstone region called the "Devil's Billiard Table." This is a region where concretions occur in great numbers, and scattered at irregular intervals. They lie well back from the high tide line. Approaching the shore line, (Plate XXI. fig. 1.), the concretions disappear, and a series of depressions, looking as though the concretions had been lifted out of them, is left. Some are empty, and others are filled with water. Still nearer the shore, the depressions become much larger, and are more irregular, many being separated only by a narrow ledge of rock. At the shore line they become mere indentations and irregularities in the coast. These larger pools have acquired a characteristic fauna and flora.

The irregular shore line caused by many pools, and the wearing away of the seaward wall, is very common. It may be seen in Plate XXII. figs. 1. and 2.

The number, size, and irregularity of pools increase with the slope, the sloping shore being more exposed to the waves than the flat shore. Often the erosion is so great that one pool occurs within another.

The majority of the smaller pools, as may be seen in most of the photographs, are circular, but the larger ones are generally elliptical, and give evidence of having been formed by the union of two or more smaller pools, the connecting rock ledges having been eroded. Such pools are shown in Plate XXIII. fig. 1.

The pools vary in size from small depressions a few inches in diameter, to those 30 feet long, 20 feet wide, and 10 to 15 feet in depth. Usually the largest are the most irregular in outline, and contain the greatest diversity of plant and animal life.

The temperatures vary with the time of day, the seasons, the depth, and the position with regard to the tides, those lying highest being warmest, since they are not subject to a change of water with each incoming and outgoing tide. One such pool was 30 feet long, and 30 feet wide, and showed traces of several connecting ridges.

Many pools, especially those in the region of the "Devil's Billiard Table," contain boulders, which appear to have the same composi-

PLATE XXI.—1. Small depressions in sandstone near high water line.
2. Regions of young pools.

tion as do the concretions. Others, in regions that apparently have been subjected for a longer time to wave action, contain no such boulders.

According to their location, illumination, and other factors to which forms must adapt themselves, the pools contain various plant and animal forms.

In the pools with overhanging edges, eel-grass occurs in great abundance, the rock layers forming a point of attachment for the holdfast. Those pools exposed to the lower tides, and the best conditions of illumination and temperature, exhibit the greatest variety and number of life forms.

Generally, though not always, the greatest variety and number occur in the largest pools. In one pool, 3 x 2 x 2½ feet were found the following animal forms: mussels, goose-neck barnacles, acorn barnacles, chitons, limpets, sea-robins, sea-urchins, sea-anemones, snails, and hermit crabs. The chitons and the sea-robins exhibited protective coloration, assuming the color of the rocks, which varies from dark red, to light pink and green. These colors are due to incrusting algæ.

The plant forms were less varied than the animal, being nearly all corallines. However, of these there were found in this single pool, six varieties, exclusive of the brown, pink, and green incrusting corallines.

These six varieties were found attached to the rocks, or to limpet shells. On the corallines, and on the limpets was found a small feathery green alga, but in very small quantities.

The occurrence of so large a number of forms in so small a pool, is accounted for by the fact that the illumination is unusually strong, that the pool is a low tide one, and that being shallow, the water becomes comparatively warm.

The age of tide pools can be studied only relatively. Those which are small, regular, disconnected and contain boulders possess the smallest number and the least variety of forms, and are probably the youngest. Regions of young pools are shown in Plate XXI. fig. 1.

As the pools advance in age, they begin to attain irregularity of outline, and to lose their circular form, becoming more and more elliptical. Small pools lose their connecting ridges,

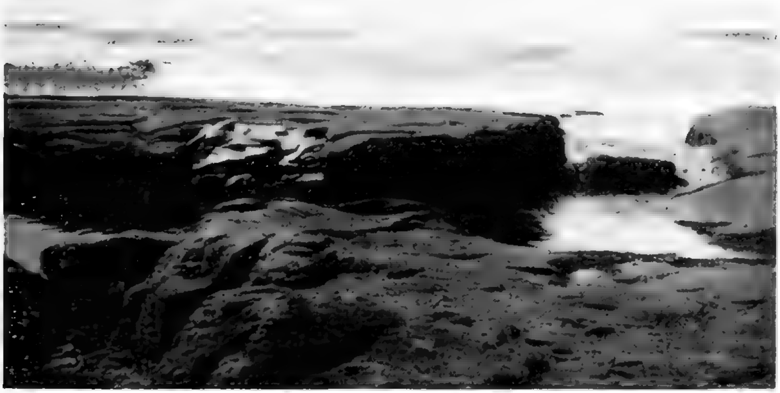


PLATE XXII.—1 and 2. Irregularities in outer shore line arising from wearing out of tide-pools.

