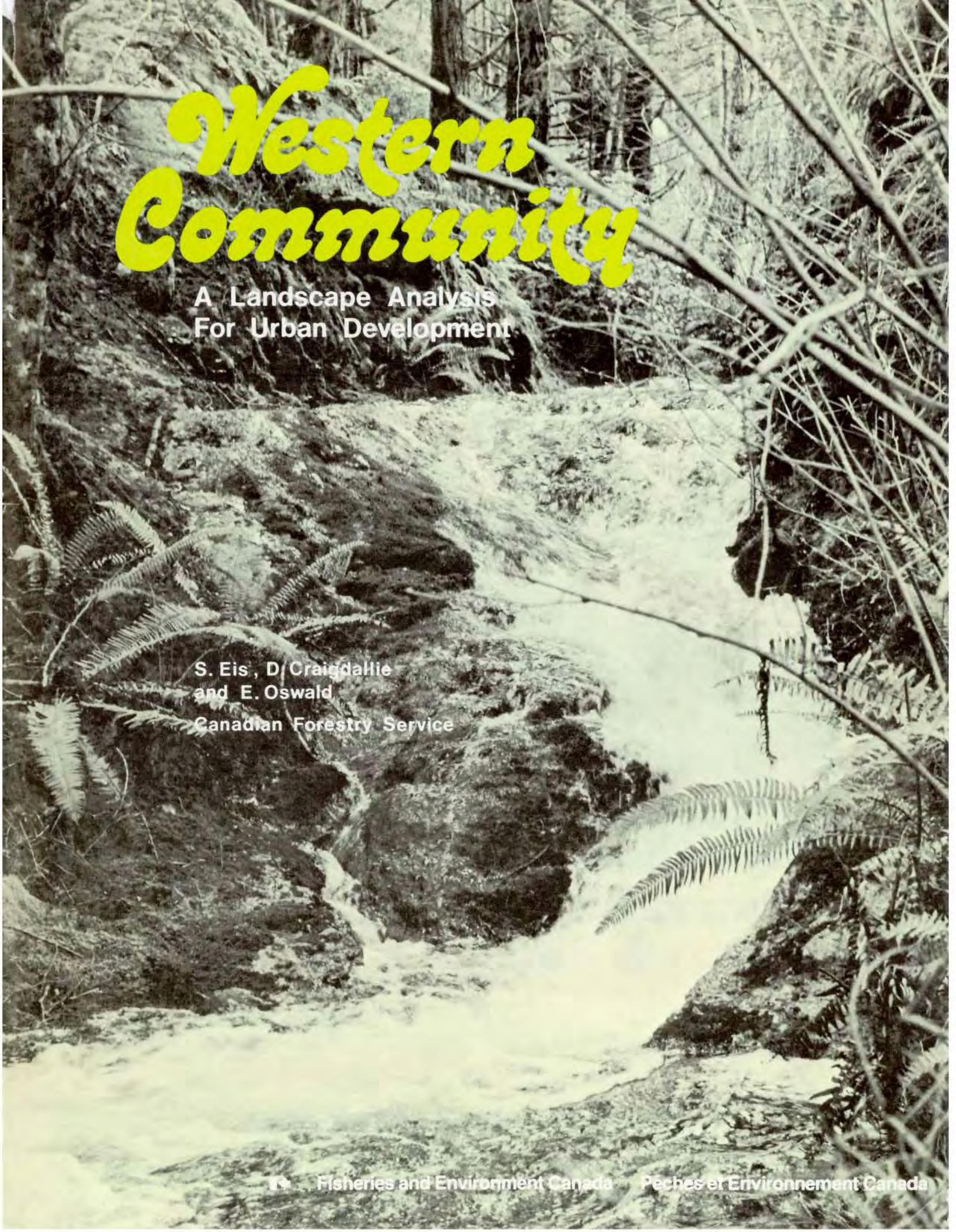
Western Community

A Landscape Analysis For Urban Development

S. Eis, D. Craigdallie
and E. Oswald
Canadian Forestry Service



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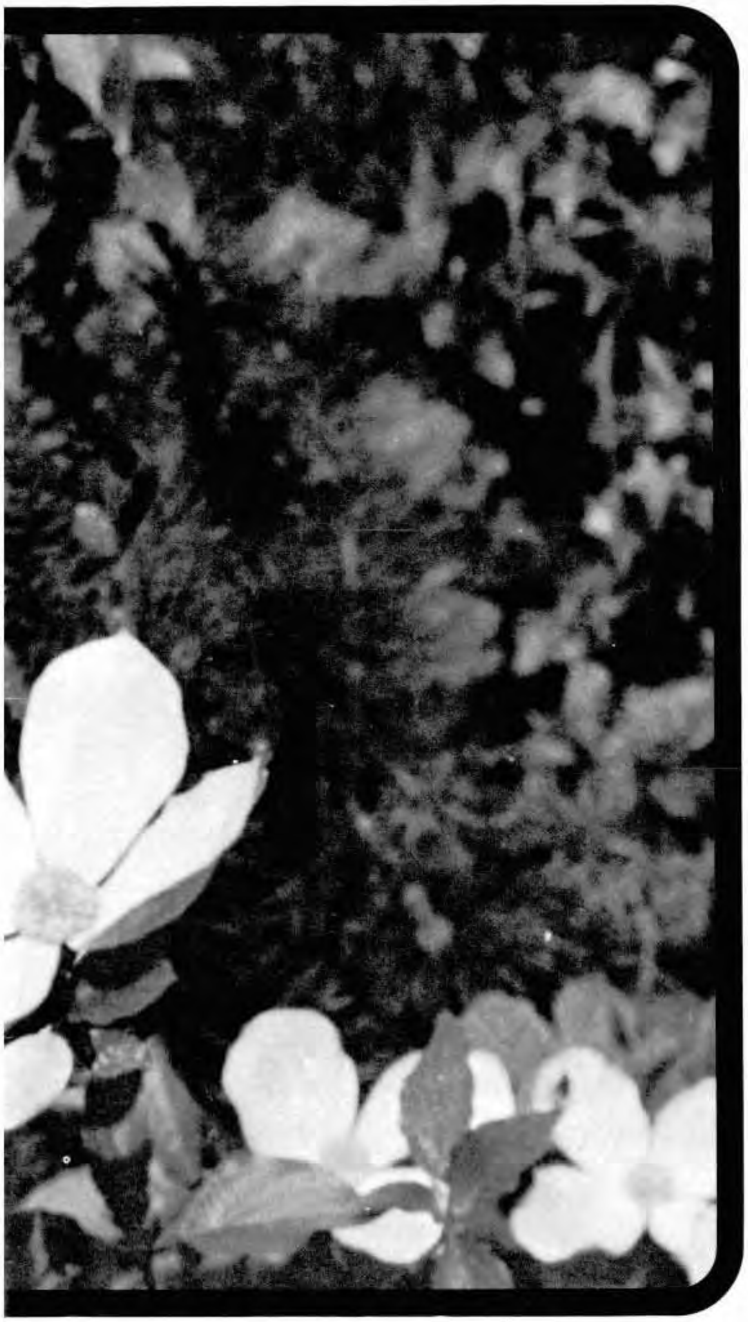
Abundance of white, petal-like bracts surrounding the greenish flowers makes Western Flowering Dogwood the most conspicuous tree in spring.

(Cover) Even during winter rains, only a small creek, cascading over rocks, drains Thetis Lake.



ABSTRACT

The population of the Western Community is expected to increase from the present 22,000 to about 54,000 by 1995. To accommodate such an increase in an orderly fashion and with minimal damage to the environment, planning and provision of services must precede the development. The purpose of this study is to provide the environmental background for planning for the expected growth. Eleven landscape units were described in terms of their environmental and vegetational characteristics and each unit was evaluated for its suitability for development, resulting social costs and the impact of urbanization and resulting human activity on the environment, soils and vegetation. A map was prepared showing the distribution of the landscape units throughout the study area.

RESUME

On s'attend a ce que la population de Western Community passera de 22,000 qu'elle est aujourd'hui a 65,000 environ, d'ici 1995. Les services et la planification requis par cette augmentation devront preceder le developpement de facon ordonnee et avec un minimum de degats a l'environnement. Le but de la presente etude etait de fournir les donnees environnementales necessaires pour planifier en vue de la croissance de population a laquelle on s'attend. Onze unites de paysage furent decrites quant a leurs caracteristiques physiques, d'environnement et de vegetation; chaque unite fut evaluee pour savoir si elle etait propice au developpement, quant aux couts des services sociaux prevus et aux repercussions de l'urbanisation de meme que les resultats de l'activite humaine sur l'environnement, les sols et la vegetation. Une carte fut preparee, indiquant la distribution des unites de paysage dans toute la region que couvre cette etude.

INTRODUCTION

Breeding of horses and riding is a hobby and recreation for which the climate and terrain are extremely suitable.

The growth of the Capital Region of British Columbia indicates that the region will have to accommodate about 370,000 people by 1995, an increase of almost 170,000 over the present level. Throughout the region, an adequate area of suitable land is available for development. Uncontrolled growth would assume the same form as it has in the past, spreading without discrimination and slowly obliterating the landscape.

In 1973, the Capital Regional Board established the following goals to guide future development:

1. Conserve the Region's non-renewable resources, including land with enduring value for agriculture, forestry or recreation.
2. Preserve the varied and interrelated biological systems of the area, including plant, animal, bird and fish life.
3. Maintain the natural beauty of the Region and all of its diversity.
4. Provide for a variety of residential opportunities, differing in character, location and density of population, so that people would have an effective choice of environments for living.
5. Ensure that people have basic services, including water supply, means of waste disposal and transportation facilities at the lowest possible cost.
6. Provide residents with a variety of employment opportunities, which are consistent with other goals.
7. Reduce dependence on private automobiles by establishing an effective system of public transportation.

The Board ruled that all decisions related to land use must be based on objective studies of the land's fitness for different purposes, and that the current market value of the land is not to be a criterion in the designation of its use (1).

Because of the large area and topographic variation of the region, several possibilities existed to direct future development into different areas. The Planning Department proposed five alternatives for development of the Region, generally adhering to the guidelines set by the Board (Fig. 1).

On request from the Capital Regional Board a study was conducted, summarizing, on an area of approx-

↑ Many trees preserved in new subdivisions provide attractive surroundings.

← On sun-exposed rocks flowers of stonecrop form yellow mats on a background of green mosses.

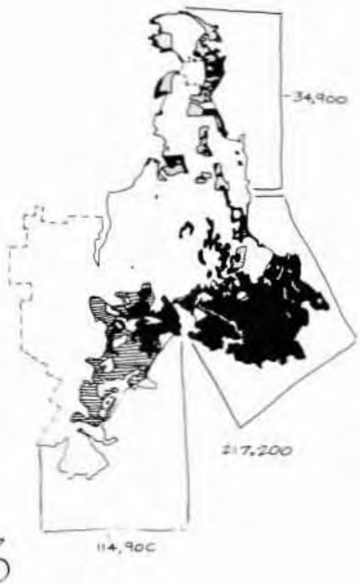
A walk around Thetis Lake provides an hour of exercise and beautiful, rugged scenery. →

1

Development would follow present policies but, major public services would be provided in a number of areas.

2

This alternative features development of the highland area and Langford-Colwood.



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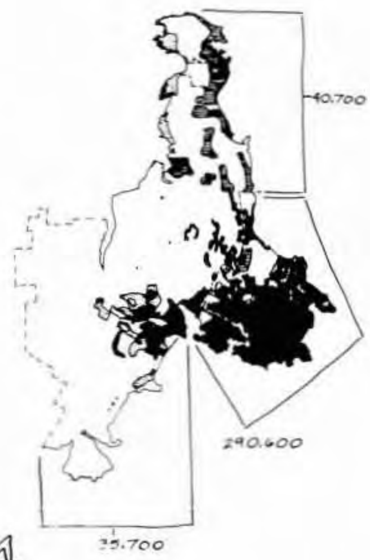
This alternative features extensive development of the Metchosin area.



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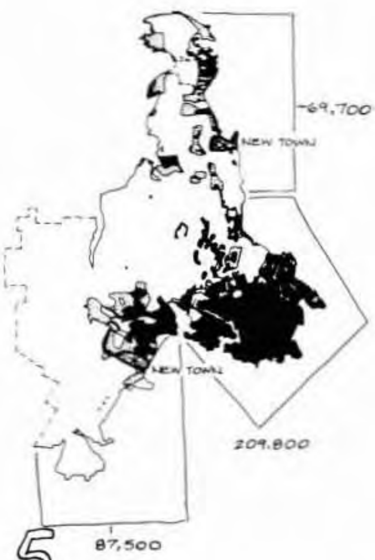
This alternative features restricted growth in Langford-Colwood and View Royal, with most growth taking place in the urban core and the Saanich Peninsula.



5

This alternative features the development of two satellite towns, one in Latoria Road area, the other at Turgoose Point in Central Saanich.

Fig. 1. Alternatives for development in the Capital Region.

imately 200 square miles (500 km^2), the natural resources and their potential in relation to urban development (2). In broad terms, it covered climate, atmospheric pollution dispersal, geology, soils, including their stability and suitability for sewage disposal by septic fields, hydrology, water supply, flooding and ponding, vegetation, forest and agricultural suitability, wildlife inventory, recreation and present land use. This study provided an inventory of the resources against which the five proposed concepts were evaluated.

By concensus among the municipalities and the Capital Region, an Official Regional Plan was developed to deal with urban development and land use (3). It is not meant to be a static document, freezing development into a permanent rigid form, but a stage in the continuous process of planning the Region. A substantial part of the implementation of the Plan is intended to take place at the local level by means of Community Plans.

The Official Regional Plan envisages that the population growth will be shared between municipalities and electoral areas and staged over time to avoid premature scattered development and to obtain economy in the provision of services. Population allocations (Fig. 2) are intended to be approximate; more detailed figures will be determined in the process of refining the Official Regional Plan and developing individual Community Plans.

The policy is that established urban areas be developed contiguously around the urban core as planned and compact communities, related to the natural environment in a harmonious manner. The communities should be of urban form and magnitude so that sanitary sewers, community water, transportation and other urban services can be economically provided.

The plan designates as potential urban areas those lands that, because of their location in relation to established urban areas, favorable topography and amenability to the provision of necessary urban services, are suitable for urban development. Agricultural areas, steep and rocky upland areas and major parks are to be considered as greenbelts, maintained inviolate of urban expansion.

The updated (1975) plan contemplates substantial redevelopment in Victoria and growth in Saanich. Colwood and Langford, presently partially developed areas of older cottages and new subdivisions, are expected to grow from the present 22,000 people to about 54,000 by 1995.

The present study is a detailed survey of the environmental characteristics of the proposed Western Community, pertinent to the expected development. It shows the intrinsic suitability of each landscape unit for certain land uses and explains why development should take place in some areas and why other areas should be reserved for open space.

This simple approach utilizes what is known about geology, climate, hydrology, soils and plant and animal ecology. While the conclusions are subjective, any person utilizing the evidence of these sciences logically and rationally would probably reach similar conclusions. However, the recommendations should be modified and improved as new information becomes available and the values of society change.

The mapping was done from color air photographs (scale 1:12,000) taken in the spring of 1975. While the vegetation was not fully developed to obscure the ground, the differences in color of developing leaves allowed identification of vegetation as an aid to recognition of site conditions. This detailed air survey eliminated the necessity of extensive groundwork.

The landscape units are a composite expression of physical, environmental and ecological factors. The map was originally drawn at the scale of 1:12,000, but was subsequently reduced to about 1:14,400 for technical reasons.

DESCRIPTION

The area of the proposed Western Community is located about 8 miles (12 km) west from the City of Victoria, south of Highway No. 1, around the present communities of Langford and Colwood. The distance from Victoria by road is approximately 10 miles (16 km).

