ISSN-0705-3274

Environment Canada / Environnement Canada
Forestry Service / Service des Forêts

Gulf Islands of British Columbia

A LANDSCAPE ANALYSIS

S. EIS AND D. CRAIGDALLIE
CANADIAN FORESTRY SERVICE / PACIFIC FOREST RESEARCH CENTRE

Victoria, B.C., BC-X-216, December, 1980

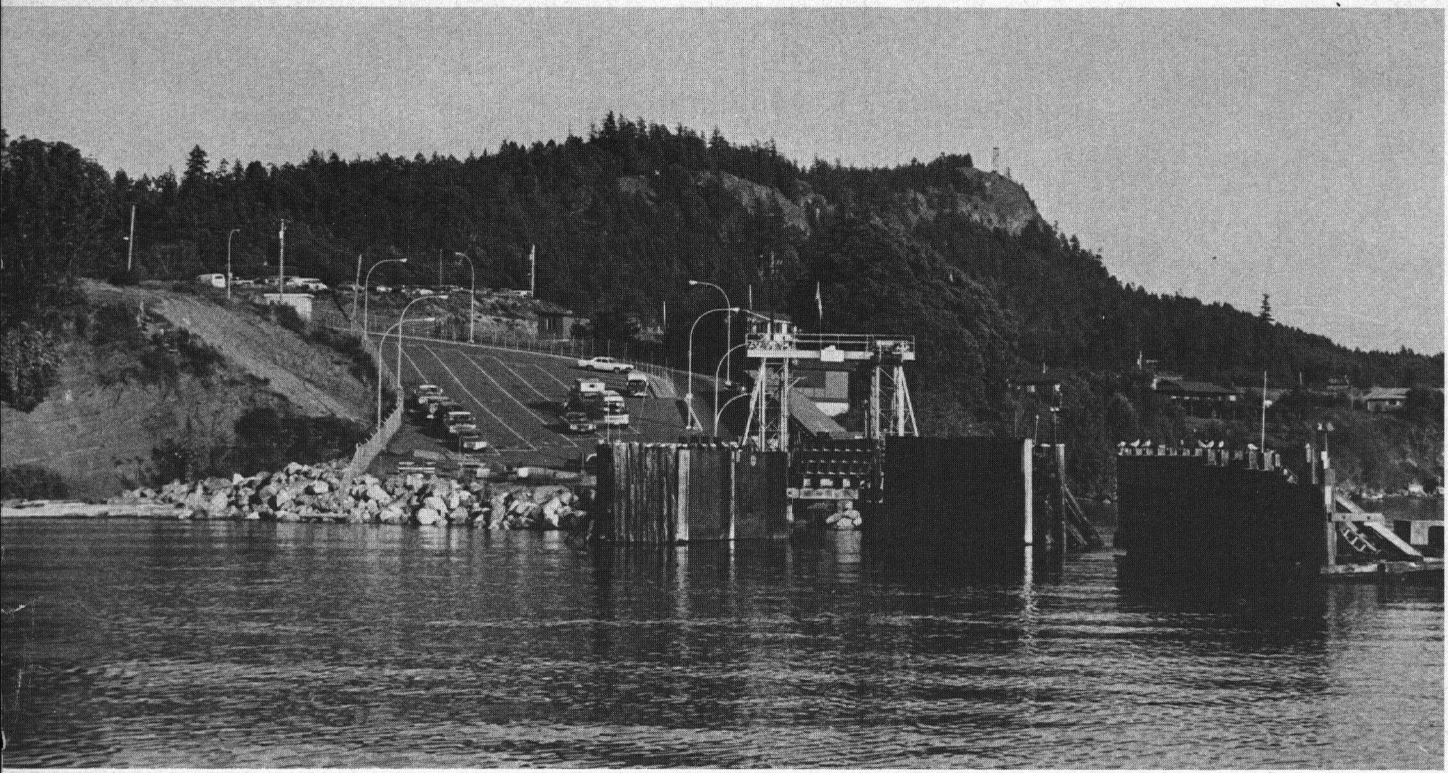


Fig. 1. Ferry docking is well organized and unloading and loading of passengers and vehicles takes only a few minutes.

Abstract

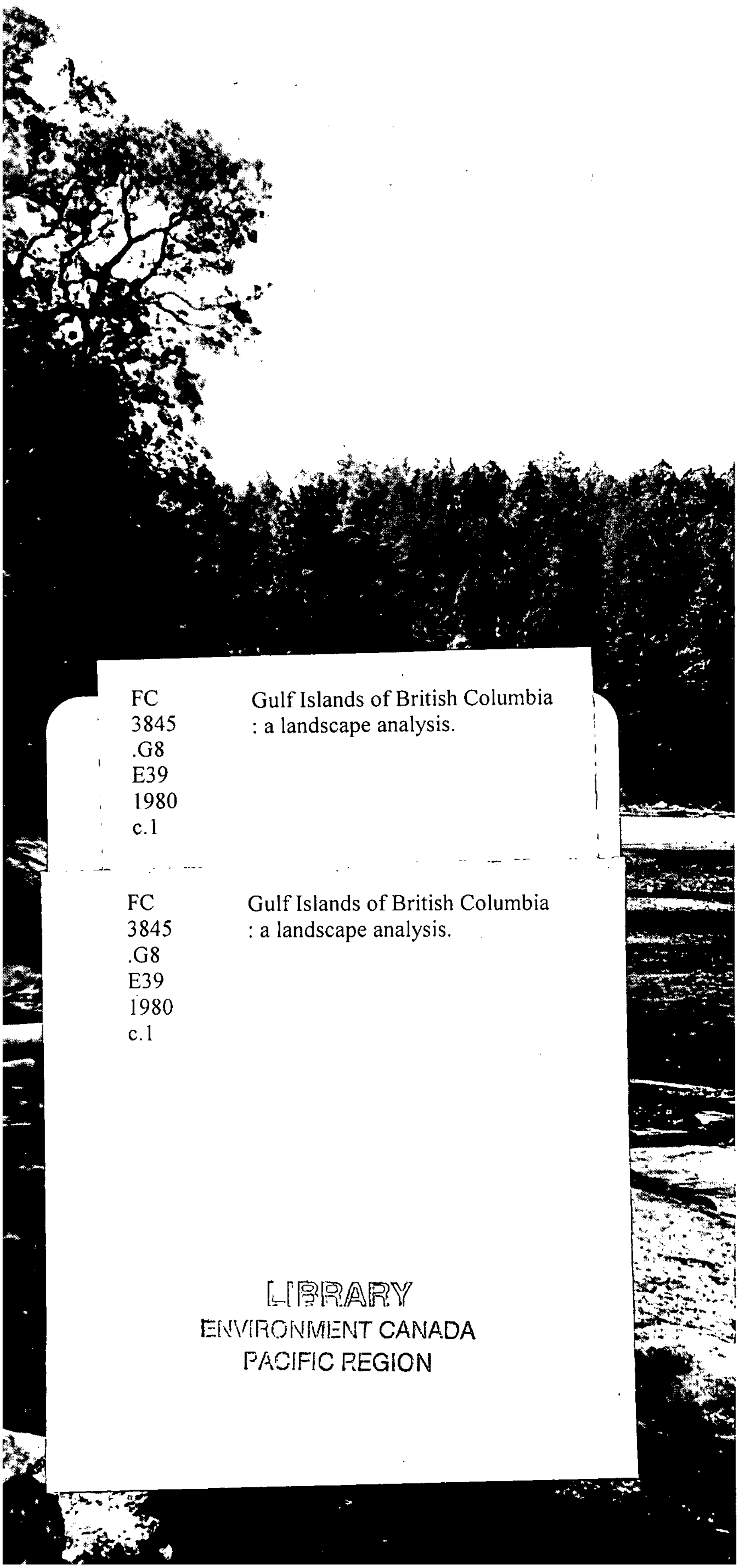
The Outer Gulf Islands are located adjacent to the southeastern coast of Vancouver Island, British Columbia and comprise six major islands: Galiano, Saturna, Mayne, North Pender, South Pender and Prevost, and a number of smaller islands. They have a total area of about 16,680 hectares. At present, the islands are lightly settled, but increasing pressure for retirement and summer cottages has resulted in several unsatisfactory subdivisions. The present study provides the environmental framework for planning and a base against which future development proposals may be assessed. Pertinent available information is summarized. Eight landscape units are described in terms of their environmental and vegetational characteristics, and impact of human activity on the environment, soils and vegetation is evaluated. Four maps are included in this study.

Résumé

Les six principales îles de la partie sud canadienne du golfe sont Galiano, Saturna, Mayne, North Pender, South Pender et Prevost; il existe en plus plusieurs îles plus petites dont la superficie totale est d'environ 16 680 hectares. A l'heure actuelle, les îles sont peu habitées, mais la demande croissante de terrains pour l'érection de chalets de villégiature et de retraite a donné lieu à plusieurs subdivisions insatisfaisantes. La présente étude fournit un cadre de planification environnementale et une base sur laquelle pourraient s'étayer les futures propositions de développement. Le lecteur y trouvera l'information pertinente disponible. Huit unités de paysage sont décrites selon leurs caractéristiques végétales et environnementales, et, pour chaque unité, l'influence de l'activité humaine sur l'environnement, le sol et la végétation y est évaluée. L'étude comporte quatre cartes géographiques.

Cover: Active Pass is a narrow channel between Galiano and Mayne Islands. It is halfway between Tsawwassen and Swartz Bay terminals and the B.C. ferries meet in it every hour. Ocean-going freighters, commercial fishing boats and hundreds of sport fishermen make it one of the busiest channels on the B.C. coast.

Contents



FC 3845 .G8 E39 1980 c.1 Gulf Islands of British Columbia : a landscape analysis.

Fig. 2. It is peaceful and quiet on the Gulf Islands.

LIBRARY
ENVIRONMENT CANAD
PACIFIC REGIO

Fig. 3. Porlier Pass is navigable by sailboats only at slack tide. Numerous rocks and water flowing in excess of 7 knots make navigation at flood tide dangerous.

Fig. 4. Sheep are still kept by some residents. Their numbers are not great and the open-range environmentally damaging grazing is a thing of the past.

Acknowledgments

The study was carried out by the employees of the Pacific Forest Research Centre, Environment Canada. Field expenses and half of the printing cost were paid by the Islands Trust, a provincial agency. Maps, produced by the Geological Survey Branch of the Energy, Mines and Resources, Canada, soil maps of the Agriculture, Canada and the Resource Analysis Branch, Ministry of the Environment, British Columbia, were used for interpretation and cross-checking. Thanks are also due to many residents for the information they provided and the access to their properties they allowed. Artistic lay-out was done by John Wiens of the Pacific Forest Research Centre.

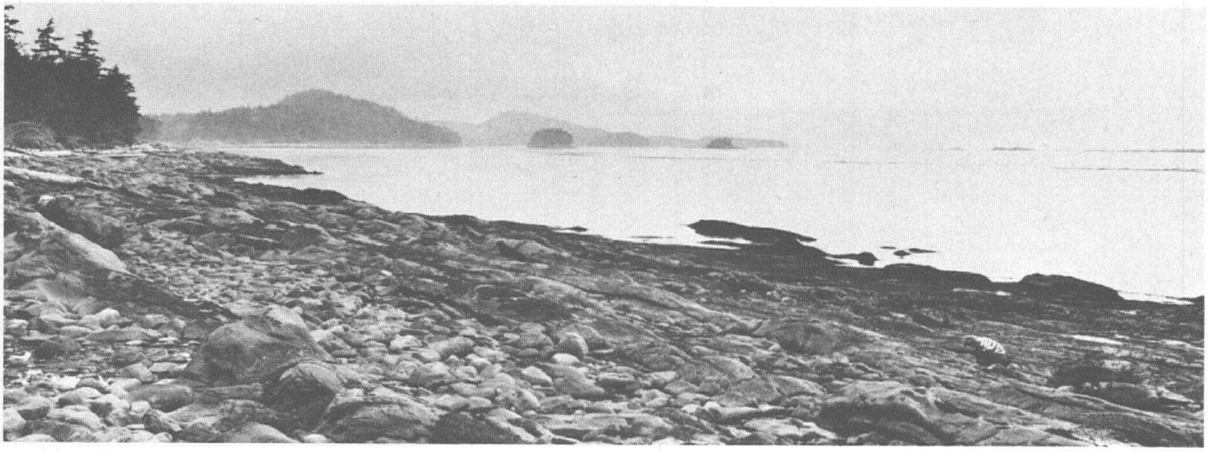


Fig. 5. Boulders over a smooth beach form much of the shore. They make walking along the shore difficult, but, in spite of it, beach-combing is a favorite pastime.

INTRODUCTION

This study of the Outer Gulf Islands, located adjacent to the southeastern coast of Vancouver Island, British Columbia, was requested by the Islands Trust, a provincial government agency, created in 1974, which has the responsibility for planning and regulating the development of the Canadian Gulf Islands. This report deals with the six most southeastern islands; namely, Galiano, Mayne, Saturna, North Pender, South Pender and Prevost Islands, and a few smaller adjoining islands.

