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Shore and Landscape Analysis of the Western Section of the Capital Regional District of British Columbia

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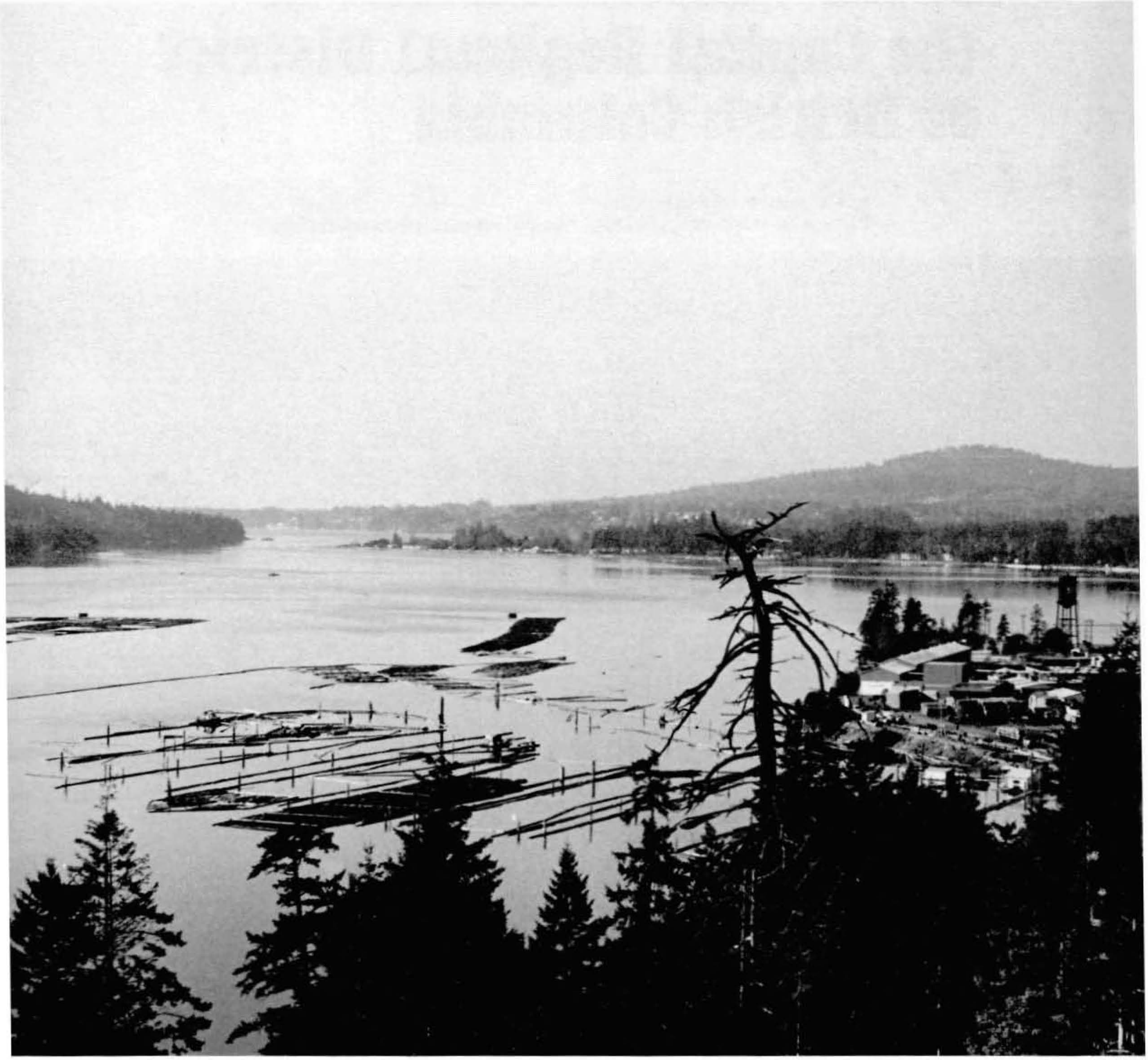

Forestry and forest products are the main industries providing cash and employment.

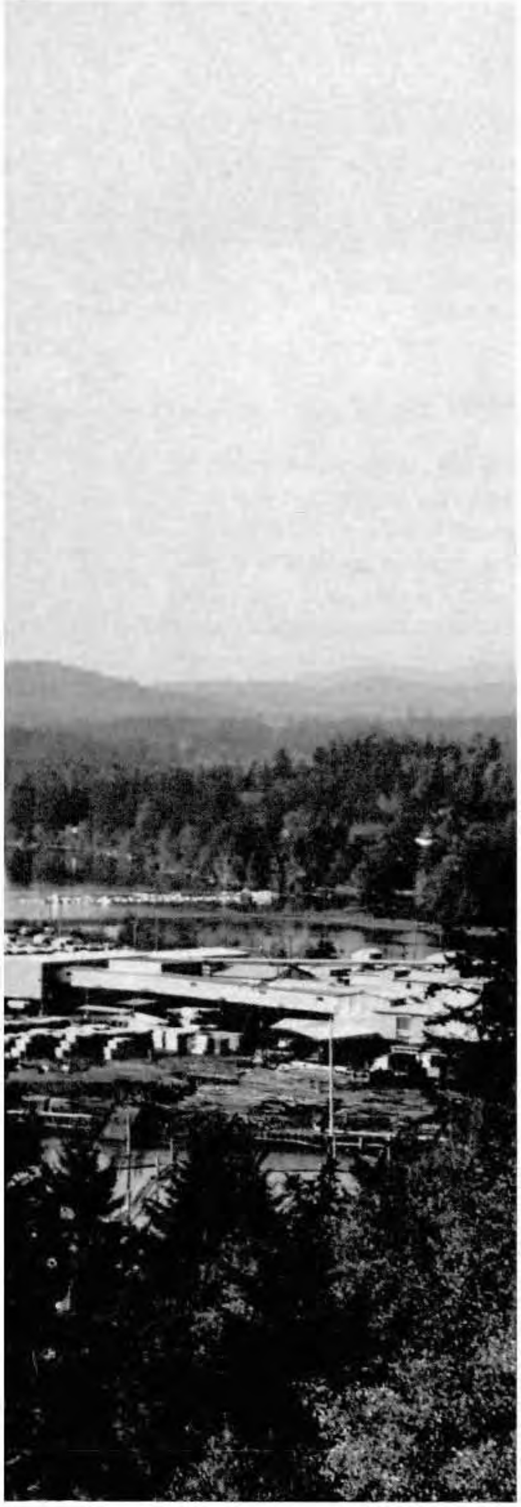

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Fig. 1. Occasionally ground swells produce breakers strong and high enough for surfing. However, water is too cold and diving suits are necessary.

ABSTRACT

The western part of the Capital Regional District of British Columbia is comprised of mountainous terrain sloping south to the Strait of Juan de Fuca. It is sparsely settled, forestry and sea fishing being the only significant industries. However, because of the proximity of Victoria with a metropolitan population of about 230,000 at present and projected to 350,000 by 1995, recreational use can be expected to increase. The purpose of this study is to provide environmental background for planning and preserving the most important features of the coast for public use. Available information is abstracted and summarized. Eleven landscape units are described in terms of their environmental and vegetational characteristics and in each unit the impact of human activity on the environment, vegetation and soils is evaluated. Two maps are included in the study. On one, at a scale of 1:20,000, the shore between Becher Bay and Owen Point, west of Port Renfrew, was divided into 157 homogeneous units. The criterion for separation was that each unit differed in some basic characteristics from the adjoining units. The descriptions include the intertidal zone as well as the adjoining land. Landscape units were mapped up to 3 km inland. The second map, at a scale of 1:100,000, presents the general distribution of landscape units in the watersheds draining into the Strait of Juan de Fuca along the mapped shore.

RÉSUMÉ

La partie occidentale du District Régional de la Capitale de la Colombie-Britannique inclut le terrain montagneux en déclin vers le sud jusqu'au détroit de Juan de Fuca. Elle est presque inhabitée, la foresterie et la pêche maritime y étant les seules industries d'importance. Cependant, à cause de la proximité de Victoria avec a population métropolitaine d'environs 200,000 actuellements et qui sera de 350,000 en 1995, on peut s'attendre à une emprise accrue des loisirs. Le but de cette étude consiste à fournir une base environnementale pour la planification et la préservation des plus impotantes caractéristiques du litteral au profit du public. Toutes les données disponibles ont été résumées et condensées. Onze unités de paysage ont été décrites en fonction des caractéristiques du milieu et de la végétation; dans chaque unité, l'influence exercée par l'homme sur l'environnement, la végétation et la sol a été évaluée. L'étude comporte deux cartes géographiques. Sur l'une, à l'échelle de 1:20,000, le littoral fut divisé en 157 unités homogènes de longueurs inégales. Le critère de division des unités a été que chacune d'elles diffère des unités adjacentes par quelques caractéristiques fondamentales. Les descriptions incluent tant la zone des marées que les unités adjacentes. On a codé les descriptions du littoral pour abréger l'ouvrage. Les unités de paysage ont été cartographiées en détail jusqu'a 3 km à l'intérieur des terres. La deuxième carte, à l'échelle 1:100,000 indique la répartition générale des unités de paysage dans tous les bassins-versants qui se drainent dans le détroit de Juan de Fuca entre Becher Bay et Port Renfrew.

Introduction

Coastal zone management is a complex activity in which all levels of government must participate. However, it is usually up to local or regional governments to take the initiative in recognizing local environmental problems within their jurisdictional boundaries and to plan and guide development or conservation projects. Decisions and controls imposed by governments affect the local economy, property values, way of life and the public use of local resources.

Planning is a difficult process, full of uncertainties. Planners must try to identify the political, economic and environmental factors that have led to the creation of our present man-influenced environment. They must also try to determine all alternatives as a basis of formulating development and conservation policies that may be available to private and public sectors. They must try to unravel the tangled cause and effect relationships that bring about change in the environment and make proposals towards achievement of the defined social objectives. Policy decisions must be implemented, presumably in the light of available information by elected political representatives who are responsible for deciding the fate of the coastal zone.

The coastal zone management problems between Becher Bay and Owen Point, west of Port Renfrew, in the Capital Region of British Columbia may be defined in many ways, depending on the interests of the observer. However, in the Juan de Fuca Strait, which is comparatively unspoiled and well-flushed by tidal currents, the problems do not appear serious. Some of them are:

1. Difficult accessibility.
2. Possibility of oil spill pollution.
3. Possibility of thermal pollution.
4. Pollution caused by boats.
5. Depletion of sport and commercial salmon fisheries.
6. Inadequate stabilization and protection of the coastal shore.
7. Destruction of wetlands.
8. Inadequate preservation of sites of natural and historic value.
9. Limited shoreline and recreation facilities.
10. Disposal of domestic and solid wastes.

Fig. 2. Deep tidal pools, full of marine life, abound below the steep cliffs.

Fig. 3. Many logs are sorted daily by species and quality at the Rayonier dry land sort at the mouth of Jordan River.

Fig. 4. Graveyard of the tall ships.

All these problems are interrelated, being parts of complex geomorphological and ecological systems. Action to deal with any one of them individually may exacerbate others.

The simplified reduction of the problem of coastal zone management is the conflict between the public choice of conservation and protection of land and water resources versus their exploitation to maximize the short-term private gains. It is basically a problem of defining policies to justify governmental constraints on private as well as public action.

While the private and public interests focus primarily on the edge of the water body, the problems become intricately entwined with land use, the distance of the influence back from the waterline and the general population pressure for a multiple use of a limited resource. Concerns that must be taken into consideration include ecology, aesthetics, transportation, development, economic costs, private property rights and many others.

The present study was conducted at the request of the Capital Regional District of British Columbia. It consists of two parts: (1) an analysis of the physical and biological characteristics of the shoreline and adjacent land on southwestern Vancouver Island along the Strait of Juan de Fuca, and (2) landscape analysis of the watersheds that drain along the mapped shore.

Prior to mapping, accessible portions of the shore were walked; inaccessible areas were visited by boat. Mapping was done by interpretation of black and white panchromatic aerial photographs at a scale of 1:15840 (4 inches = 1 mile). The maps were subsequently reduced to 1:20,000. The 10 m (6-fathom) line was interpreted from available marine charts. This line marks the extent of the near-shore shelf in terms of subtidal aquatic habitat. It is also an approximation of the subtidal aquatic fringe of the "shore process corridor" in terms of Pacific storm wave effects on the sea bottom, and the buffer zone for wave energy dissipation.

Description of the Study Area

Fig. 5. The eastern part of the study area is largely logged and supports young stands; the western part still has many mature forests.

A simple coding and numbering system was used in the inventory of the shoreline, similar to that of Bauer (1976), who inventoried the shoreline resources of the Western Community up to Wolf Island on the western side of Becher Bay, where this study begins. The inventory includes all features of the shore having a length of 30 m (100 feet) or more. However, where similar units occurred repeatedly, e.g., a series of similar pocket beaches alternating with rocky heads, they may be described only in general terms.

About 4 weeks of reconnaissance preceded the drawing of the map of landscape units in the areas that drain into the Strait of Juan de Fuca. This map is based on interpretation of aerial photographs, mainly at a scale of 1:31 680 (2 inches = 1 mile), but other scales were also used. The map was drawn at a scale of 1:50,000 and reduced for printing to 1:100,000.

The main study deals with the shore resources of southern Vancouver Island, along Juan de Fuca Strait and an adjacent strip of land about 70 km (43 miles) long and 1.5 to 3 km (1 to 2 miles) wide. It commences at the eastern end near Wolf Island within Becher Bay and extends west about 8 km (5 miles) past the village of Port Renfrew to the western side to Port San Juan Inlet immediately west of Owen Point, about 100 km (65 miles) west of Victoria.

With the exception of a few small bays, the entire shore is exposed to frequent high energy westerly winds and is battered by waves during Pacific storms. Loose materials have been eroded along the shore, and the shoreline is formed predominantly of rock outcrops interspersed with beaches of coarse material produced by erosion of local rock or deposits of glacial till. Loose materials sorted by wave action accumulated below the outcrop cliffs and frequently formed class 3 (Bauer 1976) cobble, gravel or coarse sand beaches, exposed only at low tide.

Within the strip of land mapped, the topography of the East Sooke peninsula rises to about 100 m (300 feet) above sea level at a distance of 1 km (.6 miles), after which it levels off into a plateau. From Sooke to French Beach Park, about 3 km (2 miles) west of Sheringham Point, the backshore is formed by undulating lowlands, generally less than 100 m (300 feet) a.s.l. Up to the mouth of Sombrio Creek, the land rises sharply at a rate of about 150 m per km (800 feet per mile). Past Sombrio Beach westward, the rise of land is more gradual, averaging only about 75 m per km (400 feet per mile).