and unite to form one or more large pools. Finally, most of the wall of the pool is destroyed and a large indentation in the shore line is formed. As the waves and the tides work on the indentation, it makes its way farther and farther inland, becoming finally a long narrow channel known as a tide-rift. Such a channel is shown in Plate XXIV. Often the sides are perpendicular, with overhanging ledges. Under these ledges, many life forms find lodging places, especially those kelps which require the strong wash of the tides for their development. Such a region is found a little east of "Baird's Point." Here there is a slightly sloping sandstone area, pitted everywhere with small pools which are lacking in life forms, but which exhibit the development in all stages. Plate XXI. fig. 2. is a picture of this region. At a point 30 feet above the sea, begins a series of depressions, which do not contain water, except a little here and there which is stagnant. The series begins at the vegetation zone and slopes to the sea. They are probably filled during the season when the waves and the tides are high. The region is shown in Plate XXIII. fig. 2. Plate XXV. fig. 1. shows many stages in the development of tide pools.

Many points along the coast show elevated portions of rock which are exposed only at low tide; on either side of these projections are depressions into which the tide runs. These indicate a tide-pool region so old that the barriers between pools have been worn away and only the rough rock is left.

Pools in conglomerate are few in number and possess no striking characteristics. The rock east of "Baird's Point" is flat and gently sloping, and is pitted with several hundred incipient tide-pools, very shallow, and generally circular. There are no boulders and the life forms are few. There were found only *Cladophora*, sea anemones, small barnacles, and eel grass, a marked contrast to the variety found in the sandstone pools in this same region. As the pools are washed by the high tides and possess good illumination, it may be supposed that the paucity of life forms is due to the youth of the pools.

PLATE XXIII.—1. Irregular pools formed by union of several small pools.
2. Series of pools reaching above ordinary high water.

There are some instances of a combination of sandstone and conglomerate pools. In one case, a mass of conglomerate stands surrounding a depression in sandstone. In another case, one side of the pool was sandstone, and the other was conglomerate, the sandstone being more worn than the conglomerate. In one region of conglomerate, is found a number of good sized pools, exhibiting the characteristics of sandstone pools. Upon examination it was found that these pools all have sandstone bottoms, surrounded by masses of conglomerate.

Pools in shale are found rarely. They are very long and narrow, following the lines of stratification (Plate XXV. fig. 2.). They are shallow in comparison with sandstone pools, owing to the greater difficulty of erosion of the hard crystalline rock. Very few large pools of this class are seen. Only occasionally boulders occur in shale pools, and generally in a position indicating that they have rolled in from the high banks above, and are not native to the pool. The fauna and flora usual to the sandstone pools are present, but in smaller quantities. The shale pools contain stagnant water oftener than do the sandstone pools, and in such pools, no life forms are found.

Tide pools are caused by a combination of conditions, among which may be mentioned: cracks in the rock; concretions; lines of stratification; erosion by waves, tides, and the wind; the action of carbon dioxide; variation in temperature, both of water and of the air; the action of plants and of animals.

The lines of stratification are the chief cause of shale pools, since the water, striking against the rock, finds the lines of stratification the lines of weakness. The rocks are easily broken along these lines, and the hard, angular bits of shale act as grinding tools, to deepen and widen the shallow depressions made in the shale by the beating waters.

Conglomerates afford a variety of hardness and the softer parts are easily worn out by the water. As soon as the cement holding the rock as one mass is removed, the remaining harder portions separate, and falling into the shallow depression, grind a deeper hollow into the rock.

Postelsia

PLATE XXIV.—Tide rift formed from several pools

The sandstone pools present the greatest variety of structure, and it is to be expected that the greatest variety of causes also exists. Here, as in the shales, the water striking against a line of weakness, causes erosion, and as sandstone is softer than shale, erosion occurs on a larger scale. This eroded surface may be the beginning of the pool. The action is continued by the water, by the bits of broken rock, and by the agency of plants and animals. The roots of plants strike into the rock, and both by the spreading of the cracks, caused by the increase of the size of the holdfast, and by the dissolving action of the acid formed by the plant, the depression increases in size.

Similarly, boring animals, as the rock clam, and the sea-urchin, serve to increase the size of a depression made by erosion or solution, or, they may originate the depression by boring into solid rock. A steep sandstone cliff, just west of "The Point," shows the face of the cliff honeycombed into such depressions.