Government ferries stop several times a day at the major islands which can be easily reached within two hours from downtown Vancouver or Victoria. While the distance is beyond practical limits for daily commuting, the islands are under increasing pressure for weekend recreation and retirement and summer cottages. Demands for lots combined with lack of planning and control have given rise to several rather unsatisfactory subdivisions.

This paper presents the results of a survey of the physical and biological characteristics of the islands pertinent to expected pressures for recreational use and for residential development. It emphasizes practical aspects of land use, placing importance on topography, slope and soil depth and texture. Where distinct differences in topographical configuration occur, they coincide with soil genesis and soil development processes.

The study is a synthesis of pertinent available information on geology, topography, climate, hydrology, soils and plant and animal ecology. Eight landscape units are designated. They are a composite expression of all environmental and ecological factors and express similarity in habitat within the general environment. Their intrinsic suitability for certain land uses are described and explanations are given as to why some units are suitable for residential development, while others should be reserved for recreation or open space. However, as new information becomes available or the values of society change, the recommendations and conclusions will need to be modified and updated.

The study was carried out from photo-interpretation of black and white panchromatic aerial photographs on a scale of 1:15,840 (4 inches = 1 mile), from which final maps were produced at a scale of 1:20,000. Provisional soil maps, at a scale of 1:50,000, provided by the Canada Department of Agriculture, Research Unit, Vancouver, a soil survey map by Day, Farsted and Laird (1959) and a terrain inventory map by the B.C. Ministry of Environment, Resources Analysis Branch, Victoria, were used to cross-check the interpretation of the landscape units. The intensive air survey reduced the groundwork to only nine man-weeks.

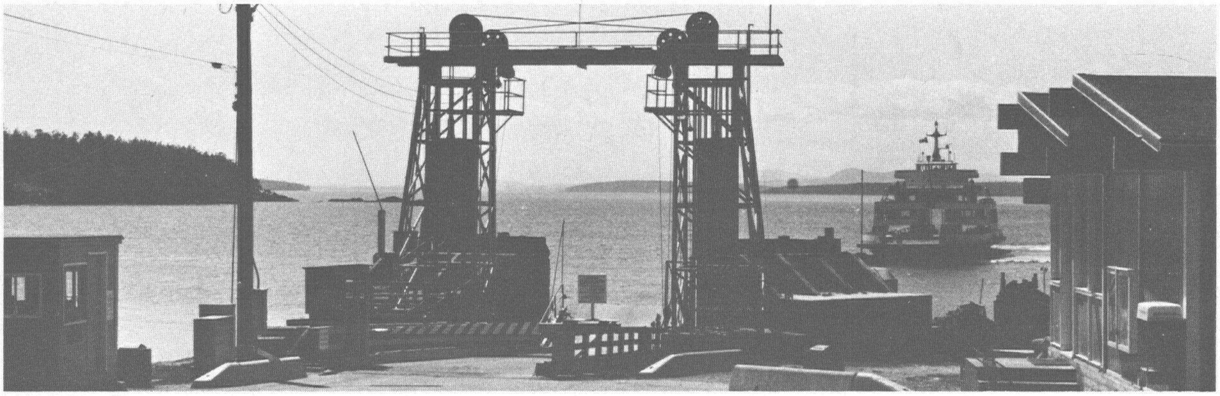


Fig. 8. Government ferries stop on the four main islands several times a day.

DESCRIPTION

The study area is situated about 15 to 35 km north and northeast of the northern tip of Saanich Peninsula, at the southeastern tip of Vancouver Island. In addition to the six main islands, it includes a few adjacent smaller islands and a number of nameless islets and rocks projecting above the water. About 16,580 ha or 41,000 acres were mapped, of which the larger individual islands comprise the following areas:

Galiano Island	5953 ha	(14,709 acres)
Saturna Island	3092 ha	(7,640 acres)
Mayne Island	2633 ha	(6,506 acres)
North Pender Island	2685 ha	(6,635 acres)
South Pender Island	810 ha	(2,001 acres)
Prevost Island	675 ha	(1,668 acres)
Samuel Island	204 ha	(505 acres)
Parker Island	164 ha	(404 acres)
Tumbo Island	121 ha	(299 acres)
Gossip Island	36 ha	(88 acres)
Curlew Island	31 ha	(77 acres)

Fig. 6. Many island residents are retired, after spending their productive lives elsewhere. Leisure activities, such as golfing, fill their days.

Fig. 7. Exposed beaches, sandy in summer, are gravelly after winter storms. Gentle wave action in spring slowly replaces the sand on the beach from deep water.

The islands have steep and rugged topography with ridges running generally in a west-northwest to east-southeast direction (Fig. 21). Ridges rise to more than 160 m (500 feet) a.s.l., with individual peaks considerably higher. On Galiano Island, Mt. Galiano is about 330 m (1015 ft) a.s.l. and Mt. Sutil is 313 m (955 ft) a.s.l. On Mayne Island, Mt. Parke is about 260 m (860 ft) a.s.l. On Saturna Island, Mt. Warburton Pike is about 400 m (1310 ft). On North Pender, Cramer Hill is over 215 m (700 ft) high. On South Pender Island, Mt. Norman, 245 m (810 ft), is the highest point. Valleys between ridges are approximately 60 m (200 ft) a.s.l.

During the last glacial period, 10 to 15 thousand years ago, the Gulf Islands were covered by a sheet of ice estimated to be about 1000 m (3000 ft) thick. As the glacier retreated, the land relieved from the weight of ice rose and tilted. Exposure of different rock surface resulted in different cleavage and greater erosion on the south shore than on other shores. There wave action undercut the rock, producing steep and often inaccessible shores without beaches, where only large boulders protrude above water at low tide. Where marine sediments of glacial or early postglacial origin formed the shore, wave action produced "feeder bluffs" below which there are stony or sandy beaches. Size of the beach material depends on the composition of bluff material and the velocity with which the wave action transports fine particles into deep waters. Bays are a continuation of valleys and as such are protected by steep topography on both sides. Heads of bays usually have a wide beach of fine sand, while along

Fig. 9. Logging is the most important local source of income. Protected deep bays offer excellent sorting and booming areas. Log rafts are towed to mills on Vancouver Island.

the sides deep water may extend close to shore. Erosion on the north shore was much slower, resulting in moderate or gentle slopes. Flat rock surfaces, often forming a bench, are typical in the intertidal zone.

HISTORY

At about the time Captain Cook visited the west coast of North America in 1778 and again in 1794, several Spanish expeditions explored the waters of Vancouver Island. A large Spanish fleet, commanded by Francisco Eliza, arrived in 1790 at Nootka to claim the west coast for the Spanish crown. In 1791, Eliza circumnavigated Vancouver Island and named the Strait of Georgia *Gran Canal de Nuestra Senora del Rosario de la Marinera.* Galiano Island was named after Dionisio Alezla Galiano, captain of the vessel *Sutil;* Mayne Island was probably named *San Carlos,* Saturna Island *Santa Saturnina* and North Pender *San Eusbio,* all after names of ships in the Spanish fleet. South Pender was called *Sayas,* meaning a skirt. Captain Jose Maria Narvaez, member of the Eliza expedition, commanding the schooner *Horcasitas,* charted shores and waters of the southern Gulf Islands. Bays and points were given Spanish names; these were the only names for more than half a century.

The gold rush in 1858 brought to a head the international boundary dispute and led to the arrival of the Hydrographic Survey Fleet. Captain Daniel Pender, Master of the H.M. Survey Vessel *Plumper,* Captain Henry George Richards, Master of the H.M.S. *Hecate* and Lieutenant James Alden, Master of the U.S.N. Survey Vessel *Active,* were

Fig. 10. Port Browning is a deep, protected bay. Recently, a number of permanent residences were constructed along the waterfront.

responsible for most of the names found on our charts today.

At that time, only Indians lived on the Islands and probably only seasonally, when their fishing expeditions took them to Point Roberts or up the Fraser River. They were Saanich and Songhees Indians speaking the Strait Salish dialect or *Lekungenung* and the Nanaimo Indians speaking *Halkomelem*.

First land ownership by a settler was that of the Hon. John Tod, Chief Factor of the Hudsons' Bay Company and member of the *Council of Government of Vancouver Island Colony*. In 1855 he purchased a large tract of land on Pender Island on which he ran a flock of sheep, commuting several times a year by sailboat.

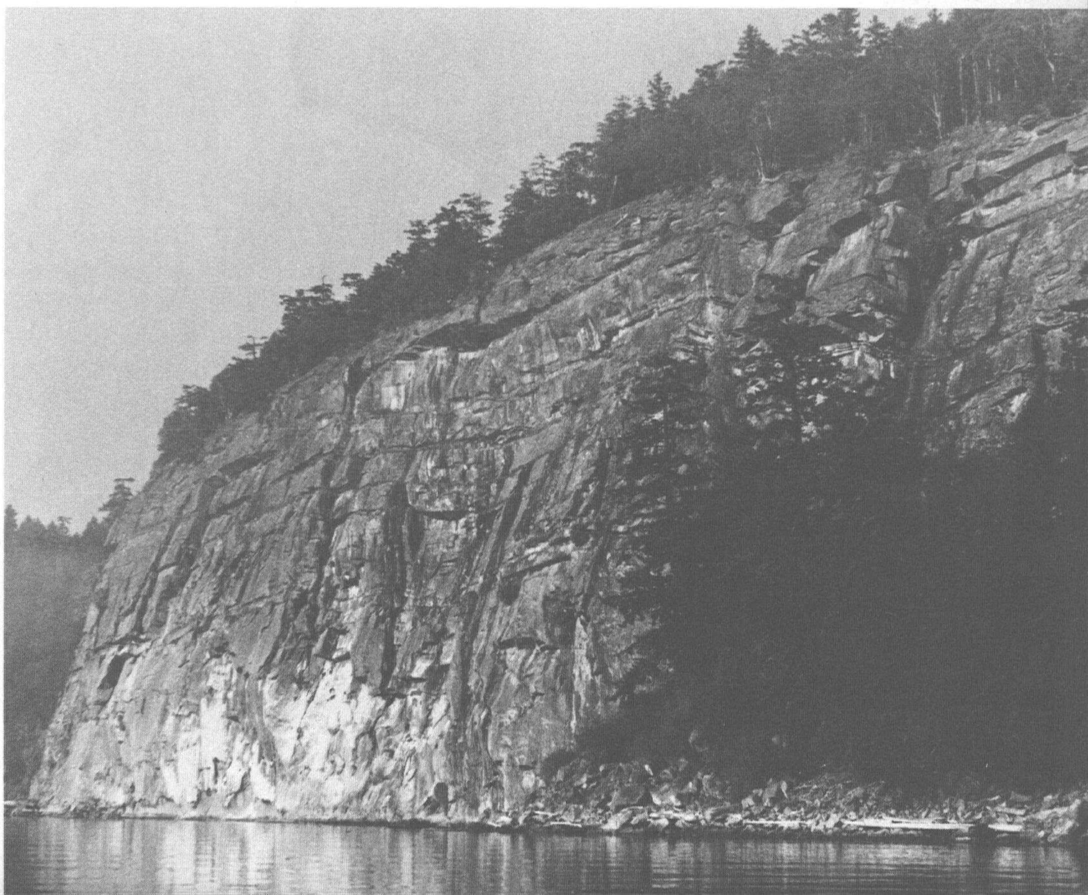
The islands were gradually settled by permanent residents. In 1886, 16 names (men only) appeared on the voter's list on Mayne Island, 15 on Galiano, 7 on Pender and 2 on Saturna. Settlers lived off the land, producing all their needs. Mixed farming prevailed; surplus produce was taken out in boats for sale in New Westminster, Victoria and Nanaimo. However, most holdings were too small to be classed as farms.

By the end of the century, most land suitable for agriculture was permanently cleared and settled. Sheep farming was the most important industry on the islands; most farmers relied heavily on wool, sheep skins and meat for their cash crop.

At the time of the early settlers there were no wharfs on the Gulf Islands, but steamers plying between New Westminster and Victoria, and between

Fig. 11. In summer, marinas offer shelter moorage for visiting boats. Some have excellent shore facilities.

Fig. 12. Weather-resistant rock cliffs are frequent along the south western shore. They provide safe nesting sites for several species of sea birds.



Nanaimo and Victoria, stopped on request to take aboard or discharge passengers and to unload supplies to small boats. Earliest of these vessels were the side-wheelers, *Princess Louise* and *Yosemite,* and a stern-wheeler, *R.P. Rithet.* They were owned and operated by the Canadian Pacific Navigation Company, which was later bought out by the Canadian Pacific Railway. Their licences allowed them to cross the Gulf of Georgia only during the summer months.

Around the turn of the century, the *S.S. Iroquois,* in conjunction with the *V. & S. Railway,* running between Victoria and Sidney, started a regular service to the Gulf Islands. The *Iroquois* sank during a storm in 1911 just out of Sidney harbour, with a heavy loss of life. Following the Iroquois tragedy, several small freighters provided unscheduled service to the islands. Later, the C.P.R. vessels stopped regularly at the islands, but in 1953 this service was terminated as uneconomical. Early in 1954, the Gulf Island Navigation Ltd. commenced a regular service out of Steveston.