The area (Fig. 3) consists of an undulating lowland, 200-300 feet (70-100 m) above sea level (a.s.l.), surrounded on three sides by rugged hills. Within the study area in the north, Mill Hill rises to 658 feet (200 m) and in the south, Triangular Hill to 726 feet (220 m) a.s.l. Outside the study area to the northwest, lies massive Skirt Mt. 1120 feet (336 m) high; to the west, Mount Wells 1150 feet (346 m) high; to the southwest, Centre Mt. 615 feet (186 m) and Metchosin Mt. 650 feet (197 m) high, form steep peaks on the border.

Much of the study area was originally a delta of two post-glacial rivers, following the present courses of the Goldstream River and Millstream Creek, and extending west as far as the present Humpback Reservoir. As the glaciers retreated and land rose, the shoreline was formed. Two miles of the shore, north of Albert Head, slope steeply down to a sandy beach. This shore is the "toe" of the delta, the beach being formed by tidal and wave erosion. Tidal Esquimalt Lagoon, separated from the sea by a narrow gravel bar, Coburg Spit, has a gently sloping shore. North of Rodd Hill, inside Esquimalt Harbour, steep rocky cliffs form the shore.

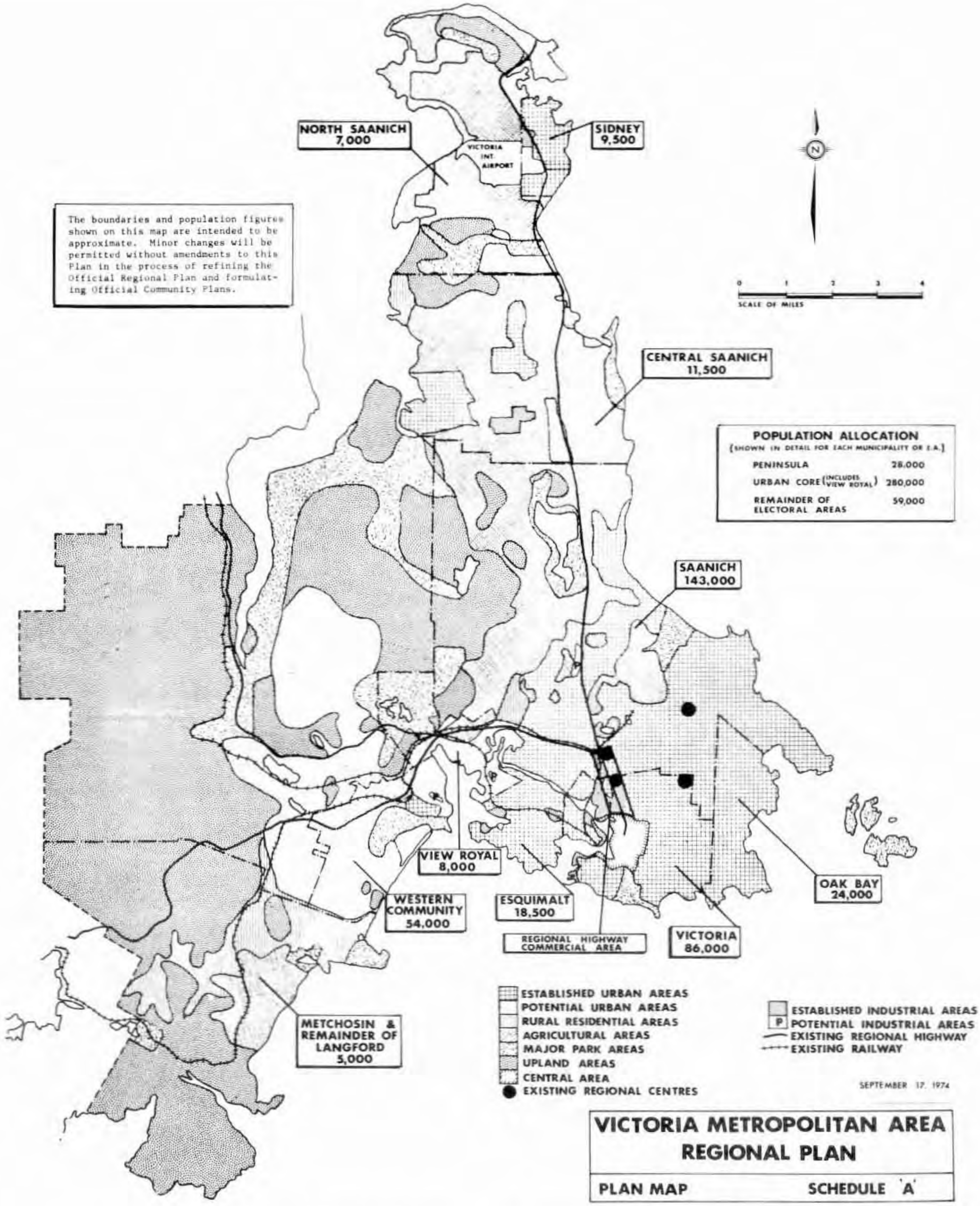


Fig. 2. Official regional plan, February 1975. Expected population distribution by municipalities in 1995.

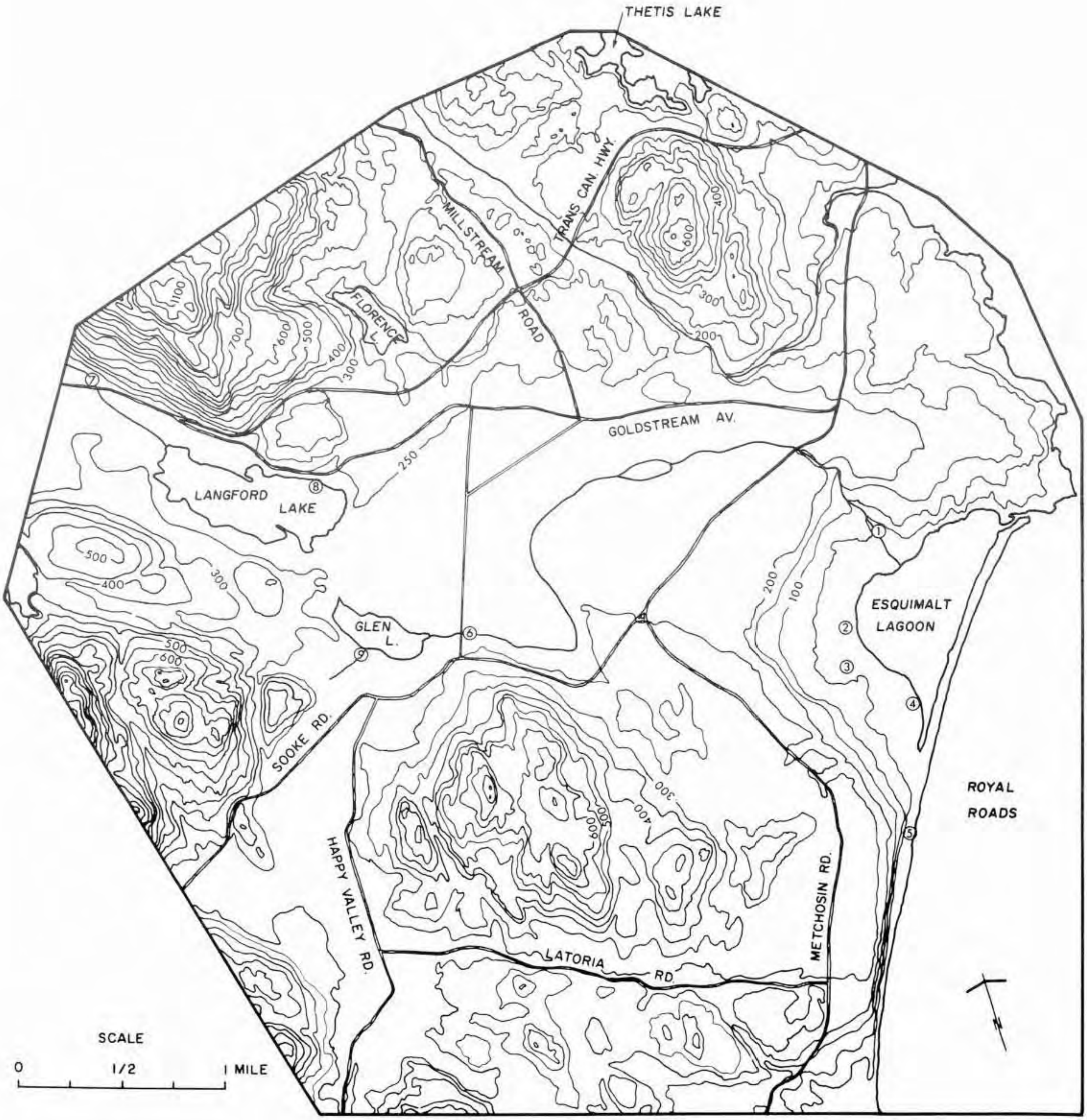


Fig. 3. Topography map showing a lowland delta of a postglacial river surrounded by rugged hills.

HISTORY

Fort Victoria was constructed in 1843, and the settlement of the study area is closely tied to this British outpost (8). The British Columbia forest industry originated in the Colwood area. On August 4, 1847, Roderick Finlayson of the Hudson's Bay Company, searching at the upper end of Esquimalt Harbour for a water source to provide power for a sawmill in the vicinity of the Fort, found a small waterfall about 500 yards upstream from the sea. A road was built from the Gorge and, in November, the first lumber was produced. But the rainfall had been extremely heavy in 1847 and the water flow in following years became intermittent so that the mill could operate for only about 6 months of the year.

The export operations of the British Columbia forest industry were started in October 1848, when the American brig, "Colony", stowed aboard a cargo of 4,270 board feet of lumber destined for California.

In 1851, Captain Langford arrived from Colwood, England, to build and manage a farm for the new Hudson's Bay Company headquarters on the Pacific coast. The farm extended from the Esquimalt Harbour west to the present Langford Lake, and eventually about 600 acres of land were brought under cultivation (8).

In 1854, another thriving business was opened at the mouth of the Mill Stream. Parson's Bridge Hotel catered to the needs of the navy men from ships in Esquimalt Harbour.

From 1862, several English and Scottish emigrants settled around the Colwood Farm. Four Hudson's Bay Company farms had been developed by then, and these and independent settlers became the backbone of trade of agricultural products for furs with Russian colonies in Alaska.

The first forest inventory took place in 1863, and extensive stands of mature Douglas-fir, 110 feet (33 m) high, were recorded throughout the area on gravels and lower slopes. On the higher slopes and ridges the productivity was low; mature trees averaged only 80 feet (24 m) in height.

By 1863, the original sawmill was unable to supply the ever-increasing demand of the colony and two more mills were built. One was on the Indian Reservation above Esquimalt Lagoon.

From 1865, there was a rapid increase in logging activity, extending from the mills throughout the area (Fig. 4). The logging was in the form of "highgrading" and removed only the best and largest Douglas-fir. As a result, forests were opened and roads were built. Logged-over lands were eagerly sought by settlers who supplemented their income by cutting cordwood; there was a ready market at nearby Fort Victoria and Esquimalt, which was becoming a harbour town. Fire was used extensively to clear the land, to fight the re-invading trees and shrubs and to improve pasture.

Land clearing, carelessness and accidents accounted for an extensive fire history. Charcoal in the soil and records indicate that the entire study area was burned and many places had repeated fires. For example, in 1860, 600 acres west of Florence Lake, over 1000 acres north of Langford Lake, southern slopes of Skirt Mt., and several smaller areas were severely burned. In 1880, a fire, which was started west of Thetis Lake to clear the land after logging, stopped 3 miles south at Millstream and Esquimalt Harbour.

From 1884 to 1886, the Esquimalt and Nanaimo Railway was built, crossing the area from Parson's Bridge west to Langford Lake. The railway construction and the passenger service, which started in October 1886, opened the area to more intensive settlement. In 1902, the Honorable James Dunsmuir, member of the British Columbia Legislature, coal baron, and builder and owner of the Esquimalt and Nanaimo Railway, bought a large tract of land around Esquimalt Lagoon and named it Hatley Park. For his residence, he built a castle that is now part of the Royal Roads Military College.

Construction on the Canadian National Railway started in 1911 but, because of the war, the service did not start until 1917. This railway traverses from Parson's Bridge southwest to Glen Lake and from there south to Metchosin.

Most of the land suitable for agriculture was settled and cleared. The hills, after logging or burning, were used for grazing, but eventually regenerated to trees. Douglas-fir is the predominant species, but hemlock, red cedar, red alder and bigleaf maple on moist sites and lodgepole pine, arbutus and garry oak on dry sites constitute an important portion of the forest composition.

Most of the study area was either clearcut or several times selectively logged and subsequently burned, and now supports a mosaic of different age-groups. Stands that originated after large-scale logging in 1920 and 1946 are most common.

Because the land was owned by many individuals, some deriving their livelihood from sources other than land, stands of old trees, several over 600 years, still exist in the area. By far the largest and best preserved are those at the Royal Roads Military College, where commercial logging did not take place after the area was acquired by the Dunsmuir family.

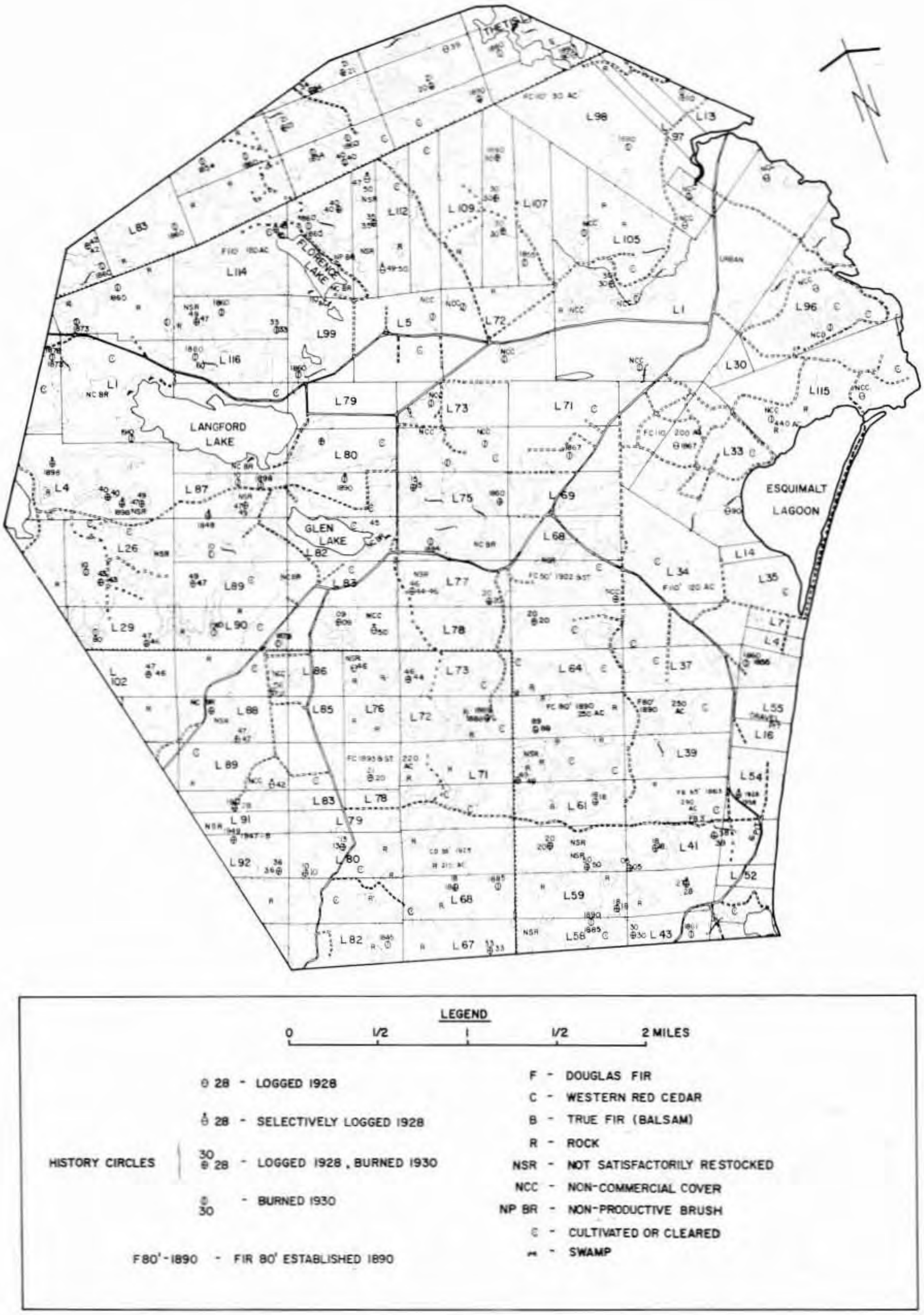


Fig. 4. Forest cover map. Forest history from 1854 to 1956.