A rather insignificant cause for the formation of tidepools is the change of temperature of the water in the pools. In the Port Renfrew region the range is small, but it is enough to bring about a slight degree of erosion.

Air is soluble, and is compressed by the weight of the water. In pools, or in the indentations caused by the partitions between the pools wearing away, especially under rocky ledges, jets of water are sometimes seen spurting out, and a booming sound is heard. Both the sound and the jet are caused by the sudden expansion of air in the water. The expansion of air is due to the removal of pressure on the enclosed air, probably by the shifting of the water.

Ordinary air currents, beating against rock, gradually erode it; storm currents cut out the rock rapidly. Air exerting its pressure through water acts in the same way, and slowly wears out the rock against which its force is directed.

The most potent cause of sandstone pools is the concretions. If the region of the "Devil's Billiard Table" be examined, it will be seen that on the land side, the concretions are solid masses firmly imbedded in the sandstone, and

PLATE XXV.—1. Tide pools in various stages of development.
2. Tide pools formed in shale.

are composed of rock much harder than the sandstone. Between the surrounding sandstone and the imbedded concretions, is a layer of very hard calcite. About half way to the shore line, the calcite has disappeared from the sides, but the concretion is still firmly attached to the underlying rock. Still further down, the concretion is loosened, and the surrounding sandstone is worn away to such an extent, that the concretion lies like a huge, round pebble in the depression. Up to this point the depression is circular, and the sides are smooth. The concretion is hurled about by the tides, and continually wears away the sides and bottom of the pool. When two or more pools lie close to one another, as may be seen in several of the photographs, the separating walls are beaten against by the concretions, until the partition breaks, and an irregular pool begins. The action of the waves and the tides, and the grinding of the rocks, continue until at last many small pools have united to form a large pool; the concretion itself is by this time broken into small pieces, or is dissolved. Added to these causes is of course the influence of plants and animals, which have acquired a position in the pool.

The question may arise as to the cause of the removal of the calcite which acts as a cement between the sandstone and the concretion. It is well known that as fresh water flows over the land, it absorbs carbon dioxide from the air, forming carbonic acid. This acid, though weak, is strong enough to cause large quantities of calcium carbonate, usually insoluble, to dissolve in the water. Sea water contains a large amount of carbon dioxide, derived partly from the inflow of fresh water,and partly from the decay of plants and animals. Twice a day it flows over the concretions, and because of the presence of carbonic acid, the otherwise insoluble calcite is freed from its bed.

The literature on the subject of tide-pools is very limited. No direct references were found, but several on potholes were available. These structures, though lying farther inland than tide-pools, are somewhat similar to them in appearance, and many of the causes of formation are the same.

The principle difference in the cause of formation is the effect of tides on the pools along the coast. Further, it is supposed that the potholes, or kettle holes, as they are sometimes called, are caused by glacial action. In the pools studied on the Vancouver coast, it does not seem probable that the formation of the pools has in any way been determined by glacial action.

The following articles give discussions on the subject:

Manning, P. C. Glacial potholes in Maine. Proc. Portland Society of Natural History.

Kjerulf. Potholes. Description of giant kettles in Norway.

Tarr. Physical Geography of New York State.

Geike. Scenery of Scotland.

Description of Plates.

Plate XX. 1. Sculpturing of shore cliffs.
2. Cliffs with seaward platform.

Plate XXI. 1. Small depressions in sandstone near high water line.

2. Regions of young pools.

Plate XXII. 1. and 2. Irregularities in outer shore line arising from wearing out of tide-pools.

Plate XXIII. 1. Irregular pools formed by union of several small pools.

2. Series of pools reaching above ordinary high water.

Plate XXIV. Tide rift formed from several pools.

Plate XXV. 1. Tide-pools in various stages of development.

2. Tide-pools formed in shale.

Some Geological Features of the Minnesota Seaside Station

Some Geological Features of the Minnesota Seaside Station.

C. W. Hall

Vancouver Island is so well known to all who may read *Postelsia* that a description of it is not necessary. Port Renfrew, on its southwestern shore, is a small harbor opening out on the Straits of Fuca. It is the seaport of the Minnesota Seaside Station. Providence Cove is a beautiful inlet about four miles toward Victoria from Port Renfrew. The geological features of the shore from Port Renfrew to Providence Cove are to be described in this short sketch.