Early pioneers collected their weekly mail at first from Salt Spring Island and later from Mayne Island which, until the turn of the century, had the only post office on the Outer Islands. In 1901, a government wharf and a second post office was built on North Pender Island at Hope Bay.

The first medical service was provided in 1897, when Dr. Gerald Barker opened a practice at Ganges on Salt Spring Island. Rowing or sailing in his small boat, he made regular visits to the Outer Islands. However, in 1904, Dr. Barker could not resist the call of gold in the Yukon, and the islands were again without medical service. From 1906 a succession of medical men served the Gulf Islands as residents or visiting physicians.

Extensive logging at the beginning of the century removed all old and valuable timber. While "highgrading" was prevalent, accessibility and proximity to the sea and easy transport of the rafts along protected channels and inlets to the mill in nearby Cowichan Bay made it economical to utilize even logs of low quality.

Slash burning, carelessness, land clearing by settlers and accidents account for an extensive fire history. Charcoal in the soil indicates that most of the study area was burned, many places repeatedly. Hills, after logging and burning, were used for grazing but eventually regenerated to trees. This re-invasion of the forest often took many years, as settlers used fire repeatedly to fight the re-invading forest and to encourage grasses and vetches to improve pasture.

The population has increased during the last two decades, as the demand for secluded private homes or cottages has grown. At present (August 1980) there are about 3050 residents on the Outer Gulf Islands and during summer, when non-resident property owners and visitors come to enjoy the beauty and tranquility afforded by island living, the population may triple.

The Outer Islands are easily accessible not only to residents of Vancouver and Victoria, but to visitors and seasonal or permanent settlers from the United States. Heavy pressure has been placed on the islands for residential and recreational pursuits. Several large-scale residential developments took place without any consideration for important environmental aspects and land capabilities.

CLIMATE

The climate of the Gulf Islands is generally described as west coast summer dry (Koppen 1931), characterized by dry, warm summer and cool, mild and wet winters. Maritime influences tend to overshadow effects of elevation, latitude and aspect.

The prevailing west-east movement of air over the southern tip of Vancouver Island is the result of control exerted by large, regularly occurring pressure systems located over the Pacific Ocean and the North American continent.

In winter, Davidson's Current brings large quantities of warm water from the south to the northeastern Pacific, resulting in transfer of heat and moisture into the air. This air mass, flowing from a generally westerly direction, is lifted and cooled over the mountains of Vancouver Island, where it releases a great proportion of its water load. As the air descends on the east side of Vancouver Island, it warms up and becomes unsaturated, producting only cloudy weather. However, depending on the location of the pressure systems, this air flow may be channeled through the Strait of Juan de Fuca into the Fraser Valley or along the Strait of Georgia into the Puget Sound area. The air flowing along these channels has not unloaded its moisture and

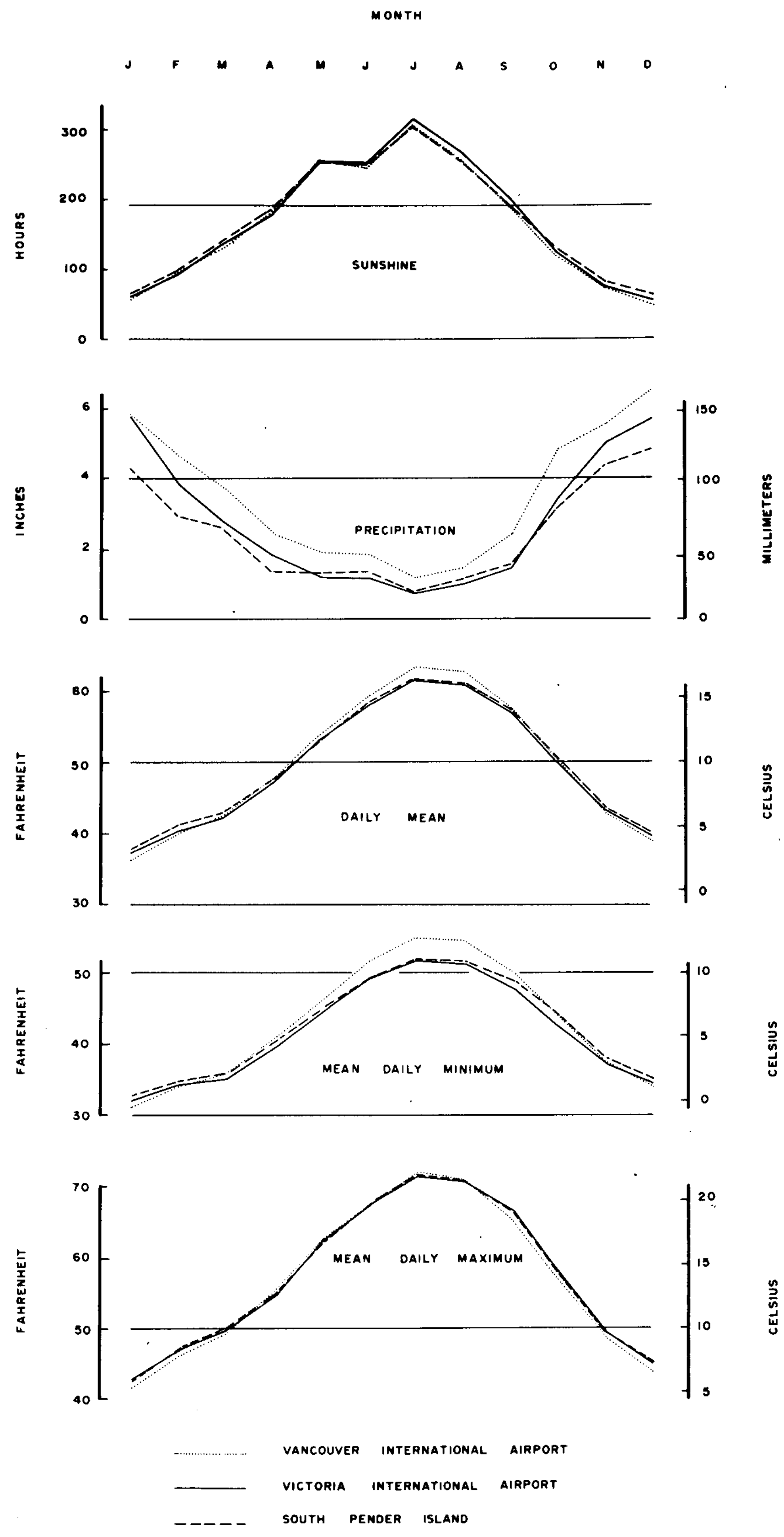


Fig. 13. Sunshine, precipitation and temperature.

Fig. 14. Resident sport fishermen keep their boats at small local marinas.

brings rain to the Gulf Islands. Since this air flowing from the Pacific is warm, it produces temperatures up to 12°C (22°F) higher than might be expected from the latitude.

Westerly winds, accompanying east-moving depressions, while rarely of gale force, are usually stormy and a succession of storms with steady rain may continue with little break for a week or more. Easterly and northeasterly winds, associated with migrating Pacific storms, may become very strong in late fall and early winter.

In summer, air flowing from the west, is cooled by the cold upwelling water that lies immediately off the coast of Vancouver Island and penetrates deep into Juan de Fuca Strait. These air masses gradually warm as they flow eastward over land and become less disposed to release precipitation. During the periods of westerly flow, the terrain differences produce striking local variations in cloudiness and precipitation. Peaks act as cloud generators, sending out lines of clouds eastward, while the remaining area is generally cloud free. As a result of an absence of a frontal flow in summer, the weather is usually cool, clear and calm, with a breeze developing regularly during the afternoons.

Four meteorological stations operate within the study area, but their temperature records are incomplete and graphs (Fig. 13) had to be constructed from calculations and interpolations. However, most available records were within 1°C (2°F) of those from the Victoria International Airport. These

Fig. 15. At low tide, millions of small California mussels cover the rocks amid patches of *Fucus,* a seaweed.

Fig. 16. Steep slope forms much of the southwestern shore.

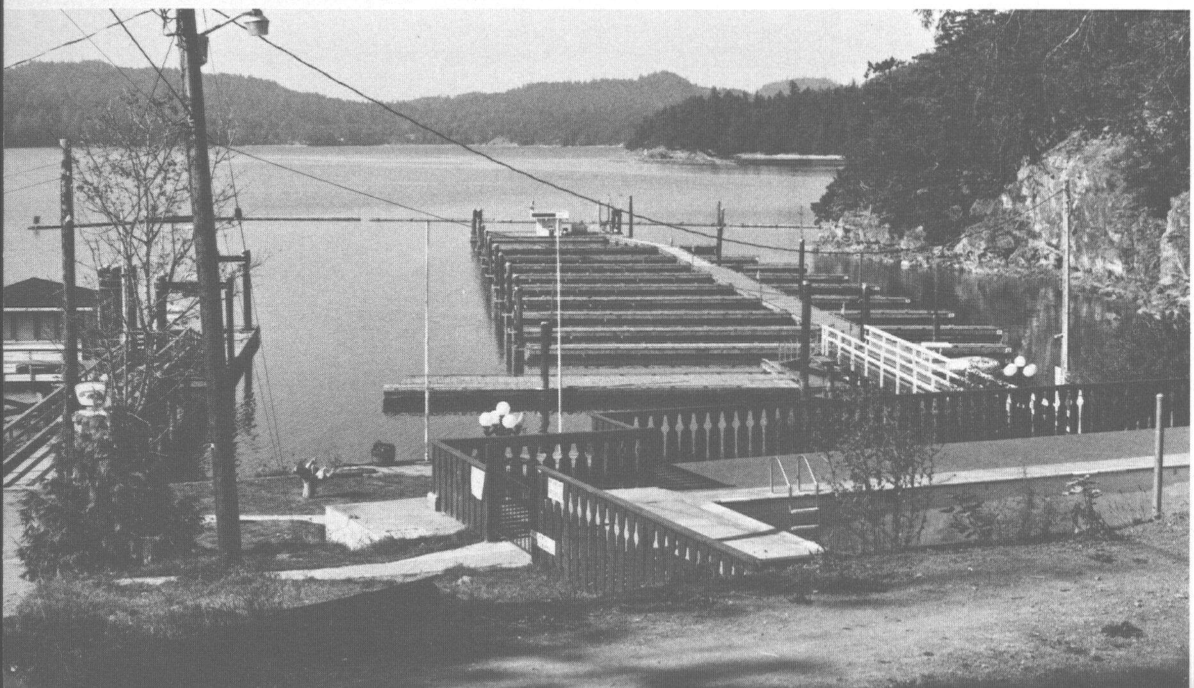


Fig. 17. Local marinas are busy during the summer and provide seasonal employment. However, by October, they are deserted.

provided an excellent reference base and the calculated data for Outer Islands can be accepted with confidence.

The four stations operating on the Outer Islands are located at low elevations, close to the seashore; therefore, their records show only minor thermal differences. Temperature gradients do exist between coastal and inland locations. They are modified by the direction of the air flow, vegetation cover and microsite characteristics. On the average, summer maximum temperatures were estimated to be about 2°C (3 to 4°F) higher and the minimum temperatures 1 - 2°C (2 - 3°F) lower per mile inland. During cloudy weather, prevailing in winter, gradients are insignificant; under clear skies, winter temperature gradients are probably similar to those in summer.

At sea level, the January mean daily temperature was calculated to be about 3.5°C (38°F), mean daily maximum about 7°C (44°F) and daily minimum 0°C (32°F). A freezing temperature of about −3°C (26°F) may be expected to occur every winter. Since a temperature of −15°C (5°F) occurred once during the 68 years on record on Saltspring Island, it may be expected that it could occur also on the Outer Islands with similar frequency. At sea level, the July mean daily temperature is about 17°C (62°F), mean daily maximum about 22°C (72°F) and minimum about 11°C (52°F).

Occasionally, a complete absence of turbulence may permit the cold air, draining from sparsely forested upper slopes, to accumulate in the low-lying areas of the valleys, but most of the islands are open to the sea and a complete lack of flow is rare. Near the shore, the number of growing degree days above 5°C (42°F) is around 1900 or 3400, respectively. A frost-free period during 5 years of available records ranged from 201 days in 1972 to 232 days in 1973. The last frost occurred on March 6 in 1971, but as late as May 28 in 1974. The earliest frost occurred on October 28 in 1971 and on November 28 in 1974. Inland, the frost-free period is somewhat shorter. Any large-scale clearing may compound the occurrence of frost, enabling the cold air to drain into low-lying areas. New buildings and roads may also redirect the flow of cold air and cause frost damage where it was not experienced before.

The total annual precipitation ranges from about 700 to 750 mm (28 to 30 inches) at sea level to more than 1000 mm (40 inches) on the 300 m (1000 feet) peaks. The precipitation is highly seasonal, approximately 75% occurring from the beginning of October to the end of March (Fig. 13). Periods of drought extending over 4 to 6 weeks are common each summer. Because the islands are located in the rainshadow of Vancouver Island mountains, heavy rains are rare even in winter. However, a rainfall of more than 50 mm (2 inches) in 24 hours has occurred in summer and in winter. The greatest rainfall in 24 hours recorded on Pender Island during 38 years on record was 72 mm (2.85 inches).