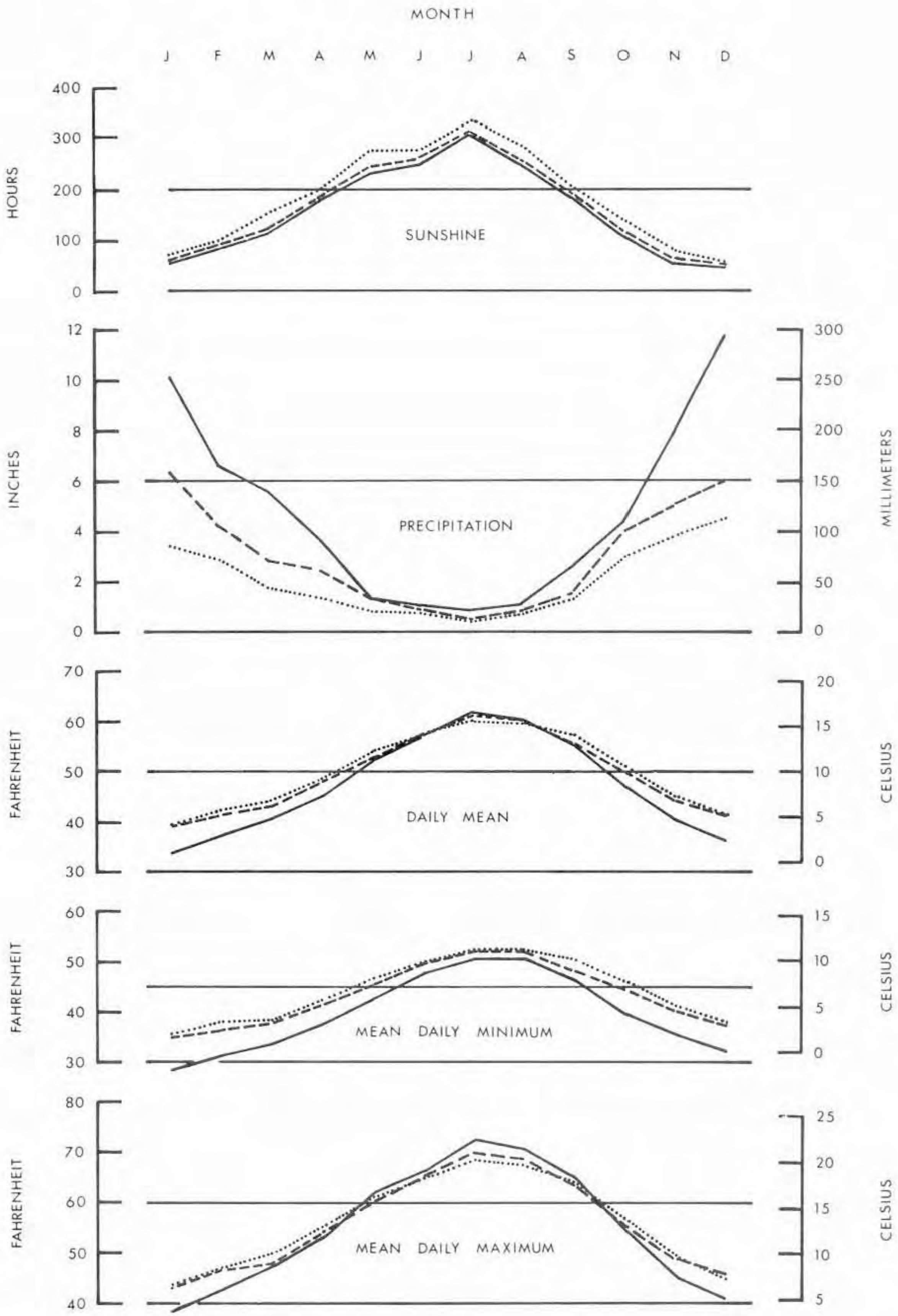


Fig. 5. Sunshine, precipitation and temperature at Humpback — and Albert Head – –, compared to Gonzales, Victoria ···· .

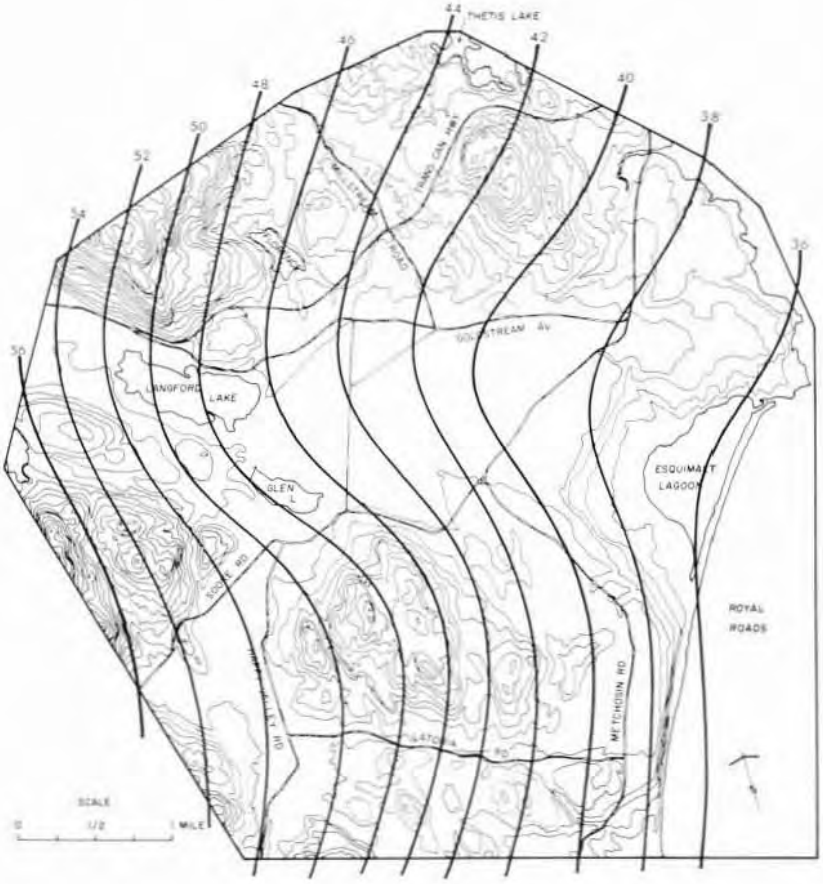


Fig. 6. Precipitation increases from about 36 inches (900 m) on the seashore to about 56 inches (1400 mm) at Humpback.

CLIMATE

The prevailing west to east movement of air over the study area is the result of control exerted by several regularly occurring large pressure systems and the channelling effect of Juan de Fuca Strait, bounded on both sides by mountainous land. In winter, the northeast Pacific receives considerable quantities of warm water from the south by way of Davidson's Current. The result is a transfer of heat and moisture into the air. Air flowing from the westerly direction in winter brings rains, but produces air temperatures up to 12°C (22°F) higher than might be expected from the latitude. In summer, the air, coming from the west, becomes cooled by the cold upwelling water that lies immediately off the coast of Vancouver Island and penetrates deep into Juan de Fuca Strait. The net result is that air becomes warm and moist in winter and cool and less disposed to precipitation in summer (4).

In winter, westerly winds, accompanying east-moving depressions, are usually stormy, and a succession of storms may continue with little break for a week or more. While westerly winds are rarely of gale force, the easterly and northeasterly winds associated with migrating Pacific storms may become very strong in late fall and winter.

In summer, the weather is usually calm, with a breeze developing regularly during the afternoons. During the periods of westerly flow, the terrain differences produce striking local variations in cloudiness and precipitation. Skirt Mt. to the north and Mount McDonald and Mount Wells to the west act as cloud generators and send lines of clouds eastward over the study area, even when

Victoria and the lowlands of Saanich Peninsula may be completely cloud free in the drier air that follows a frontal passage.

The precipitation is highly seasonal, about 83% occurring from October to April (Fig. 5). Summers are dry. Total annual precipitation ranges from about 35 inches (870 mm) at Albert Head* to about 57 inches (1170 mm) near Humpback Reservoir (Fig. 6). In every year on record, a rainfall of more than 2 inches (50 mm) in 24 hours occurred at least twice and much heavier rainfalls are possible. For example, on February 2, 1974, 4.2 inches (105 mm) fell in 24 hours at Humpback, and in December 1975, 9.73 inches (243 mm) fell during four consecutive days.

Snowfall not only varies greatly from place to place within the area but also from year to year. On an average precipitation from 1 inch (25 mm) at Albert Head to about 3.5 inches (85 mm) at Humpback is in the form of snow. While there are years (e.g. winter of 1944/45) without any snowfall at sea level, the snow cover usually ranges from about 2 inches (5 cm) at Albert Head to as much as 36 inches (90 cm) at Humpback. The snow may last from a few days to 6 weeks. A snowfall of more than 20 inches (50 cm) is known to have fallen in 24 hours (winter of 1948/49).

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

The hours of sunshine (Fig. 5) were estimated from the number of rainy days and the amount of precipitation at meteorological stations within and around the study area and are compared to Victoria, Gonzales Observatory, about 6 miles east, where sunshine is recorded. If Gonzales has over 2200 hours of sunshine a year, around 2000 hours at Albert Head and 1900 at Humpback are probably reasonable estimates. The difference is greatest in early mornings during spring and fall. In winter, when the air flowing from a westerly direction is saturated, and in summer, when the air is dry, the cloud pattern is similar to Victoria.

The temperature records (Fig. 5) available within the study area are incomplete and non-representative. Albert Head station is on a peninsula and indicates maritime influences; Humpback is at the edge of a large body of water in a generally forested area. Deforested and partly urbanized areas have temperatures somewhat warmer in summer than either station indicates. Winter temperatures recorded at the two stations give the range applicable to the lowland. The January mean daily temperature at Humpback is 34°F (1°C) and at Albert Head 39°F (4°C). Gonzales Observatory has also 39°F (4°C) (Fig. 5). The July mean daily temperature on the lowland was estimated at about 65°F (18°C), in spite of lower temperatures at Albert Head (61°F (16°C)), Humpback (62°F (16.5°C)) and Gonzales (61°F (16°C). The annual temperature minima are also more extreme. While Gonzales recorded a minimum of 4°F (-16°C) during the 73 years on record, Humpback recorded -3°F (-20°C) during a 10-year period, and temperatures below 10°F (-12°C) occurred in 4 years out of 10. The highest temperature recorded at Albert Head was 88°F (31°C) and at Humpback 89°F (31.5°C). However, it is probable that on the dry, deforested Colwood lowland, temperature maxima of over 90°F (32°C) are common.

Skirt Mt. on the north and high relief on the west provide protection from winds. Occasionally, a complete absence of turbulence may permit the cold air, draining from sparsely forested upper slopes, to accumulate in the low-lying areas, especially in Happy Valley and Glen Lake. But most of the area is wide open on the east to the sea and on the northwest through a narrow channel of Goldstream River to Saanich Inlet, and a complete lack of air flow is rare. Consequently, non-seasonal frost occurrence is rare. The frost-free period during 10 years on record at Humpback ranged from a low of 199 days in 1973 to a high of 223 days in 1975. The frost-free period in Happy Valley was estimated to be about 160 to 170 days, and on the seashore to be 260 to 280 days, similar to Gonzales with 280 days. Any large-scale clearing may compound the frost occurrence unless proper management is undertaken. New buildings and road construction may redirect the flow of cold air and cause some frost damage where it was not experienced before.

Radiation fog may form over low-lying areas at any time, and may be frequent and dense 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 temperature rise during the day or carried away by air flow. Sea fog, caused by the slow advection of warm maritime air over the 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 in summer and fall, when large inversions are caused by migrating storms over the Pacific. Occasionally, air currents may carry the sea fog ashore.

Because of the almost continuous air exchange, air pollution resulting from urbanization will not cause any serious problems in the study area. There may be a temporary increase in the amount of air pollutants when temperature inversions, occurring in the fall, temporarily prevent their dispersion.

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* Incomplete records were supplemented by estimates based on records of stations outside the study area.

PHYSIOGRAPHY, GEOLOGY AND SOILS

The physiography of the study area owes its form to geological history. The bedrock originated during the Carboniferous and Devonian periods and is composed of "Metchosin volcanic" materials, which underlie a broad belt, 5 to 7 miles wide, along the southern coast of Vancouver Island (5). Metchosin volcanics are composed of basalt flows, tuffs and agglomerates with intrusive diabase dykes. During the upper Jurassic period, they were deformed and invaded, and partly replaced, by batholitic intrusions of diorite, "Saanich" granodiorite and quartz diorite and, somewhat later, by porphyrites of the Sicker series, which all probably erupted during different deformations. An erosion cycle subdued all the deformed rocks, developing by late Tertiary time, a peneplain at the southern tip of Vancouver Island. This mature surface was dissected before the Glacial period and the south-western tip of Vancouver Island was reduced to a lowland (5).

The present landscape is the result of Pleistocene glaciation that occurred 10,000 to 15,000 years ago. During that period Vancouver Island was covered by a sheet of ice, estimated about three thousand feet thick. The enormous weight depressed the land mass 250 to 300 feet (75 to 90 m) relative to sea level. The movement of ice scoured the mountains and converted valleys into fjords and glacial troughs, in which lakes have formed (6).

As the glacier retreated, the ice was replaced by sea water and the land gradually rose to its present level. Enormous quantities of glacial meltwater established drainage patterns, cut river channels, and subsequent erosion further modified the terrain.

Loose material carried by the ice was deposited over the terrain. It often has two distinct layers. The most probable theory on their development, though not the only one, is as follows: the lower layer, a mixture of sand silt and rock resulting from abrasion and crushing under the weight of the advancing glacier, was deposited under the ice. The weight and shifting of the ice mass compressed it into a consistency of concrete. On top of this compacted layer was deposited the loose material carried within or upon the ice. Where it was not subsequently removed by meltwater, it forms a layer of fairly uniform depth up to about 4 feet (1.2 m) of unsorted, unstratified gravelly, sandy and loamy material containing many

Fig. 7. On hilltops and ridges, twisted Garry oak, arbutus and scrubby manzanita may be the only woody plants.