In the first place, the Straits of Fuca bear strong evidence of having been, until comparatively recent itme, a river valley of magnificent proportions. Its width of eight to ten miles is exceeded by but few river valleys of the land to-day. Its average maximum depth of 900 to 1000 feet from Puget Sound to the sea indicates that in its stage of maturity the stream which occupied this valley possessed a remarkable vigor. It then gathered the waters now filling several streams; the imperial Fraser of British Columbia, the Nooksachk, the Skagit, the Skykomish, the White and a score of others were confluent at places now in the bed of Puget Sound and formed the great river which flowed through the strait when its channel was a thousand feet higher than today and the Pacific coast line many miles west of its present position.

At that time Port Renfrew bay was a narrow river carrying a tumultous torrent, the confluent waters of the San Juan and Gordon rivers, then high mountain streams, into the River Fuca many miles above its mouth. The beautiful delta at the head of the bay could not then have existed; the projecting rocks on which the dock is now built formed a bold and sightly cliff hundreds of feet above the water. The eagle looked from his aerie down a narrow channel, like that of the Gordon now, across the waters of one of the largest rivers of the continent. The site of the Minnesota Seaside Station was then a lofty hillside, a rocky situation many

PLATE XXVI.—A view of the rough, wave-worn surface of the Port Renfrew shale near the Minnesota Seaside Station.

miles distant from that sea, the shore of which is now its essential feature. Slowly and steadily the land has sunk, the sea encroached upon it, and inch by inch as the milleniums have passed, the waves have worn and carved their way until now Port Renfrew is an excellent harbor for the largest ships and the Station is at the contact zone of land and water.

Walking out upon the beach in front of the laboratories at the Station one steps upon hard, shaly rocks, black in color and of harsh feel. The first noticeable feature is the extremely rough surface they present (Plate XXVI). This arises partly from their unequal hardness, readily noted by tearing fragments loose, and partly from the inclined position which the formation has assumed with reference to the surface of the sea. The softer laminæ are readily worn away by the waves and their places are shown by the deepening, slanting grooves everywhere seen upon this wave-washed rock. The hard laminæ on the other hand are quite crystalline. They present the hardness of metamorphic rocks to the touch and thus are very uncomfortable to the feet and make hob-nailed boots a necessity of Station comfort. Thus shod and equipped with a good hammer, one starts out to investigate this bottommost rock of the shore.

Through the woods eastward to Providence Cove one passes on the way a beautiful cascade formed where a small stream crosses a hard ridge of shale, and also several rock masses which show, beneath the accumulations of growing and decaying vegetation, the existence everywhere of this omnipresent shale. On clambering down into a charming glen formed where a mountain stream for ages has been plunging into the river and the sea, the same rocks are found but with a somewhat changed structure. One is in Providence Cove.

Here the rocks are compact, hardened throughout and made crystalline until they ring under the stroke of the hammer. They stand out in high, almost vertical walls, instead of reclining as a sloping shore. Where fragments loosen and fall into the sea under the action of the waves, they wear into strikingly symmetrical pebbles and boulders. Glancing across the

PLATE XXVII.—A huge dike protruding through the shale, resisting wave wear and weathering much more than the shale itself. West of Postelsia Point

well stratified rocks we observe their strike and dip near the head of the gorge. The former measures W. 45° S. magnetic, and the latter 25° northwest. Some pebbles are gathered to show the varied colors and the clear crystalline habit of the rock and one starts on the return to the Station.

Working one's way down through the almost impenetrable salal from the rude trail to the shore, little change is found in the character of the rock. Toward the west are several deeply cut ravines where streams have worn trenches to the strait. These are crossed with difficulty, because the resistant nature of the siliceous shale to weathering and wave wear produces vertical walls. Now and then a shaly condition of the rocks alternates with quite massive beds. We soon learn to distinguish these relations in the surface contour of the rock; where projecting masses stand up against the waves there is found a hard and crystalline layer quite like the walls of Providence Cove. At Kirkpatrick's we again measure strike and dip. The former is W. 10° S. and the latter 25° northwest. Many minor variations from this record are to be noted along the shore but in them all a prevailing west-southwestward direction can be seen and a northwesterly dip, sufficient to project the rock strata, could they be replaced, into reconstructed formations lying far higher than the summits of the Olympic mountains, away from which they slope.

In places the rocks are greatly crushed, the laminæ are displaced and the inclination to the horizon shows frequent variations. Here and there the rocks have yielded to a lateral crumpling until now they consist of a mass of slabs and small fragments closely packed together. Locally, a cementing has bound the fragments together with all the firmness of the original rock.