The second portion of the study describes the landscape units on about 880 km^2 (342 sq miles) of mountainous terrain immediately north of the main study area. This area covers the watersheds of the rivers and creeks that drain south into Juan de Fuca Strait. This mountainous terrain is bisected by a deep fault line containing parts of Loss Creek, Jordan River and Leech River into 2 parallel, east-west

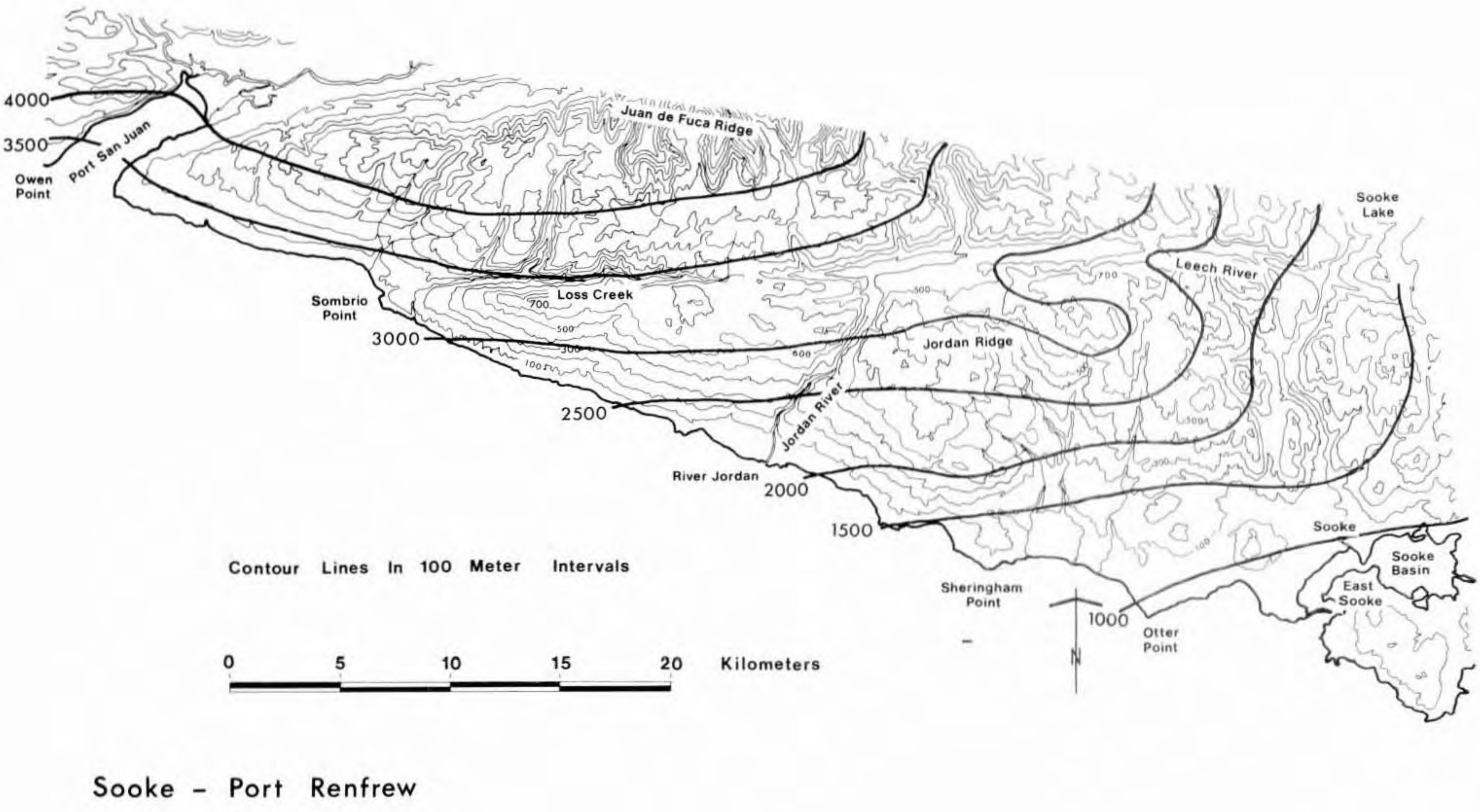

Fig. 6. Topography and distribution of precipitation in mm in the study area.

Fig. 7. China Beach is gently sloping, wide and in summer predominantly sandy. Parking facilities and a good, easy 15-minute trail make this beach very popular.

running ridges (Fig. 6). The southern one, Jordan Ridge, is about 600 m (2000 feet) high, with peaks about 700 to 800 m (2300 to 2600 feet) a.s.l. The northern one, Juan de Fuca Ridge, is about 700 m (2300 feet) high, with peaks between 850 and 1000 m (2800 and 3300 feet) a.s.l.

HISTORY

Before the arrival of the first white settlers, the eastern half of the study area was inhabited by Sooke tribes of Salish Indians, and the western half by Pacheenaht tribes of the Nootkas. Centuries of their occupancy left little impact on the land because they were neither land cultivators nor pastoralists. Their fishing, hunting and gathering activities exercised only modest demands upon the land.

In 1774, Juan Perez anchored at the entrance of Nootka Sound and claimed possession of Vancouver Island for Spain. Captain Cook, who visited the west coast of North America in 1778, and several other British and Spanish expeditions that explored the waters of Vancouver Island in subsequent years, gave names to main water bodies within the study area. The Strait of Juan de Fuca was named in 1787 by William Charles Barkley, captain of the trading ship "Imperial Eagle", in honor of the commander of the first European expedition on the west coast of North America, whose ship supposedly discovered the Strait and sailed throught it as early as 1592 (Lawrence 1965?).

Manuel Quimper, who explored the Strait of Juan de Fuca in 1790, named Port San Juan, San Juan River, Sombrio River and Jordan River. In Sooke Inlet, he took ceremonial possession of the new territory for the King of Spain, at the same time naming the inlet Porto de Reville Gigedo (B.C. Archives).

The establishment of Fort Victoria in 1843 marked the entry of European settlement to Vancouver Island. The Imperial Government granted the

Fig. 8. Waves smoothed the sandstone shelf and eroded caves in the cliffs.

entire Vancouver Island to the Hudson's Bay Company on condition that they establish satisfactory settlements on it for the purpose of colonization.

However, only the Victoria area was considered suitable for settlement. Captain W. C. Grant, the first bona fide settler in the Sooke area, describing the southern part of the island which he surveyed for the Hudson's Bay Company in 1850, wrote

> ". . . Dark frowning cliffs sternly repel the foaming sea, as it rushes impetuously against them, and beyond these, with scarcely an interval of level land, rounded hills, densely covered with fir, rising one above the other in dull, uninteresting monotony . . . ."
>
> . . . . From these regions, which are wild without being romantic, and which never approach to the sublime or the beautiful . . . ."

Captain Grant, dissatisfied with the lonely life on his isolated farm, sold it, in 1854, to John Muir, a Scotsman who, with his family, farmed in the Sooke area for many years. Muir extended his holdings to over 800 acres, built a threshing mill, a flour mill, successful logging operation and a sawmill. Occasionally, he undertook shipbuilding on contract, and built several vessels for his booming export of lumber and piles for harbour constructions in California, South America and Australia.

Fig. 9. Wildlife is abundant throughout the study area and encounters are frequent along the roads.

Because Sooke was connected with Victoria only by a rough trail and all products and supplies had to be transported by water, settlement was impeded.

In July 1864, gold was discovered in an unnamed river north of Sooke by Lieutenant Peter Leech, surveying the unknown interior of the Island for the Hudson's Bay Company, and later the same year, in San Juan River by John Foley. By November, some 1200 miners were sifting through the sands of Leech River and 300 more along the San Juan River. With businesses moving to Leechtown, Victoria was practically deserted, as the spectacle of a boom held promise of large profits to the Victoria business community.

By 1870, the boom was over. A few miners settled in the district. The census registered 24 men and 15 women, engaged mainly in farming and part-time logging. In 1872, road construction to Sooke, which started during the boom days, was completed with a subsidy from the Dominion Government.

The Otter District, situated west of Sooke, was first settled in 1874, but not until the government extended the trail from Sooke to Sombrio River in 1891 did the population substantially increase.

With the road to Sooke and a horse trail to Sombrio River, a school, regular postal service and weekly stage service, the settlement began to grow more rapidly. By 1895, there were about 65 families living in the Sooke area and 18 more along the coast west of Sooke. Of a total of 83 families, 74 were classed as farmers and part-time loggers. Because of the distance to the market, farming was necessarily of a subsistence nature and farm holdings were generally small. In Sooke District, apart from unimproved pasture, only 417 acres were under cultivation.

In the late 1880s, the government sought to attract settlers to the San Juan Valley by promising that the road from Victoria would be extended to Port San Juan. From 1889 to 1899, at least 26 families settled on the fertile land along the river. In 1896, the post office of Port Renfrew was opened, but the government of the day was uninterested in fulfilling the promises made by the previous government. Consequently, there was gradual abandonment of the farms because of the difficulty of getting the produce to markets.

Fig. 10. At low tide an eroded shelf is exposed. In the old days of logging, salvage of logs was too dangerous and many huge logs, by now destroyed by shipworms, litter the coast.

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Around 1900, the whole west coast experienced a mining boom of large proportions and about 300 men found employment in various operations. The settlement of Jordan River on a permanent basis owed its greatest boost to a hydroelectric project on the Jordan River. The British Columbia Electric Railway Company built several small dams on the river and, in 1912, installed a 5,000 horsepower generator and constructed a 45 mile high-tension line to Victoria.

In 1913, the Canadian Puget Sound Lumber and Timber Company opened a shingle mill and sawmill at the mouth of the Jordan River and started to build a logging railroad.

During World War I, the demand for lumber for war purposes and a post-war housing boom resulted in large-scale logging of the great forests along the coast. During the war years, when canned fish was in great demand, especially by the army, the prosperity of the fishing industry also contributed to the growth of the area. The high price of copper on world markets stimulated interests in mining and, in 1918, shipments totalling 177,000 pounds were made. However, with the return of normal prices for copper, mining gradually ceased.

While all these developments stimulated the economy, the study area experienced the hardships of the Depression, as did the rest of the province. In 1940, the population of the whole area from Sooke to Port Renfrew was 600, precisely that of 1928.

Relief from stagnation was provided by the advent of World War II, with its attendant demands for lumber, fish and agricultural products. After the war, the area underwent a steady boom derived from the continuously rising prices of wood products and fish, and has sustained a perceptible growth up to the present time.

CLIMATE

The air flows that originate regularly above the Pacific are subjected to the chanelling effect of the mountanous terrain situated on both sides of the Strait of Juan de Fuca. In winter, the northeast Pacific receives considerable quantities of warm water from the south by means of Davidson's Current. The result is a transfer of heat and moisture into the air. Air flowing from a westerly direction in winter brings rains, but produces air temperatures up to 12°C (22°F) higher than might be expected from the latitude. Westerly winds accompanying east-moving depressions over the Pacific may bring a succession of cyclonic storms lasting, with little break, for a week or more. However, westerly winds, while strong, are rarely of gale force. Easterly and northeasterly winds, associated with migrating Pacific storms, are channelled into the Strait of Juan de Fuca by the Olympic Mountains and may become very strong in late fall and winter.

In summer, a subtropical high pressure cell replaces the depression over the Pacific as the dominant dynamic feature. The high is oriented along a west-southwest-east-northeast axis, with an extension northward along the British Columbia coast. In summer, the air moving slowly from the west becomes cooled by the cold upwelling water that lies immediately off the coast of Vancouver Island and penetrates deep into the Strait of Juan de Fuca. As it gradually warms up above the land, it becomes unsaturated, producing, in the study area, cool and dry weather, with breezes developing regularly during afternoons.

Because the terrain rises sharply from the sea, during periods of westerly flow that accompany frontal passages, the air channelled into the Strait rises and, as it cools again, condensation of moisture takes place. Under such conditions, higher elevations may have dense cloud cover, whereas areas at sea level may be cloud free.

During calm weather in summer, subsidence produces temperature inversions. Records at Quillayate on the tip of the Olympic Peninsula in Washington, U.S., indicate inversions 63% of the time during the June-September period, with the inversion base having a mean height of 585 m (1930 feet).

Because meteorological stations are widely scattered and their records are short and incomplete

Table 1. Precipitation and snowfall data for several important locations in the study area.