Snowfall varies greatly from year to year, but mild winter temperatures result in only 3 to 4% of the total precipitation falling as snow at sea level. That results in a total snowfall of about 20 cm (8 inches) a year. Snow cover is rarely deeper than 10 cm (4 inches) and, at sea level, it rarely lasts more than a few days. The maximum amount of snow that may be expected to fall at sea level in 24 hours is about 40 cm (16 inches), which was recorded on Pender Island in the winter of 1948/49. Inland and at higher elevations, consistent with the temperature gradient, considerably more snow may be expected.

Freezing rain, a condition when precipitation which falls as rain freezes on impact with frozen ground, is rare and causes little concern. However, ice formed by this means has disrupted communications and travel for as long as 2 days.

Fig. 18. A few deserted orchards indicate the shift of the population distribution as the residents moved from subsistence agriculture of the past to leisure of retirement at present.

Fig. 19. Pleasure crafts from as far as California visit the intricate channels and bays of the Gulf Islands during the summer.

The Outer Islands receive about 2000 hours of bright sunshine at sea level (Fig. 13). With increasing elevation, the amount of sunshine is estimated to decrease to about 1850 - 1900 hours. During early mornings in spring and fall, the peaks act as cloud generators. In winter, when the air flowing from the westerly direction is saturated, and in summer, when the air is dry, the cloud pattern is similar throughout the islands.

Along the shores, fog (visibility of .75 km [.5 mile] or less) occurs on approximately 20 to 30 days per year. Warm, moist air over cold ocean water releases moisture in the form of fog, which the air currents may carry ashore. Once the sea fog has become established, it usually persists until a change of air circulation breaks down the thermal inversion. Sea fog occurs, especially in the fall, when large thermal inversions are caused by migrating storms over the Pacific.

Inland low-lying localities may receive slightly greater fog frequency than the seashore. This results from radiation fog occurring in the late night and early morning hours, when the moisture content of the air is high and radiation cooling during calm, cloudless nights is pronounced. Hills also may retain fog upslope until daytime heating and circulation cause the fog to lift. Frontal weather may result in advectional fog at higher elevations as well.

PHYSIOGRAPHY, GEOLOGY AND SOILS

On the west coast of British Columbia, the bedrock originated during Carboniferous and Devonian periods and is composed of volcanic materials of the Vancouver group. During the Upper Jurassic period, these were deformed, faulted, invaded and partly replaced by batholitic intrusions of diorite, quartzdiorite and granodiorite and smaller intrusions of porphyrites, which probably erupted during the later deformations (Clapp 1917).

The sandstones, conglomerates and shales that overlie much of the older rock formations at lower elevations were formed during four episodes of Upper Cretaceous time, some 80 million years ago (Muller and Jeletzky 1970).

During the Tertiary time, an erosion cycle subdued the older rock formations, developing a peneplain at the southern tip of Vancouver Island and over the Gulf Islands, separated from the mainland by the Coastal Trench. Before the Glacial period, the mature surface of the peneplain was gradually reduced to a lowland (Clapp 1917).

Topography consists mainly of undulating to rolling surfaces. Much of the shoreline is rugged, being characterized by wave-cut cliffs, steep promontories and off-shore rocks and islets. Streams dissect the land. Between the streams, rolling moraines, hills, ridges, kames, lacustrine and marine basins and outwash plains form a heterogenous landscape pattern, often with essentially unaltered glacial type relief.

Present landscape patterns are the result of Pleistocene glaciation which occurred 10,000 to 15,000 years ago. During that time massive ice sheets advanced from the north and covered Vancouver Island with layers of ice, estimated to be about 1000 m (more than 3000 feet) thick. The relief of the Gulf Islands was severely planed and scoured by the advancing glacier. Valley floors were gouged into fjords and glacial troughs, in which lakes have formed (Clapp 1917). The enormous weight of ice depressed the land mass 75 to 90 m (250 to 300 feet) in relation to sea level.

As the glacier gradually melted, loose material carried by the ice was deposited over the terrain. It often has two distinct layers. The lower layer was probably deposited under the ice, being formed by abrasion and crusting of the rocks under the weight of the advancing glacier. It is a mixture of sand, silt and rock, compressed by the weight and shifting of the ice mass into a consistency of concrete. On top of this layer was deposited the loose material carried within and upon the ice. Where it was not subsequently removed by meltwater, it forms a layer of fairly uniform depth up to more than 1 m (about 4 feet) of unsorted, unstratified, gravelly, sandy and loamy material containing many angular rocks of different origin.

With the retreat of the glacier, a gradual uplift of the land took place. Large streams which, before the Glacial period, eroded and developed the lowlands, revived and established drainage patterns and river channels. Large volumes of rapidly moving meltwater and subsequent erosion removed glacial deposits from higher elevations, steep slopes and along the river channels, exposing bedrock. Large rocks were deposited at the foot of slopes, gravel and coarse sand in low-lying areas and along streams, and fine-textured materials away from the main flow, where the velocity of water was reduced, as in protected bays.

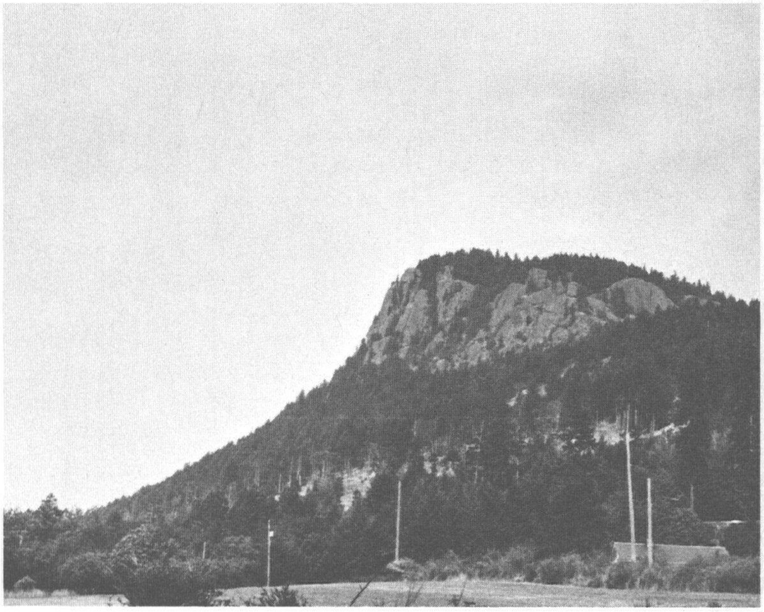


Fig. 20. Steep cliffs occur even in the interior of the islands.

Muddy post-glacial rivers covered the glacial detritus lying on the ocean floor with enormous quantities of stratified gravel, sand, loam and clay. As the uplift of the land took place, these sediments were re-worked and re-stratified by current, tide and wave action. Periodic flooding during periods of rapid run-off in winter continues the deposition of fine materials upon current floodplains.

Upland soils are generally of glacial till origin that has been eroded, somewhat changed and usually moved a short distance by gravity or colluvial action. Soils developed from this modified till are generally shallow and coarse-textured, ranging from gravelly sands to gravelly sandy loams. Deposition of sesquioxides in the surface horizons produced a reddish color in the B horizon, beginning at a depth of 15 to 30 cm (6 to 12 inches).

Rock outcrops, smoothed by movement of the glacier, are bare or covered by a thin layer of

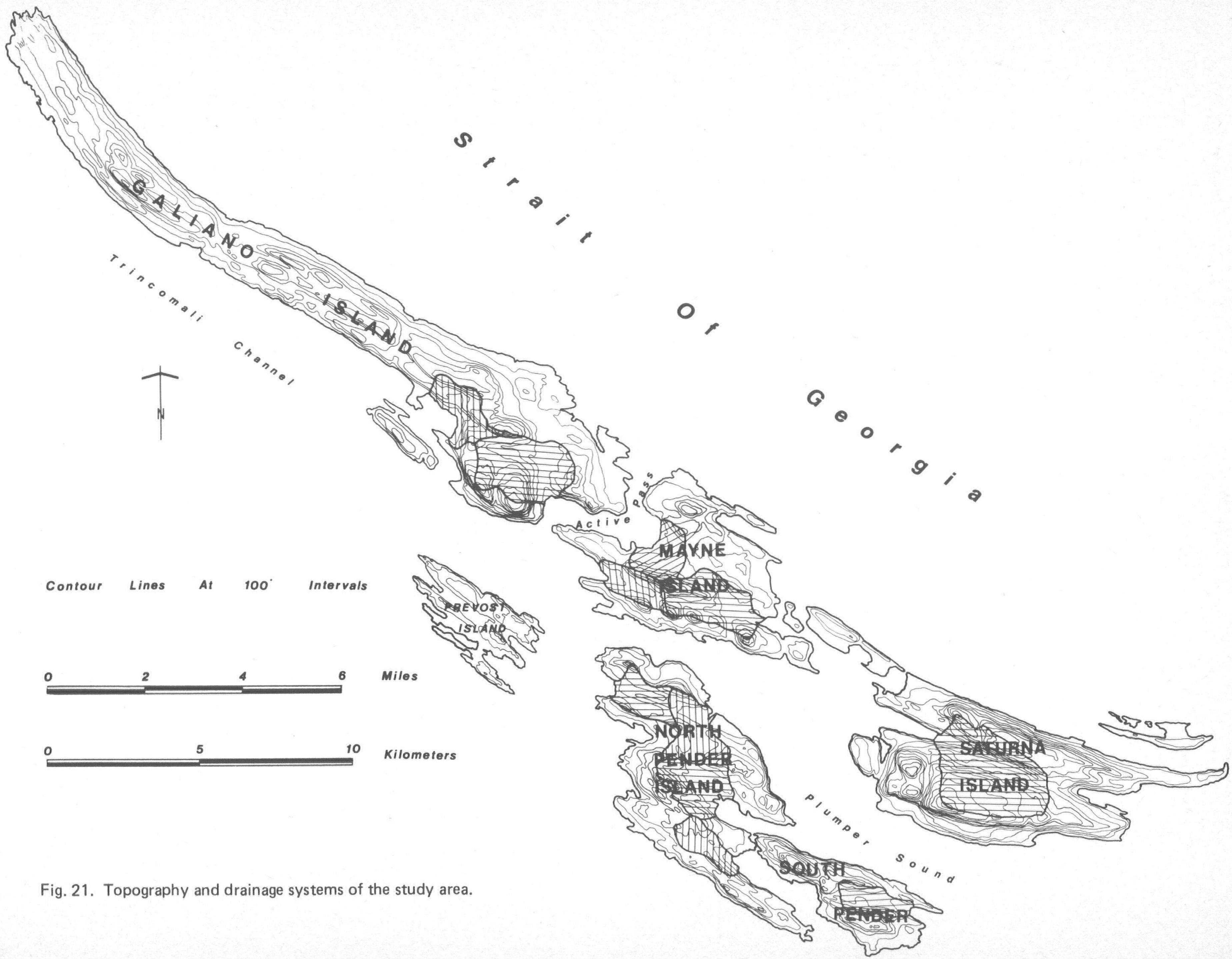


Fig. 21. Topography and drainage systems of the study area.

organic material, which may be underlain by up to 10 cm (4 inches) of coarse sand produced by the weathering of the rock substrate. The sand is also dark from the overlying organic material.

Soils derived from sandstones and conglomerates are coarse textured and well drained. Underlying bedrock is usually fractured, allowing penetration of roots and water, but the soil development is shallow. Soils derived from shale are deeper, dark in color and have a loamy texture. In depressions, they are often imperfectly drained.

The soils developed on marine deposits on higher grounds and terraces, which were exposed to high waves or fast-moving water, are predominantly of coarse gravelly sandy texture. On lower grounds, which were deep in water during submergence, or where postglacial rivers poured muddy waters into protected bays, they range from sands to clays generally with an absence of gravel. They are usually stratified with sandy materials resting upon layers of loam or clay or vice versa. Where soils of marine origin are shallow, they rest as a mantle, often only a few feet thick, over consolidated shale or bedrock. Hence, the texture of the surface soil may indicate different moisture content than that contained in deeper soil layers. On flat and depressional topography, marine deposits are usually poorly drained.

HYDROLOGY

On the Outer Gulf Islands, about 75% of the total annual precipitation falls from the beginning of October to the end of March. Summer rains are infrequent and usually light. The soil moisture deficit develops around the beginning of May and ends with autumn rains in early October. The evapotranspiration deficit is estimated to exceed about 400 mm (16 inches) at sea level, but varies considerably with aspect, slope, soils and ground cover. It is most pronounced along the wind-swept shores and sun-parched south and south-east slopes, especially on sites with shallow rocky soils.

Generally, run-off occurs only during heavy rains in winter. In summer, it is rare and may occur

Fig. 22. Rip tide is the best time for fishing. Yet, in a drizzle, there may not be a single boat there.

on sites where bedrock is at or very close to the soil surface. Where soils are deeper, summer rains are immediately absorbed by the dry and porous soil. Streams, lakes and swamps depend entirely on ground water supply. In lakes, the water level drops in summer and, before the onset of autumn rains, swamps dry out and creeks become tricklets seeping through the sand and gravel, with no surface flow.