Passing to the westward of the Station by crossing the sand beach, this same rock series comes again into view after being hidden for many paces. Its surface is even more ragged than at Providence Cove, or in front of the Johnson cabin. A smaller proportion of silica characterizes the chemical content of the rock,

PLATE XXVIII.—One of the usual dikes breaking through the shale along the plane of bedding. West of the Sand Beach.

a more shaly habit is seen in its structure and a rougher, more forbidding aspect is presented in its appearance.

As the westernmost surfaces are reached on the islands off the entrance of the bay, a shaly habit is dominant in the rock of this formation; huge dikes break through the shales and crumple, twist and wrinkle them into many shapes (Plate XXX). The even, monotonous strike and dip are destroyed and a contorted slate is developed which curls and winds around the huge dikes in many quaint forms and curves. These rock masses may be followed by boat from one rock island to another and along the precipitous shore from the entrance of the bay to the dock where rocks were first seen on our arrival at port.

The culmination of this contortion is seen on some small islands along the west side of the entrance to Port Renfrew harbor (Plate XXXII. fig. 1.) An interesting intermingling of contorted slates and intruding dikes is soon found. On this west side of the bay the slates disappear, giving place to another and overlying formation. West of Port Renfrew bay, not only dikes but mountains of granite occur. One such mountain is Mt. Edinburgh, the lofty sentinel of southern Vancouver Island. To climb the rocky side of this high peak is a famous feat among the scientific accomplishments of the Station.

The student continually searches for evidence of age as he scans the rocks. Nowhere is there a clue to guide him. They look very old; they are tilted and crumpled; veined and diked; worn away and carved again, but not one fossil and nowhere a contact relation which will give ground for a reasonable guess. From contact relations at other localities geologists have assigned this formation to the Cambrian age. But knowledge is still obscure. Both structure and environment point to a great antiquity; beyond this nothing is disclosed. The Sphinx reigns.

In traversing the coast from Providence Cove to the contact line marking the top of the shales on the west side of Port Renfrew bay, one becomes conscious of an extensive rock formation. "How thick is this series?" he asks, for much of the way has been occupied in walking across

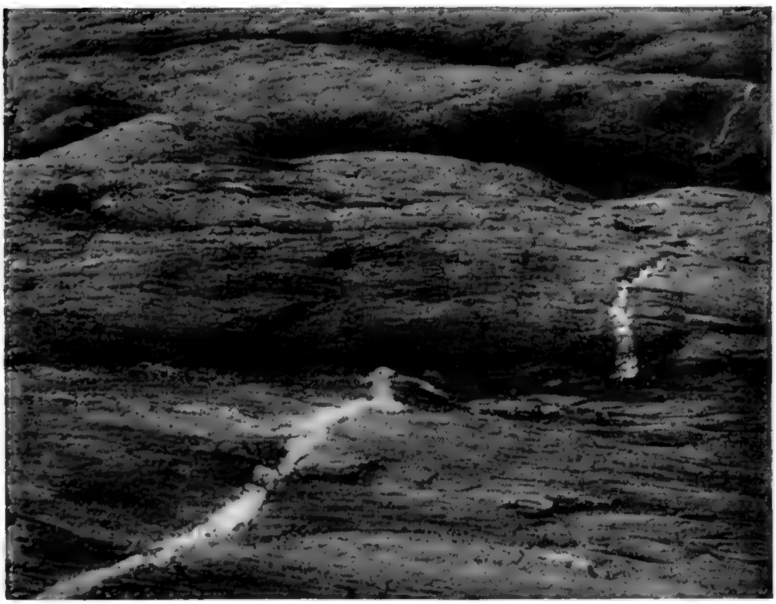


PLATE XXIX.—1. One of the small islands of the shore. The rock is the shale of the Port Renfrew series.
2. A quartz vein in the shale, faulted by subsequent crustal sliding.

the upturned edges of one continuous formation. Here and there faults are to be seen where the rocks have slipped, and on one side or the other of this structural break the rock stands relatively higher or lower than before (Plate XXXI); in places it stands at a higher angle to the surface of the sea than the average: occasionally the sea has worn away the rocks more nearly parallel with the strike than is the rule; but, when all conditions and accidents are given their full value of qualification, the total vertical thickness cannot be less than 12,000 to 15,000 feet, fully two and one half miles of sands and clays, before a change in physical conditions brought cessation of deposit. An interval of erosion and alteration was inaugurated.