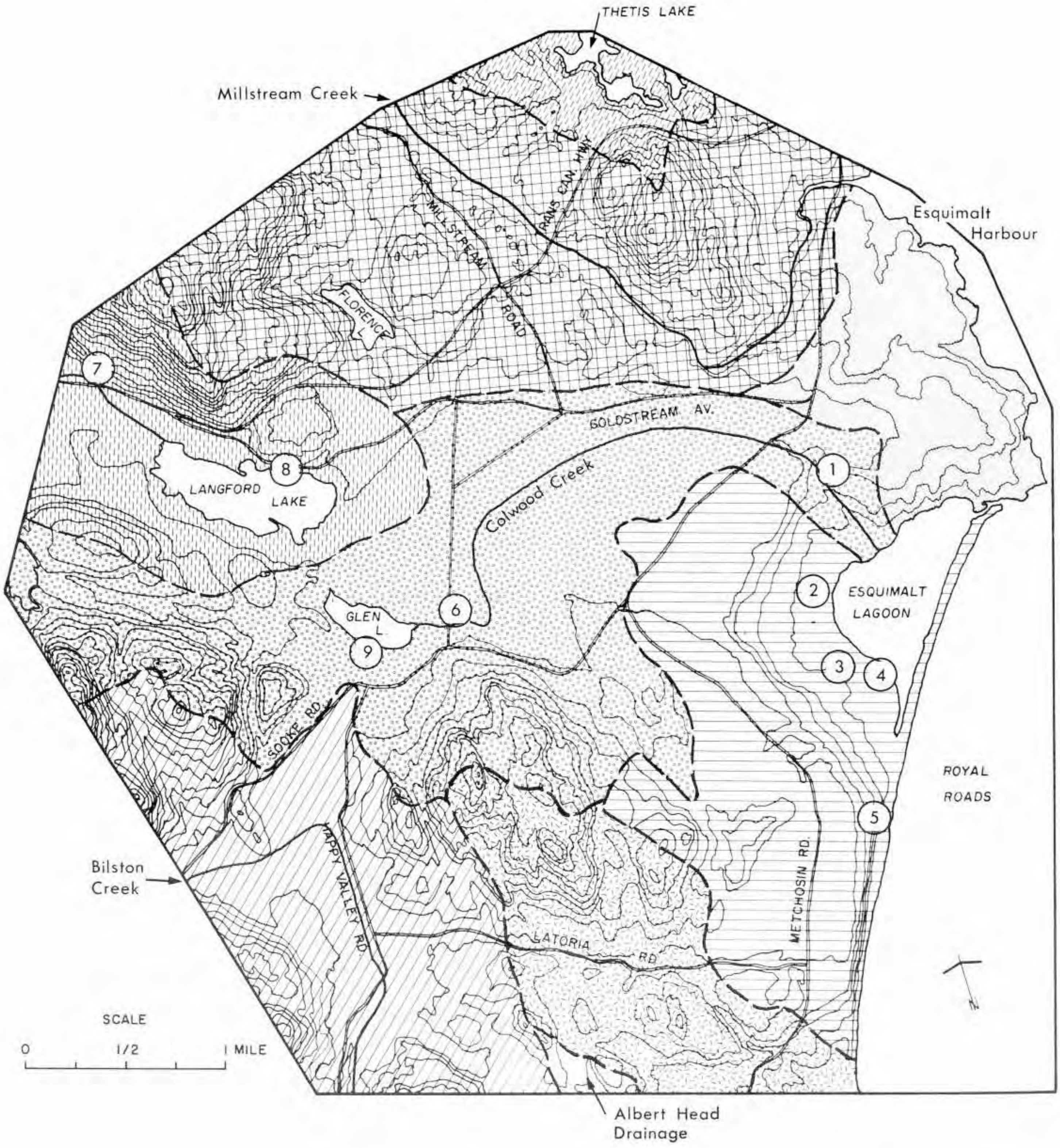


Fig. 8. Drainages and water collection locations:

1. Royal Roads
2. Royal Roads
3. Royal Roads
4. Seafield Rd.
5. Ocean Blvd.
6. Jacklin Rd.
7. Langford Creek
8. Langford Lake
9. Glen Lake

angular rocks of different origin. These two layers of glacial till commonly form a mantle on slopes and uplands, and together with some weathered products of the substratum, constitute the mass from which the soils developed.

In the larger valleys and on the coastal lowland, stratified deposits, consisting largely of glacial detritus, occur, deposited and reworked by river, lake and marine agencies. Their depth under the undulating surface of Colwood lowland is variable, depending on the configuration of the scoured bedrock.

Large volumes of rapidly moving meltwater and subsequent erosion removed glacial deposits from higher elevations, steep slopes and along the river channels, exposing the bedrock. Rock outcrops smoothed by the glacier, now bare or covered with about an inch of organic material or a few inches of mineral soil, are frequent throughout the area.

Large rocks were deposited at the foot of slopes, gravel and coarse sand in low-lying areas and along the streams. Fine-textured materials were deposited away from the main flow, where the velocity of water was reduced, as in protected bays of the river delta, or were carried farther east into the sea. After the ice receded, a capping of loam or fine sand was deposited over gravelly sands and gravels in low-lying areas and along the banks of streams. Periodic flooding during periods of rapid run-off in winter continues the deposition of fine materials upon the current flood plains.

Weathering, erosion, colluvial and alluvial action and accumulation of organic material produced the present soils. Those of glacial till origin are generally coarse-textured, ranging from gravelly sands to sandy loams. The surface mineral horizons are dark from deposition of organic compounds leached from the surface layers. Iron and aluminum oxides, leached from upper horizons have produced a reddish color in the B horizon, beginning at the depth of 6 - 16 inches (15 - 40 cm). Plant roots are distributed throughout the soil profile, but usually form a dense mat near the surface, where nutrients are most abundant, and on the surface of the compacted till, where seepage water flows (6).

Marine sediments were formed by the washing action of waves upon the surface material. The soils developed on them range in texture from gravelly sands on higher ground and terraces, which were exposed to high waves, to loams and clays on lower ground, which was deep in water during submergence, or where post-glacial rivers poured muddy waters into protected bays. Generally, the coarse marine deposits rest upon layers of loam or clay, or occasionally form a mantle only a few feet thick over bedrock or till. Hence, they may be moister than their texture would indicate.

HYDROLOGY

In the study area, over 80% of the total annual precipitation falls from October to April. The onset of the soil moisture deficit is in early May and ends with autumn rains, usually in late September at Humpback and early October near the sea. The moisture deficit amounts to about 14 inches (350 mm) at Colwood and drops to about 12 inches (300 mm) at Humpback, but varies considerably with aspect, exposure, soils and ground cover (2).

Summer rains do not cause a runoff because the precipitation is usually light and is immediately absorbed by dry and porous soil. Streams, lakes and swamps depend entirely on the ground water supply. The water level drops in lakes and, by the end of the summer, swamps dry out and creeks become tricklets seeping through the gravel, often disappearing entirely.

On till soils, estimating 4-6 inches (100-150 mm) of precipitation for winter evapotranspiration, 2-6 inches (50-150 mm) for water storage capacity of the soil, which becomes available for evapotranspiration during the growing season, and 4-8 inches (100-200 mm) for deep ground water storage, from approximately 15 inches (375 mm) near the sea to more than 30 inches (750 mm) at Humpback are available for runoff from the beginning of October to the end of April.

The marine gravelly sands have rapid internal drainage, thus surface runoff is greatly reduced. These gravelly sands are usually underlain by layers of loam and clay, which have 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 within the gravels, transforming swamps and marshes, in which, during the summer, the water level may be a foot (30 cm) below the soil surface, into temporary lakes.

The study area encompasses parts of nine drainages (Fig. 7).

At the north, 310 acres of the study area drain into Thetis Lake, but the lake lies mostly outside the study area within a park. The lake was created in its present form by damming two smaller lakes and flooding adjacent swamps and lowlands. The total lake drainage area is less than four times the size of the lake. The topography is rolling and the soils are of till origin, shallow to medium in depth, with frequent rock outcrops. Considering the total winter rainfall and losses by evapotranspiration as well as water-holding capacity of the soil and seepage (ground water), it was estimated that about 15 to 18 inches (375 to 450 mm) of rainfall is available for runoff. In summer, the water level drops at least 30 inches (75 cm) below the outlet and as this amount has to be recharged first, less than half the lake content can be flushed during the winter. Generally, the runoff is moderately rapid and, because the area is forested and lies within a protected park, the erosion is and will probably remain minimal. Water quality is excellent and turbidity, even during winter rains, is low. In winter, the small amount of water that drains northwest into Craigflower Creek flows eventually into Portage Inlet. Craigflower Creek, in its lower reaches, is a salmon spawning stream.

Millstream Creek watershed covers about 2,340 acres of the map area. The headwaters are in the Highland district to the north, on steep, rocky ridges with shallow soil, often supporting a thin forest cover. The runoff is rapid, but stabilization takes place on coarse till and alluvial soil, and in swamps and lakes before the creek enters the map area. Consequently, the flow within the map area is fairly even. However, Florence Lake watershed, which drains into the lower reaches of Millstream Creek, has steep topography with shallow soils with low water-holding capacity and, consequently, fast runoff. The lake, having a low-gradient and slow discharge channel, is subject to wide fluctuation in size and depth. The difference in water level between summer and winter is more than 3 feet (approx. 1 m) and the outlet channel is dry for about 7 months of the year. Considering that about 20 inches (500 mm) of rainfall over the area drains into the lake and the lake content is 150 acre-feet (185,000 m^3) at full level, the volume of water that flows through the lake in winter is estimated at about 5 to 6 times the volume of the lake and a good flushing takes place. There are several farms located along Millstream Creek and water contamination by animal wastes is probable. Lower reaches of Millstream Creek have been affected by urban development and the summer flow appears to contain a considerable amount of sewage effluent. Discharge from the Colwood gravelly sands is also suspected of contributing to the stream contamination, because the turbidity increases as the creek flows through the gravels.

Langford Lake watershed is a part of the Goldstream drainage system. On the map area, this drainage system covers about 1170 acres, of which about 580 acres of land drain into the lake. The remaining 590 acres drain into the ditch below the lake. The lake itself measures 158 acres. About 200 acres of the lake watershed to the north comprise slopes of Skirt Mt., with shallow rocky soils and rapid runoff. Gentle slopes with deep till soils south of the lake have moderate runoff. Only seepage through the gravels enters the lake from the east. If 20 inches (500 mm) of rainfall over the Langford Lake watershed is available for winter flow through the lake, and if summer water level is about 24 inches (60 cm) below the outlet, only the water volume equal to 5-6 feet (150-180 cm) over the lake surface is available for flushing. Since the mean depth of the lake is 22 feet (6.7 m), only a quarter of the lake volume is exchanged each year.

Esquimalt Harbour watershed covers about 700 acres. Apart from about 50 acres of outwash loams, the area has till and outwash soils over bedrock. They are generally shallow (less than 3 feet, 90 cm), with frequent rock outcrops. Consequently, runoff is rapid from most of the watershed. About 200 acres are drained by a winter-flowing creek; the remainder drains directly east into Esquimalt Harbour or south into Esquimalt Lagoon.

Glen Lake watershed was originally much larger, but a dam upstream, on Humpback reservoir, now directs all water in the Greater Victoria water supply system. At present, about 750 acres of land drain into the lake, which itself measures 51 acres. Runoff in the Lake watershed is moderately rapid and amounts to an equivalent of about 25 inches (625 mm) of rainfall. This amount of water is about four times the total volume of the lake and it can be assumed that a good winter flushing takes place.

Colwood Creek, draining Glen Lake, is a ditch through a series of swamps and depressions within the gravels. It flows into Colwood Lake and eventually into Esquimalt Lagoon. Colwood Lake is small and of little significance, occurring within the golf course where it serves as a reservoir for watering. Runoff from upland areas may result in occasional local flooding at the base of slopes but, on the gravels, runoff is non-existent. Instead, the rainfall infiltrates and is discharged as groundwater into the Colwood Creek channel. Storage in lakes and gravel deposits maintains some streamflow through the dry season.

Water quality in Colwood Creek has been affected by urbanization in spite of the fact that no large urban development is in the proximity of the stream. Glen Lake itself shows evidence that some seepage from septic fields is entering the lake and the content of nitrates gradually increases farther along Colwood Creek. Seepage originating from domestic effluent is obviously entering the channel.

Royal Roads drainage comprises 1650 acres. Apart from about 5% of shallow till and outwash soils, the area is covered by deep glacio-fluvial and marine deposits. On the terrace, the gravelly sands are usually underlain at a depth of about 100 feet (30 m) by sandy loams. Surface runoff is practically non-existent. Water that penetrates into the sand seeps out as springs along the shore, both above and below the sea level. Some areas of Colwood, designated as sloping on the surface toward Glen Creek, probably have underground seepage draining directly into the sea. The high content of nitrates indicates that the seepage water contains a high proportion of domestic sewage (Table I).

Bilston Creek, in the southwest corner of the map area, drains Happy Valley and the surrounding hills. From

Table 1. Water analyses.

Location of collections are marked on Fig. 8.

a) Collection on December 2, 1975 during heavy flow.

Location	Total Phosphorus	Organic Nitrogen	Nitrates
	ppm*	ppm	ppm
1 Royal Roads	.29	2.36	6.2
2 Royal Roads	.27	1.68	29.0
3 Royal Roads	.64	2.32	13.0
4 Seafield Road	.33	2.28	23.0
5 Ocean Blvd	.46	3.12	21.2
6 Jacklin Rd	.48	1.45	3.6
7 Langford Cr	.47	2.11	3.7
8 Langford Lk	.45	2.07	3.7
9 Colwood Cr	.66	2.01	3.6
Tap water	.45	1.10	1.3

b) Collection on May 11, 1976 at the end of winter flow.

1 Royal Roads	.05	.74	13.6
2 Royal Roads	.04	.30	27.0
3 Royal Roads	.03	.28	28.0
4 Seafield Rd	.21	.28	43.0
5 Ocean Blvd	.03	.48	24.0
6 Jacklin Rd	.02	.40	4.8
7 Langford Cr	.02	.56	9.4
8 Langford Lk	.02	.67	9.4
9 Colwood Cr	.04	.34	5.6
Tap water	.02	.25	2.0

c) Collection on August 12, 1976 during low summer flow.

1 Royal Roads	.003	.24	14.5
2 Royal Roads	.013	.45	24.1
3 Royal Roads	.003	.09	31.5
4 Seafield Rd	.750	.23	37.0
5 Ocean Blvd	.775	.40	94.0
6 Jacklin Rd	.001	.38	5.6
7 Langford Cr	.001	.69	8.4
8 Langford Lk	.003	.52	3.9
9 Colwood Cr	.002	.53	31.5
Tap water	.002	.18	0.2

*ppm = parts per million

a total of about 1600 acres, over 1200 acres are of till and outwash origin; the rest are marine loams and gravelly sand. While runoff on slopes is rapid, the wide valley bottom has slow drainage and may locally flood during winter rains. Deep loamy soils in the valley and seasonal swamps regulate and extend the stream flow throughout the year. Bilston Creek drains into Metchosin Creek and eventually into Metchosin Lagoon. Animal and domestic sewage contamination reduces water quality. There is also some turbidity in the creek.

An area on the southern boundary, measuring less than 60 acres, drains through a small winter-flowing creek directly into Metchosin Lagoon.

Albert Head drainage area comprises 900 acres of upland outwash and shallow till soils and about 60 acres of Colwood gravelly sands and loams. Runoff problems and erosion have been associated with the recent land clearing and residential development on the steep terrain and shallow soils of Triangular Hill, and can be expected to occur under similar conditions elsewhere in the study area. The drainage has moderately rapid runoff and a winter-flowing creek drains water into a tidal pool north of Albert Head.

Water temperature in lakes starts to increase in late March and, in late July and August, the upper water layers are usually 70-75°F (22-24°C). Cooling starts around the end of August and the "turnover" occurs at about 48°F (9°C), usually in late October. During the winter, the water temperature remains relatively constant between 40 and 44°F (4-7°C).