From October to March, of about 550 mm (22 inches) precipitation at the seashore, approximately 150 mm (6 inches) may be allowed for winter evapotranspiration, about 100 to 150 mm (4 to 6 inches) to recharge the water-holding capacity of soils which will become available to plants during the next growing season, and 100 to 200 mm (4 to 8 inches) for deep ground-water storage and loss. Only about 125 mm (5 inches) of precipitation are available for run-off during heavy winter rains. At 300 m (1000 feet) a.s.l., where winter precipitation amounts to about 750 mm (30 inches) and soils are shallow, 400 - 500 mm (15 to 20 inches) of water may be lost through run-off.

Most of the area of the islands drains into the sea either directly or with run-off concentrated into short streams (Fig. 21). Because the islands have steep shores with predominantly shallow soils, run-off is rapid and streams running into the gullies flow only a few days following even a heavy rain. The interiors of the islands have rolling topography on plateaus, or are formed by wide valleys between ridges. On flatter terrain, deeper soils and denser vegetation cover slow down the run-off and equalize stream flow throughout most of the winter.

VEGETATION

The Outer Gulf Islands lie within the Strait of Georgia section of the Coast Forest Region (Rowe 1972) and in the Drier Subzone of the Coastal Douglas-fir Zone (Krajina 1959).

Because of the logging and fire history, the Outer Islands now support a mosaic of forests of different age groups proceeding through various stages of succession. Generally, stands of about 60 years predominate but in the valleys, the forests are usually somewhat older and, on the ridges, may be much younger. Douglas-fir is the predominant species but lodgepole pine, arbutus and garry oak on dry and disturbed sites and southern slopes, and western hemlock, red cedar, grand fir, red alder and bigleaf maple on moist sites and northern slopes may constitute an important part of the forest composition. Pacific dogwood may be conspicuous in the spring but, generally, it occurs only locally. Black cottonwood, Pacific crabapple and willow are common along seepage channels and borders of wetlands.

Vegetation under the tree canopy is dominated by salal and, to a lesser extent, by Oregon grape, twinflower, juniper and evergreen huckleberry on dry sites and by swordfern, vanilla leaf and salmonberry on moist sites. A variety of other shrubs, ferns and mosses are present in both drier and wetter conditions. A great abundance of spring flowers occur on shallow soils with an open tree canopy, and include easter lily, blue-eyed Mary, shooting star, sea blush, camas and others.

Imperfectly drained areas support grasses, sedges, bulrushes, buttercups, cat-tails and thickets of spirea. Where water is at the soil surface for a significant part of the year, plant growth is restricted to a few species, such as marsh grasses, cat-tails, bulrushes, pond lilies and water shields.

LANDSCAPE UNITS

The landscape units mapped on the Outer Gulf Islands are similar to those mapped in the Western Community of the Capital Regional District (Eis *et al.* 1976). They are composite units, taking into consideration physiography, exposure, slope, soils, drainage and vegetation to express similarity in habitat within the general environment. The scale of the maps (1:20,000) allows only limited detail and accuracy. For that reason, small differing intrusions that occur within each landscape unit have not been depicted and intimate mosaics of several units are 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, boundary lines are only subjective interpretations.

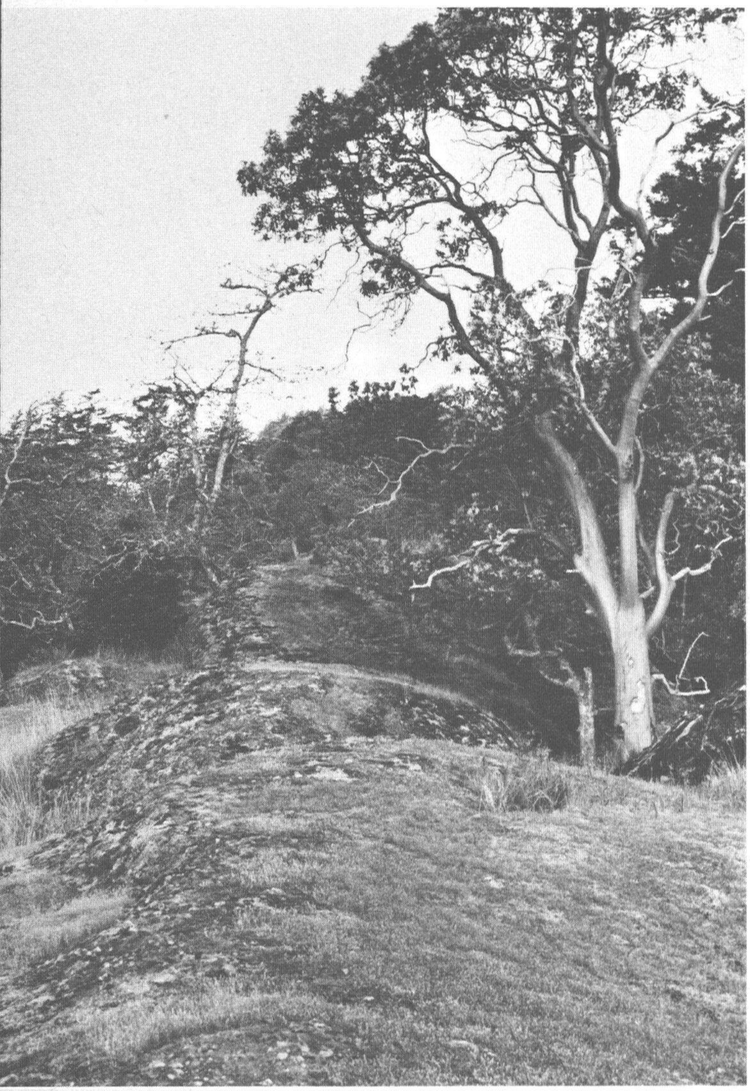


Fig. 23. The solid rock landscape unit occurs most often on ridges smoothed by the glaciers.

I. Solid bedrock

(Figs. 23, 24 and 25)

The solid bedrock landscape unit occurs at any elevation and comprises hill tops and steep slopes of intrusive or sedimentary rocks smoothed by glacial abrasion. Soil is non-existent or occurs as a thin layer of coarse sand derived in place from the weathering of the rock. It is dark, due to the high content of organic material from the decomposing remains of vegetation.

By the composition of vegetation, the solid bedrock landscape unit corresponds with the Arbutus - Garry Oak and Arbutus - Douglas-fir plant communities (McMinn *et al.* 1976). Stunted trees (Garry oak, arbutus, Douglas-fir and lodgepole pine) and shrubs (ocean spray, salal and bearberry) are widely scattered, growing only where their roots can penetrate into crevices. Rock surfaces are covered with crustose lichens and mosses. Their dense carpet retains sufficient moisture into late spring to allow a host of spring flowers to complete their life cycle before the summer drought sets in. While the diversity of species involved is not great, their abundance makes the spring aspect of the bedrock landscape unit spectacular. Blue-eyed Mary, stone crop, seablush, satin flower, fringe-cup, camas and monkey flower are probably the most conspicuous species in the open, whereas "rockland ferns", *Polypodium* and *Pityrogramma* are frequent on north-facing cliffs and in heavy shade.

The solid bedrock provides a foundation for any type of structure and, with its open space, scenic views and attractive vegetation, provides a desirable

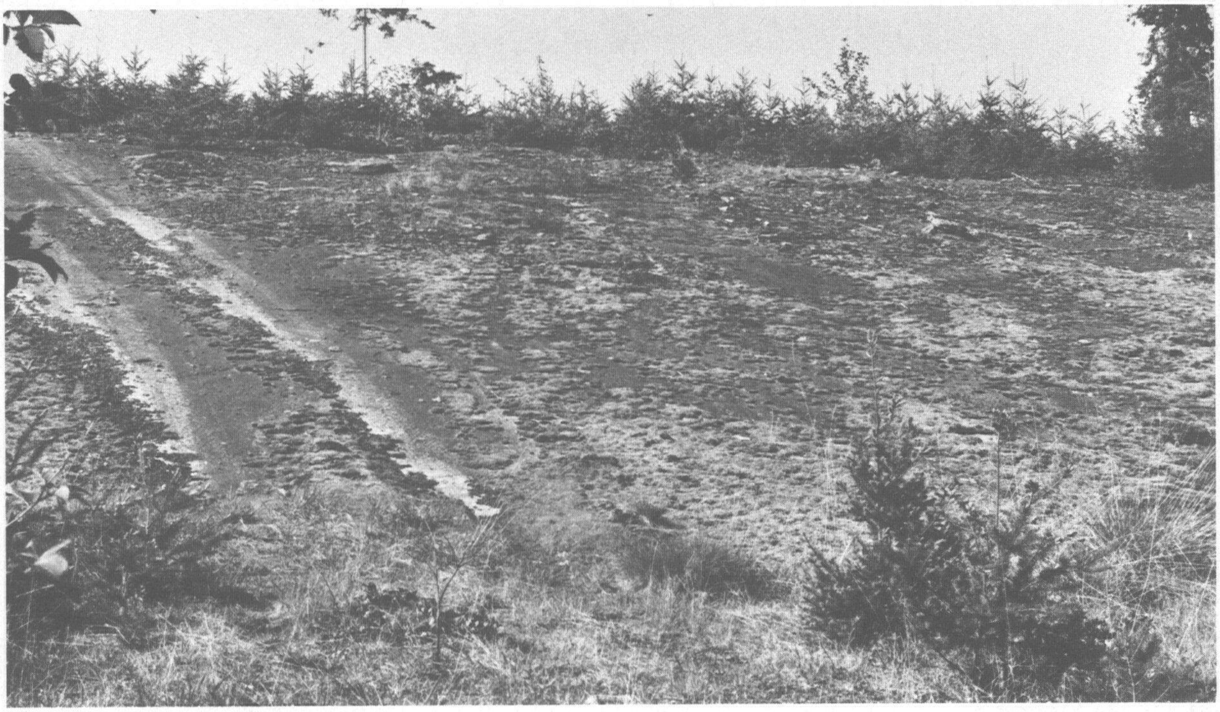


Fig. 24. Where ridges form a plateau, erosion is less severe, resulting in some soil accumulation. Solid rock landscape unit extends on slopes just below the ridge.

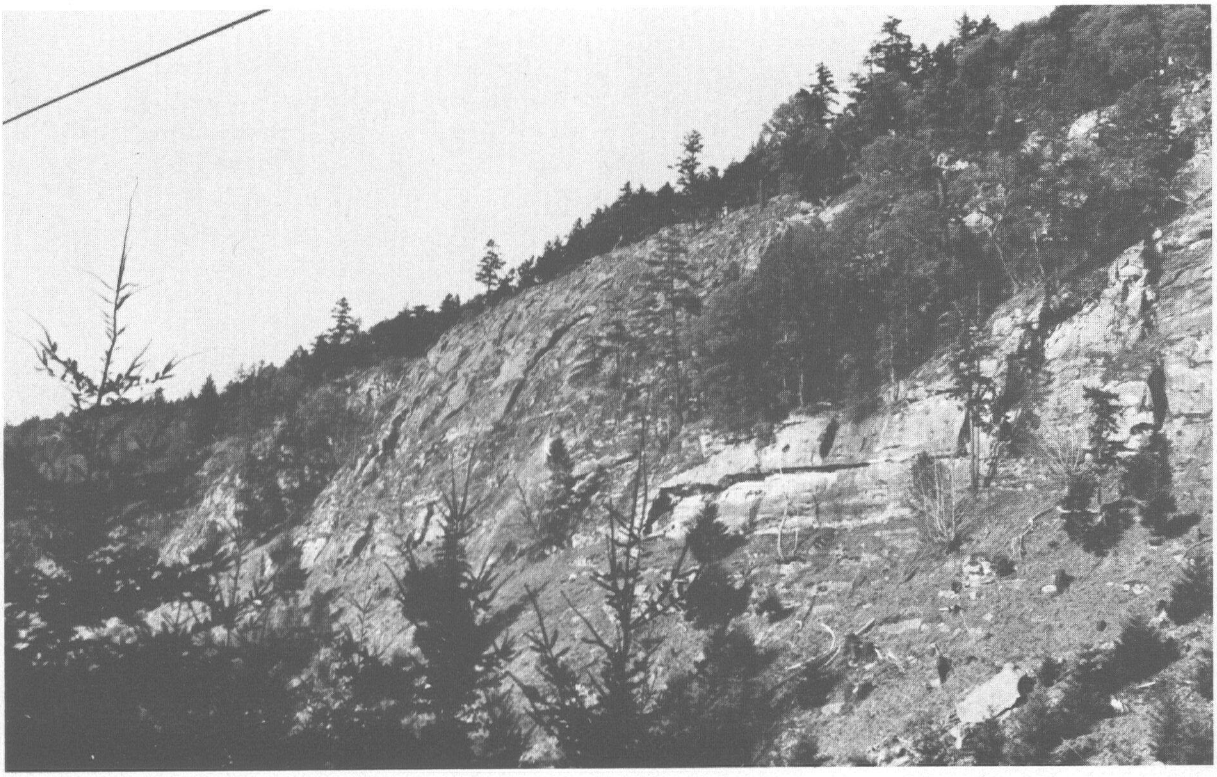


Fig. 25. On slopes, the solid rock unit often alternates with the broken rock unit, depending on weathering processes, erosion and soil accumulation.

environment for residential development. However, leveling, provision of access and services, and construction would be expensive. Suitable soil for septic fields would have to be imported but, even then, surface drainage of sewage is to be expected during the winter when the fill is saturated. Erosion of the fill will be a constant problem. Any development of this landscape unit should be postponed until other methods of sewage disposal, not requiring effluent discharge, prove satisfactory. Conventional landscaping will require fill material and top soil, and ground maintenance will be a continuous battle with erosion. A high residential density will destroy the aesthetic appeal of this landscape unit.