And thus the question of time is reached. While the geologist must look in vain for a measuring rod upon this stretch of ancient coast, one has been found in the Cretaceous along the base of the Rocky mountains where the Benton, Niobara and Pierre groups have a total thickness of 3,900 feet. Grove K. Gilbert has associated an obscure rhythm of sedimentation in these groups with a concept of the time relations involved in their accumulation. Certain cycles of deposition were observed which in the discussion were associated with the precession of the equinoxes, or a time interval of 21,000 years. With a cycle of sedimentation averaging 4 feet in thickness correlating with the precession-perihelion cycle of time, the accumulation of 3,900 feet of usually argillaceous shales involves a period of 20,000,000 years. Assuming the process of sedimentation to have gone forward at the same rate, when the Port Renfrew series was deposited, the time involved could not have been much less than seventy-seven million years! And a vast accumulation of sediment had taken place before the Providence Cove beds were formed, as can be seen along the shore for some miles to the east of this inlet. So millions of years more must be added to complete the time necessary for the entire formation.

Deposition of the sediment is only a part of the process of rock-making. The laminated habit was imprinted when the particles were laid

PLATE XXX.—A dike breaking through the shale along its bedding plane showing displacement and overlap.

down. The transformation of the accumulated, rounded grains into a crystalline, orderly mass was not accomplished in one geologic epoch but in many. That heat could have played no unusual part we do certainly know; pressure played a part, because where the topmost laminæ of the formation had been laid upon each square foot of sea bottom, at Providence Cove 1,000 tons rested, a load for a freight train of twenty cars. Time is represented in a series of results otherwise very difficult to comprehend. If fragments be broken, the ring is sharp and clear. The material is so clear of impurities that every piece is attached to its neighbor in the most intimate crystalline contact.

Much variation in this crystalline condition can be noted. At Providence Cove the rock seems throughly indurated. This is not due alone to the fact that thousands of feet more of sediment was laid upon it than upon the beds at the Station, but in part to a difference in the mineral and chemical composition of the sediment itself. Here is more silica as well as more uniformity in composition. Under a great weight and in percolating waters operating in a wide area and through great depths uniform material will produce uniform results. Hence the evenly assorted particles of quartz, clay, carbonaceous material and other incidental mineral components produce a rock evenly deformed, made crystalline and uniformly compacted into a siliceous shale which, for hundreds of feet in thickness, is a normal schist of perfect crystalline texture. This is due to the processes of mineral reconstruction reinforced by mineral solutions brought in by percolating subterranean waters.

With the quartz schists of Providence Cove compare the rocks in front of the Station and indeed generally along the shore for the distance of a mile. At the Station only thin layers of the schistose type are to be seen. Laminæ of alternating hard siliceous bands and argillaceous-carbonaceous material of a softer habit prevail. This alternation gives evidence that there had once been a succession of sand layers and muddy shoreline flats succeeding each other many times.

Again the geologist stands at Port Renfrew

PLATE XXXI.—The Port Renfrew shale with a doubly faulted dike following its bedding planes to the outcrop.

dock. The rocks here lie at an angle of inclination exceeding 50° from the sea level. The uplifting of Mt. Edinburgh more than 4,000 feet produced by its intrusion such a squeezing together that the fine elastic particles, compressed by a force exerted against the enormous beds of shale, yielded at right angles to this pressure. This yielding flattened the particles and produced a direction of weakness, a capacity to part which is called slaty cleavage. The broad, long slabs which lie about give evidence of this induced condition in the rock. Furthermore, it is to be noted, that the mineral composition of this slate differs from the schist of Providence Cove and the shale at the Station,—from the latter in being more uniform in composition and from the former in being as clearly an argillaceous-carbonaceous rock as that is a siliceous one. Applied the same pressure, temperature and time, the one is converted into a schist and the other into slate.

Aside from sedimentation and molecular change other forces have operated. Dikes and veins have taken their place in the varied mass of rock material and fault lines have developed (Plate XXVII). These intruding masses and the displacements they have effected in the original rock mean much as rock history is read, for they speak of uplift and downthrow; of crushing and tension; of the flow of molten rock material, and slow accretion from percolating waters.

The tilting of the rocks from their original horizontal position involves stress of great force. Blocks sometimes hundreds of feet in thickness are shoved over each other until they lie shifted many feet from their original position. Evidence of such displacement is seen at many places in broken structures like dikes, veins and stratification bands. These all have their story to tell.

The dikes are masses of eruptive rocks (Plate XXVIII). Long and more or less continuous fissures in the shales and slates reaching indeterminable depths were filled by molten lava pushed by some displacing agent from subterranean reservoirs. They indicate a tensional force, first producing the fissures and a crushing suffi-

PLATE XXXII.—1. Contorted shale upon a small island, west side of the entrance to Port Renfrew harbor.