Ground water resources, as a source of the domestic water supply, were not studied, as most of the present population of about 22,000 people relies on septic tanks. The only exceptions are a small area of Colwood shopping district and adjacent Belmont Park and Royal Roads Military College, which are serviced by sewers. Further, Humpback reservoir is the intake of the Greater Victoria Water District system and the pipes run from west to east through the centre of the study area. While there still may be a few water wells used in the sparsely populated outlying areas, the projected increase in population must be supplied by water from the Greater Victoria Water District.

LANDSCAPE UNITS

LANDSCAPE UNITS

The landscape units mapped in the study area are composite units. They take into consideration physiography, exposure, slope, soils, drainage and vegetation to express similarity in habitat within the general environment. The scale of the map (I: 14,400) allows only limited detail and accuracy. For that reason, small differing intrusions that occur within each landscape unit could not have been depicted and intimate mosaics of several units had to be shown either as the most prevalent unit or as the average unit, as deemed best for each situation.

The 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.

1. Solid Bedrock.

(Figs. 9 and 10) 220 acres, 1.8% of the map area.

The solid bedrock landscape unit comprises hill tops and steep slopes of exposed volcanic 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 from the weathering of the rock "in situ". The mineral soil is dark, due to the incorporation of organic material from decomposing remains of lichens and mosses.

Fig. 9. When the summer drought starts, the spectacular spring flowers disappear; the solid rock landscape unit is covered with dry grasses and mosses.

By the composition of vegetation, the solid bedrock landscape unit corresponds to the Garry oak-shrub plant community (7). 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. The rock surface is 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.

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. From an ecological point of view, denudation of the bedrock landscape unit may create "desert conditions", almost devoid of life.

The massive bedrock provides a solid foundation for any type of structure and, for residential development, this landscape unit, with open space, scenic views and attractive vegetation, provides a desirable environment. However, leveling, provision of access and services, and construction would be expensive. Suitable soil for septic fields would have to be brought in but, even then, surface drainage of the 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 any effluent discharge, are proved satisfactory.

Because the soil is extremely shallow and the only internal drainage is through rock crevices, runoff, after the moss layer becomes saturated, is immediate and rapid. 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.

Fig. 10. In solid rock landscape unit, heavy traffic destroys most vegetation and exposes bare rock.

This unit is ideally suited for open-space and greenbelt purposes, especially since it does not require any buffer zone. Because of its aesthetic value, and since it occurs only on the southern tip of Vancouver Island, it warrants consideration for conservation, at least where it still exists in its natural state.

2. Broken rock.

(Figs. 11 and 12) 1575 acres, 13.5% of the map area.

This landscape unit is characteristic of the rugged upland terrain, with hummocky rock knolls and ridges. It occurs where a thin mantle of soil (up to 1 foot, 30 cm) has 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 have been mapped separately. The thin soil has little development, except for staining by organic material.

Fig. 11. In the broken rock landscape unit, stunted trees and shrubs grow mainly in crevices between rocks.

Fig. 12. Broken rock landscape unit on Mill Hill in the foreground with Esquimalt Harbor in the morning mist in the distance.

This landscape unit coincides approximately with the Arbutus-Douglas-fir plant community. 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 where soil has accumulated and moisture is retained. Arbutus is usually most common. The presence of Douglas-fir depends on logging history, age and stage of development of the stand. 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 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, camas; grasses; crustose and fruticose lichens and mosses are usually abundant.

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

Consolidated bedrock close to the surface provides good foundation support for any kind of structure. This site also provides an attractive setting for residential development, with open-grown arbutus, Garry oak, Douglas-fir and many interesting spring flowers. However, cost of services and provision of access will be high, possibly prohibitive. Limitations will be imposed mainly by the steepness of the terrain and the shallow rocky soils, which will require a great amount of blasting. Suitable soil for septic fields does not exist in this landscape unit and there are few areas where septic tanks and fields could be constructed by bringing in suitable fill. Internal drainage through the crevices, possibility of sewage re-surfacing farther downhill and surface runoff need to be studied for each individual septic disposal field before any permit is issued. A compounding effect of effluent accumulation down slope can be expected.

Landscaping will require the addition of fill and top soil. Internal drainage through crevices is usually sufficient during summer, but in winter, because of the steepness of the terrain, runoff 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 where it occurs in its natural state.

3. Shallow Soils.

(Figs. 13 and 14) 3380 acres, 29.1% of the map area.

While it occurs in discontinuous blocks, this landscape unit is the most prevalent throughout the study area. Typically, it occurs on moderate slopes where soils accumulated to a depth of 1 to 3 feet (30-90 cm). 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 or colluvium and are 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 (6). Because of the general paucity of fine-textured mineral and organic material, a large portion of released nutrients not absorbed by the plants is leached and lost during winter rains. This loss of nutrients, combined with dryness during the summer, results in low soil fertility.

This landscape unit corresponds approximately with the Salal-Oregon grape plant community (7). It is stable when covered by vegetation, but is prone to erosion when vegetation is removed and soil disturbed, especially on steeply sloping terrain.

On the drier sites, such as flat hilltops, where soils are usually less than 20 inches (50 cm) deep, and on the steep southern slopes, stands of Douglas-fir in a mixture with lodgepole pine, arbutus and Garry oak predominate. Where soils are somewhat deeper and on northern slopes, Douglas-fir and grand fir prevail and stands are often excessively dense. 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.

Fig. 13. Shallow soil landscape unit supports stands of Douglas-fir, but arbutus may be a constant component.

Fig. 14. Douglas-fir stands are often overstocked and prone to wind and snow damage. (Top)

Fig. 15. Deep mineral soil landscape unit usually has some seepage and, where light penetrates, this unit supports lush ground vegetation. (Bottom)

Invasion by shrubs and forbs (including introduced weeds) is common, but does not hinder the 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, the shade intolerant forbs are not abundant. Lupine, vetches, yarrow, strawberry and buttercup occur around the forest edge and in openings, while shade tolerant star flower and easter lily form spectacular carpets in the 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.

This landscape unit is common on south-eastern Vancouver Island and loss of a small area to residential development constitutes an insignificant social cost. The influence of human activity will not extend far beyond the area intensively used. Inherent resilience will reduce any damage to the natural environment.

From an environmental and economical aspect, this unit is generally suitable for any kind of development. Solid rock within 36 inches (less than 1 m) from the surface provides an excellent foundation support and loose, gravelly, sandy soil can easily be moved for construction and installation of services. However, steeply sloping terrain may force local limitations on residential development. Septic field possibilities exist on deeper soils for individual residences or small cluster developments, but under intensive residential development, sewage would soon saturate the soil. 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, but the dense coniferous forest and shrubs obscure the view and make this unit less attractive and difficult to traverse. A maintained trail system will be necessary for hiking. Where slope is not a limiting factor, this unit is suitable for intensive recreational uses, such as playgrounds or camping grounds. Because the indigenous vegetation is not suitable for intensive recreation, open space and lawns will have to be provided. However, every opening created in the forest stand will result in potential wind-throw of trees on windward edges or of isolated trees. 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 artificial openings.

Annual forest productivity in this landscape unit is low (less than 60 cubic feet per acre, 5 m^3 per ha), but if profit is not the main motivation, commercial forest production could defray some maintenance cost of greenbelts and open-space areas around and within the residential areas. Selective logging or patch logging could even enhance the aesthetic value of the green belts and make them more accessible for recreation.

4. Deep mineral soils.

(Figs. 15 and 16) 1460 acres, 12.6% of the map area.

This landscape unit occupies lower slopes and flat lowlands. The soils are derived from coarse-textured till or glacio-fluvial material, often covered with recent alluvial 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 typical podzolic development. The soil depth is more than 40 inches (1 m). The loose surface soil material is underlain either by bedrock or a layer of compacted till, essentially impervious to water and root penetration. Oxides and silicates of iron, magnesium and aluminum were leached from upper layers and deposited in lower horizons. Seepage water flows over the impervious horizon for at least part of the growing season. Because of this seepage, a secondary concentration of roots occurs on top of the impervious layer.

Ecologically, this site corresponds approximately with the Swordfern and Swordfern-Salal 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 varied from 130 to 160 feet (38 to 48 m) at 100 years (more than 80 cu feet per acre, 7 m^3 per ha), 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

Fig. 16. Forest productivity is high but stands are often quite open.

are willow, honeysuckle, Oregon grape, salal, huckleberry and flowering current under the tree canopy, while ocean spray, snowberry, goats beard, buffalo berry, ninebark, blackberry and rose are frequent along forest edges and in openings. Forbs are numerous and, in addition to those listed in the shallow soil unit, include orchids, 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 soil landscape unit is well suited for residential or other development. Further, its loss will not be serious, because it is common on southern Vancouver Island. 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 re-invade disturbed areas. Generally, the influence of human activity will not extend far beyond the area actually used.

Compacted till or bedrock, underlying these soils, provides a good base for solid foundation and deep, loose, coarse-textured surface soil permits inexpensive installation of underground services and roads. Removal of the loose soil overlying the compacted till will produce essentially sterile conditions for many years.

Provided that the upper soil layers are retained, landscaping and ground maintenance will not be difficult. Erosion on flat topography is rarely serious. However, steep banks along water courses will need to be protected by vegetation, and where heavy use and destruction of vegetation can be expected, cribbing, meshing or other mechanical protection of the banks may be necessary.

Runoff and internal drainage are slower here 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 the natural flow of seepage water.

The dense growth of coniferous forest and shrubs makes this landscape unit difficult to traverse and not particularly attractive for hiking, but its carrying capacity for intensive recreation, such as sports fields or playgrounds, is excellent. Such development, of course, would mean replacing the original vegetation with lawns or a hard surface.

Forest productivity of this landscape unit is good and the stability of its soils and resiliency of its vegetation suggest an excellent potential for open space or greenbelt purposes under multiple use forest management. The value of forest products would probably pay for protection, recreation facilities and road construction and maintenance. However, opening of the forest by logging, development or road construction, will expose the trees to wind. To minimize wind damage, the same measures should apply as mentioned in the previous unit.

Under suitable management, this landscape 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.

5. Outwash sandy loams.

(Figs. 17 and 18) 890 acres, 8.3% of the map area.

At the end of the ice age, in areas open to the sea, the melt-water flow along with wave and tide action separated and washed the fine particles into the sea. However, in quiet inlets protected by surrounding hills, the sediments, albeit modified also by sea action, contain a large proportion of loam and fine sand. Examples of this are Happy Valley and Millstream Creek valley. Secondary occurrence of this landscape unit is along the seashore, where erosion by the meandering postglacial river and wave action exposed the fine sediments buried deep under the gravels.

Typically, this landscape unit occupies flat, gently sloping or slightly undulating terrain. The soil usually contains some gravel; it is deep, and underlain by bedrock or clay. The internal drainage is moderate to rapid, depending on texture. Water-holding capacity is comparatively high but, because the soils are deep, ground water or seepage may be inaccessible to ground vegetation, and the site indicates drought during the summer. The soil development is moderate to weak; content of organic material and nutrients are relatively high (6).

Similar to the previous unit, this landscape unit also coincides with the Swordfern-Salal plant community. Salal and Oregon grape are usually more abundant than swordfern, showing drier conditions in surface layers, but the productivity of deep-rooted trees is almost as high as on deep till soils. Site index for Douglas-fir varies from 130 to 155 feet (38 to 46 m) at 100 years. Douglas-fir, grand fir, western red cedar, western hemlock, bigleaf maple, red alder and an occasional dogwood form the mature stands while, after disturbance, the regeneration may contain a considerable proportion of shade-intolerant, slow-growing Garry oak and arbutus, which later become overtopped and shaded out. If seed is available, lodgepole pine may become established after logging or fire and form almost pure, dense, even-aged stands until

Fig. 17. Since the time of first settlers, the outwash sandy loam landscape unit has been cleared and used for farming.

Fig. 18. Agricultural productivity of the soil is high. However, most of this landscape unit is used only for grazing and hay is the main crop.

eventually overgrown by the longer-lived species, characteristic of the mature forest, which regenerate under its canopy.

The most abundant shrubs in the forests are salal, Oregon grape, huckleberry and honeysuckle, while rose, snowberry, ocean spray, trailing blackberry, buffalo berry and goats beard are common in openings and at the forest edge.

The indigenous ground vegetation is not site-specific and contains similar species to those on shallow and deep till soils. Grasses are especially abundant. The most conspicuous mosses are Eurhynchium oreganum, Hylocomium splendens, Polytrichum, Bryum and Dicranum spp. on the ground; Orthotrichum, Hypnum and Isothecium spp. are common on trees, together with a number of lichens. The indigenous vegetation is moderately resilient to trampling, and heavy use may eliminate some species. Most species will re-invade disturbed areas and the influence of frequent or intensive human activity will not extend far beyond the area actually used.

Because a solid foundation base may be too deep to be accessible, provisions must be made to support large, heavy buildings securely in loose and, in winter, often saturated, loamy soil which, under a unilateral or uneven pressure, may shift. Apart from this restriction, this landscape unit may support any construction. The loose, deep soil will permit inexpensive installation of services and road construction. Even if the top soil is removed, the natural fertility of this loamy soil will provide for easy landscaping and ground maintenance. Terrain covered with vegetation will not be subject to erosion; however, steep slopes which may be created during construction and landscaping will be unstable in winter. Stream banks will need protection by vegetation and possibly mechanical means, such as cribbing and meshing, to prevent sloughing. Runoff on flat topography is rather slow; consequently, local flooding may occur for short periods after heavy rains. Common sense suggests that where this unit occurs in valleys, on flat terrain, houses should not have underground basements, and drain tiles around the foundations and draining of the building site is advisable.

In the study area, this unit has been extensively settled since the turn of the century, when the forest was cleared for farming. With the exception of a large, predominantly forested block above Esquimalt Lagoon, belonging to the Military College, and a few farms, the average holding at present is less than 2 acres (1 ha), and the population is increasing.

As past usage indicates, this landscape unit is suitable for agriculture. Proximity to a large urban centre suggests orchards and market gardening, with crops such as vegetables, strawberries, early potatoes, etc. Irrigation of most crops during the summer droughts would probably be necessary, but natural fertility of the soil may make such a venture worthwhile. Locally, drainage ditches may also be necessary to drain the excess water in winter. A less labor-intensive agricultural use for which this unit is suitable is grazing.

This unit has an excellent carrying capacity for intensive recreation, such as playgrounds, golf courses, etc., but for such uses the natural vegetation would have to be replaced by grass or hardtop. The potential for hiking is limited because of a low scenic value, with the exception of some farmland. Where this unit is still overgrown by natural forest, dense stands and shrub cover will make hiking difficult and a network of paths would be advisable.

This landscape unit has good forest productivity. Stability of the soils and resilience of the vegetation suggest an excellent potential for greenbelt under a multiple-use forest management. Similar to the deep till landscape unit, the value of forest products could pay for land management and all secondary uses of this unit. The trees are generally deep-rooted but, because the natural regeneration may be too dense, they may be thin and tall. Cutting or any sudden opening of the forest will expose them to wind. While uprooting may not be frequent, heavy breakage may occur. To minimize the damage, measures mentioned in the shallow till landscape unit should be used. Heavy, wet snowfall which occurs in some years, may also cause breakage, especially in overstocked stands that were recently heavily thinned.

6. Outwash sands and gravels.

(Figs. 19 and 20) 3180 acres, 27.3% of the map area.

During the time the glaciers were retreating, Goldstream River drained south of Esquimalt Harbour into Juan de Fuca Strait. Continuous blocking of the channel by sediments caused the river to alter course, covering the whole delta 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 melt water and the period of exposure to the sea action varied.

The topography of this landscape unit is flat or gently undulating, except where erosion by wave action resulted in sloughing, which produced a steeply sloping shoreline between Esquimalt Lagoon and Albert Head.