Because the soil is extremely shallow and the only internal drainage is through rock crevices, run-off, after the moss layer becomes saturated, is immediate and rapid and erosion of the shallow soil can be expected.

Lack of heavy underbrush and an amplitude of scenic views makes this unit valuable for extensive recreational activities. If this unit should occur within a development area, it should be considered for open-space and greenbelt purposes, especially since it does not require any buffer zone. Because of the steepness of the terrain and general lack of soil, the natural vegetation is easily damaged and, when disturbed, requires considerable time to become re-established. To maintain the vegetation, while allowing for recreational use, a system of well-marked trails should be provided. However, once the vegetation is destroyed and the rock denuded, this site can bear any amount of traffic. Because of its aesthetic value and because its vegetation occurs only on southern Vancouver Island and adjacent Gulf Islands, it warrants consideration for conservation, at least where it still exists in its natural state.

Where the solid rock landscape unit abuts on the seashore, it comprises steep, rocky shores or cliffs and usually extends down to the water line. The hard rock resists the energy of waves and wind; consequently, this landscape unit undergoes little noticeable change. However, during the 10 thousand years since glaciation, the exposed rock has been undercut and the present cliffs have formed. Rocks have split from the steep surface and accumulated in the water. They provide habitats for a wide range of marine life, including barnacles, mussels, starfish, fishes, anemones, snails and several species of seaweed.

Stability of this landscape unit along the shore permits its development. Limited management will be necessary to maintain an environmental balance as long as development does not force radical changes. However, the limitations that apply generally to the solid bedrock unit are particularly applicable when it forms the seashore. Buildings erected close to the sea will be subject to high winds and salt spray damage, and their maintenance will be costly. Setback of all structures, utilizing the natural configuration of the landscape, is advisable.

Fig. 26. Because of lack of moisture during the summer, the tree growth is slow. Douglas-fir, lodgepole pine, arbutus and an occasional oak is the typical composition of the forest.

2. Broken rock

(Figs. 26, 27 and 28)

The broken rock 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) has accumulated over bedrock, where boulder fields were deposited by glacial activity, or where the surface of the bedrock was broken by weathering processes and soil accumulated in interstices. This landscape unit invariably contains small areas of exposed bedrock which, because of their size, could not have been mapped separately.

The soil is usually coarse-textured sand or

Fig. 27. Open forest, with trees rooted in crevices of the rock, is typical of the broken rock landscape unit.

Fig. 28. Typically, the broken rock landscape unit has about 10 cm of sandy soil with high organic content. Often the rock may be moved with a bulldozer, other times blasting may be necessary.

sandy loam and is well to excessively drained. Rock fragments may constitute a significant proportion of the soil profile, especially in lower horizons. Soil development is weak and only a slight alteration in color with increasing depth can be detected. Only the surface is dark, from a high content of decomposed organic material. Underlying bedrock is often fractured, forming plates at the contact between soil and rock. Fissures serve as discharge avenues for percolating water and, by allowing roots to penetrate, they increase effective soil depth.

By the composition of vegetation, the broken rock landscape unit corresponds with the Arbutus - Douglas-fir and Arbutus - Lodgepole pine - Douglas-fir plant communities (McMinn *et al.* 1976). Most species of trees, shrubs, forbs, mosses and lichens occurring on solid bedrock (Unit 1) occur also in this unit, but several deep rooted species are present where soil depth permits their survival. Trees and shrubs are established in crevices and where soil has accumulated and moisture is retained. Arbutus is usually the most common species after logging or fire. Douglas-fir regenerates somewhat later and its presence depends on logging history and availability of seeds in adjacent stands. Tree spacing, while open, is dependent on the nature of rock material, availability of moisture and the amount of accumulated soil is somewhat denser than in the solid bedrock unit. Shrubs, such as wild rose, huckleberry, trailing blackberry, Oregon grape and salal; forbs, such as tiger lily, easter lily, chocolate lily, star flower, lady slipper and camas; crustose and fruticose lichens and mosses are usually abundant.

The commercial timber values within this landscape unit are low because of slow growth associated with summer drought. Lack of heavy underbrush and abundance of scenic views gives this unit a high value for extensive recreation, such as hiking. Stability of the soil and vegetation is variable because microsites range from bare rock surface to deep fissures filled with organic material. Recreational activities may result in trampling which, in turn, may cause denudation and loss of the thin soil, especially on sloping terrain. Greatest damage will occur during dry summer months, when the moss layer is dry and brittle and the coarse sand, upon disturbance, is prone to shifting. Well-marked trails, to control traffic, should be provided to prevent degradation of the habitat.

The broken rock landscape unit provides an attractive setting for residential development, with open-grown trees and many interesting spring flowers. Solid bedrock close to the surface provides a solid foundation for any kind of structure. However, cost of installation of services and provision of access may be high, possibly prohibitive, because of the steepness of the terrain and the necessity of blasting. Suitable soil for septic fields rarely exists in this landscape unit, but there usually are areas where septic tanks and fields could be constructed by bringing in suitable fill. Internal drainage through the crevices, possibility of sewage re-surfacing downhill and surface run-off will need to be studied for each septic disposal field before a permit is issued. A compounding effect of effluent accumulation down slope can be expected.

Landscaping may require additional fill and top soil. Internal drainage through crevices is usually sufficient during summer, but in winter, because of the steepness of the terrain, run-off may create serious erosion problems, especially where the soil is loose and vegetation is sparse. Similar to the solid bedrock landscape unit, an intensive residential development will degrade the aesthetic beauty of this landscape unit.

The broken rock landscape unit is ideally suited for open space and green belt use, and warrants consideration for conservation.

3. Shallow soils

(Figs. 29, 30 and 31)

This landscape unit is the most prevalent throughout the study area, occurring on moderate slopes where soils accumulated to a depth of 30 to 100 cm (1 to 3 feet). It usually 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. Soils are derived from stoney till, colluvium or shales and are usually coarse textured with rapid internal drainage and low water-holding capacity. Soil development is weak to moderate with a dark-brown surface horizon , yellowish-brown middle horizon (B) and grayish-brown lower horizon (C). A grayish, thin eluviated layer (Ae) at the surface may be present (Day *et al.* 1959). Because of a high content of stones, general paucity of fine-textured mineral material and only a thin layer of organic matter, a large proportion of the released nutrients not absorbed by the plants are leached out during winter rains. This loss of nutrients combined with dryness during the summer results in low soil fertility.

The shallow soil landscape unit corresponds approximately with the Salal - Oregon grape plant

Fig. 29. Douglas-fir with arbutus and pine are the common tree species in shallow soil landscape unit.

Fig. 30. Sometimes Douglas-fir may be the only species.

Fig. 31. In the shallow soil landscape unit, the soil is about 50 cm deep over well-weathered substrate. Roots may penetrate in the fragmented substrate.

community (McMinn *et al.* 1976). It is stable when covered by vegetation, but is prone to erosion when vegetation is removed and soil is disturbed, especially on steeply sloping terrain.

On drier sites, such as flat hilltops, where soils are usually less than 50 cm (20 inches) deep, and on steep southern slopes, stands of Douglas-fir in mixture with lodgepole pine, arbutus and Garry oak predominate. Where soils are somewhat deeper and on northern slopes, Douglas-fir and grand fir prevail often in excessively dense stands. As in most overstocked coniferous forests, Douglas-fir in this landscape unit is prone to wind-throw and wind-break after opening of the stand. Invasion by shrubs and forbs, including introduced weeds, is common, but does not hinder regeneration of trees.

Salal and Oregon grape are characteristic plants for this unit. On the drier sites, rose, trailing blackberry and introduced Scotch broom, and on moister sites, huckleberry, juneberry and ocean spray, are common.Because of a dense tree and shrub cover, shade intolerant forbs are not abundant. Lupine, vetches, yarrow and strawberry occur around the forest edge and in openings, while the shade tolerant star flower and easter lily form spectacular carpets in partial shade. Bracken fern, along with mustard and several species of composites, become abundant in disturbed areas. Mosses are common and consist of shade tolerant forest species, such as *Eurhynchium oreganum, Hylocomium splendens, Rhytidiadelphus loreus* and *Dicranum* spp. Lichens are common on the ground, as well as on the bark and branches of trees.

The shallow soil landscape unit is common on the Gulf Islands, as well as on southern Vancouver Island, and the loss of an area to residential or any other development or use will not constitute a significant social cost. Influence of human activity will not extend beyond the area intensively used. Unless development or use cause a radical change of environment, the high degree of stability and resilience of the native vegetation will minimize any damage to the natural environment.

From an economic aspect, this unit is generally suitable for any kind of development; however, steeply sloping terrain may introduce local technical limitations. Solid rock within 1 m (40 inches) of the surface provides excellent foundation support and loose, gravelly or sandy soil can be easily moved for construction and installation of services. Septic field possibilities for individual residences or small cluster developments exist on areas with deeper soils, but under intensive residential development sewage would soon saturate the soil and lower slopes and depressions between bedrock humps would become "sewage sinks". For a high density residential development, sewers will be essential. Landscaping and ground maintenance should not be difficult, except on steep slopes, where protection from erosion will be needed.

The shallow soil landscape unit has generally an excellent carrying capacity for recreation. Where slope or broken topography is not a limiting factor, intensive recreational uses, such as playgrounds or campgrounds, could be considered, but open space and grass may have to be provided since the indigenous vegetation is not satisfactory. Dense coniferous forests and shrubs usually obscure the view and make this unit less attractive and difficult to traverse. If hiking is to be encouraged, a maintained trail system will be necessary.

Openings created in the forest may result in wind-throw of isolated trees or trees on windward edges. Buffer zones of solid rock or broken rock landscape units, in which trees growing in rock crevices are more wind-firm, and, wherever possible, natural forest edge should be left as boundaries around any artificial openings.

Annual forest productivity in this landscape unit is low medium, about 4 to 5 m^3 per ha (60 to 70 cubic feet per acre) per year. This unit is suitable for forestry and, when it is used as greenbelt or open-space around and within residential areas, selective logging could even enhance the aesthetic value of the greenbelts, making them more accessible for recreational use.

4. Deep mineral soils

(Figs. 32, 33 and 34)

This landscape unit covers lower slopes and flat or gently undulating lowlands. Soils are derived from glacio-fluvial deposits, deep glacial till, mud slides or deep weathered shales. They may be covered with more recent alluvial or glaciofluvial deposits of variable thickness. Generally, they are of loam or sandy-loam texture, with gravel or larger stones present in variable proportions, well drained and showing some podzolic development. The soil depth is more than 1 m (40 inches). Loose surface material is often underlain by a layer of compacted till, essentially impervious to water and root penetration, below which may be bedrock or, at low elevations and in depressions, marine clay. Seepage water flows over the impervious horizon for at least part of the growing season.

Fig. 32. Selective logging for Douglas-fir on the Outer Islands resulted, in deep mineral soil landscape unit, in conversion to young cedar stands. Now, around 60 years old, they approach pole size.

In the deep mineral soil landscape unit, run-off and internal drainage are slower than in the previous unit, but rapid enough to prevent flooding. Drainage systems may be required where artificial obstructions, such as foundations and roads, will impede natural flow of seepage water.

Ecologically, this site corresponds approximately with the Swordfern and Swordfern-Salal plant communities (McMinn *et al.* 1976). The combination of a large volume of loamy soil with good water-holding capacity, moderate to high level of nutrients and seepage during at least part of the growing season provides, within the regional climate,

Fig. 33. Clearcutting usually results in an invasion by alder. As seed of other species becomes available, Douglas-fir with cedar understorey will form the new forest.

Fig. 34. The soils are deep, generally loamy and often underlain in clay. Round stones indicate that they have been transported by water.

good conditions for plant growth. Site index for Douglas-fir varies from about 38 to 48 m (130 to 160 feet) at 100 years and the increment exceeds 6 m^3 per ha (85 cubic feet per acre), which is the highest forest productivity within the study area. Douglas-fir, grand fir, western red cedar, western hemlock, red alder, bigleaf maple and an occasional dogwood form a closed canopy and eliminate slow-growing, shade-intolerant arbutus and Garry oak from stand composition. However, arbutus, Garry oak and lodgepole pine may become established on disturbed sites and persist until overgrown and shaded by other species. The most abundant shrubs are Oregon grape, salal, huckleberry and honeysuckle where sufficient light penetrates the crown canopy, while salmonberry, ocean spray, snowberry, buffalo berry, goat's beard, blackberry and rose are frequent in openings and along forest edges.

Forbs are numerous and, in addition to those listed in the shallow soil unit, include lily-of-the-valley, trillium, vanilla leaf, foam flower, bedstraw and several grasses and sedges. Where seepage occurs, swordfern may be abundant. 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.