2. Non-conformable contact of Miocene horizontal sandstone upon the tilted edges of the Port Renfrew shale. Just east of Providence Cove.

cient to crowd the flowing rock into every crack and cranny of the superjacent formations. When crystallized this rock became so hardened that it has resisted erosion more than the enclosing country rock and it now stands like an ancient ruined wall upon the dark shales and slates. In age relations the dikes are younger than intruded shales and older than all overlying rocks. To him who has seen the base of Mt. Edinburgh the origin of the dikes seems closely associated with the out-thrust of that huge pile of granite.

During the compressing and tilting of the shales as well as subsequent to the intrusion of the dikes there were formed master joints and minor joints, together with numberless cracks anastomosing in every direction. These openings afforded surfaces on which the decomposition processes, yielding large quantities of quartz and less quantities of other mineral substances, deposited their minerals. This material, thus again deposited. filled these cracks and recemented the rock into a solid mass. Thus the veins were formed which present so striking a feature of many a rock surface. They are almost wholly quartz veins (Plate XXIX). They present no regularity of direction beyond that seen in the shaly partings and less conspicuous master joints of the district. Rarer minerals noted are feldspar and pyrite. Gold no doubt occurs because it has been found in paying quantities at several points along the coast adjacent to Providence Cove and Port Renfrew, and gold is one of the most universal minerals of ancient crystalline rocks.

After all these events the upturned edges of the rocks were worn down. The present surface rocks once were rock masses thousands of feet below the surface. The slow and unerring processes of uplift, weathering and wear have loosened millions of cubic feet of this rock to become the play of the waves and the compacted material of subsequent geologic epochs. How many times transport and deposit have been effected along this coast does not yet appear; but the record is spread of one.

Out of the material worn off the tilted shales another formation was built. Its beginning and progress have been so recent that within the rock are fossils of a relatively recent type. Mollusks not distantly related to the ancestral types of the mussels now swarming the rock shelves of the coast then lived and contributed their shells to the coastal detritus of their day. Thus fragments of shale, crystalline grains of quartz and fossil fragments accumulated and laid down a bed of Miocene sandstone hundreds of feet in thickness. It covered the surface of the ancient shale formation, uneven with high knobs, rough and wave worn surfaces. Many stream channels and pre-Tertiary glens disclosed anew and channeled out again since the old River Fuca took its place among the geographic features of the Pacific coast, increase the interest of the Station student.

The nature of the material forming this uppermost formation commands attention. In front of the Station buildings, adjoining the rough, harsh surface upon which we first stepped down, lies a coarse rock of only medium hardness. Within it are many huge boulders formed of great masses of broken dike material, slabs of shale and varied beach boulders. Binding these together are masses of broken shale, chips of myriad shells and other material incident to shore line deposit. Such is the base of the Miocene sandstone. Quite steadily the fragments of shells and shale diminish in quantity and the rock becomes a sandstone of the light gray, medium grained, siliceous type, so common everywhere as a shore-fringing sediment. Its cementing material in the lowest layers is calcium carbonate whose origin is in the shell fragments of the Tertiary shore.

Within this sandstone are many variations of texture and hardness. Walking over the planes of gentle slope which dip beneath the waters of the Strait of Fuca, the way is difficult because of ridges and mounds which are of harder and more unyielding rock. Between these the waves have washed out the softer sand, plants have loosened the sand grains by crowding between them their root-like processes to search for mineral foods and secure mechanical support. The alternating harder and softer portions afford place for varied work of the waves. The hard rock is the projecting reef on which *Postelsia* and its companion plants cling with vigorous energy; the soft is that which is carved into tide-pools to become the homes of numerous animals as well as plants.

Examining closely these roughened rock surfaces it is noted that the hardened ridges are associated with the cracks or joints of the rock. It can be reasoned that these openings facilitate the mingling of waters along the crevice walls as well as their flow upward or downward as the ground waters ascend or descend in their course. Added waters facilitate the crystallization of mineral particles whether they are newly added to the mass or older material already there. This molecular change forms a compact cement for the sand grains involved in it. As the trickling waters continue to make their way the zone of cemented sand grains becomes wider and wider until very perceptible hardened bands can be followed where the waves and weather have worn the rock. Such is the case at the interesting "Chair of Neptune" near Johnson's cabin.