Location	Precipitation annual total	Snowfall annual total	Years on record
At seashore			
Becher Bay	960 mm (38 inches)	8 cm (3 inches)	0
Otter Point	1170 mm (46 inches)	13 cm (5 inches)	3
Jordan River	1180 mm (70 inches)	38 cm (15 inches)	3
Port Renfrew	3800 mm (150 inches)	74 cm (30 inches)	6
Inland			
East Sooke	980 mm (39 inches)	48 cm (19 inches)	12
Sooke Lake	1300 mm (51 inches)	115 cm (46 inches)	55

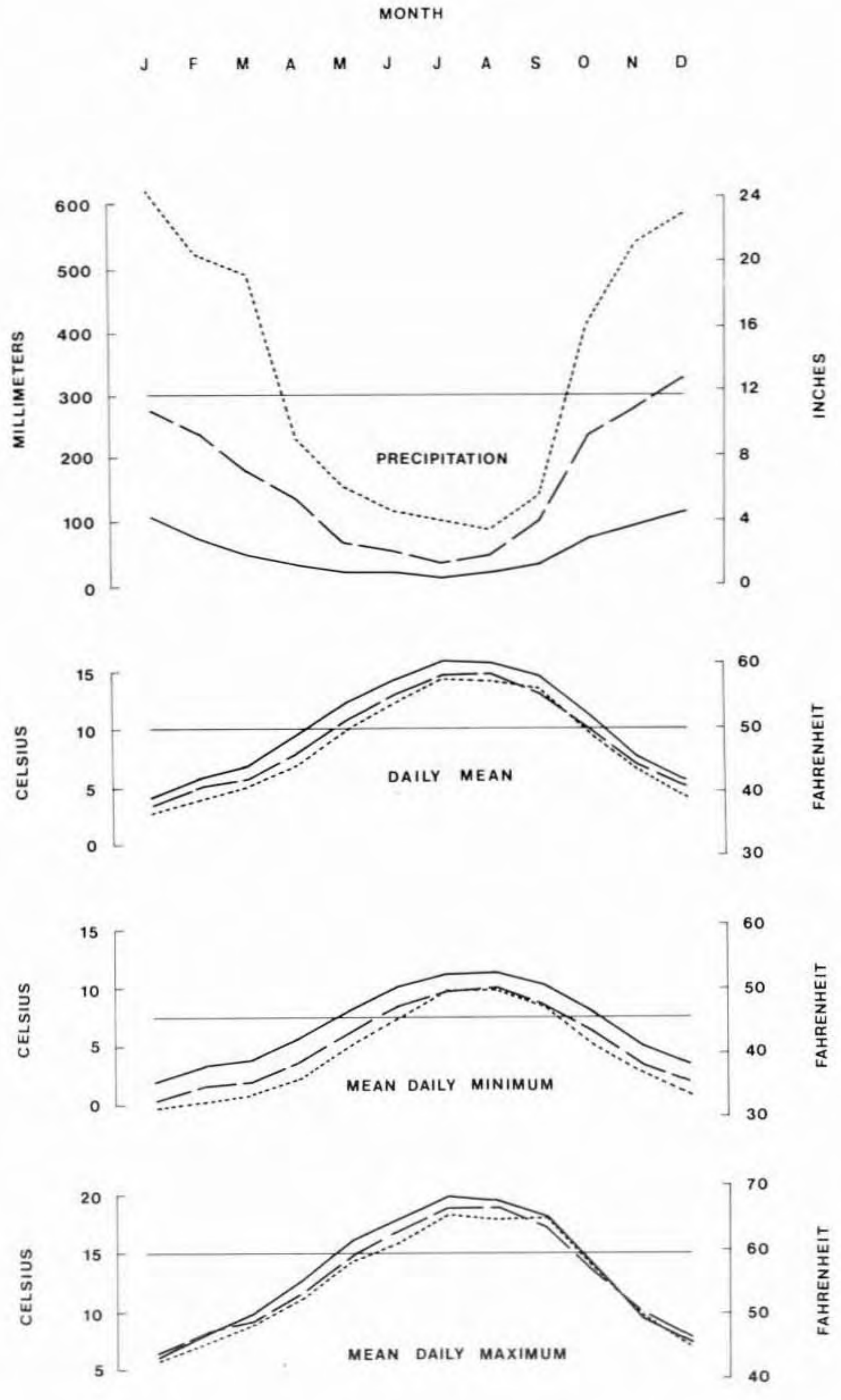

Fig. 11. Precipitation and temperature summaries: Port Renfrew - - - - - -, River Jordan —— ——, Victoria, Gonzales Observatory ———.

Fig. 12. On the exposed coast, the rock surfaces are black with mussels.

(Climate of British Columbia, 1916 to 1976), a great amount of interpretation was necessary.

Generally, precipitation is highly seasonal, about 78% occurring from October 1 to April 1. Summers are dry (Fig. 11). Total annual precipitation increases from east to west (Fig. 6), ranging at sea level from about 960 mm (36 inches) at Becher Bay, to about 3800 mm (150 inches) at Port Renfrew (Table 1).

Even in the eastern, driest part of the study area, a rainfall of 50 mm (2 inches) in 24 hours occurs several times each year and much heavier rainfalls are possible. At Sooke Lake, during 55 years on record, 188 mm (7.4 inches) of precipitation during 24 hours occurred on January 21, 1935, corresponding with an estimated 110 mm (4.3 inches) at East Sooke and 130 mm (5.1 inches) at Otter Point. On that day, Jordan River recorded 122 mm (4.8 inches). At Port Renfrew, during 7 years on record, the highest precipitation occurred on December 25, 1972 and amounted to 232 mm (9.1 inches).

Because of the warming effect of the sea in winter, snowfall is infrequent along the seashore and snow cover rarely lasts more than a few days. Farther inland, because of elevation effect, snowfall increases (Table 1). At 750 m (2500 feet) elevation on San Juan Ridge, snowfall averages about 300 cm (120 inches) annually. The road to Port Renfrew, which in a number of places is around 200 m (660 feet) above sea level, receives about 125 cm (50 inches) of snowfall a year. Although winter precipitation is usually in the form of rain, snowfalls, when they occur, may be heavy. More than 90 cm (36 inches) accumulated in 24 hours at Sooke Lake on November 27, 1948 (Greater Victoria Watershed records).

Freezing rain, a condition when rain freezes on impact with frozen ground, is rare and of little concern. However, ice is said to have formed by this process on the road to Port Renfrew in the past and disrupted communications and travel for several days.

Hours of sunshine could only be estimated, as no meteorological station within the study area collects sunshine data. Victoria, Gonzales, with 2183 hours per year, Estevan Point with 1690 hours, and Cowichan Lake with 1385 hours, were used for estimates. Becher Bay has about 2000 hours, East Sooke and Otter Point about 1950 hours, Jordan River about 1850 and Port Renfrew less than 1750. Sooke Lake has about 1700 hours and the San Juan Ridge less than 1400 hours. The differences between localities are greatest in the early morning hours during spring and fall. In winter, when the air flowing from a westerly direction is saturated or when passing depressions bring rain, and in summer, when the air is dry, the amount of sunshine is similar throughout the whole area.

Apart from the Sooke Lake station, with a 44-year record, temperature data on other stations have been collected only recently and provide only general information. Along the coast, mean daily temperatures are uniform and the differences among stations are partially the result of the years on record and the station's microenvironment. From the years in which records overlap and from daily observations (Monthly records, 1928-1978), it was estimated from similar locations near the seashore, that the mean daily temperatures at Jordan River are about 0.5°C (1°F) higher, at Otter Point about 1°C (2°F) higher and at Becher Bay somewhat less than 1.5°C (2.5°F) higher than at Port Renfrew. The differences in winter appear to be somewhat less than in summer. Inland, the mean daily temperatures are slightly higher in summer, while in winter, they are slightly lower than at the nearest sea coast station (Table 2).

Fig. 13. Winter storms remove sand from the beaches into deeper water, leaving long stretches of gravel and cobbles.

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Table 2. Temperatures at selected locations in the study area.

Location	Mean daily temperature January	Mean daily temperature July	Years on record
At seashore			
Becher Bay	4.4°C (39.9°F)	14.9°C (58.8°F)	0
Otter Point	4.3°C (39.7°F)	14.4°C (58.0°F)	3
Jordan Point	3.4°C (38.1°F)	14.3°C (57.7°F)	5
Port Renfrew	3.2°C (37.6°F)	14.2°C (57.4°F)	6
Inland			
East Sooke	4.0°C (39.2°F)	14.8°C (58.6°F)	12
Sooke Lake	3.3°C (37.4°F)	15.1°C (59.2°F)	44

Fig. 14. The sandy beach at the Indian Reserve at Port Renfrew stretches from the town site to the mouth of Gordon River.

Fig. 15. At Jordan River, logs are sorted, scaled and bundled on dry land. Booms are built in the river mouth and towed away at high tide.

Generally, the differences between years were greater than between locations. The annual temperature extremes were also more extreme in locations away from moderating influence of the sea. Even along the seashore, morning frost was recorded in all localities every December, January and February, but usually lasted only a few days. In most years, the minimum temperature was only about –4°C (25°F). The lowest temperature ever measured at Port Renfrew was –11°C (12°F), at Jordan River –15.6°C (4°F) and at Sooke Lake –16.1°C (3°F). The highest temperature ever recorded at Port Renfrew was 30.6°C (87°F), at Jordan River 31.1°C (88°F) and at Sooke Lake 34.4°C (94°F). Reliable data from other stations are unavailable.

The funnel-shaped ends of the Juan de Fuca Strait, with the high Olympic Mountains to the south and the Vancouver Island mountains to the north, concentrate and redirect the moving air masses, and the constriction increases the velocity of flow. In winter, westerly winds are most common along the Strait, averaging, on the exposed coast, about 18 km/h (12 m.p.h.). While in the early morning hours, they may be only 3 to 5 km/h (2-3 m.p.h.), the afternoon and evening velocity often exceeds 30 km/h (20 m.p.h.). January has the highest mean monthly wind velocity, averaging about 25 km/h (16 m.p.h.). Gale-force winds usually blow from an easterly direction but occur only once or twice each year, usually in late fall or early winter. They are the results of steep barometric gradients associated with migrating Pacific storms. The highest velocity recorded at Sheringham Point exceeded 94 km/h (58 m.p.h.). During June to October, easterly winds are frequent, averaging about 16 km/h (10 m.p.h.). Because of the topographic control exercised by the land masses, winds blowing from south, north and northeast are weak and infrequent.

A complete lack of air flow is very rare; consequently, occurrence of non-seasonal frost is rare. The first frost occurs in early November and the last around the middle of April. However, in 1972, East Sooke and Port Renfrew recorded frost as early as September 27 and East Sooke, in 1975, as late as May 24. The frost-free period at Port Renfrew ranged from a low of 157 days in 1972 to a high of 223 days in 1976, averaging 198 days over an 8-year period. From incomplete records, Jordan River was estimated to have about 210 frost-free days and Otter Point 230 days. Sooke Lake, between 1937 and 1946, averaged 213 days and East Sooke, from 1967 to the present, 188 days.

During periods of calm, radiation fog may form over lowlying areas, especially in late fall and early winter, when moisture content of the air is high and cooling during cloudless nights is pronounced. Radiation fog is of local occurrence and is dissipated by a temperature rise during the day or carried away by air currents. Sea fog, caused by the slow advection of warm maritime air over cold ocean water, is frequent over Juan de Fuca Strait. Once the sea fog has become established, it will persist until a change of air circulation breaks down the thermal inversion. Sea fog is quite common throughout the year over Juan de Fuca Strait, when large inversions are caused by depressions and storms over the Pacific Ocean. Occasionally, air currents may carry the sea fog ashore.

GEOLOGY AND SOILS

The portions of the study area, south of the Loss Creek, Jordan River and Leech River fault line, are underlain by dark volcanic rocks of Eocene origin (Metchosin volcanic), consisting mainly of basalt, tuff and gabbro (Clapp 1917), rich in calcium, magnesium and iron. By mechanical weathering, they break up into boulders, pebbles and sand grains and, through chemical weathering, into loamy and clayey debris. Associated with the volcanic rocks are subordinate deposits of limestone and of more resistant sedimentary rocks, such as chert, argillite and greywacke. Granitic rocks of Paleozoic and Lower Mesozoic origin prevail north of the fault line. They consist mainly of schist, gneiss and quartz diorite and contain more potassium and sodium. They yield weather-resistant boulders and pebbles but eventually break down into debris of sandy texture.

Shales, sandstones and conglomerates of Pliocene origin form shelves and cliffs along the seashore from San Juan Point eastward almost to Sheringham Point. Chemically, they are intermediate between volcanic and granitic rocks. Shales consist mainly of silt and clay size particles and readily break down into debris of loamy or clayey texture. Sandstones and conglomerates are more resistant to weathering than shales. Their disintegration products are generally of sandy to loamy texture.

Although these minerals provide material for the present soils, the deposits in which they are contained are relatively recent. About 15,000 years ago, glacial ice spread over the entire study area, eroding the pre-existing materials and spreading a blanket of

Fig. 16. Many deep gullies were eroded in the shelf. They are filled with water and where they extend to the cliffs, the access along the shore is difficult, if not impossible.

Fig. 17. At low tide, the smooth sandstone shelf provides easy access along the shore.

glacial till, ranging from less than 1 m (3 feet) to more than 30 m (100 feet) thick, over the terrain.

At the height of this glaciation, ice probably covered all of Vancouver Island except, perhaps, a few of the highest peaks. Upon retreat of the glacier, the sea re-entered Juan de Fuca Strait. Vancouver Island, relieved of the weight of ice, has risen and tilted relative to the sea, so that now the highest marine deposits are found at elevations of about 180 m (600 feet) at Campbell River, 90 m (300 feet) at Victoria and Alberni, and about 20 m (60 feet) on the west coast. At Port Renfrew, marine deposits occur up to about 36 m (120 feet) a.s.l. and at Sooke, up to about 73 m (240 feet) a.s.l. (Clapp 1917).

As the ice melted and the land rose, large volumes of rapidly moving meltwater eroded glacial deposits in higher elevations and on steep slopes, often exposing bedrock. Large rocks were deposited at the foot of slopes. Landslide debris and creek deposits accumulated in favorable locations.

Soils developed on glacial till parent material are widespread on higher topography. They usually consist of two distinct layers. The lower layer, commonly refered to as "hardpan", is usually pale yellowish gray and exceedingly hard. According to one theory, it resulted from abrasion, crushing and compaction under the weight of the advancing glacier. On top of this compacted layer has been deposited loose material carried within and upon the ice. Another theory considers present soils to be derived by weathering processes from underlying compacted till. Where the soil was not subsequently removed by meltwater streams, it forms a fairly uniform layer, up to about 1 m (3 feet) deep, of unsorted, unstratified, gravelly, sandy and loamy material containing many angular rocks of different origin. Loamy and clayey till soils contain predominantly material derived from shale and volcanic rocks. Some till soils of sandy texture are derived from granite or sandstone, others are sandy because they contain materials derived from inter-glacial sands (Day et al. 1959).

The hardpan, underlying the till soils, effectively prevents water from moving downward, so that soils in low locations are subject to flooding during the winter and those on higher ground are not as dry in summer as would be expected from their texture. Such unmodified till soils are found only above the level of post-glacial marine submergence.

In some areas, associated with till soils are glacio-fluvial soil. They originated where the till surface was washed by streams or covered by a layer of glacio-fluvial gravel. The most extensive glacio-fluvial deposits occur where the major valleys lead from the mountains onto the coastal lowland. They often form ridged or hummocky areas and flat terraces and benches above the valley floors.

As the land rose, glacial streams cut gullies into deep glacial, interglacial, as well as marine deposits, and transported the eroded material into the valleys. As the rivers reached the retreating sea, they deposited series of gravelly deltas over the marine deposits, while fine-textured materials accumulated away from the main stream, as in protected bays of the deltas, or were carried farther into the sea.

Below the elevation of marine submergence, till still forms the substratum, but the soil surface is developed from marine materials derived generally from tills. Some of these marine soils differ little from till soils, but most are distinctly coarser in texture. Typically, they form a "veneer" or "mantle" up to 1.5 m (5 feet) thick on hills and slopes and up to 10 m (30 feet) on level ground. In very general terms, this marine mantle has been formed by the washing action of waves upon the surface materials of slopes and hilltops and consists of fine materials containing few stones on level ground and coarse materials containing many stones on sloping land.

Bottom lands along the rivers and deltas at the river mouths are largely built of alluvial gravels and sands, although they usually bear a thin surface veneer of loamy, silty, clayey or organic material. Alluvial fans, where streams flow from steep mountainside gullies onto flatter ground, range from stony or gravelly sandy loams to almost entirely stones. However, these areas are generally too small to show on the map.