The coarse deposits are the parent material of soils in the entire Langford and Colwood lowland. Generally, they are deep (up to 60 feet, 20 m) and are underlain by bedrock, colluvium, till or marine clay. Internal drainage is rapid, water-holding capacity is low, and generally drought 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.

Fig. 19. Frequency of arbutus and sparce ground cover indicate high water deficit on outwash sands and gravels.

Fig. 20. Forest productivity is low.

Fig. 21. Gravel operation of Construction Aggregates Ltd.

This landscape unit coincides with the Salal-Oregon grape plant community. Douglas-fir is the predominant tree, with lodgepole pine, arbutus and, occasionally, Garry oak forming a temporary admixture in younger stands. Where gravels are shallow over outwash loam or till or where seepage occurs, western red cedar, western hemlock and red alder may also be common. The forest productivity is generally low. Only locally will Douglas-fir reach a height of 120 feet (36 m) at 100 years. The average mature height for the landscape unit is approximately 100 feet (30 m), with areas of repeated fire history only in the vicinity of 80 feet (24 m).

The indigenous vegetation is not site specific, containing most elements of the shallow till soil and broken rock landscape units, because 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 under the trees, while in the open, rose, trailing blackberry, snowberry and broom are common. Forbs are mainly early flowering ephemerals, such as crocus, camas, shooting star, blue-eyed Mary, and drought resistant composits, such as asters, goldenrod, etc. Locally, grasses may predominate. The most common mosses are Eurhynchium oreganum, Rhacomitrium spp. and Dicranum spp. They all occur mainly under trees in moderate shade. Apart from the ephemerals, which are intolerant to trampling, the vegetation is fairly resilient. However, vigor of the perennial vegetation is rather low because of drought in summer. For this reason, re-invasion of vegetation into disturbed areas will be slow to moderate.

Deep gravel deposits on flat topography provide a good foundation for any kind of construction, provided their loose structure is taken into consideration of the design and size of support. The very rapid internal drainage does not allow water to saturate the soil profile and cause soil instability. The installation of services and road construction is comparatively inexpensive. Landscaping will not be difficult. However, soil fertility depends on the amount of top soil and incorporated organic material, and ground maintenance will require their periodic addition, frequent fertilization and watering which, on a broad scale, such as in parks, may not be practical.

This landscape unit is the most important source of gravel and sand for the building industry in the Capital Region. While erosion is no problem on flat topography, steep banks created by excavations, landscaping or road construction are subject to erosion until the material finds its natural stable slope. For any construction near such steep banks, the steepness should be reduced to what is considered a natural stable slope and the soil stabilized by deep-rooted trees and shrubs.

The gradual erosion of steep banks along the seashore is a natural phenomenon and no preventive measure will be permanent. However, it is almost certain that this erosion has been negligible during the last few years. Construction Aggregates Ltd., a company that owns a large gravel operation above the sea bank (Fig. 21) is discarding unsold grades of sand on the beach. This material, spread along the shore by tide and wave action keeps the beach clean and acts as a buffer (Fig. 22) dissipating the force of waves before they hit the base of

Fig. 22. Unsold, discarded grades of sand and gravel protect the shore and keep the beaches clean, but probably build an underwater sand bar across the mouth of Esquimalt Harbor.

the bank. At the same time, this material is probably slowly filling Esquimalt Harbour and building an underwater sand bar across its mouth.

This landscape unit has been extensively settled and holds most of the population of the study area. With the exception of a small area around Colwood Corner and Belmont Park, the whole study area is on septic tanks. In the late fall of 1975 and spring and summer of 1976, water seeping from the gravels was tested for contamination by phosphorus and nitrogen either of which would indicate presence of sewage. Except in a few isolated cases, the content of nitrogen in organic form and of phosphorous was not significantly higher than that in water from the municipal water supply (Table 1). This water comes from the Greater Victoria Water Supply Area in uninhabited mountains and is of highest quality. However, nitrogen in the form of nitrates was, in some cases many times higher than in the municipal water (Table 1). This indicated that the seepage contained a high proportion of water that originated as household waste, but that the gravels and underlying loams removed phosphorus and converted nitrogen into compounds which are the objectives of treatment plants. It appears that the capacity of the gravels was not approached, and that the study area was an inherent treatment plant that could not be duplicated by man. The seepage now goes into the sea, the only logical destination of water from an outfall of any treatment plant that could be built in the study area.

It is definitely not suggested that planning of development in the study area should not include sewers, or secure land for them and for a treatment plant in case the need arises in the future. However, their building can perhaps be postponed. By the time they may be needed, advances in technology, standards, recycling or other methods of waste disposal and social attitudes may make the present ideas obsolete. In the meantime, monitoring of water quality in the lakes and along the beaches is recommended. These comments apply only to this landscape unit.

The agricultural potential of this landscape unit is low and the statements of its extensive use for agriculture in the time of the first settlers must have applied only to grazing. Any meaningful improvements appear to be too costly to be practical.

Forest productivity is low. However, its potential for greenbelt or for open space purposes, under a multiple-use management, which would not place a high value on forest products, is excellent. The trees are deep-rooted and not subject to wind-thrown, but wind or snow breakage may occur where trees are dense and of small diameter.

The carrying capacity for intensive recreation, such as playgrounds, golf courses, sports fields, trailer parks, picnic areas, etc., is excellent; but, as in the previous units, the natural vegetation would have to be replaced by lawns or hardtop. The potential for hiking is limited because of low scenic value. While young forests may be dense, the shrub cover is usually not dense enough in mature stands to prevent hiking. However, intensive use would eliminate most of the spring flowers.

7. Marine clays.

(Figs. 23 and 24) 91 acres, 0.8% of the map area.

The fine materials carried by the post-glacial Goldstream River were mostly carried far into the sea. However, possibly prior to glaciation and during periods of partial thawing, fine-textured materials accumulated in the estuaries and lagoons of the Colwood Inlet. An area of such marine clay is exposed above the Esquimalt Lagoon, and a smaller one above a protected lagoon north of Albert Head. It is probable that deposits of marine clay occur under gravels throughout the Colwood delta.

The topography is gently sloping (less than 5%). The internal drainage is very slow and heavy surface runoff is common. When saturated and disturbed, the clay will flow; when dry, it becomes hard. Soil development is weak, with little color difference between horizons, except for the surface 6 to 10 inches (15 to 25 cm) where dark staining from a high content of organic material is normal. This 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 runoff from surrounding slopes, forming a thicker surface layer and permitting deeper root penetration.

This landscape unit corresponds with the swordfern plant community. The most common trees are western red cedar and western hemlock, but young stands may form 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. Bracken fern, grasses and sedges become 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 Braythecium spp. are the most common ones. Also, liverworts are frequent. The 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 interphase and protection from insolation by vegetation. The ground vegetation is moderately resilient.

This landscape unit is considered only marginally suitable for residential development, and high density or large, heavy construction should be avoided. A compacted and undisturbed layer of clay can take a considerable weight, because water flows over it without appreciable penetration. However, when disturbed during construction and installation of service, it will become saturated and unstable. Sewage disposal will be costly, because lack

Fig. 23. The most common trees on marine clays are red cedar and western hemlock and their growth is good.

Fig. 24. After disturbance, this landscape unit regenerates to broadleaf species and shrubs. Repeated disturbance encourages grasses.

of percolation prevents use of septic tanks and fields. While erosion of clay covered by vegetation is not critical, after construction, the loose, water-saturated soil will flow. Immediate re-vegetation is mandatory. Grasses may give the best results. Landscaping must involve minimal soil disturbance.The soil can be somewhat improved and stabilized by the addition of sand and organic material. For agricultural uses, this landscape unit is compatible only with grazing, and pasture capability is high. Production of crops would require costly 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, the runoff in winter months amounts to about 30 inches (75 cm) of rainfall, not counting any additional runoff from higher slopes. Such an amount of water 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. However, because of flat terrain, intensive recreation facilities requiring a large hardtop surface can be built. It is also unattractive for hiking, being overgrown by dense trees and shrubs. A system of maintained trails would have to be provided for winter use. Steep banks of a few temporary creeks need to be protected by vegetation and where heavy trampling can be expected, by mechanical means.

The best use of this landscape unit appears to be open-space or greenbelt combined with multiple-use forestry. The forest productivity is comparatively high and while Douglas-fir may not be common, other valuable species will produce a high value of forest products. Trees are generally shallow-rooted in the surface soil underlain by clay and will suffer wind damage if the forest is suddenly opened.

WETLAND LANDSCAPE UNITS

The following landscape units constitute various stages of the process of filling in of depressions, which were left without drainage following the retreat of the ice. The fill-in process depended on the surrounding topography and its surfacial material, and on the size and depth of the lakes.

The numerous smaller depressions scattered throughout the till and outwash soils outside the Colwood delta were formed in depressions gouged in the rock by shifting of ice masses. Glacial till and, subsequently, glacio-fluvial materials constitute most of the deposits in these depressions.

As the land gradually rose, the glacial meltwaters were forcing their way through tidal flats of Colwood delta, piling sediments, finding new channels and abandoning old ones. Where drainages was impeded, lakes were formed. Glacio-fluvial, lacustrine and alluvial deposits are the most common deposits of these lakes.

Vegetation developed around and within the lakes and plant remains were deposited in the water. The rate of decomposition was dependent on the plant species, mineral content of water and the rate of winter flushing. In stagnant water, the accumulation of organic material was rapid and the soils formed are almost entirely organic. In lakes, which are a part of a stream system, the accumulation was slower and, because the stream brought alluvial sediments during each flood, the organic soils may contain a large proportion of mineral materials.

8. Deep organic soils.

(Figs. 25 and 26) 240 acres, 2% of the study area.

This landscape unit occupies flat areas where the original depression was completely filled by vegetative material with some mineral content. It receives constant seepage from adjacent slopes and, because of the naturally impeded drainage, free water is always available within 3 feet (1 m) 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 soil is sufficient to permit tree growth.

The surface soil is formed by decomposing organic material of variable thickness, from as little as 1 to more than 10 feet (30 cm to more than 3 m). The mineral component of the surface layers consists of fine-textured sediments, resulting from periodic inundation with a small amount of dust. 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 cobbles. Below this layer, which is still dark because of the high organic content, a layer of colluvial or glacio-fluvial origin may occur, consisting of gravel and rocks embedded in a sandy or loamy matrix that was probably deposited before the vegetation developed. This layer is usually underlain by compacted glacial till or bedrock.

The surface organic soil contains a large amount of nutrients in the decomposing material; this landscape unit also receives 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 reduces the depth of usable soil, eliminating Douglas-fir and allowing only those species to survive that can withstand extended flooding of their root systems.

This landscape unit includes the wet end of the Swordfern plant community and the Cottonwood - Crabapple - Willow community.

Apart from an occasional Douglas-fir growing on humps, the main species occurring in this landscape unit are western red cedar, grand fir, western hemlock, bigleaf maple, red alder and cottonwood. The multi-storied canopy of the tree layer is usually dense, effectively controlling the density of the shrub layer. Trees, rooting shallow in the organic material of low consistency, are subject to wind-throw, which opens the canopy. In such openings willow, crabapple, red osier dogwood and spirea become rapidly established, and in large openings, such as after logging, they take over the entire area and prevent the re-establishment of trees.

Swordfern, lady fern, vanilla leaf and miner's lettuce are the characteristic understorey species, but foam flower and lily-of-the-valley may be locally most common. Grasses and sedges usually become abundant after logging. Logs, stumps and litter are usually covered by mosses; the 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 residential development. Its depresssional position with impeded drainage renders it subject to occasional flooding. Further, the organic material is not stable enough to support foundations or road beds. When drained, it will decompose and settle. Undoubtedly, it is possible to stabilize the organic soils by rock fill, but that will be costly and, in the long run, probably unsatisfactory for any heavy

Fig. 25. Deep organic soil landscape unit is a wet habitat. Epiphytic mosses are characteristic of shaded situations while ferns are common in the open. (Top)

Fig. 26. Periodic flooding and heavy shade under cedar canopy may eliminate all ground vegetation. (Bottom)

structure unless the organic material is excavated.

This unit also is unsuitable for intensive recreation, and not especially attractive or suitable even for low-intensity recreation activities, such as hiking. During winter rains, it may be flooded and inaccessible. The vegetation, generally shallow-rooted because of the high water table, will be damaged if trampled and the soil, if not held by vegetation, will be subject to erosion when disturbed. This unit does, however, provide a habitat for a variety of wildlife and, therefore, attracts 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 residential development, make it important as a water storage facility during fast runoffs, because it equalizes the stream flow and controls floods.

Because of environmental limitations, this unit is best suited for greenbelt and wildlife habitat. 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 because of an invasion of spirea which, in 3 years, can form impenetrable thickets.

9. Bogs and Fens.

(Figs. 27, 28 and 29) 220 acres, 1.9% of the study area.

This landscape unit differs from the previous one in that the fill-in process has not reached the same advanced stage, possibly because of the greater depth of the depression and different vegetation. The previous unit was formed under more aerated and nutrient richer conditions, while this unit was formed under anaerobic, stagnant conditions. The source of water for a bog is precipitation; a fen has a flow at least during winter rains. During the summer, the water level is usually 8 to 16 inches (20 to 40 cm) below the soil surface, but after heavy rains, the depth of water may reach several feet.

During the winter, fens serve as flood control basins by storing water, thus slowing the stream flow and controlling the flow extremes.

Because of the high water table and lack of

Fig. 27. While an occasional tree-size willow, cascara and crabapple may be present, spirea usually forms impenetrable thickets.

Fig. 28. Where better light conditions exist, skunk cabbage may replace spirea. It may reach 4 feet (120 cm) in height.

Fig. 29. Even during summer droughts free water is always available. During winter rains this landscape unit may be under 4 feet (120 cm) of water.

aeration of the soil, trees are generally rare. Red alder, willow, cascara, crabapple and hawthorn may be present, but they usually attain smaller sizes than on better drained soils. Shrub-size willow and spirea usually form a dense, continuous and impenetrable cover. Grasses, sedges and bulrushes are abundant if not shaded out and suppressed by spirea. Skunk cabbage, cress, Indian hellebore and lady fern may be abundant locally. Other forbs are rare. Sphagnum spp. and mosses, such as Drepanocladus spp., Hypnum spp., Mnium spp. and Fontinalis spp., are often present, but rarely abundant.

Bogs and fens are unsuitable for residential development. Drainage 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. Costly dredging and filling with rock would be necessary to raise the area above the level of winter floods.

Intensive recreational use is also impractical for similar reasons. However, study and observation of wildlife and plant life could be an important recreation and education function of bogs and fens. Some means of access may have to be provided. The organic material could be excavated and used for mulching, topsoil or to improve soil elsewhere. The bog would then become a lake. If the shore can bear heavy recreation pressure; for example, if it is landscape unit 3 or 4, and the shore facilities could be provided, such an artificial lake could have a high recreational potential.

Because of environmental limitations imposed on any kind of construction within this landscape unit, and because of the value of this unit in stream flow regulation and flood control, bogs and fens are recommended for open space use or, if recreation pressure justifies it, for conversion into lakes.

10. Marshes.

(Figs. 30 and 31) 17 acres, .14% of the study area.

This landscape unit occupies shallow bays and shores of existing lakes and individual depressional areas in which free water stands permanently at or above the soil surface and which, from the beginning of winter rains until late in spring, are flooded to a considerable depth.

The surface soil is predominantly organic, as much as 10 feet (3 m) thick, and contains a variable proportion of fine mineral material of alluvial origin, sedimented during winter floods. Since the soil is permanently submerged, anaerobic, acidic processes predominate and the decomposition of organic material is extremely slow. The organic material is usually underlain by glacio-fluvial materials of loamy and sandy texture containing a variable amount of gravel and, below that, by a layer of compacted glacial till, bedrock or clay.