The deep mineral soil landscape unit is the second most common unit on the Gulf Islands and on southern Vancouver Island and the loss of an area to residential or any other development, for which this unit is well suited, should not constitute a serious social cost. Apart from damage to herbaceous vegetation, which is generally intolerant to heavy trampling, this landscape unit can sustain heavy use without serious harm. Most of the vegetation is resilient and within a short time will reinvade disturbed areas. Influence of human activity will not extend far beyond the area actually disturbed.

Compacted till or bedrock, underlying these soils, provides a good base for foundations and the deep, loose, coarse-textured surface soil permits inexpensive installation of underground services and roads. Provided that upper soil layers are retained, landscaping and ground maintenance will not be difficult. However, removal of the loose soil overlying the compacted till will produce essentially sterile conditions for many years. Erosion on flat topography is rarely serious.

High forest productivity, stability and fertility of the soils suggest that the most suitable management of this landscape unit is forestry or uses complimentary with forestry, such as open space, greenbelt or extensive recreation. However, coniferous forests with a dense shrub layer are difficult to traverse and may not be particularly attractive for hiking; maintained trail systems would be required.

Under suitable management, the deep mineral soil unit could be used for orchards or grazing. However, frequency of sloping terrain, lack of organic matter, stoney texture of the soil and insufficient inherent fertility constitute limitations to any form of intensive agriculture.

Where clearing of this landscape unit takes place for agriculture, development or by logging, the exposed trees and the new forest edge may become prone to wind damage. To minimize this damage, the same measures should apply as mentioned in the previous unit.

5. Poorly drained marine clays

(Figs. 35, 36 and 37)

Fine material carried by muddy post-glacial rivers were largely deposited in the sea, mainly around the estuaries of the then existing rivers, in

Fig. 35. Marine clay landscape unit occurs in the valleys which, during the uplift of the land, formed quiet lagoons and bays. Flat terrain makes them suitable for agriculture, but depressions may hold stagnant water until late spring.

Fig. 36. Because of prolonged wetness in spring, the best utilization of the clay landscape unit is grazing.

Fig. 37. In the marine clay landscape unit, the soil surface layer has often a high organic content and may be friable, especially if it has been ploughed. However, below the ploughed layer, gray clay forms an impermeable layer.

lagoons and in inlets. When the ice melted, the land, relieved of the weight, rose and marine clays were elevated as much as 90 m (300 feet) above the present sea level.

The marine clay landscape unit occurs on flat or gently sloping topography. The heavy soils, having very slow internal drainage and minimal infiltration, may have extensive surface run-off where they occur on slopes, while on flat topography, they may be prone to flooding. The clay soil is usually moist even in summer because of the high water-holding capacity of the surface layer, impermeability of the lower layer, some seepage at the interface and protection from insolation by vegetation. When saturated and disturbed, the clay soil flows; when dry, it becomes hard. Soil development is weak, with little color difference between horizons, except for the surface 10 to 15 cm (4 to 6 inches), where dark staining from a high content of organic material is normal. Mottling is common below the organic-rich layer. The organic-rich layer constitutes the root zone, since lack of aeration prevents deeper root penetration.

Occasionally, the clay may have a thin capping of loam brought by heavy winter run-off from surrounding slopes, forming a thicker surface layer and permitting deeper root penetration.

The marine clay landscape unit corresponds with the Swordfern plant community. The most common trees are western red cedar and western hemlock, but young stands may be formed by thickets of red alder, bigleaf maple, willow and cottonwood, with a dense cover of shrubs where light permits their survival. The most common shrubs are salmonberry, thimbleberry, blackberry, wild rose, goat's beard, twinflower and spirea. Forbs are also numerous, and include trillium, vanilla leaf, foam flower, miner's lettuce, swordfern, lady fern, lily-of-the-valley, bedstraw and others. Grasses and sedges are abundant in openings. Mosses are plentiful on litter, logs, stumps and as epiphytes on trees, *Eurhynchium oreganum, Hylocomium splendens, Isothecium spiculiferum, Hypnum* spp. *Plagiothecium* spp. and *Brachythecium* spp. being the most common. Liverworts are also frequent.

Marine clays are only marginally suitable for residential development. In a compacted, undisturbed state they can take considerable weight because water flows over them without appreciable penetration. Sewage disposal will be costly because lack of percolation prevents use of septic tanks. While erosion of clay covered by vegetation is not critical, after construction and installation of services, the loose, water-saturated soil becomes unstable and may flow. Immediate re-vegetation of disturbed soil is mandatory; grasses may give the best results. Landscaping must involve minimal soil disturbance. The soil can be somewhat improved and stabilized by addition of sand and organic material.

For agricultural uses, this landscape unit is compatible only with grazing, but pasture capability is high. Production of other agricultural crops would require costly soil amelioration by improving drainage, addition of sand and organic material and, in summer, irrigation. Thus ameliorated, this unit could be used for market gardening or small-fruit orchards. While crop production may be very good for a few years, the site would eventually deteriorate. Because the internal drainage of clay is extremely slow, unless ponding takes place, the run-off will gradually remove the top soil, loosened annually by tillage.

This landscape unit is not particularly suitable for recreation, being wet and mucky during the winter. It is also not particularly attractive for hiking, being overgrown densely by trees and shrubs. A system of maintained trails may have to be provided for winter use.

Fig. 38. Wet organic soils occur in depressions which usually have impermeable clay substrate. Because of stagnant water and anaerobic conditions, decomposition of vegetation remains is extremely slow.

6. Wet organic soils

(Figs. 38 and 39)

This landscape unit occupies flat areas which were originally depressions gouged in the bedrock by shifting glaciers and, when the ice retreated, were left without drainage. Glacial till and subsequently glacio-fluvial materials were deposited over the terrain; the depressions became shallow lakes filled with muddy water, from which lacustrine deposits sedimented. Vegetation developed around and within these lakes, plant remains were deposited in the water and the depression gradually filled up. The rate of decomposition of organic material and accumulation of soil was dependent on annual addition of mineral sediments, dissolved mineral content of water, plant species and the rate of winter flushing. In stagnant water, away from a stream flow, accumulation of organic material was rapid and the soils formed are almost entirely organic. In lakes, which in post-glacial time were a part of a stream system, organic material was partially flushed out, but because the stream brought alluvial mineral sediments during each flood, the organic soils may contain a large proportion of mineral materials.

In the wet organic soil unit, surface soil formed by decomposing organic material is of variable thickness, from as little as 30 cm (12 inches) around the edges of the unit to more than 3 m (10 feet) in the center. With increasing depth, the proportion of fine mineral material gradually increases. If the surrounding terrain is flat, the mineral component is mainly loam; if the terrain is steep, the soil may contain a considerable proportion of sand, gravel and stones.

The organic soil landscape unit receives seepage from adjacent slopes and, because of naturally impeded drainage, free water is always available within 1 m (3 feet) of the soil surface. During heavy winter rains the area may be flooded, but water rarely stands above the soil surface for long periods and aeration of the surface soil is sufficient to permit tree growth.

The organic soils contain large amounts of nutrients in the decomposing material and receive a considerable amount of nutrients in the seepage water that flows from surrounding hills. In spite of this, forest productivity is not high. The high water table and periodic flooding reduces the depth of

Fig. 39. Water above the soil surface is common during the winter in wet organic soil landscape unit. Skunk cabbage in shade and sedges in the open are the most common plants after soil surface dries.

usable soil, eliminating Douglas-fir and allowing only those species to survive that can withstand winter flooding of their root systems.

An occasional Douglas-fir may exist on humps or higher ground, but the main tree species are western red cedar, western hemlock, grand fir, red alder, bigleaf maple and cottonwood. In a mature forest, the multi-storied canopy of the tree layer is usually dense, effectively controlling the density of the shrub layer. Trees, rooting shallow in organic material of low consistency, are subject to wind-throw, which opens the canopy. In such openings, willow, crab-apple, red osier dogwood and spirea become rapidly established. In large openings, such as after logging, these shrubs take over the entire area, preventing the re-establishment of trees.

The wet organic soil landscape unit includes the wet end of the Swordfern plant community and the Cottonwood-Crabapple-Willow community (McMinn *et al.* 1976). Swordfern, lady fern, vanilla leaf and miner's lettuce are the characteristic understory species. Grasses and sedges usually become abundant after logging. Logs, stumps and litter are usually covered by mosses; most common are *Eurhynchium oreganum, Hylocomium splendens, Isothecium spiculiferum, Plagiothecium* spp., *Brachythecium* spp. and *Hypnum* spp. The most abundant epiphytic mosses growing on trees are *Orthotrichum* spp., *Homalothecium* spp., *Neckera menziesii* and *Isothecium spiculiferum.* Also several species of liverworts are present.

This landscape unit is unsuitable for development because its depressional position with impeded drainage renders it subject to flooding. The organic material is not stable enough to support foundations and road beds; when drained, it decomposes and settles. Stabilization with rock fill will be costly and, where the organic layer is deep, probably unsatisfactory for any heavy construction.

The wet organic soil unit is also unsuitable for recreation. During winter rains it may be flooded and inaccessible. It does, however, provide a habitat for a variety of wildlife and therefore attracts the attention of persons interested in outdoor education.

The depressional position, impeded drainage and organic soils with a high water-holding capacity, which make this unit unsuitable for development, make it important as a water-storage facility during fast run-offs because it equalizes the stream flow and controls floods.

Because of inherent environmental limitations, this unit is best suited for greenbelts and wildlife habitats. Harvesting of trees or any other interference with the tree layer will result in extensive wind-throw. Wind-firm buffer zones around this landscape unit are mandatory to maintain the trees. Should the trees become damaged, reforestation will be difficult unless the shrubs are controlled; in 3 years, spirea, cascara, willows and Pacific crab apple can form impenetrable thickets.

7. Bogs, fens and marshes

(Figs. 40 and 41)

In this landscape unit, fill-in processes have not reached the same advanced stage as in the deep organic soil unit, possibly because of the originally greater depth of depressions or different vegetation. The wet organic soil unit is formed under at least periodically aerated and nutrient rich conditions, while the fill-in process in bogs, fens and marshes occurs under generally anaerobic conditions in stagnant water. During the summer, the water level is usually at or just below the soil surface, but from fall, the ground is under water until late spring or early summer. Thus this landscape unit serves as as flood control basin by storing water and controlling the flow extremes.

Because of the high water table and lack of aeration of the soil, trees are generally rare. Red alder, willow, cascara, crabapple and hawthorn may be present along the edges, but they attain much smaller sizes than on better drained soils. Shrub-size willow and spirea usually form a dense impenetrable cover in bogs and fens, while in marshes, the vegetation is composed of sedges, marsh grasses, bulrushes and cat-tails, with shrubs only along the edges. Where light conditions permit, skunk cabbage, cress, Indian hellebore and lady fern may be abundant. *Sphagnum* spp. and wetland mosses, such as *Drepanocladus* spp., *Hypnum* spp., *Mnium* spp. and *Fontinalis* spp., are present on debris above the summer water level, but rarely abundant.

Bogs and fens are unsuitable for residential development. Draining is usually impractical because of the low gradient of the outlet. Even when drained, the organic material, often up to 12 feet (4 m) thick, would not provide a solid foundation.

Recreational use can be only light and specialized because of frequent flooding. Since this landscape unit provides cover and food for many species of birds, mammals, reptiles and amphibians, study and observation of these could be an important recreational and educational function. Unfortuna-

Fig. 40. Large depressions where water is permanently at or above soil surface form a bog or fen landscape unit. At its edge are usually wet organic soils and, somewhat higher, the marine clay landscape unit.

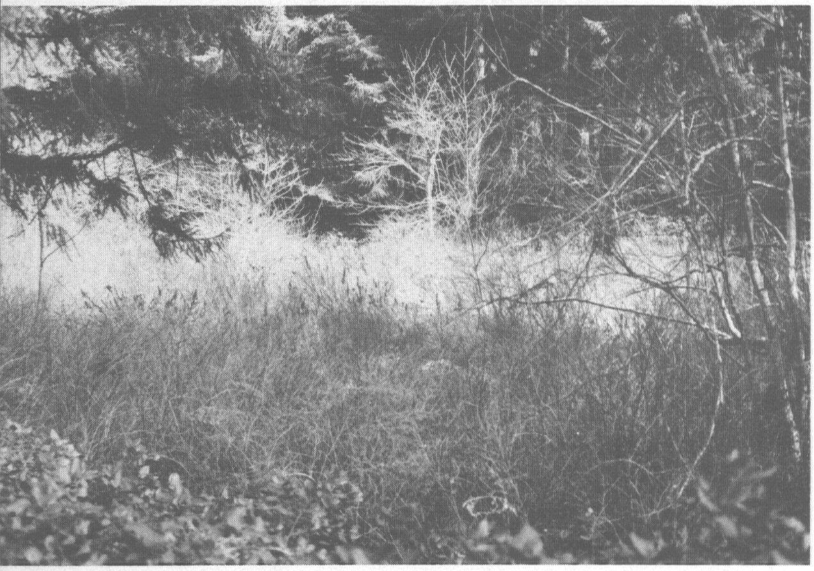


Fig. 41. Spirea or sedges are the most common plants in bogs.

tely, stagnant water provides suitable breeding conditions for many species of biting insects, such as mosquitoes, sand flies, black flies, gnats and midges.