HYDROLOGY

Although supporting data from the study area are not available, it was estimated that the soil moisture deficit begins in early May at Becher Bay and Sooke, middle of May at Jordan River and late May or early June at Port Renfrew, and ends with autumn rains in early September at Port Renfrew and late September at Sooke and Becher Bay. It amounts to about 330 mm (13 inches) at Sooke and Becher Bay, about 250 mm (10 inches) at Jordan River and 180 mm (7 inches) at Port Renfrew. At higher elevations, which receive greater precipitation, the soil moisture deficit is less. It also varies greatly with aspect, exposure, soil and ground cover.

Fig. 18. Deep tidal pools, eroded into the shelf, are teeming with marine life.

Summer rains are usually light and any precipitation is immediately absorbed by litter and dry, porous soil. Consequently, runoff is very rare, and streams, lakes and swamps depend entirely on the ground water supply. By the end of the summer, the water level drops in lakes, swamps dry out and creeks become tricklets seeping through the gravel, often disappearing entirely.

In winter, a great amount of water is available during periods of rains or snow melt. However, subzero temperatures at higher elevations equalize the runoff by freezing water in the litter and soil surface and allow the ground water to be gradually depleted. It was estimated that about 600 mm (24 inches) of precipitation is available for winter runoff at Becher Bay, 760 mm (30 inches) at Otter Point, 1350 mm (54 inches) at Jordan River and 3400 mm (135 inches) at Port Renfrew. Sandy soils, frequent at low elevations, have rapid internal drainage and surface runoff is greatly reduced.

Sandy soils are usually underlain by layers of clay, loam, glacial till or rock which have a slow internal drainage and probably an undulating uneven surface. Consequently, as soon as winter rains saturate the water-holding capacity of the sands, seepage water collects in low-lying areas, transforming swamps and marshes, in which water may have been below the soil surface during the summer, into temporary lakes. Further, the great porosity of sandy soils has a moderating influence on the peak flow of creeks, but extends the flow into rainless periods. At high elevations, organic soils exist on large areas of flat, undulating and hummocky topography with numerous swamps. Since the summer water level in swamps is 50 cm (20 inches) or more below the winter level, runoff in the fall is usually delayed until late November, when the organic soils have recharged their water-holding capacity and water in swamps has risen to the level of the outlets.

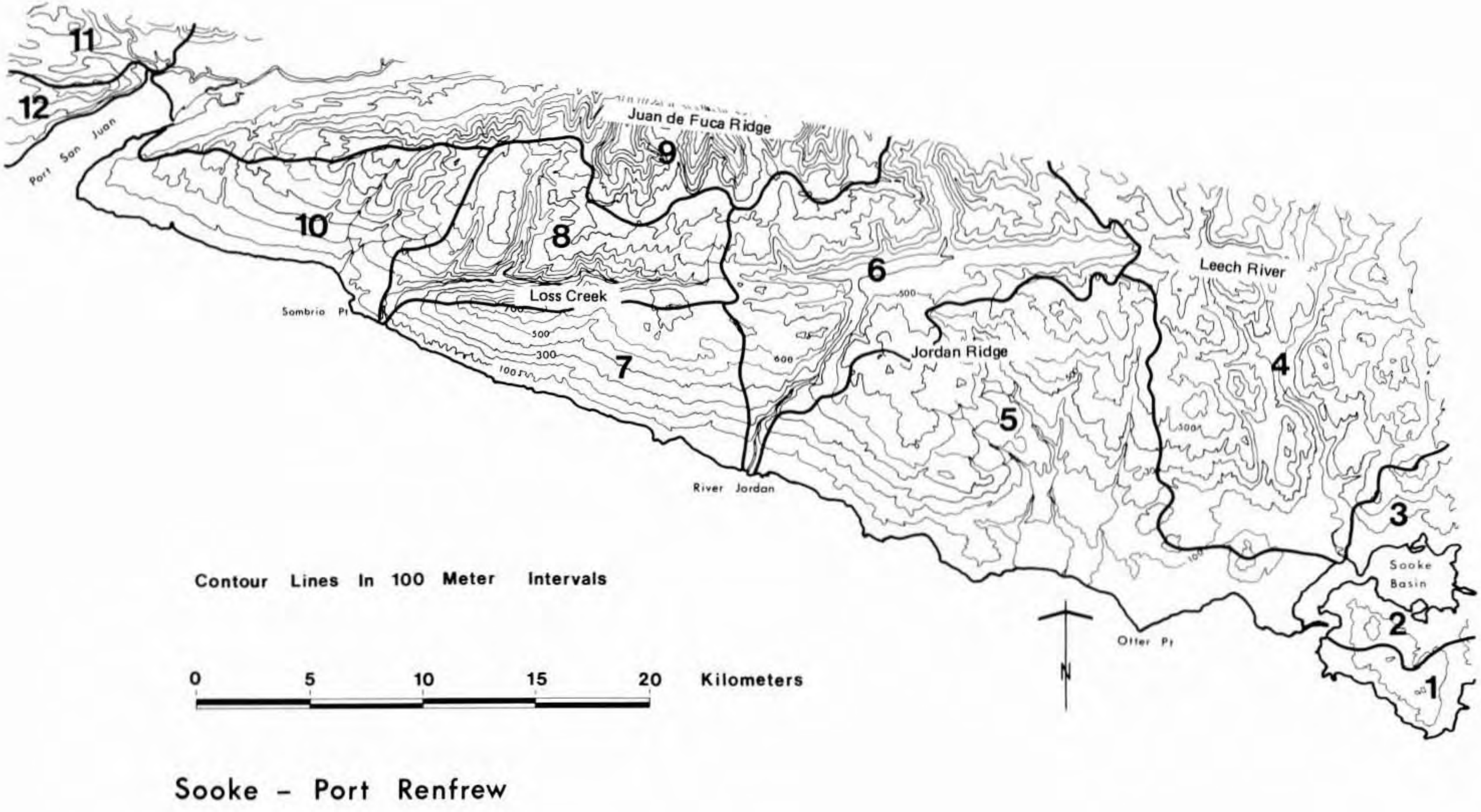

Fig. 19. Topography and drainages of the study area.

Fig. 20. French Beach is only one of many attractive beaches; it is probably one of the most accessible and is very popular.

DRAINAGE PATTERNS

There are twelve drainages in the study area (Fig. 19).

Sooke River watershed (No. 4, Fig. 19) covers about 178 km^2 (69 sq miles) of the map area. Its northern part, the Sooke Lake drainage, has generally moderately shallow to moderately deep glacial till soils on sloping topography. Precipitation available for winter runoff amounts to about 1200 mm (48 inches). The lake was raised in 1970 and became the main reservoir of the Greater Victoria Water District. It covers approximately 570 ha (1400 acres). The release of water into Sooke River is controlled by domestic consumption and, during the summer, the lake level drops. Recharging of the reservoir in winter acts as a buffer, reducing the discharge of water into the river. Leech River, the largest tributary from the west, drains undulating topography with moderately deep glacial till soils. The runoff, estimated at about 1100 mm (44 inches), is fairly rapid, as most of the watershed has been logged and supports only young forests. In its lower reaches, Sooke River flows through steep, hilly and rugged topography covered with shallow, coarse, till soils with large areas of exposed bedrock. Consequently, runoff from the lower watershed is also rapid. Near its estuary, Sooke River flows through an area of marine gravels which have rapid infiltration and a minimal amount of runoff. During heavy rains, Sooke River rises rapidly and after the rain, falls gradually. Since a part of the watershed was diverted for domestic water supply, the maximum flow is well below that which existed in the past. During heavy rains, water is usually turbid but as there is little active logging in the watershed, it soon clears up. Sooke River has a population of resident cutthroat and rainbow trout, winter run of steelhead, and more than 10,000 chum, about 100 coho and a few spring salmon spawn in its lower reaches. However, a waterfall about 4 km (2.5 miles) from the sea prevents escapement into the upper stream. De Mamiel Creek, the lowest tributary of Sooke River, has a run of about 10,000 chum and at least 500 coho (Environment Canada, Fisheries Service).

Ayum Creek drains the southern slopes of Mount Quimper, an area of approximately 15 km^2 (6 sq miles), into Sooke Basin (No. 3, Fig. 19). Up to the elevation of about 60 m (200 feet) a.s.l., gravelly sands predominate on moderately sloping topography. Higher elevations have steeper slopes and broken, rugged topography with shallow glacial till soils and large areas of exposed broken bedrock. The upper watershed of Ayum Creek has a rapid runoff; on gravelly sands of the lower watershed, mostly infil-

Fig. 21. Vertical shale cliffs are common in the western part of the study area and often form heads separating the beaches.

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tration takes place. Ayum Creek has a small population of resident cutthroat trout and an average run of about 300 chum and up to 50 coho salmon.

East Sooke Peninsula covers about 28 km^2 (11 sq miles). The topography is an undulating plateau with generally shallow soils and frequently exposed bedrock. The northern slopes (No. 2, Fig. 19), about 13 km^2 (5 sq miles), drain into Sooke Basin; the southern slopes (No. 1, Fig. 19), about 15 km^2 (6 sq miles), drain into Juan de Fuca Strait. There is no concentration of runoff into larger streams; instead, numerous gullies drain directly into the sea.

The area between Sooke River and Jordan River watersheds (No. 5, Fig. 19), approximately 180 km^2 (70 sq miles), is drained by Tugwell, Muir, Kirby, Jacob, Rockbottom, Sandcut and Desolation creeks and several smaller, unnamed, winter-flowing streams, all discharging directly into Juan de Fuca Strait. The southern slopes of Jordan Ridge, which form the headwaters of these creeks, have generally shallow stoney soils of glacial till origin. The lower watersheds of Jacob, Rockbottom, Sandcut and Desolation creeks have deep glacial till soils and, below an elevation of about 75 m (250 feet), stratified marine gravelly sands on slopes of about 15 to 20%. The lower watersheds of Tugwell, Muir and Kirby Creeks have deep, stratified gravelly loamy sands and sandy loams overlaying impervious, hard, sandy marine clays on slopes averaging about 10%. The glacial till soils of hilltops and slopes have rapid runoff, but considerable infiltration takes place on deeper sandy soils covering gentler topography. Generally, stream flow rises rapidly during rains and, because of the steep gradient of the creeks, it also falls rapidly after the rain. Exceptions are the lower reaches of Tugwell, Muir and Kirby creeks, because of the gradual drainage from deep sandy soils. Tugwell, Muir and Kirby creeks have small populations of resident cutthroat and some sea-going cutthroat and steelhead. The rest of the streams are too steep and rocky and their summer flow is too low for any fish to survive. Tugwell Creek has a run of about 25 chum and 10 coho; Kirby Creek about 25 chum and 150 coho and Muir Creek about 100 chum and a few coho.

Jordan River drains an area of approximately 123 km^2 (47 sq miles) (No. 6, Fig. 19), consisting of the north slopes of Jordan Ridge and the south slopes of San Juan Ridge. The watersheds of upper Jordan River and its upper tributaries have predominantly shallow till soils with low water-holding capacity and steep topography. Consequently, the runoff is rapid and erosion after logging can be expected. Several dams have been constructed in the Jordan River Valley, controlling the water, most of which is released through the tunnel to the power station near the mouth of the river. Only the tributaries below Elliott Reservoir contribute to the flow fluctuation in the lower reaches of Jordan River. The reservoirs and upper tributaries have a good population of resident cutthroat and rainbow trout. The low, and in summer often non-existent water flow below Elliott Reservoir drastically reduces the rearing populations of resident trout and eliminates all sea-going fish. Return of salmon for spawning is probably very low and possibly nil.

The southern slopes of Jordan Ridge between Jordan River and Loss Creek watersheds (No. 7, Fig. 19), approximately 63 km^2 (25 sq miles), are drained by numerous short, steep, winter-flowing creeks. During the summer, the flow is very light and often amounts only to seepage through the gravel. The topography is moderately steep (about 20%), sloping directly south toward Juan de Fuca Strait. Below about 400 m (1300 feet) a.s.l., soils consist of deep, coarse, gravelly sandy loams with moderately rapid infiltration and internal drainage. At higher elevations, especially on steeper slopes, shallow gravelly tills predominate. Flat and hummocky topography at higher elevations has shallow (about 50 cm, 20 inches), poorly drained organic soils over impervious shale or bedrock. The organic soils usually have a thin forest cover, poor tree growth and extensive grassy areas with numerous, but usually rather small, swamps where the organic layer may be more than 3 m (10 feet) deep. Light summer rains infiltrate into the soil without runoff, but during heavy rains in winter, the runoff transforms creeks into torrents. While the flow in the creeks rises rapidly once the organic soils have been saturated, the gradual drainage from these soils prolongs the duration of the flow. The steepness of the creeks and intermittent flow in summer does not allow any permanent fish population to survive.

Loss Creek, flowing westward through a narrow, steep valley between Jordan Ridge and San Juan Ridge, drains approximately 74 km^2 (29 sq miles) of the study area (No. 8, Fig. 19). The headwaters of Loss Creek and its upper tributaries flow from steep, rocky ridges with shallow till soils and from poorly drained plateaus covered by organic soils with numerous bogs. The runoff rises rapidly and after the organic soils are saturated in late fall, it drops off only gradually because of slow drainage from the plateaus. The lower part of Loss Creek watershed, including Noyse and Jack Elliott drainages, has poorly drained organic soils and deep sandy loams on moderately sloping topography, with good water-holding capacity and rapid infiltration rates. All these conditions account for a moderately rapid rise of water in Loss Creek following a rain, and prolonged flow after a rain. They also account for low but continous summer flow. The upper reaches of Loss Creek have a small population of resident cutthroat, but a waterfall about 150 m (500 feet) from the sea stops fish from going upstream.

The slopes of San Juan Ridge west of Loss Creek watershed up to the village of Port Renfrew (No.10, Fig. 19), approximately 66 km^2 (26 sq miles), are drained directly into Juan de Fuca Strait and Port San Juan by numerous but mainly winter-flowing creeks. Sombrio and Minute creeks at the eastern side of the study area run through steep, narrow gullies, while the slopes of all the other creeks are only moderate (about 15%). Low elevations, up to about 300 m (990 feet) a.s.l., have deep marine and colluvial soils of gravelly sandy loam or loamy sand texture; higher elevations support shallow glacial till soils on slopes and poorly drained organic soils on flat or undulating topography. The rise and drop of water level in the creeks are rapid but the low run is prolonged because of the gradual drainage of the organic soils. Freezing at high elevations may reduce the flow in the creeks. Because of the lack of water in summer, there are no fish in these creeks.