To be observed here under a differing

phase of the same process are the spherical concretions. These structures from a chestnut to hundreds of tons in size, are among the most interesting geological features of the shore. The smallest seldom attract attention; they are of the size of marrowfat peas. But east of the Station, past two or three projecting points of the coast, is an area just above high tide where the sandstone layers are quite nearly horizontal. Many tide-pools are here, washed out of the softer sandstone, and here also are many concretions. One spot contains so many of these spherical masses from two to four inches in diameter that it has been named the "Devil's Billiard Table." A hundred paces from it, towards the Station, is another spot where the spherical bodies are quite as numerous but of only one-fourth to one-half the size of those on the Devil's table.

More generally distributed, however, are the larger concretions from the size of a quart measure to that of a five-gallon jug. These frequently are encircled by an outer ring or two, reminding one of pictures of the planet Saturn

PLATE XXXIII —A large lenticular flattened concretion near the base of the Miocene sandstone. In front of the Station buildings

and its rings. Usually the concretions present the same hardness from circumference to center, but the large ones have a softer central portion. When worn off by the waves and weathering, they form hollows upon the surface and become tide-pools, later developing into many and diversified forms. An interesting concretion partially buried in a vertical rock wall is seen in front of the Station buildings. Its shape suggests that it was once somewhat spherical but subsequently by a reduction in thickness of the sandstone formation as a whole through dissolving and removing a portion of its calcium carbonate, the concretion had become considerably flattened (Plate XXXIII).

The question arises: How are these concretions formed? They consist of sand grains aggregated by a cement of calcium carbonate. This can be shown by dropping a fragment of fresh material into a test tube containing dilute chlorhydric acid. After a violent effervescence the sand grains lie in a loose mass in the bottom. Often in breaking a fresh concretion and holding the fractured surface in the light, a reflection may be caught showing that the calcium carbonate is in the form of large rhombohedra of calcite. If the imprisoned grains of quartz could be removed, the calcite would show a texture as coarsely crystalline as is frequently seen in vein calcite. In other words, the calcium carbonate, in undergoing a molecular transition from the organic to the mineral stage, envelopes the grains of quartz and other contents of the concretionary mass in precisely the same form it would assume in being deposited as vein calcite in a coarsely crystalline mineral vein. Thus, there is present in these interesting structures an exhibition of the strength of the force of crystallization. Although exercised upon a very common rock constituent, the result is clearer than is usually seen in rock formations of any geologic age or type of rock. It is doubtless force of crystallization which underlies the notable symmetry of these bodies. A large rhombohedron of calcite, rounded off, would have a form like most of the larger so-called concretions of this coast. Crystallization has drawn the calcite around these nuclei from among adjacent quartz grains sufficiently to compact and develop crystalline masses. It is quite obvious that the concretions have been formed since the rock was accumulated. Locally where calcium carbonate was abundant it has involved nearly the entire material of the formation. In this way the rugged rock masses of Postelsia point and its immediate neighborhood have been hardened into enduring outposts along a rocky shore. Animal and plant remains have been factors in the hardening process. Remains of turtles, molluscan species, and many fragments of lignified wood and seaweed are found in these hardened masses. Segregations of plant remains occur when hardened rock masses are broken. That they yielded both carbon and oxygen for the hardening process seems quite clear.

In looking across the Straits of Fuca when the air is clear, snow fields are seen upon the Olympic mountains. They terminate in long-tongued glaciers slowly flowing down through the valleys until they are lost in tumbling streams. The question occurs: Were there ever such snow fields and glaciers around the Seaside

Station? Perhaps, when this spot was upon the mountain side, as the great River Fuca swept past in the bottom of the valley. Can we find along the shore or in the forest any evidence whatever upon which to form an answer to the question?

The answer is nearer than we think. The Station building, the Sea Palms, stands upon a mass of clay, sand and gravel, with some large boulders within it which could have been formed in no other way than by the agency of glacial ice. It is till or unmodified drift. It contains many kinds of rock material wholly foreign to this part of the coast, of rocks not known to occur within the drainage basin of the creek quietly flowing past the laboratories. Again, the material is arranged in the manner wave action is never known to transport and deposit pebbles and boulders.

Elsewhere, repeatedly such material is found. Beyond the boundary of this particular shore line, glaciated rock surfaces show striæ of glacial origin,—enough to establish the prevalence, at some time in the past, of a lower temperature than now prevails. Yet no great fields of drift can be found. Patches are to be seen here and there. These small areas constitute the record. The great mountain masses of moving ice, of which New England, New York, Ontario, and the states of the middle west give convincing testimony, seem not to have developed here. Local glaciers there were, but the evidence of the expansion of a Continental Ice Sheet to enwrap this portion of the outlying island of Vancouver is slight.

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