Fig. 30. In marshes free water stands permanently at or above the soil surface.

The vegetation is composed of sedges, marsh grasses, bulrushes and cat-tails. Spirea and, occasionally, willow may occur on hummocks and around edges elevated above the permanent water. Wetland mosses, similar to those in the previous unit, are present on debris above the summer water level.

This landscape unit, in its natural state, does not have any residential or intensive recreational potential. Organic material could be excavated and, after liming and oxidation in the air, used for mulching or improvement of top soil. The lake, of which the marsh is a part, could be enlarged or a new one created. This would greatly increase the recreational potential of the area, especially is surrounding landscape units could bear heavy recreational traffic.

An important function of this landscape unit, as in the preceding one, lies in flood control and stream flow regulation. It also provides cover and food for many species of birds, mammals, reptiles and amphibians and could be important for outdoor education. On the negative side, it is a breeding ground 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 state, 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 intensity recreational lake. Stocking the lake with fish would increase its value and further reduce the population of insects.

Fig. 31. With water and abundance of food, marshes are important wildlife habitats.

11. Lakes.

(Figs. 32 and 33) 302 acres, 2.6% of the study area.

The depressions occupied by Thetis and Florence lakes were gouged in the bedrock by progressing glaciers, though Florence Lake was later dammed by glacio-fluvial deposits. Glen and Langford lakes are in the river bed of the post-glacial Goldstream River. The lakes were partially filled with glacio-fluvial deposits, which were subsequently covered with fine-textured alluvium, dark from the high content of organic material. The lake floors are covered with a layer, up to 24 inches (60 cm) thick, of a loose, muddy, almost slimy, mixture of organic and fine mineral material which, with the slightest disturbance, becomes suspended.

The lakes are generally shallow (Figs. 34 and 35). Mean depth ranges from 12 feet (3.5 m) in Florence Lake to 21 feet (6.11 m) in Langford Lake. The maximum depth measured was 56 feet (17 m) in Langford Lake. Except for some steep rocky banks around Thetis Lake, the shores are moderately or gently sloping and provide easy access to the lake. The shoreline of Langford and Glen lakes is mainly gravel; that of Thetis and Florence lakes is shallow soil (Unit 3); both units are well suited for recreational use. However, small areas of gently sloping banks of alluvial silt or clay also occur at all lakes. These, because of seepage and capillary action, are wet and any recreational use will turn the soil into mud.

Only a few species of flowering plants occur in the lakes. Where water is less than 3 feet (1 m) deep and the bottom is muddy, water forget-me-not, common bladderwort and water smartweed may occur. Yellow pond lily and water shield, with floating leaves and roots anchored in mud, may occur in water up to 7 feet (2 m) deep. Duckweed, one of the smallest of flowering plants, is often found floating in backwaters.

The dissolved oxygen content of water is high throughout the year because of surface mixing and production by algae. However, in summer, during the time of temperature stratification, when mixing and circulation is at its minimum, the oxygen level decreases with depth.

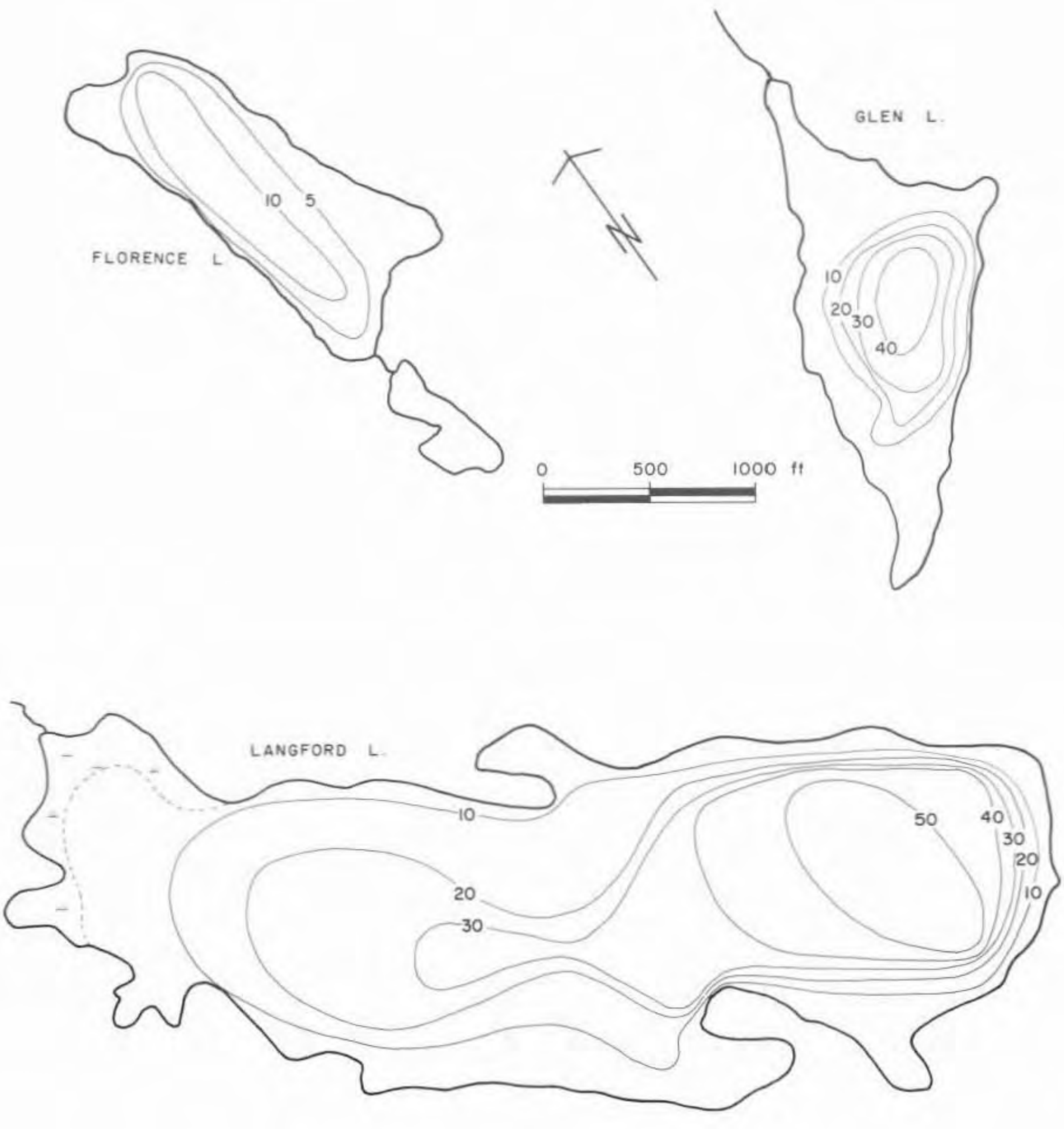
In addition to flood control and stream regulation, the main function of the lakes in the study area is recreation. Swimming, fishing and cultural and educational uses are relatively high because of the proximity of a large population and already settled shores. With the proposed development, the expected tripling of the population and the progressively greater amount of leisure time, the recreational use of the lakes will greatly increase. More points of public access and onshore space with full facilities will be necessary to improve the recreation potential, while protecting water quality.

Fig. 32. Thetis Lake lies within a large park and its water quality appears excellent. However, the creek running out of the lake is only winter-flowing. Even during heavy winter rains, it is only about 3 feet (1 m) wide (cover page).

Fig. 33. Langford Lake is already threatened by pollution. The expected population growth will increase the threat.

Only Florence and Glen lakes have sufficient winter flow, coming from sparsely populated catchment areas, to exchange their content with relatively clean water. As long as this remains unchanged, and the pollution from the surrounding residential properties can be eliminated, their water can be expected to remain relatively clean. Thetis Lake is within a park and at present the quality of water is excellent, in spite of insufficient winter flushing. About one-third of the catchment area lies to the northwest, outside the park boundary, and undoubtedly will eventually be subject to pressure for residential development. The highest pollution standards are recommended for this part of Thetis Lake watershed because of the possible danger of water deterioration.

Most of the Langford Lake drainage is privately owned. The density of settlement is not heavy, but it can be expected to increase rapidly in the future. About two-thirds of the lake shore is built up and the lake is heavily used for recreation. Only about a quarter of the lake volume of 3100 acre/feet (3.8 million m^3) is replaced annually by winter runoff. In summer, the water is stagnant. Late-summer buildup of algae is probably a result of higher concentration of nitrates and phosphates (Table 1). While the quality of water still appears to be quite acceptable, the expected population increase will undoubtedly cause further deterioration. Strict control of sewage disposal throughout the whole watershed and self-restraint of residents in the use of fertilizers is recommended.



GLEN LAKE

ELEVATION	207 ft.	63.1 m
SURFACE AREA	26.70 ac	10.8 ha
MEAN DEPTH	14.7 ft.	4.5 m
MAXIMUM DEPTH	45 ft.	13.7 m
PERIMETER	6,000 ft.	1829 m

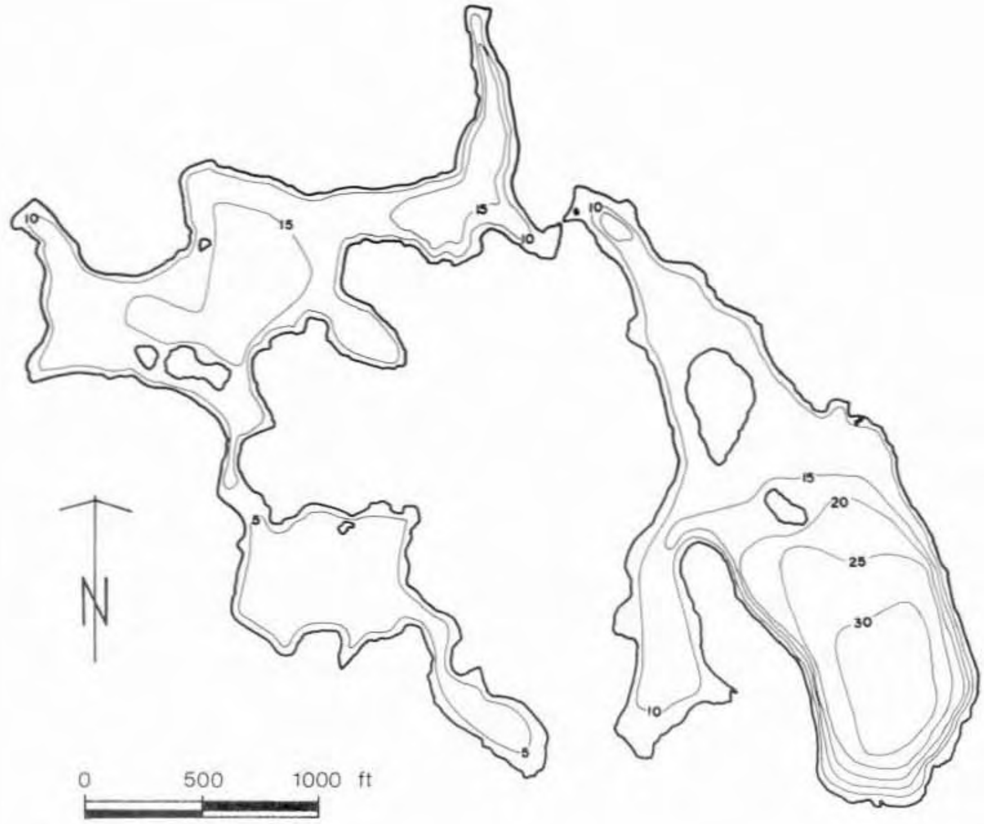
LANGFORD LAKE

ELEVATION	202 ft	61.6 m
SURFACE AREA	148.0 ac	59.9 ha
MEAN DEPTH	21.0 ft.	6.4 m
MAXIMUM DEPTH	56.0 ft	17.1 m
PERIMETER	15,840 ft.	4828 m

FLORENCE LAKE

ELEVATION	248 ft	75.6 m
SURFACE AREA	23.50 ac	9.5 ha
MEAN DEPTH	6.3 ft	1.9 m
MAXIMUM DEPTH	14 ft	4.3 m
PERIMETER	4950 ft	1509 m

Fig. 34. Depth contours and general information on Florence Lake, Glen Lake and Langford Lake.



THETIS LAKE

ELEVATION	200 ft.	61.1 m
SURFACE AREA	91 ac	36.8 ha
MEAN DEPTH	13 ft.	4.0 m
MAXIMUM DEPTH	32 ft.	9.8 m
PERIMETER	22,704 ft.	6920 m

Fig. 35. Depth contours and general information on Thetis Lake.

CONCLUSIONS AND RECOMMENDATIONS

The environment is a major factor in determining the quality of life. This concept of "quality of life" is gaining favor as the focal point for converging economic, social and environmental planning objectives. It expands the narrow measure of well-being measured by the standard economic indices, as per capita income, to include other social indicators and environmental and ecological amenities which are a vital part of everyone's life.

To implement the concept of quality of life, ecological inventory preceding the planning stage of an urban development must acquaint the decision-makers with probable consequences to the environment of allocating specific land resources to specific uses. Its particular objective is to permit optimum exploitation of the resource, consistent with human needs, while creating the least environmental imbalance. Human intervention creates stresses in the natural environment, in which the natural processes over thousands of years have approached a stable and usually healthy equilibrium.

The changes that take place are usually gradual and often are not perceived to be the result of human activity. By the time the degradation in the environment becomes obvious, the remedies are costly or even impossible, and consequences have to be borne by the public. To prevent such deterioration and the social cost of loss or rehabilitation, the planning of any urban development must apply ecological principles and turn the properties inherent in each variation of the landscape into opportunities - it has to work with the natural forces instead of fighting them.

The following recommendations are a summary of the inventory of the proposed development area in terms of social values. They are based on the evaluation of the properties and natural processes that are taking place now

Fig. 36. Colwood golf course, which lies on the well-drained outwash gravels, provides excellent recreation even during winter months. (Below)

Fig. 37. Easter lily is not a conspicuous plant, but its abundance gives character to the spring scene. (Centre)

Fig. 38. A lagoon north of Albert Head is completely separated from the sea by a gravel bar. (Right)

in each landscape unit and on the changes that are likely to occur as a result of increased population density and intensive use. It is realized that the recommendations are based on subjective evaluation of the inventory. However, they are not based on any preconceived idea or sentiment and aesthetics did not play an important part in the conclusions. With further study and increasing understanding of the natural processes, the recommendations should be improved and, as the needs and values of society change, they can be modified.

In the study area, four landscape units (Nos. 6,4,5 and 3) are suitable for development. They form a large, irregular basin surrounded by sloping, rugged terrain and cover a total of 8910 acres or 77.3% of the study area. This appears sufficient to accommodate the expected population growth. Their ranking is rather subjective and depends on the type of the proposed development, possible alternate uses and personal preferences.

In terms of socio-economic costs, the site deemed best suited for development is the outwash sand and gravel landscape unit (No. 6). The following reasons support this contention:

(a) It is the second largest unit in the study area, forming a large block of 3180 acres or 27.3% of the study area.
(b) Intensive use will cause little damage beyond some surface soil compaction.
(c) Soil erosion is insignificant.
(d) Internal soil drainage is excellent; unless large areas are built up or paved, the danger of flooding or ponding is minimal, even during heavy rains.
(e) Natural vegetation is resilient and will re-invade any disturbed area.
(f) Road construction on relatively flat terrain with gravelly soils will be easy and relatively inexpensive.
(g) Stoney mineral soil provides a solid foundation for roads or any planned structure.
(h) Because of its topography and soils, this unit is excellent for commercial, institutional and light industrial uses, as well as sports fields, playgrounds, etc.
(i) Excavation of underground services and their installation will be easy and relatively inexpensive.
(j) The effect of human activity during construction will be only temporary and will not extend far beyond the area actually disturbed.
(k) Landscaping and ground maintenance will be easy, but will require periodic addition of top soil and frequent fertilization and watering.
(l) Forest and agricultural productivity is low and amelioration on a large scale is impractical.
(m) Because of the size and position of this unit, the drainage of cold air from surrounding slopes, and thus unseasonal frost and radiation fog, will be of only local occurrence.