Fig. 22. In the Botanical Beach area, there are several beaches, each about 200 m long. Below them, at low tide, a wide shelf extends far into the sea.

Within the mapped area, the San Juan River watershed covers about 120 km^2 (47 sq miles), comprised of the north slopes of San Juan Ridge, the lower valley of San Juan River and a small section of the south-facing slopes of Seymour Ridge (No. 9, Fig. 19). In the eastern section, steep topography (about 25% slope) and shallow till soils predominate. The creeks run directly downhill and the resultant erosion has created deep ravines. The western section covers a wide river valley with loamy soils overlying coarse gravelly sands or gravels and moderately steep (about 15%) slopes covered with gravelly sandy loam of colluvial or till origin. The runoff is rapid at high elevations and on steep topography where the soils are shallow, but considerable infiltration takes place on deeper soils at lower elevations. In the San Juan River valley, where gravelly sands predominate, runoff will occur only during heavy rains. The water level in the tributaries can be expected to rise and fall rapidly. The river itself, because it is draining a large area of varying topography and soils, has a more even flow. However, indications of flooding exist along the lower channel. San Juan River has a good population of resident cutthroat, some rainbow trout and some sea-going cutthroat and steelhead. On the average, about 5,000 coho, 200 chum, 300 sockeye and 750 spring salmon annually migrate into the San Juan River system to spawn. However, recent escapements have been much smaller.

The mapped area west of Port Renfrew covers approximately 32 km^2 (12.3 sq miles). The southern slopes of Pandora Peak (No. 12, Fig. 19) fall steeply to the San Juan Inlet and have shallow soils and rapid runoff. The ridge has a moderate slope (10-15%) and deeper soils. Because of close proximity to the sea, concentration of runoff water into large streams does not take place; instead, numerous short, winter-flowing streams drain this area directly into the sea. The north slopes of the ridge (No. 11, Fig. 19) drain into an unnamed creek which empties into Gordon River about 2 km (1.2 miles) from its estuary. The runoff from these areas is moderately rapid. It is improbable that any of the small streams could have any fish. Gordon River, however, has a good population of resident cutthroat and rainbow trout and some return of steelhead, coho and chum salmon. Some netting of sea-going fish takes place on the Indian Reserve at the delta of San Juan and Gordon rivers.

Shore Inventory

It is important to note that the seashore in the zone of land-water interphase is not a stable system, but undergoes constant changes as a result of tides, currents, winds and waves. Where the shore is formed by rock out-crops, the changes may be very slow, but the unconsolidated materials of glacial and early post-glacial marine sediments may erode very rapidly.

Generally, marine sediments, exposed during the uplift of the land, cover the slopes above the sea and often form feeder bluffs that provide material for the beaches.

The anatomy of the beaches remains usually constant but their profile may shift markedly with seasons and the beach surface material may change in response to winter storms and summer calms. As the beach and berm are eroded by winter storms, material is carried out and deposited offshore. Accumulated sand decreases the offshore beach slope, thereby presenting a more gradual bottom surface to storm action. This longer surface dissipates, through friction, a large amount of energy that would otherwise focus on the beach.

After a storm, the beach material is usually coarse, often composed of cobbles or gravel. During a period of calm weather, the sand, deposited offshore during a storm, becomes suspended by normal wave action and is carried gradually back onto the beach. A beach, predominately gravelly in spring, may be covered by more than 20 cm (8 inches) of fine sand in August, with all intermediate fractions often completely missing.

In the following inventory, the shore was divided into more or less homogeneous units by separating any shore unit that was sufficiently different in some basic characteristics from the adjoining unit. For the description of a shore unit, its geographic location must be located on the map and the unit, by its number, referred to the table, in which the description of the unit has been coded. The description includes the intertidal zone as well as the shore.

DESCRIPTION OF THE SEA SHORE FROM WOLF ISLAND IN BECHER BAY TO OWEN POINT, WEST OF PORT SAN JUAN

Unit No.	Immediate shore access	Shore ownership	Unit length m	Shore type and height m	Shore slope degrees	Shore material	Number of beaches and type	Beach class	Intertidal material	Intertidal width m	Intertidal slope degrees	Energy zone	Shore walkability
1	difficult	private	375	cliffs 5	80	1,2	–	–	1,2	0	80	1	no
2	possible	private	55	bluffs 3	60	3	pocket	3	5,1,2	10	15	1	easy
3	easy	private	200	bank 3	50-20	3	pocket	2,3	4,5	15	10	1	easy
4	difficult	private	40	cliffs 6	70	1,2	–	3	5	3	15	1	low tide
5	easy	park	35	bank 3	40	3	pocket	3	4,7	9	20	1	easy
6	difficult	park	150	cliffs 6	70	1,2	–	–	1,2	0	70	1	No
7	possible	park	30	gravel bar	20	4	pocket	2	5,4	10	20	1	possible
8	difficult	park	300	cliffs 8	60	1,2	–	–	1,2	3	60	1,2,3	difficult
9	easy	park	40	gravel bar	30	4,2	pocket	2	4,5	10	20	2	easy
10	difficult	park	130	cliffs 8	60-40	1,2	–	–	1,2	5	50	2	No
11	easy	park	340	bank 3	25	3,1	pocket	2	5,4,2	15	15	2	easy
12	difficult	park	320	cliffs 10	70-40	1,2	–	–	1,2,6	5	50,10	2	difficult
13	locally	park	9450	cliffs 15	80-40	1,2	–	–	1,2	0-3	80-40	3,2	No
14	easy	park	35	bank 3	50	1,3	pocket	2	5,4	10	20	1	easy
15	easy	park	35	bank 12	50	1,3	pocket	2	5,4	10	20	1	easy
16	easy	park	25	bank 5	30	3	pocket	2	4	8	20	1	easy
17	possible	private	840	cliffs 4	60	2,1	4 pocket	2	4	8	15	2,3	difficult
18	easy	public	900	gravel bar	20	4	drift	1	3,4	50	5	3	easy
19	none	private	1900	bluffs 20	80	3	4 drift	3,2	4,2	30	10	3,2	low tide
20 a	none	private	150	bluffs 20	80	3	drift	3	4	15	15	3	low tide
b	easy	private	460	bank 3	30	3	drift	1	5,4	20	10	3	easy
c	possible	private	350	bluffs 10	70	3	drift	2	4	15	15	3	low tide
21	easy	C.P.R.	250	berm 3	30	4,5	drift	1	4	15	15	3,2	easy
22	easy	C.P.R.	450	berm 3	20	4,5	–	–	4	5	30	1	difficult
23	easy	both	320	bank 3	20	3,4	drift	2	4	8-12	20	2	easy
24	possible	private	110	cliffs 6	70	1,2	altered	3	4	8	20	1	low tide
25	easy	private	950	bank 3	20,60	4,1	3 drift	2,1	4,2	15	15	2	easy
26	easy	private	240	cliffs 4	70,30	1,4	5 pocket	2,1	4,2	7	20	3,2	low tide
27	easy	private	350	cliffs 4	70,30	4,1	3 pocket	2,3	5,4,1	10	20	2,3	low tide
28	easy	private	300	bank 2	30	4,3	2 drift	1,2	4,5,2	10	20	3,2	easy
29	easy	private	320	cliffs 5	30,70	3,1	2 pocket	2,3	4,2	10	20	2,3	easy
30	possible	both	160	fill 6	30,40	5,4	pocket	1,2	4	12	15-20	2	easy
31	easy	private	870	cliffs 5	70,50,30	1,3	3 pocket	2,3	4,2,1	8	15-60	3,2	easy
32	difficult	private	535	cliffs 10	80,50	1,3	5 pocket	3	1,2,4	0,5	80,25	3,2	no
33	possible	private	275	slope 8	50	3,2	drift	2	4	10	20	3	easy
34	difficult	private	85	cliffs 6	80	1,2	–	–	1,2	3	80	3	no
35	possible	private	290	slope 5	60	3	drift	2	5,4,2	15	15	3	easy

Unit No.	Immediate shore access	Shore ownership	Unit length m	Shore type and height m	Shore slope degrees	Shore material	Number of beaches and type	Beach class	Intertidal material	Intertidal width m	Intertidal slope degrees	Energy zone	Shore walkability
36	none	private	100	cliffs 5	80,60	1,2	–	–	1,2	0	80	3	no
37 a	difficult	private	50	cliff 4	60	1,2	drift	3	4,5	15	15	3	easy
b	easy	private	760	bank 3	30	4	drift	2	4,5	20	10	3	easy
c	easy	private	975	berm 2	20	4,5	drift	1	4,5	20	10	3	easy
38	easy	private	110	bar 2	20	4	drift	1	4	20	15	3	easy
39 a	different	private	160	bluff 5	80	3	drift	2	4,5	15	15	3	easy
b	possible	private	365	bank 10	50	3	drift	2	4,5,2	20	15	3	easy
40	easy	B.C.F.P.	220	berm 3	40	4,5	drift	1	4,7	15	15	3	easy
41	easy	B.C.F.P.	180	bank 2	30	4	drift	1	4	10	30	2	easy
42	difficult	private	1600	cliffs 10	80	1,3	drift	2	4,5,2	15	10-15	3	easy
43	easy	private	700	berm 2	25	4	drift	1	4	25	10	3	easy
44	possible	private	225	bank 4	35	4,2	drift	3	5	5	30	2	low tide
45	difficult	private	400	bluff 10	80	3,1	3 drift	2	4,5,2	10	25	3	low tide
46	possible	private	290	Slope 5	60	3,1	1 drift	3	5	5	30	3,2	low tide
47	difficult	crown	880	cliffs 8	80	1,2	6 pocket	3	4	0,8	80,25	3,2	no
48	possible	private	1730	cliffs 8	80,50	1,4	14 pocket	3,2	4,1	0,15	80,15	3,2	in parts
49	easy	park	1000	berm 3	20	3,4	drift	1,2	5,4,2	25	10	3	easy
50	possible	Rayonier	365	cliffs 5	70	1,2	shelf	–	6,2	15	5	3	low tide
51	possible	Rayonier	270	slope 8	70,40	1,2	3 pocket	2,3	4,2	10	15	3,2	low tide
52	difficult	Rayonier	700	cliffs 6	70	1,2	4 pocket	3	4	0,5	80,30	3,2	no
53	easy	Rayonier	440	Slope 4	60,40	2,3	4 pocket	2,3	4,5	2,8	25	2,3	low tide
54	difficult	Rayonier	350	cliffs 7	70,50	1,2	–	–	1,2	2	70	3	no
55	difficult	Rayonier	170	cliffs 8	80	1	2 pocket	3	5,4	10	15	2,3	low tide
56	difficult	Rayonier	300	cliffs 10	80	1,2	shelf	–	1,2,6	2,5	80,20	3,2	no
57	easy	private	240	bank 2	20	3	pocket	2	5,4,1	15	15	2	easy
58	none	private	420	cliffs 10	80	1,2	–	–	1,2	0,2	80	3	no
59	difficult	private	160	slope 12	60	3	2 pocket	2,3	5,2,1	25	15	3	easy
60	difficult	private	425	cliffs 12	70	1,2	2 pocket	3	6,5	15	10	3	low tide
61	possible	private	160	bluff 10	70	3,1	drift	3	5,2	15	10	3	low tide
62	difficult	private	485	bluff 12	70	3,1	5 pocket	3	5,4,2	15	15	3	low tide
63	none	private	220	cliffs 12	80	3,1	pocket	3,2	5,2	10	20	3,2	low tide
64	difficult	private	195	cliffs 12	80	1,2	–	–	2,1	3	60	3	no
65	none	private	205	cliffs 10	80	1,2	2 pocket	2,3	4,2,1	10	20	3	possible
66	none	private	150	cliffs 12	80	1,2	–	–	1,2	2	70	3	no
67	none	private	160	cliffs 12	80	1,2	pocket	2,3	4,2	10	20	3	possible
68	none	private	180	cliffs 10	80	1,2	–	–	2,1	4	60	3	difficult
69	none	private	90	cliffs 5	80	1,2	shelf	–	1,2	8	5	3	low tide
70	none	private	160	cliffs 9	90	1	shelf	–	1,2,4,5	10	5	2	low tide

Unit No.	Immediate shore access	Shore ownership	Unit length m	Shore type and height m	Shore slope degrees	Shore material	Number of beaches and type	Beach class	Intertidal material	Intertidal width m	Intertidal slope degrees	Energy zone	Shore walkability
71	none	private	100	cliffs 7	70	1,2	–	–	2,1	4	50	3	no
72	easy	Rayonier	1020	bank 5	40	3	drift	2	5,4	30	10	3	easy
73	easy	Rayonier	485	bank 5	40	3	drift	2	4,3	40	5	3	easy
74	easy	Rayonier	790	bank 6	50	3	drift	2	5,4	30	5	3,2	easy
75	easy	Rayonier	195	bank 2	30	4	drift	2	4,3	25	5	2	easy
76	easy	Rayonier	820	bank 2	30	4	drift	1	4,3	60	3	3	easy
77	easy	Rayonier	–	bank 2	30	5	–	–	7	–	–	1	–
78	easy	Rayonier	300	bank 2	25	4	drift	1	4,3	50	3	3	easy
79	possible	private	1830	bank 8	50	3	drift	2	3,4	25	5	3	easy
80	easy	park	580	bank 2	30	3,4	drift	1,2	4,5	50	5	3,2	easy
81	none	Rayonier	790	cliffs 8	80	1,2	–	–	1,2	2	70	2,3	no
82	none	Rayonier	75	cliffs 12	90	1,2	pocket	2	5,4	30	10	3,2	easy
83	none	Rayonier	275	cliffs 12	80	1,2	–	–	1,2	2	80	3	no
84	possible	Rayonier	460	bank 10	40,90	3,1	drift	2	5,4,2	35	5	3	easy
85	difficult	Rayonier	460	cliffs 8	90	1,2	–	3	5,4,2	20	10	3	possible
86	none	Rayonier	760	cliffs 15	90	1,2	–	3	5,4,2	6	20	3	difficult
87	none	Rayonier	670	cliffs 15	90	1	drift	3	3,4	5	40	3	difficult
88	none	Rayonier	290	cliffs 20	90	1	–	3	4,2	6	30	3	low tide
89	difficult	Rayonier	340	cliffs 20	90	1	drift	3	3,4	10	20	3	low tide
90	difficult	Rayonier	650	cliffs 15	90	1,2	–	–	2	2	60	3	no
91	easy	Rayonier	1700	bank 2	20	3	drift	2,3	5,4	40	5	3	easy
92	easy	Rayonier	190	bank 3	30	3	pocket	2	4,3	25	10	3	easy
93	possible	Rayonier	110	slope 8	60	3	–	–	2	5	40	3	possible
94	difficult	Rayonier	820	cliffs 12	80	1,2	shelf	3	1	20	10	3	possible
95	none	Rayonier	790	cliffs 15	90	1,2	–	–	2	3	80	3	no
96	possible	Rayonier	70	cliffs 15	80	1,2	pocket	2	5	30	10	3	easy
97	none	Rayonier	350	cliffs 20	90	1,2	shelf	–	1	10	20	3	difficult
98	possible	Rayonier	60	cliffs 15	90,20	1,2,3	pocket	3	5	15	15	3	easy
99	difficult	Rayonier	580	cliffs 10	80,20	1,2	shelf	–	1	10	5	3	no
100	difficult	Rayonier	480	cliffs 15	90	2,1	4 pocket	3	3	5	20	3	no
101	possible	Rayonier	80	bank 10	30	3	pocket	2	5,4	30	10	3	easy
102	none	Rayonier	535	cliffs 15	80	1,3	2 pocket	3	2,1,5	5,10	80,20	3	no
103	possible	Rayonier	90	bank 10	70	3	pocket	3	5,2	15	15	3	easy
104	none	Rayonier	230	cliffs 15	90	1,2	–	–	1,2	2	70	3	no
105	possible	Rayonier	1600	cliffs 15	90	1,2,3	drift	3	4,3,2	15	20	3	low tide
106	difficult	Rayonier	410	cliffs 15	90-20	1,2	drift	2,3	4,2	30	5	3	easy
107	none	Rayonier	1600	cliffs 15	90	1,2	–	3	4	1	80	3	no
108	none	Rayonier	340	cliffs 15	90	1,2	–	–	1,2	0	90	3	no
109	none	Rayonier	60	cliffs 15	90	1	pocket	3	4,2	10	15	3	easy