Ecological considerations indicate this landscape unit, in its natural stage, belongs in the open space or greenbelt area. However, near a high density residential development, excavation, possibly combined with damming, would convert the area into a high-use recreational lake. Stocking the lake with fish would increase its value and further reduce insect populations.

8. Lakes

(Figs. 42, 43 and 44)

Material deposited under water in lakes is predominantly organic, often as much as 1 meter thick, and contains a variable proportion of fine mineral material of alluvial origin, sedimented during winter floods. Under anaerobic, acidic conditions, decomposition of the organic material is slow. This mucky and easily disturbed layer is underlain by glacio-fluvial material of loamy or sandy texture and below that, by a layer of till, bedrock or marine clay.

Fig. 42. Buck Lake is a water reservoir for the Magic Lake subdivision of 1300 lots. A number of houses have been built around the lake. Deterioration of water quality is inevitable.

Fig. 43. The lakes contribute substantially to the aesthetic value of the islands.

Vegetation is confined to the water's edge, where sedges, marsh grasses, bulrushes and cat-tails may be common. Sphagna and wetland mosses, such as *Hypnym* spp., *Mnium* spp., *Fontinalis* sp. and *Drepanocladus* spp., are present on debris and hummocks elevated above the summer water level. Where water is less than 1 m (3 feet) deep, water forget-me-not, bladderwort and water smartweed may occur, with roots anchored in the muddy bottom. Lily and water shield may occur in water up to 2 m (7 feet) deep. Duckweed, one of the smallest of flowering plants, is often found floating freely in backwaters.

In addition to flood control and stream regulation, the main function of the lakes in the study area is recreation. Swimming, fishing and cultural and educational uses are relatively high because of the proximity of two large population centers, Vancouver and Victoria, and the popularity of the Gulf Islands. With the progressively greater amount of leisure time, the recreational use of the lakes can be expected to increase. More points of public access and onshore space will be necessary to improve recreation potentials, while protecting water quality.

Conclusions

The eight landscape units described and mapped reveal a variety of natural environments. The first four units, occurring on approximately 93% of the area studied (Table 1), are suitable for recreation and residential development. However, there are limitations. If subdivisions are established and thus the population increases, problems of water supply and sewage disposal will arise.

There are resources of ground water on the Gulf Islands. However, in the first three landscape units, the soil is shallow or non-existent. In the deep mineral soil landscape unit, places may be located that would yield a sufficient supply of seepage water from shallow dug-out wells for a low-density population. Dug-out wells in marine clays may produce a good supply of water if layers of clay alternate with layers of permeable silt or sand, as often is the case. Seepage through clay is too slow. In wet organic soils, bogs, fens and marshes, water is predominantly of surface run-off origin; it is stagnant and its quality is poor. However, drawing from a dug-out well in

Fig. 44. Growth of algae around the shores of Magic Lake indicates rapidly increased nutrient content, resulting from domestic effluents entering the lake.

mineral soil some distance away would allow filtering and thus improve quality. Water in lakes comes from run-off and seepage and its quality is usually good. However, the watershed of the lakes and, for that matter, of bogs, fens, marshes and wet organic soils if they should be used for domestic water supply, should be considered as a water supply watershed and not as another area for subdivision. With increasing population, water quality will deteriorate. Generally, water of the best quality comes from wells drilled deep through the rock into permeable strata below. But this source is also of too limited a supply to support a large population.

Since the column of fresh water is in a dynamic equilibrium, floating as a disc on the top of heavier salt water, the fresh water level must not be withdrawn so far as to allow salt water infiltration. This suggests that withdrawal should be distributed among a number of wells, especially near the seashore.

Sewage disposal presents another problem. The non-existent soil in the first two units renders them unsuitable for septic tanks and, moreover, the employment of this technique is certain to eventually pollute the groundwater supply. Sewers and a sewage treatment plant should be a requirement before a development is permitted. Preferably the development should be delayed until satisfactory self-contained sewage disposal systems are developed. With low population density, sewage disposal should not cause problems on the shallow mineral soil unit (No. 3) and difficulties are not expected in the deep mineral soil landscape unit.

Poorly drained marine clays, wet organic soils, bogs, fens, marshes and lakes are not suitable for development. The soils, developed in aquatic environments, are unstable to provide solid foundations and present vegetation and depressional positions indicate at least periodic flooding. Even filling flat land around these units may be unsatisfactory. Filling would reduce the water storage capacity and would result in increased erosion and sedimentation, making the depression more shallow. During winter storms, water may reoccupy the developed areas, potentially causing damage to existing structures.

Table 1. Distribution of landscape units on major islands giving % and areas in hectares and acres.

			1 Solid bedrock	2 Broken rock	3 Shallow soils	4 Deep mineral soils	5 Marine clays	6 Wet organic soils	7 Bogs, fens & marshes	8 Lakes
Galiano	%		0.6	8.3	27.9	57.9	4.6	0.6	–	0.1
	ha	5,953	35.7	494.1	1660.9	3446.8	273.8	35.7	–	6.0
	acres	14,709	88.3	1220.8	4103.8	8516.5	676.6	88.3	–	14.7
Saturna	%		3.9	4.1	52.5	33.7	5.6	–	0.2	–
	ha	3,092	120.6	126.8	1623.3	1042.0	173.1	–	6.2	–
	acres	7,640	298.0	313.2	4011.0	2574.7	427.8	–	15.3	–
Mayne	%		0.9	3.4	35.4	52.2	7.4	0.6	0.1	–
	ha	2,633	23.7	89.6	932.1	1374.4	194.8	15.8	2.6	–
	acres	6,506	58.6	221.3	2303.1	3396.1	481.4	39.0	6.5	–
North Pender	%		2.4	8.2	50.3	30.7	6.5	0.2	0.4	1.3
	ha	2,685	64.4	220.2	1350.6	824.3	174.5	5.4	10.7	34.9
	acres	6,635	159.2	544.1	3337.4	2036.9	431.3	13.3	26.5	86.3
South Pender	%		0.9	13.3	49.0	27.5	7.6	0.6	0.5	0.6
	ha	810	7.3	107.7	396.8	222.8	61.6	4.9	4.0	4.9
	acres	2,001	18.0	266.1	980.5	550.3	152.1	12.0	10.0	12.0
Prevost	%		0.2	20.2	66.4	2.8	7.9	2.0	–	0.5
	ha	675	1.4	136.3	448.2	18.9	53.3	13.5	–	3.4
	acres	1,668	3.3	336.9	1107.6	46.7	131.8	33.4	–	8.3
Samuel	%		2.0	14.9	54.2	14.5	14.4	–	–	–
	ha	204	4.1	30.4	110.5	29.6	29.4	–	–	–
	acres	505	10.1	75.2	273.7	73.2	72.8	–	–	–
Parker	%		–	18.3	54.0	26.7	1.0	–	–	–
	ha	164	–	30.0	88.6	43.8	1.6	–	–	–
	acres	404	–	74.0	218.2	107.8	4.0	–	–	–
Tumbo	%		–	6.4	54.8	27.1	11.7	–	–	–
	ha	121	–	7.7	66.3	32.8	14.2	–	–	–
	acres	299	–	19.1	163.9	81.0	35.0	–	–	–
Gossip	%		–	–	82.8	17.2	–	–	–	–
	ha	36	–	–	29.8	6.2	–	–	–	–
	acres	88	–	–	72.8	15.2	–	–	–	–
Curlew	%		–	–	78.6	17.6	3.8	–	–	–
	ha	31	–	–	24.4	5.5	1.1	–	–	–
	acres	77	–	–	60.5	13.6	2.9	–	–	–

References

Anon. 1972. Climate of Gulf Islands. Draft. Agroclimatology sector. B.C. Dept. of Agriculture. Canada Land Inventory.

Anon. 1974. A Gulf Islands Patchwork (correlated by Mrs. B.J.S. Freeman).

Anon. 1976. Climate of British Columbia. 1916-1976. Tables of temperature, precipitation and sunshine. British Columbia Dept. of Agriculture. 83 pp.

Anon. Monthly Records. Meteorological Observations in Western Canada, 1928 to 1978. Environment Canada.

Clapp, C.H. 1917. Geological Survey of Sooke and Duncan map areas. Vancouver Island. Can. Dep. Mines. Ottawa, No. 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. British Columbia Soil Survey.

Eis, S., D. Craigdallie and E. Oswald. 1976. Western community, a landscape analysis for urban development. Canadian Forestry Service, PFRC, Victoria, B.C. Report BC-X-153. 47 pp.

Krajina, V.J. 1959. Bioclimatic zones in British Columbia. Vancouver, University of British Columbia Botanical Series No. 1. 47 p.

Koppen, W. 1931. Grundriss der Klimatkunde, 2nd ed. Berlin, Walter de Gruyter.

McMinn, R.G., S. Eis., H.E. Hirvonen, E.T. Oswald and J.P. Senyk. 1976. Native vegetation in British Columbia Capital Region, Department of Environment, Canadian Forestry Service, PFRC, Victoria. B.C. Report BC-X-140. 20 pp.

Muller, J.E. and J.A. Jeletzky. 1970. Geology of the Upper Cretaceous Nanaimo Group, Vancouver Island and Gulf Islands; Geol. Survey Canada. Paper 69-25.

Rowe, J.S. 1972. Forest Regions of Canada; Department of the Environment. Can. Forest. Serv., Publ. No. FO47 - 1300.

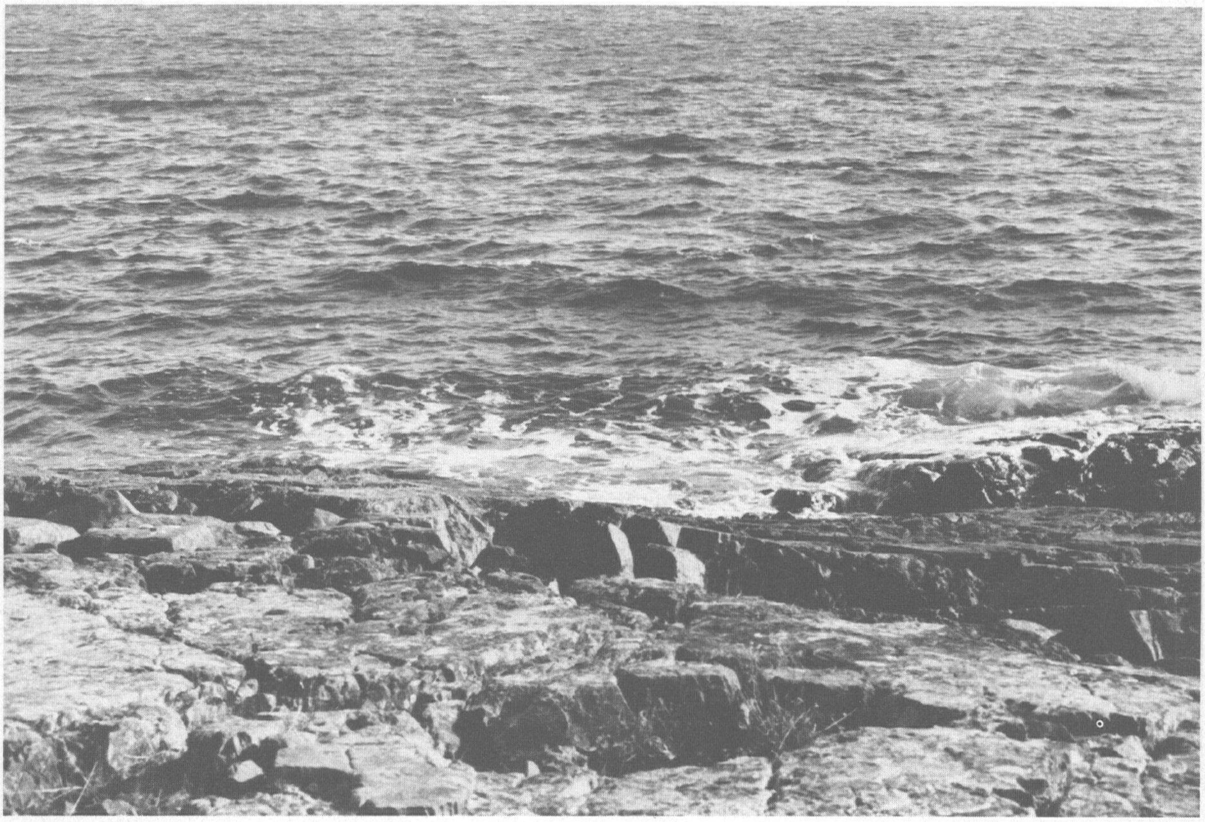


Fig. 45. On the north exposed shore, a shale bench often forms the intertidal zone.

Fig. 46. Typically the southeastern shores are rugged, with small sandy or gravelly pocket beaches between rocky heads.

Environment Canada
Canadian Forestry Service
Pacific Forest Research Centre
Victoria, B.C., Canada, V8Z 1M5
BC-X-216, December, 1980