Only two considerations detract from the suit-

Fig. 39. Little used trails on Mill Hill offer interesting forest scenery year round.

ability of this unit for development:

(1) A large area of flat lowland provides a rather unattractive and monotonous environment for residential development.

(2) Coarse gravelly sands of low productivity impose limitations on landscaping and gardens.

The deep mineral soil unit (No. 4) was ranked second in its suitability for development. The following facts support this contention:

(a) Loss of a small area will be insignificant, because this unit is common on the south-east coast of Vancouver Island.

(b) The unit covers 1460 acres, or 12.6% of the study area, and usually is within or next to other units suitable for development.

(c) Intensive use will cause little damage beyond surface soil compaction.

(d) Soil erosion on gently sloping terrain will be insignificant.

(e) Road construction on flat terrain with loose soil will be easy and therefore relatively inexpensive.

(f) Stoney mineral soil provides a solid foundation for roads and any planned structure, especially since bedrock is usually less than 10 feet (3 m) below the surface.

(g) Excavations for underground services and their installation will be easy and relatively inexpensive.

(h) The effect of human activity during construction will only be temporary and will not extend beyond the area actually disturbed.

(i) Natural vegetation is resilient and will rapidly re-invade any disturbed area and protect the soil.

(j) Landscaping and ground maintenance will be comparatively easy and relatively inexpensive.

The following reasons detract from this unit's suitability for development:

(1) Flat lowlands provide a rather unattractive environment for permanent living, with a poor view.

(2) This is a very productive landscape unit for forestry.

(3) Frequency of fog and unseasonal frost will be high because of the drainage of cold air from slopes.

(4) Channelling and concentration of air currents in the valley may result in wind damage.

The Outwash sandy loam landscape unit (No. 5) was ranked third:

(a) This unit covers 890 acres or 8.3% of the study area.
(b) Intensive use will cause little damage beyond surface compaction.
(c) Soil erosion on a flat terrain is insignificant.
(d) Natural vegetation is resilient and will rapidly re-invade any disturbed area.
(e) The topography makes this unit excellent for commercial, institutional and light industrial uses, as well as sports fields, playgrounds, etc.
(f) Road construction on a flat terrain will be easy and relativey inexpensive.
(g) Excavation for underground services will be easy and inexpensive.
(h) The effect of human activity during construction will be only temporary and will not extend far beyond the area actually disturbed.
(i) Landscaping and ground maintenance will be easy.

The considerations that detract from this unit's suitability for development are:

(1) Flat lowland provides a rather unattractive environment for residential development.
(2) High soil productivity for agriculture and forestry suggests that this unit should not be developed unless necessary.
(3) Frequency of fog and unseasonal frost will be fairly high because of cold air drainage.
(4) Channelling and concentration of air currents in the valleys may result in wind damage.
(5) During heavy rains and runoff from the slopes, local flooding may occur.
(6) The design of foundations for buildings must take into consideration the deep loamy soils which, when wet, may become unstable.

Shallow mineral soil landscape unit (No. 3) was ranked fourth in its suitability for development:

(a) This unit is the largest in the study area, covering 3380 acres or 29.1% of the study area.
(b) This unit is also very common on southeastern Vancouver Island and a loss of an area for urban development will be insignificant.
(c) Moderate slopes with a variable topography provide an aesthetic setting for residential development with an attractive view.
(d) Solid bedrock within 3 feet (1 m) from the surface will provide an excellent support for foundations.
(e) The effect of human activity during construction will not be great and will not extend far beyond the area disturbed.
(f) Stoney sandy loams on moderate slopes are not prone to serious erosion.
(g) Vegetation is resilient, but trampling will reduce the vigor of most species.
(h) Occurrence of fog and unseasonal frost will be less frequent than on the previous three units.

The limitations inherent to this unit are:

(1) Excavation, road building and installation of services will require frequent blasting of rocks and will be considerably more expensive than in previous units.
(2) Sloping and broken terrain is unsuitable for playgrounds and sports fields.
(3) Where intensive development would take place, the scenic value may be lost.
(4) Landscaping and ground maintenance, while having greater scope due to diversity of topography, will have to aim at preventing erosion and will be more costly.
(5) Wind damage will be a problem.

The properties of the four landscape units considered suitable for development result in different degrees of suitability for different kinds of development. The large size and relative position of each unit makes it possible to take advantage of their complementary nature. The large block of outwash gravelly sands (Unit 6) in the map centre is suitable for any development and preference should be given to those requiring heavy construction and/or flat terrain, such as schools, commercial and business centres, industrial zones, sports fields and the main transportation and underground services network. In the surrounding areas, these uses should be located on deep mineral soils (Unit 4). Residential areas should be on shallower till soils (Unit 3) of the surrounding slopes, with side roads and secondary services leading into them. This organization would provide attractive living areas, with a pleasant view of the valley and surrounding hills, away from the concentration of fog and frost. The landscape unit No. 3 is generally more desirable and provides a healthier living environment than the lowlands below it. However, the construction costs will be higher. The deep outwash sandy loam landscape unit (No. 5) is also suitable for most kinds of development. However, social costs will be greater than on outwash sands (Unit 6) or deep mineral soil (Unit 4), mainly because of a loss of potential agricultural land.

Ideally, the remaining landscape units, because of their limitations, should form the open space and be excluded from urban development. If located within the development area, they could be used to break up the residential development into smaller clusters.

It would be unrealistic to expect that human activity will not affect the open-space areas situated within or close to large population centres. Bare rock and broken rock landscape units, located on hilltops and steep slopes, are covered with carpets of mosses over bedrock or shallow, lithic soils that took thousands of years to develop. Heavy traffic will cause erosion of these soils and destruction of vegetation, especially flowers, unless pathways are provided and traffic is excluded from the remaining areas. Trees will not be seriously damaged because their roots usually penetrate into rock interstices. Far more serious is the danger of fire. Dry mosses and grasses are highly inflammable during the summer and the spread of fire on steep topography is rapid. An accidental fire could cause more damage than heavy trampling over many years.

The marine clay landscape unit is only marginally suitable for development and no new development should be allowed until better methods of sewage disposal are developed, or sewers with treatment plants are installed. At present, effluent discharge from the recent development above Esquimalt Lagoon is causing pollution of water in the lagoon and eventually will have to be cleaned up at great public expense.

The following landscape units are subject to periodic flooding and, as such, should be exempted from all development that could be damaged by high water. Any intensive development will carry high long-term social costs.

The organic soil landscape unit is a wet forest habitat, situated on flat, low topography, usually adjoining bogs, marshes and lakes. Because it is a rather unattractive environment with difficult winter accessibility, it is not anticipated that it will be extensively used and the damage will probably not be serious. However, if heavy traffic is locally anticipated, an elevated pathway should be provided.

Areas with fluctuating water table, such as the marsh and bog landscape units, are important flood control basins. They are usually densely overgrown by spirea, which forms an impenetrable barrier to human use. They are also important wildlife habitats and should be preserved wherever possible. However, because they are breeding grounds of biting insects, it is suggested that, close to built-up centres, they should be excavated and flooded to form a recreational lake, or those areas not associated with a current lake could be partially drained and developed into intensively managed parks or flower gardens; e.g. Japanese gardens, or parks similar to Butchart Gardens or Beacon Hill Park.

It must be expected that the quality of water in the lakes will deteriorate with increased population. However, Glen Lake and Florence Lake, which are flushed during the winter, and Thetis Lake, which is inside of a large park, should retain acceptable water quality as long as effluents are not permitted to enter the lakes or streams, and fertilizers, herbicides and insecticides are used with caution. A special plea is made for Langford Lake. Only about a quarter of its water volume is flushed during the winter and the lake already shows signs of pollution, even with the present level of population. Without the concern of everybody living within its watershed, with the expected population growth, this lake is in real danger of becoming a cesspool.

It must be expected that the recreational use of the lakes will increase and planning of on-shore facilities, provision of beaches and cleaning of mud from the lakes' bottoms would greatly enhance their recreational potential. Recreational areas adjoining lakes should be located in landscape units recommended for intensive uses.

An environmental evaluation should be a part of every planning proposal. If the factors on which the evaluations and interpretations are based are known, understood and agreed upon, it should be possible for society to insist that the development respond to these values, i.e., that it takes place in areas intrinsically most suitable. The development should preserve a healthy environment and, to achieve this, it must be based on long-term minimal social cost.

Planning must satisfy the expected needs of society and prevent uncontrolled, disorderly and destructive development, in which nature is forced to recede and on which a few may make short-term profits, while remedies and long-term costs are the responsibility of the public.

The social costs of a project of this magnitude will be large but the benefits will be worth it. However, there always will exist a discrepancy between what society would like to have and what costs it is willing to incur to achieve it.

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Fig. 40. Trillium is a characteristic plant of shaded deep soils.

Layout: J. Wiens

Canadian Forestry Service
Pacific Forest Research Centre
506 West Burnside Road
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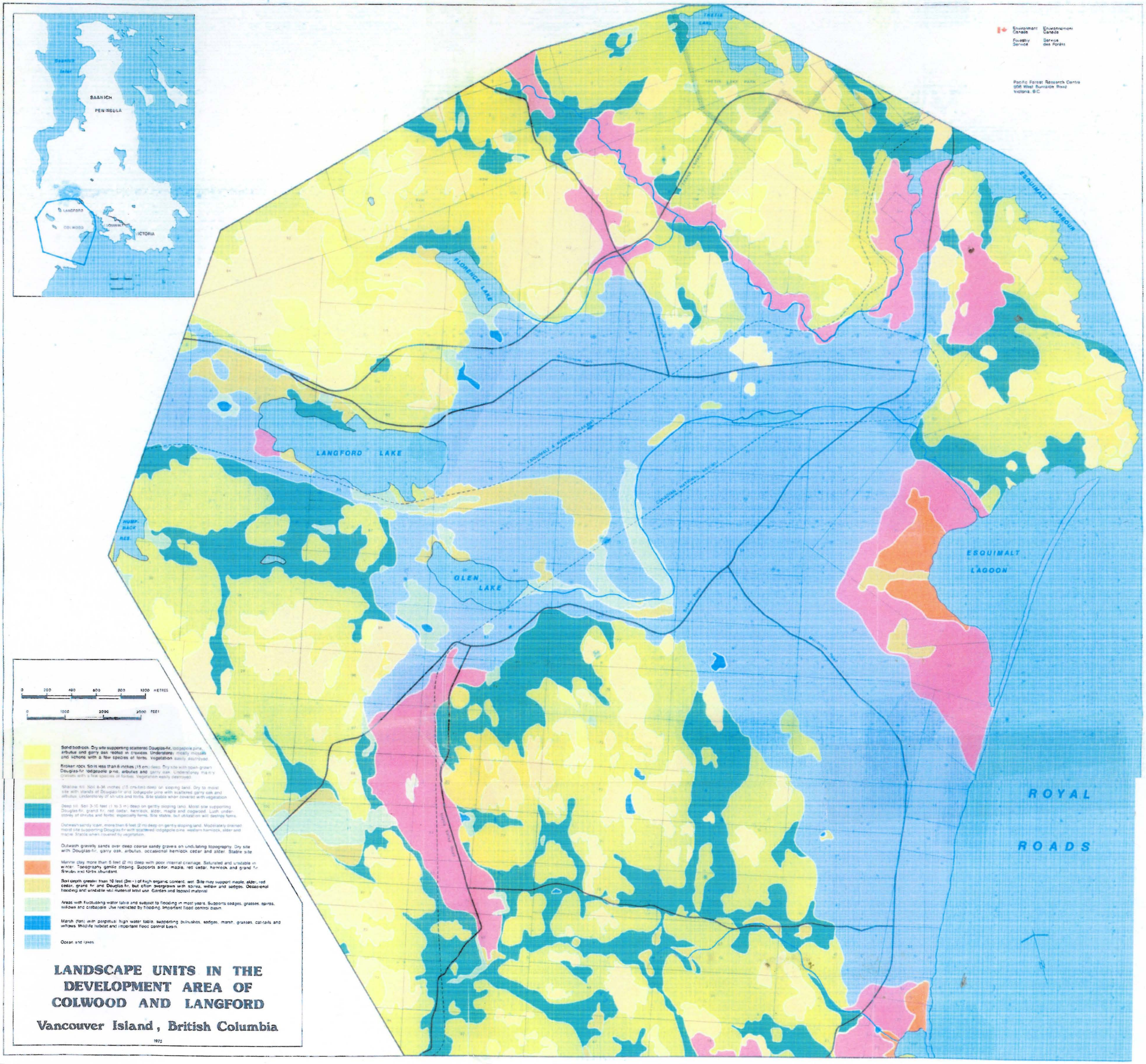

SAANICH
PENINSULA
VICTORIA
LANGFORD
COLWOOD
FLORENCE LAKE
LANGFORD LAKE
GLEN LAKE
ESQUIMALT HARBOUR
ESQUIMALT LAGOON
ROYAL ROADS
HUMP BACK RES.
Environment Canada Environnement Canada
Forestry Service Service des Forêts
Pacific Forest Research Centre
506 West Burnside Road
Victoria, B.C.
0 200 400 600 800 1000 METRES
0 1000 2000 3000 FEET
Solid bedrock. Dry site supporting scattered Douglas-fir, lodgepole pine, arbutus and garry oak rooted in crevices. Understorey mostly mosses and lichens with a few species of forbs. Vegetation easily destroyed.
Broken rock. Soil is less than 6 inches (15 cm) deep. Dry site with open-grown Douglas-fir lodgepole pine, arbutus and garry oak. Understorey mainly grasses with a few species of forbs. Vegetation easily destroyed.
Shallow till. Soil 6-36 inches (15 cm-1m) deep on sloping land. Dry to moist site with stands of Douglas-fir and lodgepole pine with scattered garry oak and arbutus. Understorey of shrubs and forbs. Site stable when covered with vegetation.
Deep till. Soil 3-10 feet (1 to 3 m) deep on gently sloping land. Moist site supporting Douglas-fir, grand fir, red cedar, hemlock, alder, maple and dogwood. Lush understorey of shrubs and forbs, especially ferns. Site stable, but utilization will destroy ferns.
Outwash sandy loam, more than 6 feet (2 m) deep on gently sloping land. Moderately drained moist site supporting Douglas-fir with scattered lodgepole pine, western hemlock, alder and maple. Stable when covered by vegetation.
Outwash gravelly sands over deep coarse sandy gravels on undulating topography. Dry site with Douglas-fir, garry oak, arbutus, occasional hemlock cedar and alder. Stable site
Marine clay more than 6 feet (2 m) deep with poor internal drainage. Saturated and unstable in winter. Topography gentle sloping. Supports alder, maple, red cedar, hemlock and grand fir. Shrubs and forbs abundant.
Soil depth greater than 10 feet (3m +) of high organic content, wet. Site may support maple, alder, red cedar, grand fir and Douglas fir, but often overgrown with spirea, willow and sedges. Occasional flooding and unstable soil material limit use. Garden and topsoil material
Areas with fluctuating water table and subject to flooding in most years. Supports sedges, grasses, spirea, willows and crabapple. Use restricted by flooding. Important flood control basin.
Marsh (fen) with perpetual high water table, supporting bulrushes, sedges, marsh, grasses, cat-tails and willows. Wildlife habitat and important flood control basin.
Ocean and lakes
LANDSCAPE UNITS IN THE DEVELOPMENT AREA OF COLWOOD AND LANGFORD
Vancouver Island, British Columbia
1975