Unit No.	Immediate shore access	Shore ownership	Unit length m	Shore type and height m	Shore slope degrees	Shore material	Number of beaches and type	Beach class	Intertidal material	Intertidal width m	Intertidal slope degrees	Energy zone	Shore walkability
110	none	Rayonier	110	cliffs 15	90	1	–	–	1	0	90	3	no
111	easy	Rayonier	195	bank 5	50	3	pocket	2	5,4	40	5	2	easy
112	none	M & B	180	cliffs 10	90	1,2	shelf	–	2	70	5	3	easy
113	easy	M & B	600	bank 3	40	3	drift	2	5,4,2	50	5	3	easy
114	easy	M & B	90	bank 3	40	3	drift	2	4	90	2	3	easy
115	possible	M & B	300	bluff 6	50	3	drift	3	3	50	5	3	easy
116	difficult	M & B	160	cliffs 6	80	1	shelf	–	–	40	5	3	easy
117	possible	M & B	350	bank 6	50	3	shelf	–	–	50	5	3	low tide
118	difficult	M & B	60	bank 6	60	3	shelf	–	–	30	5	3	low tide
119	none	M & B	90	cliffs 10	80	1	shelf	3	4	40	5	3	low tide
120	possible	M & B	150	bank 8	50	1	shelf	–	1,2	25	5	3	low tide
121	difficult	M & B	4200	cliffs 8	90-30	1,2	shelf	–	1,2	0,6	5	3	no
122	difficult	B.C.F.P.	1700	cliffs 6	90-40	1,2	shelf	3	1,2,4	40	5	3	no
123	none	B.C.F.P.	610	cliffs 8	80	1,2	–	–	1,2	7	60	3,2	no
124	easy	B.C.F.P.	60	bank 3	20	3	pocket	2	4	15	15	2,1	easy
125	none	B.C.F.P.	215	cliffs 8	80	1	–	–	1,4	2,10	80-30	2	no
126	difficult	B.C.F.P.	1800	boulders 6	80-30	1,2	shelf	–	1,2	0-20	80-5	3	no
127	easy	B.C.F.P.	820	slope 7	70-30	1,2	shelf	–	1,2	25	5	3	easy
128	easy	private	200	slope 3	20	3	shelf	2	1,5,4	25	10	3	easy
129	easy	private	170	slope 5	30	2	shelf	–	1	10	10	3	easy
130	easy	private	200	slope 5	50	1,2	shelf	–	1,2	25	5	3	easy
131	easy	private	280	bank 3	20	3	pocket	2	5,4	45	5	3	easy
132	easy	private	290	cliffs 10	90	1	shelf	–	1,2	35	5	3	easy
133	possible	private	120	slope 7	50	3,1	shelf	2,3	4,5	60	5	3	easy
134	possible	private	2100	slope 6	50	1,3	6 pocket	–	1,2	30	20	3	low tide
135	none	private	850	cliffs 12	90	1,2	–	–	1,2	2	80	3	no
136	none	private	75	cliffs 15	70	1,2,3	pocket	3	5,4	20	15	3	easy
137	none	private	580	cliffs 15	90	1,2	shelf	–	1,2	6	35	3	no
138	none	B.C.F.P.	300	cliffs 20	90,70	1,2	–	–	1,2	0	80	3	no
139	none	B.C.F.P.	760	cliffs 12	80	1,2	shelf	3	1,2,5	0,20	90-10	3	difficult
140	easy	B.C.F.P.	130	slope 4	20	3	pocket	2	5,4	20	15	1	easy
141	possible	private	610	slope 8	60	1,2	shelf	–	1,2	6	45	3	difficult
142	possible	private	700	slope 10	60	1,2,3	shelf	3	1,2,5	15	20	3	no
143	difficult	B.C.F.P.	460	slope 5	60	1,2,5	shelf	–	1	5	45	3	no
144	easy	B.C.F.P.	40	slope 3	15	3	pocket	2	5,4,7	40	5	1	easy
145	difficult	B.C.F.P.	300	slope 7	45	2,1	shelf	–	1,2	5	40	3	no
146	difficult	B.C.F.P.	165	cliffs 7	80	1,2	–	–	2,1	1	50	3	no
147	difficult	B.C.F.P.	425	slope 2	50	2,5	–	–	2	5,7	45	3	difficult

Unit No.	Immediate shore access	Shore ownership	Unit length m	Shore type and height m	Shore slope degrees	Shore material	Number of beaches and type	Beach class	Intertidal material	Intertidal width m	Intertidal slope degrees	Energy zone	Shore walkability
148	easy	BCFP	650	slope 4	40	2,4	drift	3	5,4	50	10	2	easy
149	easy	reserve	2400	berm 2	20	4	drift	1	5,4	50	10	2,3	easy
150	difficult	park	2650	cliffs 4	80	1,2	5 pocket	3,2	5,4,2	0,10	80,20	2	no
151	possible	park	1500	slope 8	60	3,2	8 pocket	3	5,4,2	0,10	80,20	2	no
152	possible	park	1050	slope 8	50	3,2	drift	3	5,4,2	10	20	2	low tide
153	easy	park	135	slope 3	30	3,2	pocket	2,1	5,2	30	10	2,1	easy
154	possible	park	1500	slope 10	60	3,2	9 pocket	3	5,4,2	20	20	2	low tide
155	easy	park	775	slope 5	30	3,2	5 pocket	2,3	5,2	30	15	2	low tide
156	easy	park	375	slope 5	30	3,1	shelf	3	6,2	30	5	2,3	low tide
157	easy	park	550	slope 3	20	1,3	shelf	–	6,2	100	5	3	low tide

TERMS USED IN THE DESCRIPTION OF THE SHORE UNITS

Immediate shore access is descriptive and refers to the physical access from the water level onto the shore. It does not refer to the access from a public road.

Shore ownership, - **Private** includes private land and that owned by small logging companies; where the shore is owned by large logging companies, these companies are named. **Park** means provincial or regional park or park reserve. **Both** should be interpreted as private land with public access provided. **Crown** indicates a provincial forest without park designation. Checking the land ownership was a time-consuming process and inaccuracies have to be expected. Also, land ownership may change, and therefore needs periodic updating.

Unit length is the estimated length in metres. Where possible, the unit was walked; elsewhere the distance was measured on air photographs.

Shore type and height are simple descriptive terms. The number denotes the height in metres to a plateau or lodge above the shore.

Shore slope is an estimation in degrees. One number gives an average slope. Where two numbers are given, there are two distinctly different areas on the shore with corresponding slopes.

Shore material is coded: 1 - bedrock, 2 = boulders, 3 = unconsolidated loose material of glacial outwash or marine origin, 4 = gravel, 5 = man-altered. Several numbers indicate several shore materials with descending importance.

Number of beaches and their type refers to either pocket beaches where materials are moved by tides and waves in a predominantly up and down direction, whereas in drift sector, the movement is predominantly horizontal. The number indicates that several essentially similar beaches are included within one shore unit, the beaches being separated by rocky heads or boulders but are a part of the same sector.

Beach class is coded: 1 means that a dry berm is exposed even during mean higher high tide. 2 means that a berm, usually below a bluff, is under water during mean higher high tide. 3 denotes a narrow beach, usually below a steep cliff, exposed only during a low tide.

Intertidal material is coded: 1 = bedrock, 2 = boulders, 3 = cobbles, 4 = gravel, 5 = sand, 6 = sandstone or conglomerate shelf, 7 = man-altered or intruded by industrial activity.

Intertidal width is the horizontal width between the low tide and the high tide in metres.

Intertidal slope is the estimated slope of the intertidal zone in degrees. Where two numbers are given, there are two distinctly different slopes in the intertidal zone.

Energy zone is an estimate of the velocity and force of the waves and wind. 1 = low, in protected situations, 2 = moderate in partly protected situations or where the orientation of the shore moderates the impact of waves, and 3 = high, on exposed shore.

Shore walkability describes in decriptive terms the degree of difficulty of walking along the shore.

Landscape Units

The general environment of the landscape units mapped in the western part of the Capital Regional District are similar to those mapped in the Western Community (Eis et al, 1976) and the Highlands (Eis and Oswald 1975).

All landscape units described take into consideration physiography, exposure, slope, soils, drainage and vegetation to express similarity in habitat within the general environment. The scale of the map (1:100,000) allows only limited detail and accuracy. For that reason, small differing intrusions that occur within each landscape unit cannot be depicted and intimate mosaics of several units had to be shown as the most prevalent unit or as the average unit, as deemed best for each situation.

Mapping is based on the assumption that the boundaries between units are definite and that the habitat on one side of the line differs significantly from that on the other side. While this is often true, there are many situations where, because of the gradual transition between similar habitats, the boundary lines are only subjective interpretations.

Eleven landscape units were distinguished.

1. Solid Bedrock

(Figs. 23 and 24) 5.4 km^2 (1.76 sq miles), 0.6% of the map area.

The solid bedrock landscape unit comprises hilltops and steep slopes of exposed rock, smoothed by glacial abrasion. It can occur at any elevation. Soil is either non-existent or occurs as a thin layer of coarse sand derived in place from the weathering of the rock. It is strongly acidic and dark, owing to the incorporation of organic material from decomposing remains of vegetation.

The peaks and steepest slopes are occupied by crustose and foliose lichens and mosses which are firmly attached to the substrate and form loosely integrated colonies (Cladonia sp. Rhacomitrium canescens, Polytrichum piliferum, Dicranum scoparium and Grimmia apocarpa being the most common). These initial colonizers cause a certain amount of mechanical disintegration as well as chemical corrosion of rock surfaces. However, the process of soil formation is slow because of the resistance of the rock to weathering and the removal of loosened particles by wind, water and gravity action. Apart from damage to the vegetation, this landscape unit is very stable since no significant changes can occur in this ecosystem.

Fig. 23. In the solid bedrock landscape unit, the soil is often non-existent, or it occurs as a thin layer of coarse sand over the rock.

Fig. 24. In the solid bedrock landscape unit, after the vegetation is trampled, little further damage can occur.

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Where weathering products were removed from convex steep slopes and accumulated in crevices and depressions, shrubs and trees as well as herbs and grasses became established. Trees, mainly Douglas-fir, are usually widely separated and their growth is extremely slow, often less than 15 m (50 feet) in height at 100 years.

The organic material which developed under the trees in this landscape unit probably took several generations of trees to accumulate to the present depth of 10 to 15 cm (4 to 6 inches). Logging and yarding of the logs disturb the humus layer and cause erosion. Slash burning, following logging, is especially detrimental as it removes most of the organic material, leaving only ashes and loose coarse sand, which are washed away during the first heavy rain. Since logging of this landscape unit is only marginally economical at best, and causes the destruction of productivity for many years, preservation of this unit is recommended. In its advanced natural succession, this unit is an important wildlife habitat in spring and summer.

2. Broken Rock

(Fig. 25 and 26) 128 km^2 (50 sq miles), 14.6% of the map area.

This landscape unit is characteristic of rugged upland terrain, with hummocky rock knolls and ridges. It occurs where a thin mantle of soil, up to 30 cm (12 inches) thick, accumulated over bedrock, where boulder fields were deposited by glacial activity, or where the surface of the bedrock was broken up by weathering processes and soil accumulated in the interstices. This landscape unit invariably contains smaller areas of exposed bedrock which, because of their size, could not be mapped separately. The thin soil is usually podzolized, but sometimes shows little development, except for staining by organic material. The soil surface is strongly acidic, but soil acidity decreases with depth.

Fig. 25. In the broken rock landscape unit, the trees grow in crevices of the rock. They are usually widely separated and, because of their restricted root systems, growth is slow.

Fig. 26. Logging is only marginally economical and, if it is followed by slash burning, the productivity of this landscape unit may be destroyed for many years.

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In addition to all species occurring on solid rock, this landscape unit, having deeper soils and numerous crevices, contains large areas overgrown by a grass, Danthonia spicata, especially in the eastern part of the study area. In the western part, where the rainfall is greater, deeper soils are often colonized by a moss Polytrichum commune, growing usually in thick mats, difficult for other species to penetrate. A few species of herbs and grasses may occur, but their ground cover is usually insignificant. In the early stages of succession, establishment of salal (Gaultheria shallon) indicates locally deeper soils and greater accumulation of organic material. Succession leads to increasing dominance of salal and elimination of mosses and lichens, resulting in biotic uniformity.

Trees and shrubs have established in crevices where soil has accumulated and moisture is retained. Douglas-fir is the most common species. Arbutus is usually a companion species in the eastern, drier part of the study area, whereas red cedar is frequent in the western, wetter part. Tree spacing, while open, is dependent on the nature of the rock material and the amount of accumulated soil, and is usually denser than in the solid rock unit.

The values of harvestable timber within this landscape unit are low because of the slow growth. Logging and yarding disturbs the humus layer and causes erosion. Slash burning removes most of the organic material on steep slopes, leaving only ashes and sand, resulting from weathering of the rocks. The ash and sand are washed away during rains and deposited into crevices or completely removed from the site, resulting in lower water-holding capacity and decreased productivity. Logging of old stands may be economical in this landscape unit, but slash burning should not be a general policy.

3. Shallow Mineral Soils

(Figs. 27 and 28) 287 km^2 (112 sq miles), 32.8% of the map area.

This landscape unit is the most prevalent throughout the study area. Typically, it occurs on moderate slopes where mineral soils accumulated to a depth of about 30 cm to 1 m (1 to 3 feet). It invariably contains small rock outcrops (Unit 1), areas of broken rock (Unit 2) and pockets of deep soil (Unit 4) too small to be mapped individually. The soils are derived from stoney till, colluvium or shale and are coarse-textured, with rapid internal drainage and low water-holding capacity. Soil profile development is moderate, with a dark-brown surface horizon (A), yellowish brown middle horizon (B) and grayish brown lower horizon (C). A grayish eluviated layer (Ae) is usually present just below the organic material, especially in the western, wetter part of the study area. Sesquioxides of Fe, Al and Mg, leached by humic acids from the eluviated horizon, precipitate at various levels of the middle horizon and result in the formation of a hardpan. This usually leads to the reduction of the effective soil depth.

Because of the general paucity of fine-textured mineral and organic material, a large proportion of released nutrients, not absorbed by the plants, is leached out during winter rains. This loss of nutrients, combined with shallow soil depth and dryness during the summer months, results in low to medium forest productivity.

Fig. 27. In the eastern part of the study area, the shallow soil landscape unit supports often overstocked stands of Douglas-fir.

Fig. 28. Western hemlock, western red cedar and lodgepole pine are typical of the shallow soils in the western part of the study area, where precipitation exceeds 2,000 mm.

Fig. 29. Productivity is high in the deep mineral soil landscape unit.

In the eastern part of the study area, this landscape unit corresponds approximately with the Salal-Oregon grape plant community, and in the western part, with the moister Moss-Salal community, with absence of Oregon grape but abundance of mosses, mainly Eurhynchium oreganum and Plagiothecium undulatum. The Salal-Oregon grape community is confined to localities which, during the growing season, do not have any lateral seepage. The Moss-Salal community may have some seepage for a part of the growing season. Both these communities are stable under a forest canopy, but after logging, when vegetation is damaged and soil is disturbed, they are prone to erosion, especially on steeply sloping terrain.

In the eastern part of the study area on drier and warmer sites, such as hilltops and slopes, and where the accumulation of organic matter is less and podzolization is weak, stands of Douglas-fir in mixtures with western red cedar, western hemlock and amabilis fir predominate. In higher elevations, the cooler north slopes and on deeper soils with more available moisture during the growing season, western hemlock, amabilis fir and western red cedar form the mature stands, with Douglas-fir contributing only a small proportion of the volume. In the western part of the area, approximately above 350 m (1000 feet) a.s.l., yellow cedar may be locally significant. In the eastern part on dry, warm sites, Douglas-fir is probably a self-perpetuating species, but elsewhere throughout the study area the establishment of Douglas-fir is largely the consequence of forest fires, large-scale clearcutting and subsequent planting. The productivity of this landscape unit is low to moderate (less than 5 m^3 per ha (70 cubic feet per acre)) per year and the site index of Douglas-fir varies from about 22 to 33 m (75 to 110 feet) at 100 years.

Stands of Douglas-fir as well as western hemlock are often overstocked in this landscape unit, especially where they regenerated immediately after logging or fires, before the shrubs and forbs could invade the site and compete with the regeneration. As in most overstocked coniferous stands, Douglas-fir and hemlock are prone to windthrow and snowbreak after opening, especially along the newly created forest edge.

4. Deep Mineral Soils

(Figs. 29 and 30) 212 km^2 (82.8 sq miles),
24.2% of the map area.

This landscape unit occupies lower slopes and flat lowlands. The soils are derived from coarse-textured till sometimes covered with outwash deposits of variable thickness. Generally, they are of loam or sandy-loam texture, with some gravel or

Fig. 30. Deep mineral soil has often some seepage and, where light penetrates through the canopy, it usually supports lush vegetation.

Fig. 31. The coastal area is dissected by many steep ravines. They are dry in summer, but carry torrents during fall and winter rains and during spring snow melt.

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larger stones usually present. They are moderately well drained and show some podzolic development. The soil profile is characterized by a thin, dark-brown surface horizon (A), over about a 1 m (36 to 44 inches) thick layer of yellowish brown to pale brown, loose, permeable loamy sand or gravelly loamy sand (B), which lies over pale brown or gray brown gravelly sand or compacted gravelly till (C). Even where sand forms the soil solum, it is often cemented at the depth of about 50 cm (20 inches) because oxides and silicates of iron, magnesium and aluminum were leached from upper layers and deposited there. Seepage water flows over the impervious horizon for at least part of the growing season.

Ecologically, this landscape unit corresponds with the Swordfern-Salal and Swordfern-Moss plant communities. The combination of a large volume of loamy soil with good water-holding capacity, moderate level of nutrients, and seepage during at least part of the growing season provides, within the regional climate, good conditions for plant growth. Site index for Douglas-fir varies from about 36 to 48 m (120 to 160 feet) at 100 years and forest productivity is usually more than 7 m^3 per ha per year (100 cu ft per acre). Douglas-fir, grand fir, western red cedar, amabilis fir, western hemlock, red alder, bigleaf maple and an occasional dogwood form a closed canopy and eliminate shade - intolerant species from the shrub layer. However, salal, Oregon grape and huckleberry are usually present where more light penetrates to the ground. Apart from swordfern, deerfern and ladyfern, forbs found in this landscape unit include vanilla leaf,

Fig. 32. Many high bridges had to be built along the road to Port Renfrew. The high cost of construction delayed the road for many years.

foam flower, bedstraw and several grasses and sedges. Numerous mosses, such as Hylocomium splendens, Eurhynchium oreganum, Plagiothecium undulatum, Dicranum spp. and liverworts, cover the forest floor, stumps and logs, whereas Isothecium spiculiferum, Orthotrichum spp. and Hypnum spp. are common epiphytes on trees.

5. Steep Ravines and Steep Eroded Sea Shore

(Figs. 31 and 32) 142 km^2 (55.5 sq miles), 16.3% of the map area.

The velocity of glacial meltwater and constant pounding by stones and boulders carried by it eroded steep ravines into the rocky substrate. As the land gradually rose, the exposed deep marine gravelly loams were eroded by wave action and the present steep slopes above the sea were formed. These slopes of marine deposits were also eroded into ravines, in early post-glacial times.

Since the retreat of ice, the ravines carry only storm water in summer and drainage from rains and melting snow in winter. Their flow is generally intermittent. Weathering produced a thin mantle of coarse stony soil along the sides of the ravines among the protruding areas of bedrock, but erosion prevents greater accumulation. Water-holding capacity is low and, in the eastern part of the study area, drought occurs regularly during the summer.

On the upper slopes, this unit coincides with the Salal-Oregon grape and the Moss plant communities. In the eastern part of the study area, Douglas-fir is predominant, with lodgepole pine locally common in young stands. Arbutus may also occur. The lower slopes, where some accumulation of the soil occurs and where some seepage exists, coincide with the Swordfern community but devil's club may also be present. After disturbance, red alder, broadleaf maple and willows are most frequent, but these are subsequently replaced by Douglas-fir and eventurally shade-tolerant western hemlock and western red cedar.

Along streams, Douglas-fir may reach a height of as much as 45 m (150 feet) at 100 years, but on the steep slopes with shallow rocky soils, productivity is much lower, with site index (100 years) often as low as 28 m (92 feet) and mature trees about 35 m (115 feet) in height.

On the slopes, the indigenous vegetation contains elements of broken rock landscape unit and shallow till soils, because a similar lack of moisture exists there during the growing season. However, because bedrock is frequently exposed the tree cover is relatively open, allowing greater access of light below the canopy. In addition to salal and Oregon grape, red huckleberry, ocean spray, trailing blackberry and manzanita are common but, because of the summer drought, they are usually not vigorous. Of the forbs, bracken, vanilla leaf and bedstraw are the most conspicuous. In pockets of deep soils and where seepage occurs, ferns may be abundant. Mosses are frequent under forest canopy but, after disturbance, their numbers and vigor diminish; Eurhynchium oreganum, Plagiothecium undulatum, Hylocomium spendens, Rhytidiadelphus loreus and R. triquetrus are most common.

Because of the steepness of the terrain and coarse, loose soil material, there is a constant problem of erosion. While it may not be serious under a mature forest, removal of trees and disturbance of the soil during logging will result in removal of most of the loose soil and exposure of the bedrock on the sides of the ravines. Consequently, reforestation will be difficult, and subsequent productivity low.

6. Outwash Sandy Loams

(Figs. 33 and 34) 7.8 km^2 (3.1 sq miles), 0.9% of the map area.

During the re-emergence of land at the end of the ice age, in areas open to the sea, the meltwater flow separated and washed the fine particles into the sea. However, in quiet inlets protected by surrounding hills and in shallow bays, the sediments, albeit modified by sea action, contain a large proportion of loam and fine sand.

Typically, this landscape unit occupies flat, gently sloping or slightly undulating terrain. The soil usually contains a variable proportion of gravel. Typically, the surface 30 cm (12 inches) of the soil is dark brown, permeable sandy loam or loam (A) overlying about 30 cm (12 inches) thick, yellowish brown, permeable loamy sand, sandy loam or loam, containing often a high proportion of gravel (B), over gray impermeable marine clay or compacted sandy loam till (C). The internal drainage is moderate to rapid, depending on texture. Water-holding capacity is comparatively high, but ground water seepage occurs only in spring and the site indicates drought

Fig. 33. The outwash sandy loams have been settled and cleared for farming.

Fig. 34. Agricultural productivity is potentially high but, because of market conditions, the outwash loam landscape unit is used mainly for grazing.

during the summer. The podzolic soil development is moderate to weak; content of organic material and nutrients are relatively high.

Similar to the deep soil landscape unit, this unit coincides with the Swordfern-Salal and Moss plant communities. Salal and Oregon grape are usually more abundant than swordfern, indicating drier conditions in surface layers, but the productivity of deep-rooted trees is as high as on deep till soils. Site index for Douglas-fir varies from 36 to 46 m (120 to 155 feet) at 100 years. Productivity is more than 7 m^3 per ha (100 cu ft per acre) per year. Douglas-fir, grand fir, western red cedar, western hemlock, bigleaf maple, red alder and, occasionally, dogwood form the mature stands while, after disturbance, the regeneration may locally contain a large proportion of shade-intolerant lodgepole pine.

The shrubs and indigenous ground vegetation are not site specific and contain similar species to those on shallow and deep till soils. Grasses are especially abundant. The most conspicuous mosses are Eurhynchium oreganum, Hylocomium spendens, Polytrichum spp., Bryum and Dicranum spp. Several species of lichens are also common.

In the Sooke area, this unit has been extensively settled since the turn of the century, when the forest was cleared for farming.

7. Outwash Sands and Gravels

(Figs. 35 and 36) 18.2 km^2 (7.1 sq miles),
2.1% of the map area.

During the time the glaciers were retreating, Sooke River, San Juan River and Gordon River drained south into inlets of Juan de Fuca Strait. Waters originating from the melting glaciers transported enormous amounts of sediments. As the force of the rushing streams subsided, the material was deposited at mouths of the rivers. Continuous blocking of the channel caused the rivers to alter their course, covering inlets to a uniform depth. Stream and wave action rounded the stones and separated the finer sediments, transporting them farther into the sea. The coarse, heavy sediments remained. Areas of sand and pebbles occur, intermingled with areas of almost pure gravel and cobbles, as the velocity of meltwater and the period of exposure to the sea action varied. With the uplift of the land, subsequent erosion often modified the surface topography. This

Fig. 35. Layers of sand and gravel are usually intermingled and either may form the surface layer.

Fig. 36. Sands and gravels are highly permeable and, in summer, dry. Though depth of the available soil may compensate for low water-holding capacity, Douglas-fir and locally lodgepole pine are the main tree species.

landscape unit occurs on gentle slopes and undulating topography along the sides of the estuaries of major rivers.

Outwash sands and gravels are generally up to 20 m (60 feet) deep and are underlain by bedrock, colluvium, till or marine clay. Internal drainage is rapid, water-holding capacity is low and drought normally occurs in summer. Soil development is moderate, content of organic material is low and nutrients are rapidly leached. The coarse soils of this landscape unit, where they occur on flat topography, are stable, regardless of the vegetation cover.

The vegetation in this landscape unit coincides with the Salal-Oregon grape plant community. Douglas-fir is the predominant tree, with lodgepole pine locally forming a significant but temporary admixture in younger stands. Where gravels are shallow over outwash loam or till and where seepage occurs, western red cedar, western hemlock and red alder may also be common. Where moisture is available during the growing season, Douglas-fir may reach a height of 38 m (125 feet) at 100 years but, generally, productivity is much lower. The average mature height of Douglas-fir in this landscape unit is only about 35 m (114 feet), corresponding with site index of about 28 m (95 feet). In areas that have a history of frequent fires, productivity may be considerably lower.

The indigenous vegetation is not site specific, containing most species of the shallow till soil and broken rock landscape units because a similar lack of water during the growing season characterizes these units. Shrubs, both salal and Oregon grape, form a dense but not vigorous ground cover because of the lack of available moisture in summer. Forbs are infrequent, but locally grasses may predominate. Mosses are common, especially Eurhynchium oreganum, Rhacomitrium spp. and Dicranum spp.

Because of the flat terrain, coarse soil material and minimal surface run-off resulting from rapid infiltration and good internal drainage, water never saturates the soil profile to cause soil instability and erosion. However, any steep banks created by excavation or road construction will be subject to erosion until the material finds its natural stable slope.

8. Alluvial Floodplains

(Figs. 37 and 38) 9.3 km^2 (3.6 sq miles),
1.07% of the map area.

In the study area, active floodplains occur only near the estuary of San Juan River, Gordon River and, to a small extent, along the lower reaches of Kirby Creek and Sooke River. It is probable that the gravels underlying floodplains are of glacial outwash origin. They were deposited as the glacier retreated and the accompanying uplift of the land was almost complete. Their elevation is not more than a

Fig. 37. Alluvial flood plains usually developed on outwash gravels. Seepage of the river water is always close to the soil surface. Flooding occurs periodically during snow melt.

Fig. 39. Wet organic soils occur mainly at high elevations on flat topography where decomposition of organic matter is slow in wet and cold environment. The main tree species are western hemlock, western red cedar and yellow cedar.

← Fig. 38. Loamy surface soil over gravel is potentially suitable for agriculture. At the present time, it supports very productive stands of Sitka spruce and western hemlock.

few metres above sea level. Similar to outwash gravels of earlier origin which occur at higher elevations, these gravels were also stratified by stream, wave and tide action as the sea gradually subsided. Fine-textured materials were deposited in protected inlets away from the main flow, settled in deep water in the inlet or were carried farther into the sea.

As the ice melted, loose glacial deposits covered the exposed hills. Erosion took place, especially on steep slopes. However, precipitation was the only source of water in post-glacial rivers; consequently, the amount of water and its velocity were greatly reduced. As water from the steep slopes entered the valley, its carrying capacity gradually diminished and sedimentation took place. Coarse gravels were deposited along the steep upper streams, sand on moderate and gentle slopes and silt, loam and clay over the outwash gravels in the valley. Because the terrain was flat, erosion and cutting of a deep stream channel rarely took place. However, occasional blocking of the channel resulted in large-scale floodings and additional sedimentation of fine-textured materials out of the turbid water, until a new channel was opened and the floodplain gradually drained.

The surface soil layer usually consists of 10 to 15 cm (4 to 6 inches) of dark brownish gray, permeable, granular silty loam (A) over 30 to 60 cm (12 to 24 inches) of brownish gray to grayish brown, mottled, friable sand, silt or loam (B) over compact brownish gray mottled, stratified gravellly sandy alluvium (C). Except for spring floods, the surface horizon is moderately well drained, but in depressions, it may be poorly drained and somewhat mucky.

The soils of this landscape unit are typically highly fertile and productive, and potentially suitable for agriculture. The surface horizon has a high content of organic material and a high moisture-holding capacity; their physical conditions are favorable for agriculture and irrigation water, if needed, can be readily supplied from shallow dugouts into the underlying gravel.

Because of the remoteness from an urban centre and because most of the floodplains landscape unit is within an Indian Reserve, forest occupies most of the area. Logging took place about 60 years ago and the area regenerated probably to alder and shrubs and subsequently to Sitka spruce and western hemlock, with red cedar and amabilis fir understory gradually becoming established. On higher ground, above the level of high flood water, may be an occasional Douglas-fir and, along the streams, broadleaf maple, alder, willow, Pacific crabapple or cascara may predominate. While shrubs are rarely vigorous under a dense canopy of trees, they are always present and immediately colonize any area where light conditions improve. This may retard or even prevent the regeneration of desirable commercial tree species. By far the most common shrub is salmonberry, but thimbleberry, spirea, red-osier dogwood, red elderberry, Indian plum and devil's club may predominate locally. Ground vegetation is composed mainly of swordfern, maidenhair fern, ladyfern and, occasionally, deerfern. Other forbs are rare. Only vanilla leaf, foam flower and western trillium may be locally conspicuous. Mosses, Eurhynchium oreganum, Rhytidiadelphus loreus and several species of Mnium, Brachythecium and Pogonatum are frequent on the ground, as well as on decaying wood.

Because of the flat terrain, erosion does not occur. However, a blockage of the channel may occur and flooding and sedimentation may result. The river may also relocate its channel.

9. Wet Organic Soils

(Figs. 39 and 40) 58.9 km^2 (23.0 sq miles), 6.7% of the map area.

Abrasion of rock surfaces under the weight of the advancing glacier smoothed the tops of San Juan and Jordan ridges, and as the glacier melted, torrents of meltwater removed most of the loose material into the sea, exposing flat or gently rolling topography with practically bare rock surfaces. Where a veneer of glacial till remains, its depth rarely exceeds 30 cm (1 foot). Under the high precipitation prevailing at high elevations (generally above 500 m, 1600 feet a.s.l.), mosses, liverworts and sphagna became established and soil was gradually built. While glacial till and the weathering of the rock substrate provided some coarse material, the soil is largely organic. Depressions which existed within this landscape unit and, after the retreat of ice, formed shallow lakes, gradually developed through the stage of bogs into deep pockets of organic material. In the heavy fall rains, the soils are saturated and each year are under a deep layer of snow for 3 to 4 months. The impervious rock substrate prevents drainage and gradually melting snow provides additional water and keeps the soils fully saturated and cold.

Fig. 40. Wet organic soils are dotted with many small sphagnum bogs, too small to be mapped individually.

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While the organic soil contains a large amount of nutrients, these are largely unavailable because of slow decomposition caused by low temperatures, saturation and anaerobic, acidic conditions. The high water table reduces the depth of usable soil, generally eliminating Douglas-fir or limiting its growth to humps and allowing only those species to survive that can withstand extended flooding of their root systems.

The main tree species are western red cedar, western hemlock and amabilis fir on gentle slopes, whereas mountain hemlock and yellow cedar are common on flat terrain and in depressions, especially at higher elevations. The tree canopy is multi-storied, but quite open, allowing for sufficient light to reach the rather thin shrub layer. Cascade, dwarf and black huckleberry, western teaberry, Labrador tea and bog laurel are the most common shrub species, whereas twisted stalk, deer fern, ragweed and several species of sedges are common forbs. The humps and decaying wood are covered with mosses, Homalothecium megatilum, Rhytidiopsis robusta and Dicranum spp., whereas depressions are overgrown by sphagna.

As the terrain is flat or gently sloping, the soils are rarely subject to erosion, especially where they are covered by undecomposed remains of vegetation. However, after logging, the skidroads will become channels concentrating the runoff, and serious erosion can be expected. Also, because the trees are shallow-rooted, harvesting of trees or any interference with the tree layer may result in extensive windthrow.

10. Bogs

(Figs. 41 and 42) 0.8 km^2 (0.3 sq miles), 0.09% of the map area.

As the ice retreated, water filled the depressions gouged in the rock by shifting ice masses. Initially, some till and glacio-fluvial materials were deposited in these lakes and as the climate warmed up, vegetation developed around the edges and in the water. The rate of decomposition and soil formation was dependent on the plant species, mineral content of the water and winter flushing. The soils formed in stagnant water are almost entirely organic.

During the summer, the water level is usually 20 to 50 cm (8 to 20 inches) below the soil surface, with areas of open water, where the fill-in process has not been completed. After heavy rains and during spring snow melt, the water level is at or above the soil surface. Thus bogs serve as flood control basins by storing water, slowing stream flow and controlling flow extremes.

Because of the high water table, cold soil conditions and lack of soil aeration, trees are rare and their growth is very slow. At low elevations where the climate is moderate, red alder, willow

Fig. 41. Leaf bogs developed in depressions at low elevations. Areas with high water table in summer support grasses and sedges; humps and edges are overgrown by spirea, cascara and willows.

Fig. 42. In bogs, humps, elevated above the high water table, and edges, progress through spirea-willow-crab apple and cascara-alder stages gradually to western hemlock-western red cedar composition.

and, occasionally, western hemlock and red cedar may be present, whereas at high elevations, mountain hemlock and yellow cedar predominate. Of shrubs, dwarf huckleberry, western teaberry, Labrador tea and bog laurel are most common. Forbs, except for grasses and sedges, are infrequent. The depressions and flat areas are covered by deep layers of sphagna, whereas humps and wood debris support colonies of mosses, Homalothecium megatilum, Rhytidiopsis robusta and Dicranum spp. being most conspicuous.

Except for an occasional tree at the edge, when logging takes place next to this landscape unit, harvesting of trees is not feasible. Therefore disturbance and erosion will not take place.

11. Open Water

(Figs. 43 and 44) 5.2 km^2 (2.0 sq miles), 0.62% of the study area.

This landscape unit comprises the rivers, lakes and marshes where water stands permanently above the soil surface. The material deposited under water in the lakes and marshes is predominantly organic, often several metres thick, and contains a variable proportion of fine-textured mineral material of alluvial or aeolian origin, sedimented during winter

Fig. 43. Lower reaches of San Juan River are deep and quiet tidal water. During spring run-off, the river often overflows its banks.

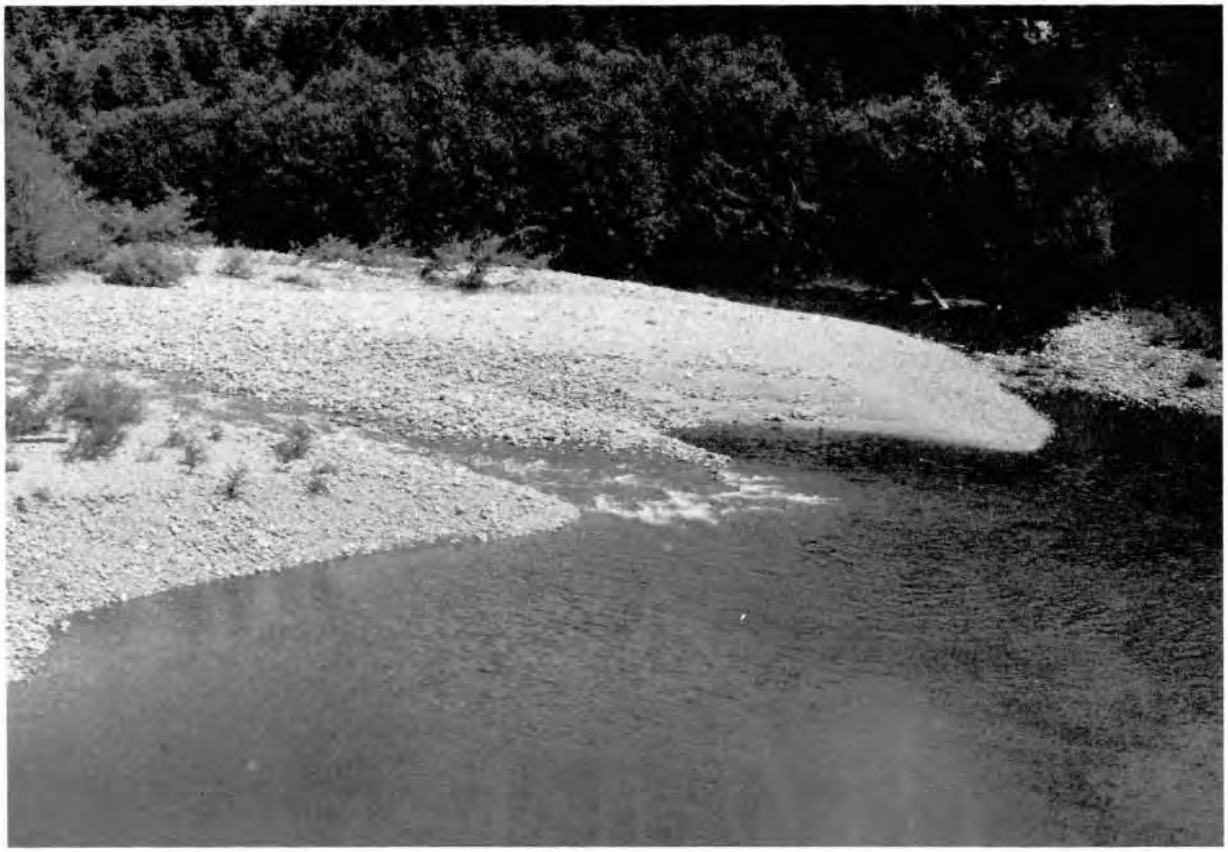

Fig. 44. In all rivers, the water level is low in summer. During fall and winter rains and spring snow melt, they become torrential streams.

floods. The soil is permanently submerged, and anaerobic, acidic processes predominate; therefore, the decomposition of organic material is extremely slow. The organic material may be underlain by glacio-fluvial material of loamy or sandy texture containing a variable amount of gravel and below that, by a layer of compacted till, bedrock or clay. In the slow-moving rivers, the sediments may be of similar origin but their thickness over gravels is much less. Where water flows rapidly, sand, gravel or even bedrock may form the river bed.

Vegetation is confined to the water's edge. Sedges, marsh grasses, cat-tails and bulrushes are common. Spruce and willow may occur on hummocks elevated above the permanent water. Sphagna and wetland mosses such as Hypnum spp., Mnium spp., Drepanocladus spp. and Fontinalis spp., are present on debris above the summer water level. Where calm water is less than 1 m (3 feet) deep and the bottom is muddy, water forget-me-not, bladderwort and water smartweed may occur. Pond lily and water shield with floating leaves and roots anchored in mud may occur in water up to 2 m (7 feet) deep. In the active river channels, vegetation is practically non-existent; the abandoned channels have vegetation similar to marshes.

REFERENCES

Anon. An inventory of land resources and resource potential in the Capital Regional District. Edited by C. V. Stanely-Jones and W. A. Benson. May 1973. 186 pp.

Anon. Climate of British Columbia. 1916 to 1976. Tables of temperature, precipitation and sunshine. British Columbia Dept. of Agriculture.

Anon. Environment Canada, Fisheries Service, personal communications.

Anon. Monthly records, Meteorological observations in Western Canada 1928 to 1978. Environment Canada.

Bauer, W. 1976. Western community marine shore analysis. Capital Regional District Planning Department, Victoria, British Columbia. 48 pp.

Clapp, C. H. 1917. Geological Survey of Sooke and Duncan Map Areas, Vancouver Island. Can. Dept. Mines. Ottawa 96. 445 pp.

Day, J. H., L. Farstad and D. G. Laird. 1959. Soil Survey of Vancouver Island and Gulf Islands, British Columbia. Report No. 6 of the British Columbia Soil Survey.

Eis, S. and E. T. Oswald. 1975. The Highland Landscape. Can. Forestry Service. P.F.R.C., Victoria, B.C. Report BC-X-119. 36 pp.

Eis, S., D. Craigdallie and E. Oswald. 1976. Western Community A Landscape Analysis for Urban Development. Canadian Forestry Service, P.F.R.C., Victoria, B.C. Report BC-X-153. 47 pp.

Lawrence, J. C. (about 1965.) A brief history of Sooke District. (The southwest coast of Vancouver Island from Metchosin to Bamfield including Sooke, Otter, Jordan River and Port Renfrew). Victoria. n.d. 152 pp.

McMinn, R. G., S. Eis, H. E. Hirvonen, E. T. Oswald and J. P. Senyk. 1976. Native Vegetation in British Columbia's Capital Region, Department of Environment, Canadian Forestry Service, P.F.R.C., Victoria, B.C. Report BC-X-140.

Stranix, D. 1967. Notes and Quotes. A brief historical record of Colwood, Langford, Metchosin, Happy Valley and Glen Lake. Victoria Joint Centennial Committee. 112 pp.

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